chance flood) not determined.

chance flood) determined.

Limit of FEMA study.

Hazard | Geologic |

Category Units¹

carried without substantial increase in flood height.

Description

Oatm. subject to periodic riverine and flash flooding flash flood.

Stream channels, floodplains, and low terraces

Active pediments and sloping depositional

floods from adjacent upland areas during

Bedrock badlands and mesa tops that may be

subject to flood hazards during cloudburst

storms, but could not be classified due to a

along normally dry ephemeral streams (smaller Flash flood

surfaces flanking ridges and other upland areas sheetflood,

Valley bottoms and minor ephemeral drainages subject to possible sheetfloods and minor flash

that are chiefly inundated by sheetfloods, but possible flash

—— Base Flood Elevation line, elevation in feet above mean sea level.

Oal₁, Oa₁, Active floodplains and low terraces along

High Qac, Qay, drainage basins) and active alluvial fans that

Qat₂, Qae possibly by flash floods and debris flows

during cloudburst storms.

cloudburst storms.

Llack of alluvial deposits

¹Refer to UGS geologic quadrangle maps (see Sources of Information) for descriptions of map units.

Qats, Qat₂ and accompanying erosion.

Oath, perennial streams (large drainage basins)

Qat₂, are periodically inundated by flash floods and

debris flows during cloudburst storms.

EXPLANATION

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

FLOOD INSURANCE RATE MAP (FIRM) ZONES

Zone AE - Special Flood Hazard Area (SFHA) subject to inundation by the 1% annual chance

Floodway Area in Zone AE - The floodway channel of a stream plus any adjacent floodplain

FLOOD-HAZARD CATEGORIES BASED ON GEOLOGIC DEPOSITS

MAPPED BY THE UTAH GEOLOGICAL SURVEY

Zone A - Special Flood Hazard Area (SFHA) subject to inundation by the 1% annual chance

flood (100-year flood). Base Flood Elevations (water-surface elevation of the 1% annual

flood (100-year flood). Base Flood Elevations (water-surface elevation of the 1% annual

area that must be kept free of encroachments so that the 1% annual chance flood can be

Hazard Type

debris flow

ood, flash

lood, and

Comments

Fork of the Virgin River,

North Creek. South Creek

ormally dry streams and

Illuvial fans with compar-

tively small drainage bas

ubject to flooding during

Active depositional surface

of upland areas subject to

looding during cloudburst

/alley bottoms subject to

equent flooding from

djacent upland areas during

udburst storms.

· Areas of active erosion in

which flood hazards are ur

ermined due to a lack of

appable alluvial deposits.

n the flanks and at the base

oudburst storms.

hunes Creek.

irgin River, North and Eas

flooding in the study area.

management practices.

unpublished data) and provide ample evidence of the destructive power and life-threatening nature of

The high flood hazard results from the complex interaction of the area's rugged topography and southwestern Utah's seasonal weather patterns. Three principal types of floods occur in the study area: riverine (stream) floods, flash floods, and debris flows. All three flood types are associated with natural climatic fluctuations and may, under certain circumstances, occur simultaneously. Two additional types of floods may also occur within the study area—unintentional water release from water-retention structures, and flooding due to the breach of rock-fall or landslide dams—neither of which are necessarily associated with precipitation events. The risk from flooding can be significantly increased by wildfires (Neary and others, 2005) and by human activities such as placing structures and constrictions in floodplains and erosion-hazard zones, developing areas without adequate flood and erosion control, and poor watershed

SOURCES OF INFORMATION

Sources of information used to evaluate flood hazards in the SR-9 study area include (1) the 12 Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRMs) that cover the study area (FEMA, 2009), (2) Engineering Geologic Map Folio, Springdale, Washington County, Utah (Solomon, 1996), and (3) the distribution of young, water-deposited geologic units shown on the four Utah Geological Survey (UGS) 1:24,000-scale geologic quadrangle maps that cover the study area (Virgin [Hayden and Sable, 2008], Springdale West [Willis and others, 2002], Springdale East [Doelling and others, 2002], and Smithsonian Butte [Moore and Sable, 2001]).

FLOOD TYPES

Riverine Floods

Riverine flooding along major drainages in southwestern Utah is usually regional in nature, lasts for several hours or days, commonly takes place on perennial streams, and typically can be predicted days to weeks in advance. Riverine floods usually result from rapid melting of the winter snowpack or from area. Alluvial fans are relatively prolonged heavy rainfall associated with major frontal storms, or from both conditions simultaneously. They typically occur in watersheds of over 200 square miles that include terrain high enough to accumulate a substantial snowpack. Where uncontrolled, riverine floods can inundate large areas along floodplains and cause extensive erosion and flood damage (including bridge scour) as was demonstrated in the study area along the Virgin River during large riverine floods in 2005 and 2010. Data were insufficient to prepare a separate flood-erosion-hazard map for the study area; therefore, when developing in flood-prone areas, erosion hazard should be evaluated on a site-specific basis.

Measurements or careful estimates of historical peak flows on parts of the Virgin River system date to 1909 (U.S. Army Corps of Engineers, 1973), but are not available for every year. The largest recorded flood on the Virgin River (period of continuous record 1925–2012) occurred in December 1966; the U.S. Geological Survey (USGS, 2011) reported a maximum instantaneous discharge of 9150 cubic feet per second (cfs) on the North Fork of the Virgin River near Springdale. The two most recent major riverine floods on the Virgin River in January 2005 and December 2010 (figure 1) produced maximum daily discharges on the North Fork of the Virgin River near Springdale of about 2900 cfs and 3500 cfs, respectively (USGS, 2011). Both floods were regional events, and the 2005 flood is the most damaging flood on record in southwestern Utah, resulting in about \$85 million in private property losses and an estimated \$145 million in damage to roads, bridges, parks, and utility lines (FEMA, undated). Damage from the 1966 flood, which occurred when population densities in southwestern Utah were much lower,

held the previous damage record of \$14 million in 1966 dollars (U.S. Army Corps of Engineers, 1973).

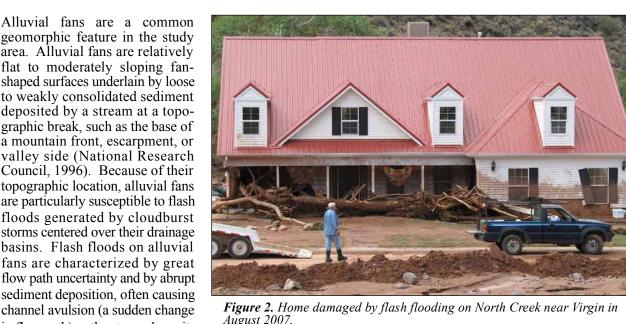


Figure 1. Rockville home damaged by flooding on the Virgin River in December 2010 (photo credit Kurt Sparenberg).

Flash Floods

Flash floods are sudden, intense, localized events that occur in response to cloudburst rainfall that often accompanies convective, monsoonal thunderstorms. Because cloudburst storms result from strong convective cells produced by differential atmospheric heating, flash floods are typically a summertime phenomenon in desert regions. Flash floods in the SR-9 study area can affect both perennial and during the Holocene (past 11,700 ephemeral drainages and alluvial fans. The Virgin River and its larger tributaries are subject to periodic flash flooding (figure 2), but the most intense and unpredictable floods often take place in small- to medium-sized watersheds characterized by ephemeral stream flow and normally dry stream channels.

Alluvial fans are a common geomorphic feature in the study flat to moderately sloping fanshaped surfaces underlain by loose to weakly consolidated sediment deposited by a stream at a topographic break, such as the base of a mountain front, escarpment, or valley side (National Research Council, 1996). Because of their topographic location, alluvial fans are particularly susceptible to flash floods generated by cloudburst storms centered over their drainage basins. Flash floods on alluvial fans are characterized by great flow path uncertainty and by abrupt sediment deposition, often causing



113°07'30"

in flow path) as the stream loses its ability to carry its sediment load (National Research Council, 1996).

Debris Flows Floodwaters typically contain a large amount of sediment ranging in size from clay to boulders. As the Hamilton (1995) and Biek and others (2010) identified as many as 14 natural lakes and ephemeral ponds that formed in canyons in and near Zion National Park due to the impounding effects of landslides, rock proportion of sediment increases, flash floods transform into debris floods and finally debris flows. A

Flooding Associated with Rock-Fall or Landslide Dams

erosion, and the former lakes were recognized chiefly by the fine-grained lacustrine sediments deposited

Future volcanic eruptions and lava flows are very low-probability events; however, the abundance of

narrow canvons and the prevalence of rock falls and landslides in and upstream from the SR-9 study area

Figure 4. Major reservoirs in and near the study area.

FLOOD DISCHARGE AND FREQUENCY ESTIMATES

Limited estimates of flood discharge and frequency have been made for selected drainages upstream from

the SR-9 study area. The estimates either pertain directly to perennial drainages that flow through the

study area, or are illustrative of the kinds of flows that might be expected from ephemeral drainages that

are similar in size to some of those within the study area. Martin (NPS, unpublished internal report, 1996)

determined the following discharge values: 100-year discharge = 9150 cfs, 500-year discharge = 13,500

made a floodplain analysis for the North Fork of the Virgin River in the vicinity of Zion Lodge and

unalysis by Smillie (NPS, unpublished internal report, 1988) Table 1. Adjusted flood discharge and

determined the following flood discharge values for Oak Creek: frequency data, North Fork of the Virgin

cfs, probable maximum flood = 100,000 cfs. A floodplain

100-year discharge = 3200 cfs, 500-year discharge = 5500 cfs,

probable maximum flood = 24,000 cfs. Sharrow (NPS.

estimate for Sammy's Canyon of about 2000 cfs. Table

pringdale (NPS, unpublished internal report, 1998).

unpublished internal report, 2008) reported a 100-year discharge

ummarizes adjusted flood frequency and discharge data

ompiled by the NPS for the North Fork of the Virgin River at

0 Kilometers 5

make the likelihood of future

natural water impoundments a

near certainty. Impoundment

of a stream by a rock-fall or

landslide dam can produce a

potentially significant flood

hazard, both from inundation

upstream of the dam due to

onding and flooding down-

stream of the dam due to over-

topping or breaching of the

dam. The degree of hazard

depends on the size of the

mpoundment, the charac-

eristics of the impounding

material, and the hydrology of

the impounded drainage. If a

rock fall or landslide is large

enough to block a perennial

stream or an ephemeral stream

subject to large flash floods

or high seasonal flows, and

the natural dam consists chiefly

upstream inundation could be

extensive and overtopping and

subsequent rapid erosion of the

impounding mass could result

landslide is relatively small and/

and downstream hazard would

be reduced.

of impermeable material, then

bridges, and of depositing thick layers of mud, rock, and other debris (figure 3). The volume and frequency of debris flows depends on several factors, including the amount of sediment in a drainage basin that is available for erosion and transport, the magnitude and frequency of storms, the amount of vegetation in the drainage, and soil conditions (Costa and Wieczorek, 1987; Costa, 1988; Giraud, 2004, 2005; Coe and others, 2008). Drainage basins that have experienced a wildfire are

debris flow moves as a viscous fluid capable of transporting large boulders, trees, and other heavy debris

over long distances. Like flash floods, debris flows are fast moving and under some conditions can exceed

35 miles per hour (USGS, 1997). Their greater density and high speed make debris flows particularly

dangerous to life and destructive to property. Debris flows are capable of destroying buildings, roads, and

generally more susceptible to debris flows (Gartner and others, 2005; Giraud, 2005). The sediment carried by a debris flow can be deposited anywhere on an active alluvial-fan surface. The active fan surface includes those areas where modern deposition, erosion, and alluvial-fan flooding may occur. In general, those parts of the fan surface where sediment has been deposited years; Cohen and Gibbard, 2010) are considered active unless proven to be otherwise. Typically, the upper part of an active alluvial fan

Figure 3. Sediment deposited by a small debris flow that discharged from an ephemeral drainage in Zion National Park in 1979. Such drainages are common in the State Route 9 Geologic-Hazard Study Area (photo burial depths, and event frequency courtesy of the National Park Service).

Debris flows are less common than flash floods in the SR-9 study area, but occur periodically in drainages where softer, more easily eroded bedrock crops out in the drainage headwaters. Such bedrock units include the Moenkopi. Chinle, Moenave, and Kaventa Formations, all of which weather to produce more sediment in a catastrophic water release. than the more-resistant Navajo Sandstone and Kaibab Formation. Debris flows typically occur in short, Conversely, if the rock fall/ steep tributary channels, but not in the large river channels of the Virgin River and its major tributaries. The 1998 Sammy's Canyon debris flow in Zion National Park, which inundated part of the Watchman or consists of highly permeable campground and the current locations of the Zion Canyon Visitor Center and shuttle maintenance facility, material, impoundment of a is a good example of a debris flow emanating from a small, ephemeral drainage with soft, sedimentlarge volume of water would be producing bedrock formations in its drainage basin (Lund and Sharrow, 2005; Lund and others, 2007). unlikely, and both the upstream

has a higher debris-flow hazard due

to greater velocities, impact pressures,

(Giraud, 2004, 2005).

Unintentional Water Release from Water-Retention Structures

The unintentional release of water due to the failure of an engineered water-retention or conveyance structure is a rare occurrence, but may under some circumstances occur with little warning. There are two significant dams within the SR-9 study area: South Creek Dam (Trees Ranch Reservoir) on South Creek, a tributary to the East Fork of the Virgin River, and the Quail Creek Diversion on the Virgin River close to the western boundary of the study area (figure 4). Two additional significant water retention structures are present upstream from the study area: Kolob Creek Dam on Kolob Creek (a tributary to the North Fork of the Virgin River above Zion Narrows), and Blue Springs Dam on Blue Creek (a tributary to the Left Fork of the North Fork of the Virgin River) (figure 4). A failure of any of these dams is considered a rare and unexpected event, the possibility of which is mitigated by periodic inspections by the Utah Division of Water Rights, Office of Dam Safety. However, a dam failure could cause significant flooding downstream—how significant depends on reservoir volume and nature of the failure (Harty and Christenson, 1988; Solomon, 1996).

South Creek Dam was constructed in 1988. The dam is 91 feet high and 955 feet long. The impoundment behind the dam (Trees Ranch Reservoir) has a surface area of 63 acres and a storage capacity of 2250 acrefeet at the dam spillway crest (Utah Division of Water Rights, 2011a). South Creek Dam is classified as a "High Hazard" dam by the Utah Division of Water Rights, Office of Dam Safety. Utah Code 73-5a-106, "Dams classified according to hazard and use," defines high-hazard dams as "those dams which, if they fail, have a high probability of causing loss of human life or extensive economic loss, including damage to critical public utilities" (Utah State Legislature, 2011). The town of Rockville is 5 miles downstream from South Creek Dam. South Creek Dam experienced a "dam incident" in 2010, categorized by the Utah Division of Water Rights, Office of Dam Safety as a "shallow downstream slope failure" (Utah Division of (Utah Division of Water Rights, 2011a). The flood break map for South Creek Dam shows that the maximum flood flow at Rockville from a "rainy day" dam breach would be 63,140 cfs, with a

Utah Geological Survey Special Study 148 State Route 9 Corridor Geologic-Hazard Study Area

falls, and lava flows. The impoundments ranged from a few acres in area and a few feet deep, up to miles Where development is proposed in areas identified as having a potential flood hazard, a site-specific long and hundreds of feet deep. The most notable were Lake Grafton and Coalpits Lake, which formed investigation should be performed early in the project design phase. The investigation should clearly behind lava-flow dams and flooded portions of the SR-9 study area, and Sentinel, Hop Valley, and Trail establish whether a flood/debris-flow/erosion hazard is present at a site and provide appropriate design Canyon Lakes that formed behind rock-fall/landslide dams. The natural dams have been breached by

> The failure of a water-retention structure or breach of a natural dam represents a low-probability, but highhazard event in the SR-9 study area. Monitoring and periodic inspection of constructed dams and reservoirs help ensure their safety, and Emergency Action Plans that include a notification plan for downstream communities are required for each dam by the Utah Division of Water Rights, Office of Dam Safety. Similarly, future natural dams within or upstream of the study area should be evaluated for safety and receive periodic inspections. Natural dams from landslides or rock falls are considered to be particularly hazardous, and should be regularly monitored to determine their vulnerability to overtopping

or catastrophic breaching.

Publication 05-6, 16 p.

NATIONAL

River at Springdale (after NPS, Water

| Frequency | Period | North Fork

0.9900

0.9800

Resources Division, internal report, 1998).

Adjusted Discharge

(cfs)

Springdale gage

(years) Virgin River at

MAP LIMITATIONS

This map is based on limited geological, geotechnical, topographic, and hydrological data; site-specific investigations are required to produce more detailed flood-hazard information. The map also depends on the quality of those data, which varies throughout the study area. The mapped boundaries of the floodhazard categories are approximate and subject to change as new information becomes available. The flood hazard at any particular site may be different than shown because of geological and hydrological variations within a map unit, gradational and approximate map-unit boundaries, the generalized map scale, and topographic changes along drainages that postdate mapping. Small, localized areas of higher or lower flood hazard may exist within any given hazard area, but their identification is precluded because of limitations of the map scale. The map is not intended for use at scales other than the published scale, and is designed for use in general planning to indicate general hazard areas and the need for site-specific investigations.

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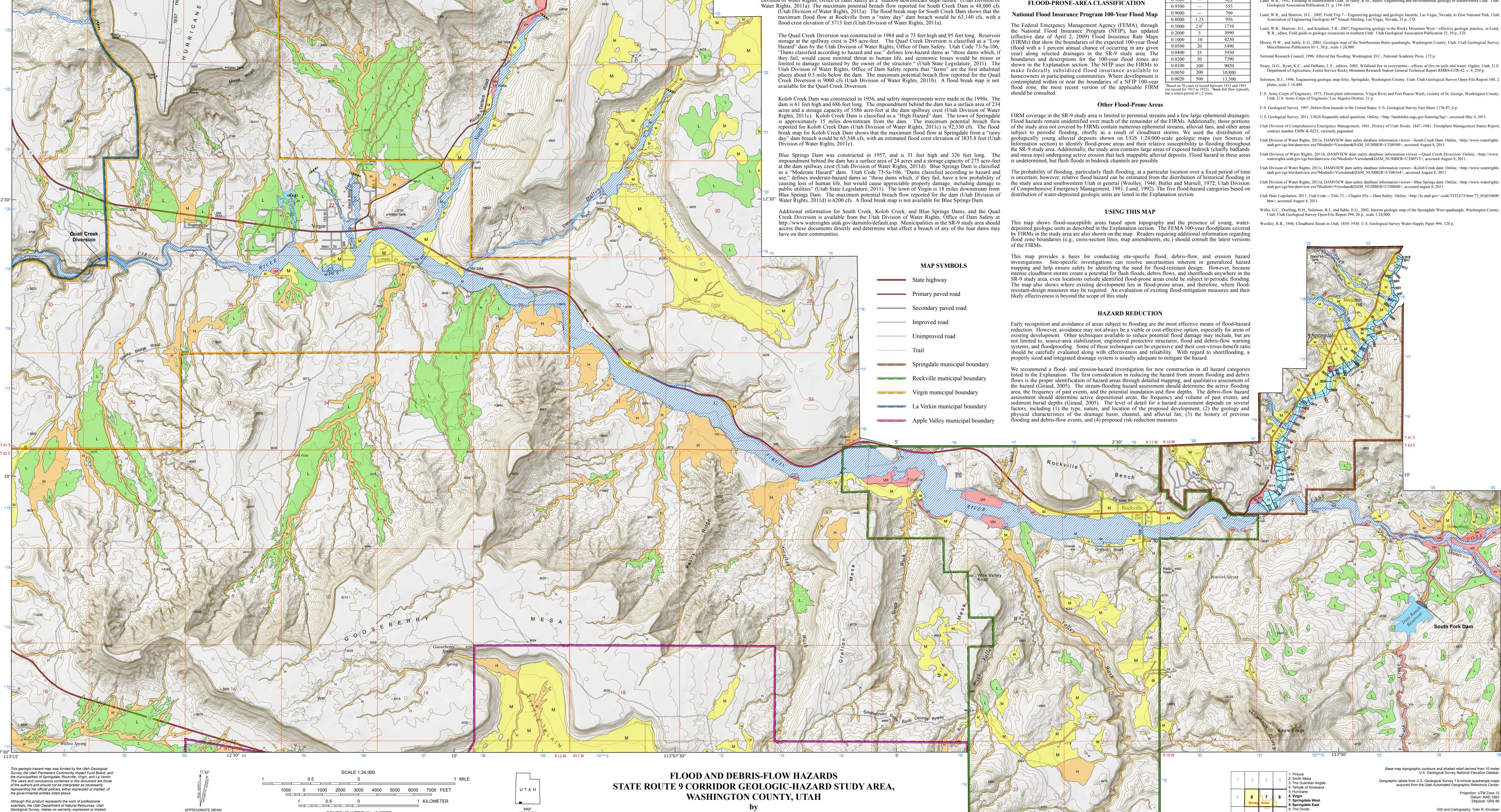
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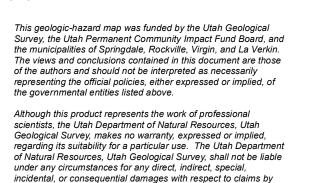
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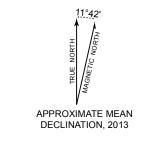
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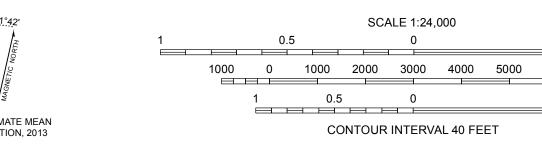




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