

# Zion Resource Brief

National Park Service  
U.S. Department of the Interior



## Resource Management and Research Division:

### Physical Sciences: Climate Change, Air Resources, Geology, Paleontology, & Hydrology

#### Introduction

The Resource Management and Research Division oversees both natural and cultural resources in Zion National Park, Cedar Breaks National Monument, and Pipe Spring National Monument. The division includes seven programs: Wildlife Management, Vegetation Management, Physical Sciences, Cultural Resource Management, Environmental Planning, Geographic Information Systems, and the Museum program. The resource programs administer numerous research activities that are conducted by outside universities and other agencies. Additionally, we receive support for long-term monitoring by the Northern Colorado Plateau Network. (Visit <http://science.nature.nps.gov/im/units/ncpn/> for more information about what this program is doing in each park.) The resource programs are involved with various outreach projects, including Zion Canyon Field Institute courses. This hand out describes our physical sciences division.

#### Climate Change

Changes in the climate that have been documented in western North America have been observed at Zion, where the temperature record goes back to 1928. Since then patterns for the annual mean temperature have been similar to North American averages: increasing temperatures until the mid 1950s, then gradual decrease through the 1970s, followed by a more rapid increase through the present. The overall trend between 1928 and 2007 is an increase of 2 degrees Fahrenheit over that 80 year period. Over the last 25 years the trend has been an increase of 0.6 degree F in each decade, a rate of increase consistent with climate projections into the next century. Following a similar pattern, the long term trend for the number of days each year over 100° F has increased from 35 early last century to 56 in the 2001-2010 decade. Alternatively, in analyzing the number of days below freezing each year, a similar but less pronounced trend is found with the number of below freezing days falling from 79 early in the record to 75 in recent times, and to only 68 since 2001. In the Virgin River, the average



Dalton Wash Air Quality Station

yearly date when half the volume of the spring runoff has passed has crept from around May 6 to April 28 in recent years, or 8 days earlier.

The National Park Service established an office of Climate Change Response in 2010. This office is producing products useful for understanding and interpreting climate change. The NPS has also developed a NPS Draft Climate Change Response Strategy.

Climate conditions are monitored at the following 7 locations in and near Zion:

1. Zion –NOAA site located behind the headquarters building (daily temperatures and precipitation since 1928)
- 2&3. RAWS (Remoted Automated Weather Station) in Zion Canyon north of Watchman housing, and at Lava Point (hourly data since 1995, with wind and fuel moisture),
4. East Entrance (operated by NOAA to assess particular storm events only),
5. Dalton Wash at the air quality station (high quality hourly data since 2000),
6. At the north end of Cave Valley (Natural Resource Conservation Service SCAN station, high-quality hourly data in real-time since 2010), and
7. Kolob Canyons administrative area (NOAA permanent station; hourly data in real-time since 2010).

2013 saw the coldest temperature in several years when the low reached -4° on December 9th, and the 14.5 inches of heavy snow that fell on December 7th and 8th was the 3rd highest 2-day total on record.



## Air Resources

The Colorado Plateau, along with much of the Great Basin outside of the Wasatch Front, has some of the best air quality in North America. The distance that a person can see is commonly greater than 100 miles and, on a few days a year, can approach the maximum possible of over 200 miles. (Compare this with average summer visibility in the eastern U.S. of less than 10 miles.) Unfortunately, having exceptionally clear air makes this area more vulnerable to even a small amount of new pollution. The best visibility typically occurs in the winter when polluted air is trapped in the source areas by temperature inversions. In the summer when warm air mixes and the predominant airflow is from the south, visibility typically decreases. Higher humidity in the summer also helps to accentuate the haze. Haze in Zion comes from sources as far away as Los Angeles, California's Central Valley, and Mexico, though nearer sources like Las Vegas and fires also contribute.

Ozone levels measured at Zion occasionally approach those known to damage vegetation, and damage has been documented on elderberry leaves in Cedar Breaks National Monument. The national ozone standard of 75 ppb is occasionally exceeded. Over the last decade, this has occurred on average 1.5 times per year, which is notable because the area would be out of compliance if the standard were exceeded four or more times per year. At Zion we monitor particulates, visibility, ozone and climate at the NPS Air Quality monitoring station on BLM land near Virgin, Utah.

In the most recent Air Quality in National Parks Trends and Conditions (2009) the following trends are identified for the 1999-2008 period for Zion (or for Bryce Canyon for parameters not monitored at Zion). Visibility significantly improved on the clearest days, but there was no identifiable trend on hazy days. Ammonium levels showed a possible degradation, nitrate levels showed a possible improvement, and sulfate levels showed significant improvement. The period of record for ozone at Zion is, as yet, too short for a trend determination.

## Geologic Resources

The Zion National Park and Springdale area is well known for the spectacular formations and colorful geologic features. Among engineering geologists, it is also well known for the variety of geologic hazards present. Rockfalls are common though damage and injury have fortunately been rare. An unfortunate exception occurred on December 12, 2013 in Rockville, when a cluster of rocks broke away from the cliffs of Shinarump conglomerate, and smashed a house on the west end of town instantly killing its two occupants.

Large landslides have occurred many times in Zion in the recent geologic past and are a major influence on the landscape. Prominent among these is the Sentinel Landslide in Zion Canyon where slides have damaged the scenic drive three times in the last century and resulted in the construction of a major retaining wall to protect the road. Large flood events in 1998 and 2010 caused damage to the structure, and an evaluation in 2012 by the Federal Highways Administration suggests that some additional widening of the river channel may be necessary to improve its function. The date for this work has not yet been set. A researcher from the University of Utah is currently studying the Sentinel Landslide, to better describe its origin and age.

An interesting side benefit of a current project to construct a new irrigation system (described in the Hydrology section) was that the deep excavation confirmed that the valley floor south of the Sentinel Landslide has an accumulation of 40-60 feet of rock and fine debris overlying the bedrock. The origin of this layer is debris carved out of the Sentinel Landslide by the North Fork as it excavated a channel into the landslide.





Other prominent landslides include the slope on which the switchbacks are constructed, a large slide damming Hop Valley, older slides and lava dams in North Creek and Coalpits wash, and three slide dams in the Taylor Creek drainages. Several areas of large landslides and slumps occur in and around Springdale where slopes move on the Chinle formation.

Collapsing soils have damaged the park greenhouse, and a large debris flow occurred in Sammy's Canyon just prior to construction of the Shuttle Bus Maintenance Facility. A publication completed in 2010 titled Geologic Hazards of the Zion National Park Geologic-Hazard Study Area, Washington and Kane Counties, Utah by the Utah Geological Survey (available online at: [www.geology.utah.gov](http://www.geology.utah.gov)) describes nine types of geologic hazards.

A rockfall in fall 2010 smashed into the sign shop at the Zion maintenance yard busting a large hole in the 18-inch thick sandstone wall. It was almost an exact repeat of a rockfall in 1941. In response, rockfall barriers have been installed on the slope above the maintenance building.

The U.S. Natural Resource Conservation Service will be conducting a soil inventory and mapping project in Zion in 2014.

## Paleontological Resources

The Zion area is rich with paleontological resources. In addition to the well known occurrences of petrified wood in the Chinle Formation, dozens of track sites have been identified in the Kayenta, Moenave, and Moenkopi formations and, more rarely, in the Navajo Sandstone. The tracks were left by dinosaurs and earlier dinosaur-like creatures large and small. Monitoring of 21 sites in 2012 showed that several had been damaged or lost due to natural erosion in the 5 years since they were last visited. The exceptional rate of erosion in Zion exposes many fossils, but also takes them away. Five new sites were documented in 2012 including the discovery of a fossil of the genus *Sanmiguelia* which are some of the earliest known flowering plants.



Rockfall near Canyon Junction-2012



Rockfall barrier above Zion Maintenance Yard



Fossil of a *Sanmiguelia* species found in 2012.



## Hydrology

### *Fecal Bacteria in the North Fork*

The North Fork of the Virgin River continues to have high levels of fecal bacteria upstream of the Narrows. After seeing an indication of a problem in 2009, a program of intensive monitoring was initiated and continues to the present. The results indicate that the water in this reach regularly fails to meet water quality standards, so the State of Utah has designated the North Fork as “out of compliance” for fecal bacteria. A solution to this problem is in sight because the Utah Division of Water Quality is funding, and several agencies are implementing, a project north of the park to convert the open-ditch irrigation system to a cooperative pressurized pipe irrigation system. This will permit irrigators to control the application of water and greatly reduce surface run-off from livestock pastures. Construction is planned for fall 2014 and spring 2015.

### *Stream flow*

Most of the overall volume of water that flows down the Virgin River does so during the spring runoff. In wet years these spring floods can reach 2,000 to 3,000 cubic feet per second (cfs) and last for weeks. Stream flow was above average in 2011, somewhat below average in 2012, well below average in 2013, and will be even lower in 2014. These flows are dictated by the amount of winter snowfall. There is some hope for the winter of 2014/2015 because forecasters are predicting an El Nino developing in the Pacific next fall, giving us a much better chance of above average winter precipitation.

Summer floods are much shorter in duration, lasting only a few hours, but the river can rise from 40 cfs to a few thousand cfs in just a few minutes. Even though the flood surges advance downriver at a speed of only about 5 mph, hikers cannot outrun a flood. Since 1950 there have been eight flood-related fatalities in Zion, which accounts for 34% of the 23 fatalities that have occurred in Utah in that time. Hikers are advised to check weather forecasts and inquire at the visitor center for safe hiking conditions before entering narrow canyons during the summer rainy season.

The Zion Backcountry permits staff use the Utah Flash Flood Hazard Rating System developed by the National Weather Service and published daily. The park, however, has adapted the terminology in the ratings to better convey the level of risk to visitors in slot canyons.

The word “low” was particularly troublesome because visitors perceived this as floods are very unlikely to happen, when in actuality it means that some scattered storms will occur, and some slot canyons will flood. Even though the canyons that flood might be widely scattered, the consequences of even a small flood to people in a slot canyon can be fatal.

## Flash Flood Hazard Rating Systems

### *NOAA Terms    ZION Flood Hazard Terms*

Dry	Not Expected
Low	Possible
Moderate	Probable
High	Expected

The summer monsoon was exceptionally active in 2013, producing 39 distinct flood peaks at the river gage at Virgin, Utah during July and August.

The region experienced several years of drought beginning in 1999, and in 2002 the park received its lowest precipitation on record (5.01 inches). That year the Virgin River experienced the lowest flows (22 cfs) observed since measurements began in 1927. Drought conditions generally continued until the spectacular winter of 2005 which was, by far, the wettest on record when total precipitation reached 31.65 inches. Since then, 2006 - 2009 were all below average in total runoff, 2010 and 2011 are above average and 2012, 2013 and 2014 were again below average.





## Water Rights & Consumption

The federal government, including the NPS, must use water within the state administered system of water rights. Zion has some water rights that were purchased from previous landowners and others gained by virtue of being set aside by Congress as a park. The latter of these are called Federal Reserved water rights and are primarily used to maintain the natural resources of the park, though some use for drinking water, irrigation, etc., are also permissible. These uses are recognized by the State of Utah in the Zion National Park Water Rights Settlement Agreement. This agreement was adopted in 2002 by the Fifth District Court of Utah. It is a formal legal recognition of NPS rights to all water flowing through or arising in the park, yet it allows existing water uses upstream to continue, and provides for some small increases in water use.

Water flow through the park will remain largely unaltered, a very rare condition in the arid west, with natural patterns of flooding and periods of low flow. The NPS takes water from several springs to supply culinary water for park facilities (Temple of Sinawava, Grotto Spring, Wylie Retreat Spring, and Birch Creek Springs). It also has two wells (at East Entrance and Kolob Canyons) and two diversions on the North Fork of the Virgin River for irrigation water. A project is currently under construction to replace the park's old irrigation ditches with a pipeline that will carry pressurized irrigation water. This provides an opportunity to conserve potable water by using river water for irrigation at all park facilities in lower Zion Canyon.

## Physical Sciences Resources

- Geological - *Water, Rock, & Time* by Robert Eves' provides an excellent description of the Geology of Zion. Another good source is the Zion chapter in the Utah Geological Society book *Geology of Utah Parks and Monuments*. An accompanying CD-ROM is also available from the Utah Geological Society presenting detailed geologic notes for roads and trails in the park.
- Hydrology - Real-time streamflow data are available for the North and East Forks of the Virgin River, and for the Virgin River at the town of Virgin at: <http://waterdata.usgs.gov/ut/nwis/current/?type=flow>.
- Air Quality - Though it is a little dated, the publication *Introduction to Visibility* by Bill Malm is an excellent resource. Real-time ozone and climate data can be viewed at: [http://www.nature.nps.gov/air/data/current/data\\_ZION.cfm](http://www.nature.nps.gov/air/data/current/data_ZION.cfm).