West Salt Creek Landslide

Presenter: Chad Wellman

* Chad Wellman Bio
* Grew up in Virginia Beach Virginia. Lived on tidal water and boated the Atlantic Ocean, Chesapeake Bay, and Lynnhaven Inlet on a regular basis. Graduated from Virginia Tech May 2000 with a Bachelor of Science in Civil Engineering.

Started with the Forest Service in January of 2010. Currently a Project Engineer for the GMUG stationed at the Gunnison Ranger District in Region 2. Live in Crested Butte and enjoy building, biking, hiking, walking my dogs, snowboarding and skiing. I have 2 dogs and a cat.

* Credits:
* **Dr. Rex Cole**
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* Education
  Ph.D. University of Utah
  B.S. Colorado State University
  A.S. Mesa State Junior College
* Ben Stratton USFS Hydrologist

* The tragedy of landslides:
* Three people died in the West Salt Creek Landslide
* The slide killed 51 year old Mesa County Road and Bridge Department worker Clancy Nichols, his 24-year-old son Danny who was a geologist and District Water Manager 46-year-old Wes Hawkins.
* On Saturday, March 22, 2014, at 10:37 a.m. local time, a major mudflow occurred 4 miles east of Oso, Washington, United States, when a portion of an unstable hill collapsed, engulfing a rural neighborhood, and covering an area of approximately 1 square mile (2.6 km2). Forty-three people were killed.
* Heavy rain in Vargas Venezuela triggered a landslide in December 1999 that killed 30,000

Mass wasting, is the geomorphic process by which soil, sand, and rock move downslope typically as a mass, largely under the force of gravity, but frequently affected by water and water content.

Types of mass wasting include creep, slides, flows, topples, and falls, each with its own characteristic features, and taking place over timescales from seconds to years.

Mass wasting occurs on both terrestrial and submarine slopes, and has been observed on Earth, Mars, Venus, and Jupiter's moon Io.

When the gravitational force acting on a slope exceeds its resisting force, slope failure (mass wasting) occurs.

The steepest angle that a cohesionless slope can maintain without losing its stability is known as its **angle of repose**.

Factors that change the potential of mass wasting include: change in slope angle, weakening of material by weathering, **increased water content**; changes in vegetation cover, and overloading.

Water can increase or decrease the stability of a slope depending on the amount present.

Small amounts of water can strengthen soils because the surface tension of water increases soil cohesion.

This allows the soil to resist erosion better than if it were dry.

If too much water is present the water may act to increase the pore pressure, reducing friction, and accelerating the erosion process and resulting in different types of mass wasting (i.e. mudflows, landslides, etc.).

A good example of this is to think of a sand castle. Water must be mixed with sand in order for the castle to keep its shape. If too much water is added the sand washes away, if not enough water is added the sand falls and cannot keep its shape. Water also increases the mass of the soil, this is important because an increase in mass means that there will be an increase in velocity if mass wasting is triggered.

Types of mass movements:

Types of mass movement are distinguished based on how the soil or rock moves downslope as a whole.

Creeps

Soil creep is a long term process. The combination of small movements of soil or rock in different directions over time are directed by gravity gradually downslope. The steeper the slope, the faster the creep. The creep makes trees and shrubs curve to maintain their perpendicularity, and they can trigger landslides if they lose their root footing. The surface soil can migrate under the influence of cycles of freezing and thawing, or hot and cold temperatures, inching its way towards the bottom of the slope forming terracettes. This happens at a rate that is not noticeable to the naked eye.

Landslides

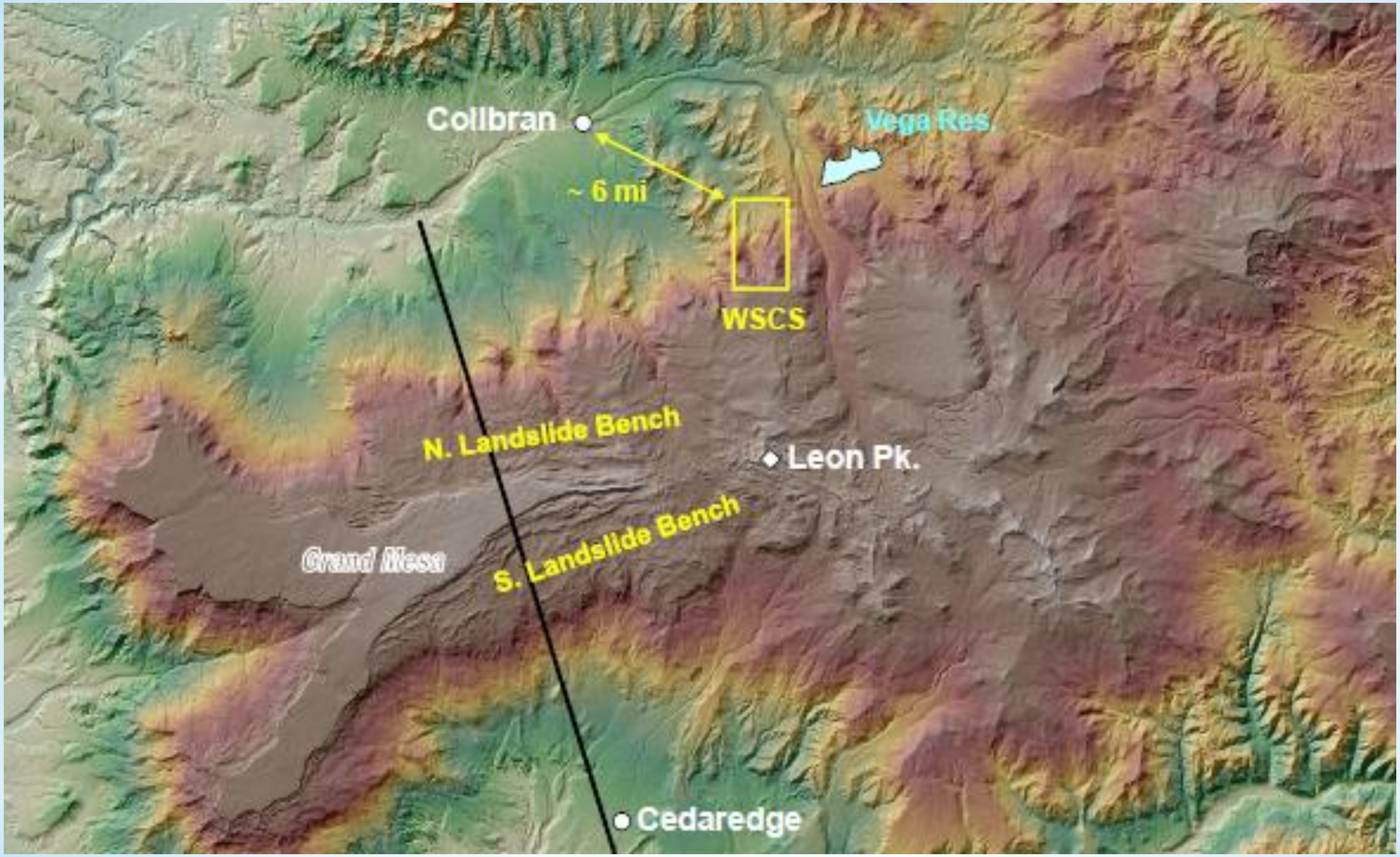
A landslide is a rapid movement of a large mass of earth and rocks down a hill or a mountainside. Little or no flowage of the materials occurs on a given slope until heavy rain and resultant lubrication by the same rainwater facilitate the movement of the materials, causing a landslide to occur. The common forms of landslides are slump, debris slide, rock slide, rock fall, debris fall and avalanche.

Flows
Movement of soil that more resembles fluid behavior is called a flow. These include avalanches, mudflows, debris flows, earth flow, lahars and sturzstroms. Water, air and ice are often involved in enabling fluidlike motion of the material.

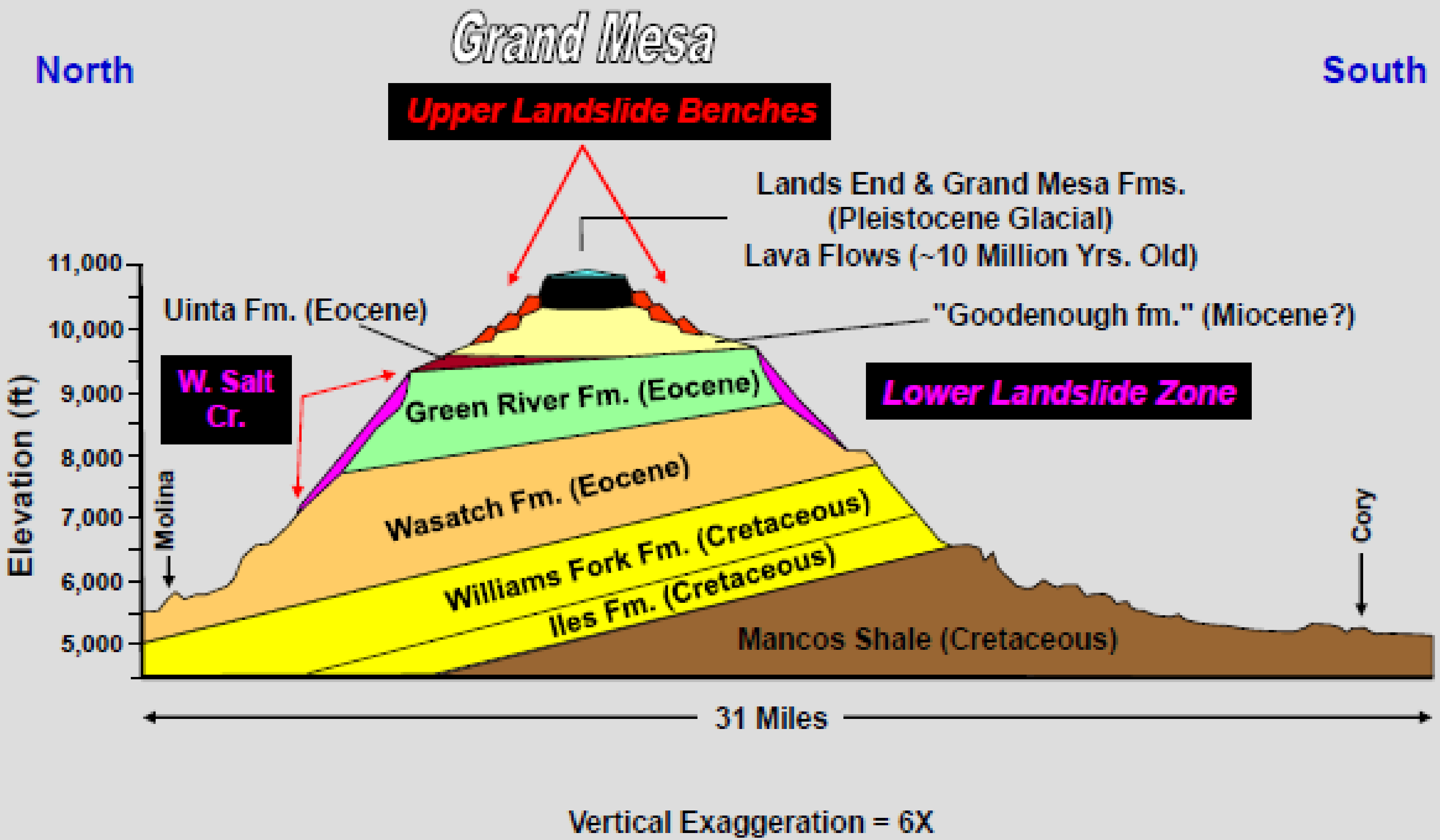
Slump
A slipping of coherent rock material along the curved surface of a decline. Slumps involve a mass of soil or other material sliding along a curved surface (shaped like a spoon). It forms a small, crescent-shaped cliff, or abrupt scarp at the top end of the slope. There can be more than one scarp down the slope.

Falls
A fall, including rockfall, is where regolith cascades down a slope, but is not of sufficient volume or viscosity to behave as a flow. Falls are promoted in rocks which are characterized by presence of vertical cracks. Falls are a result of undercutting of water as well as undercutting of waves. They usually occur at very steep slopes such as a cliff face. The rock material may be loosened by earthquakes, rain, plant-root wedging, expanding ice, among other things. The accumulation of rock material that has fallen and resides at the base of the structure is known as talus.

* Geology:
* The mesa is topped by a hard volcanic basalt. This layer, formed approximately 10 million years ago by basalt flows, suppressed erosion compared to the surrounding sedimentary rock layers, which suffered rapid downcutting from the action of the Colorado and the Gunnison rivers.



The Grand Mesa is the largest flat top mountain in the world. It is about 500 square miles in area and reaches 11,000 feet above sea level and is about 6000 feet above the surrounding valley floors. Over 300 lakes, including many reservoirs created and used for drinking and irrigation water, are scattered along the top of the formation. The Grand Mesa is flat in some areas, but quite rugged in others.



Grand Mesa
North
South
Upper Landslide Benches
Lands End & Grand Mesa Fms.
(Pleistocene Glacial)
Lava Flows (~10 Million Yrs. Old)
Uinta Fm. (Eocene)
"Goodenough fm." (Miocene?)
W. Salt Cr.
Lower Landslide Zone
Green River Fm. (Eocene)
Wasatch Fm. (Eocene)
Williams Fork Fm. (Cretaceous)
Iles Fm. (Cretaceous)
Mancos Shale (Cretaceous)
Molina
Cory
Elevation (ft)
11,000
10,000
9,000
8,000
7,000
6,000
5,000
31 Miles
Vertical Exaggeration = 6X

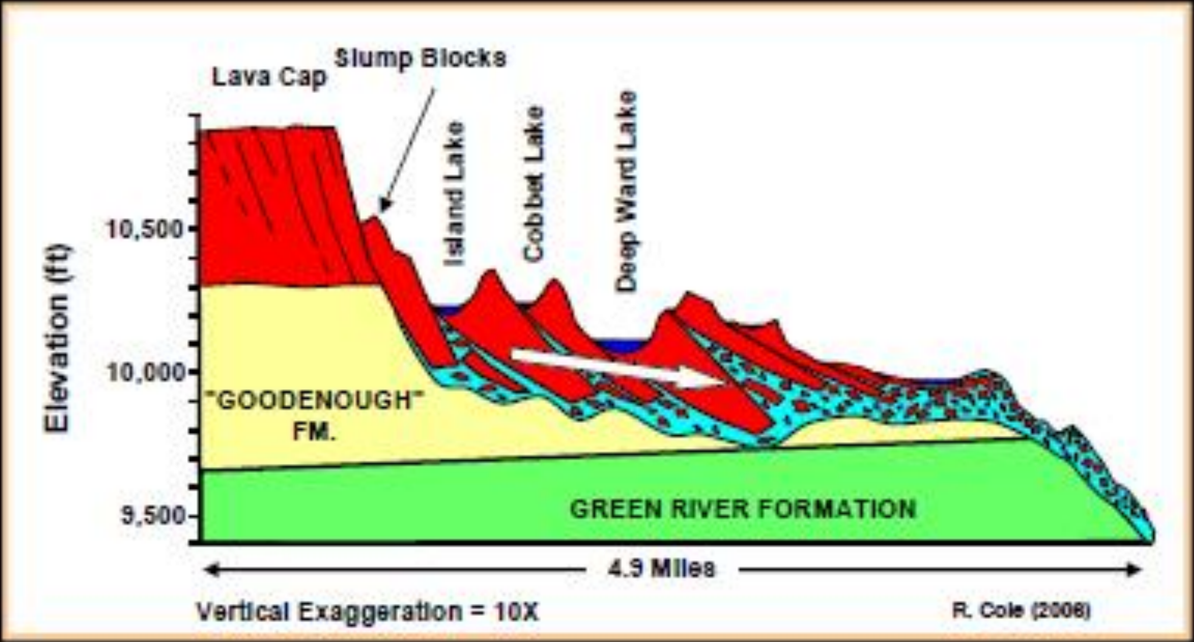
Upper Landslide Benches on Grand Mesa

Colorado Mesa University Geology Program

View from Land of Lakes Overlook

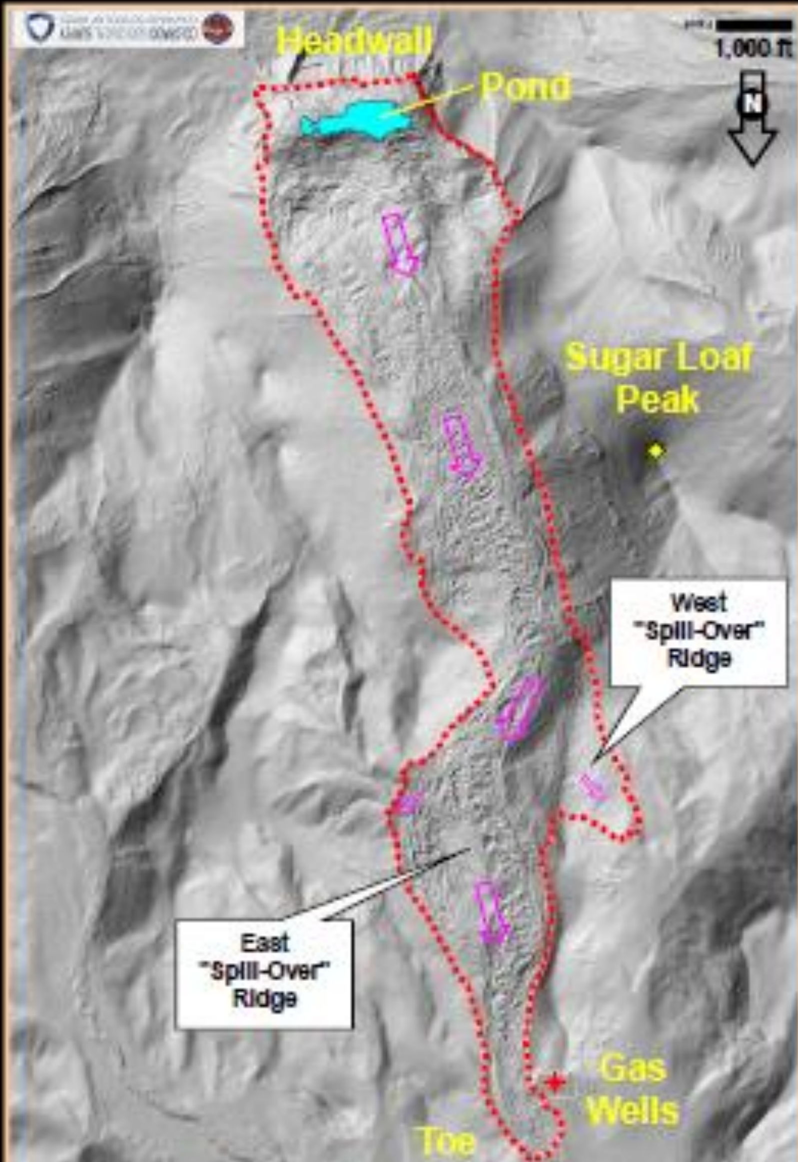
View from Skyway Point

Diagrammatic Cross Section of Upper Landslide Bench

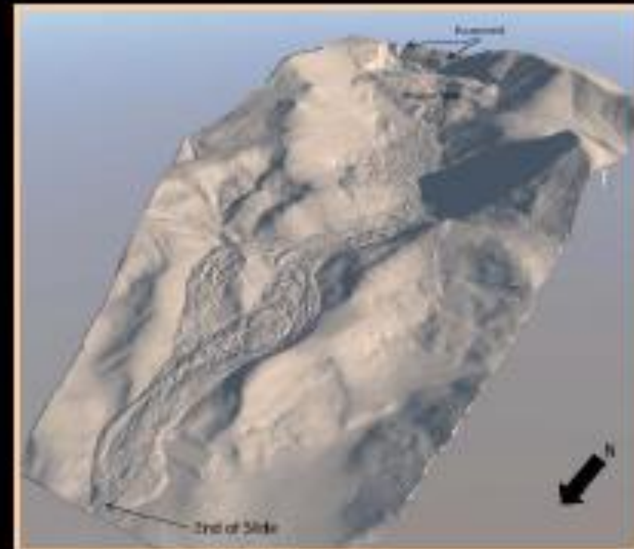


Summary

Geology Program



Hillshaded LiDar Digital Elevation Model of the West Salt Creek Landslide



- Flow Length: ~ 2.7 mi
- Max Width: ~ 0.53 mi
- Elevation: 9,740 - 7,420 ft
- Area: 500 - 600 acres
- Volume: ~ 39 million yd^3
- Weight: ~ 50 million tons
- Max Thickness: ~ 150 ft
- Max Velocity: 50-75 mph
- Occurred in 4-5 Pulses over about 2-5 Minutes

LiDAR Data from CGS; Images from Mesa County

Lower Landslide Zone @ W. Salt Cr.

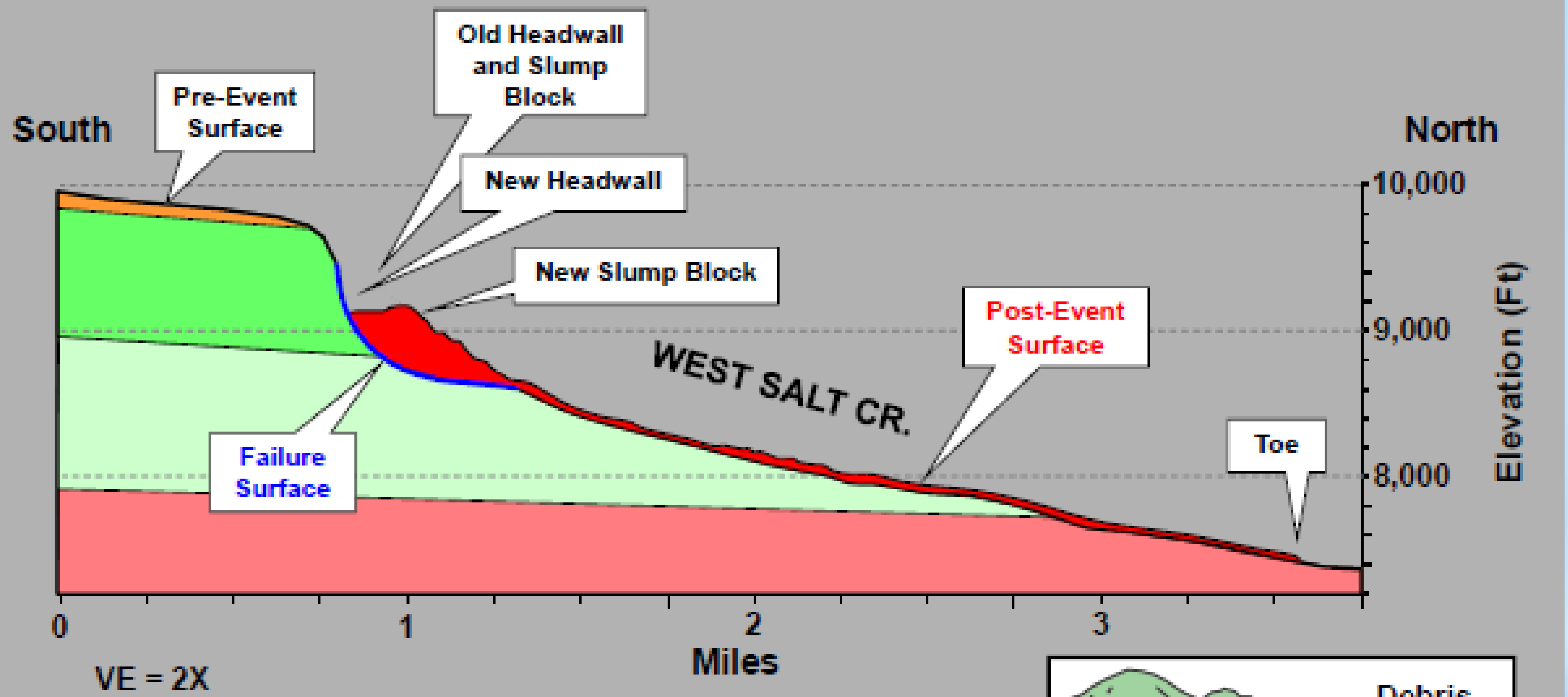
Geology Program

1 Mile

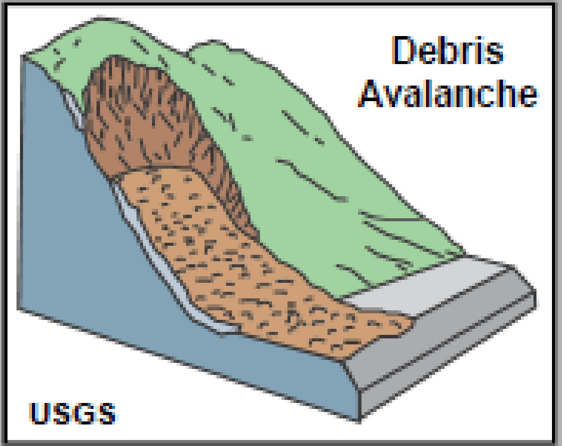
Photo by Aaron Ontiveroz (Denver Post)
May 26, 2014

Geologic Cross Section

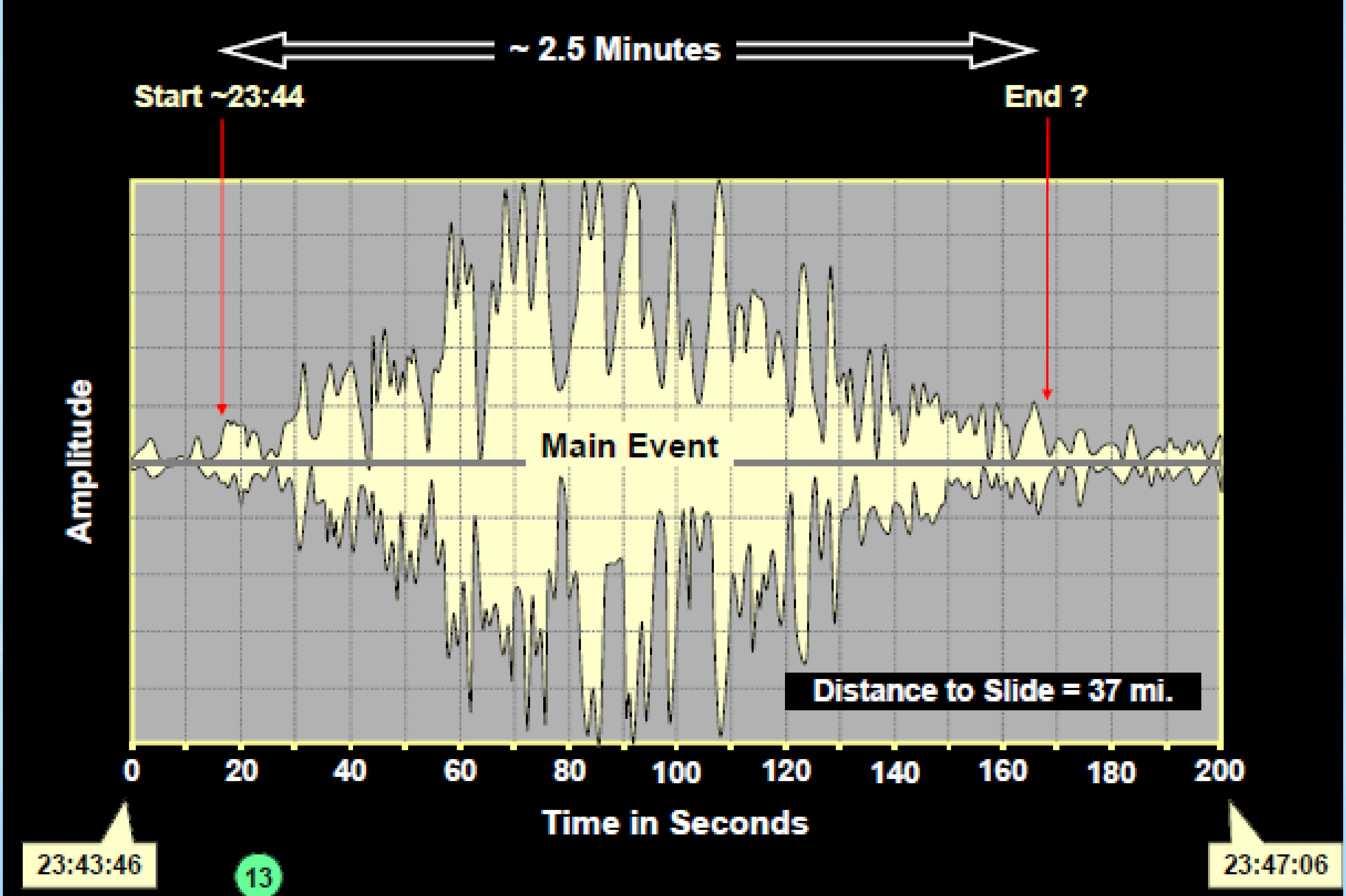
Colorado Mesa University Geology Program



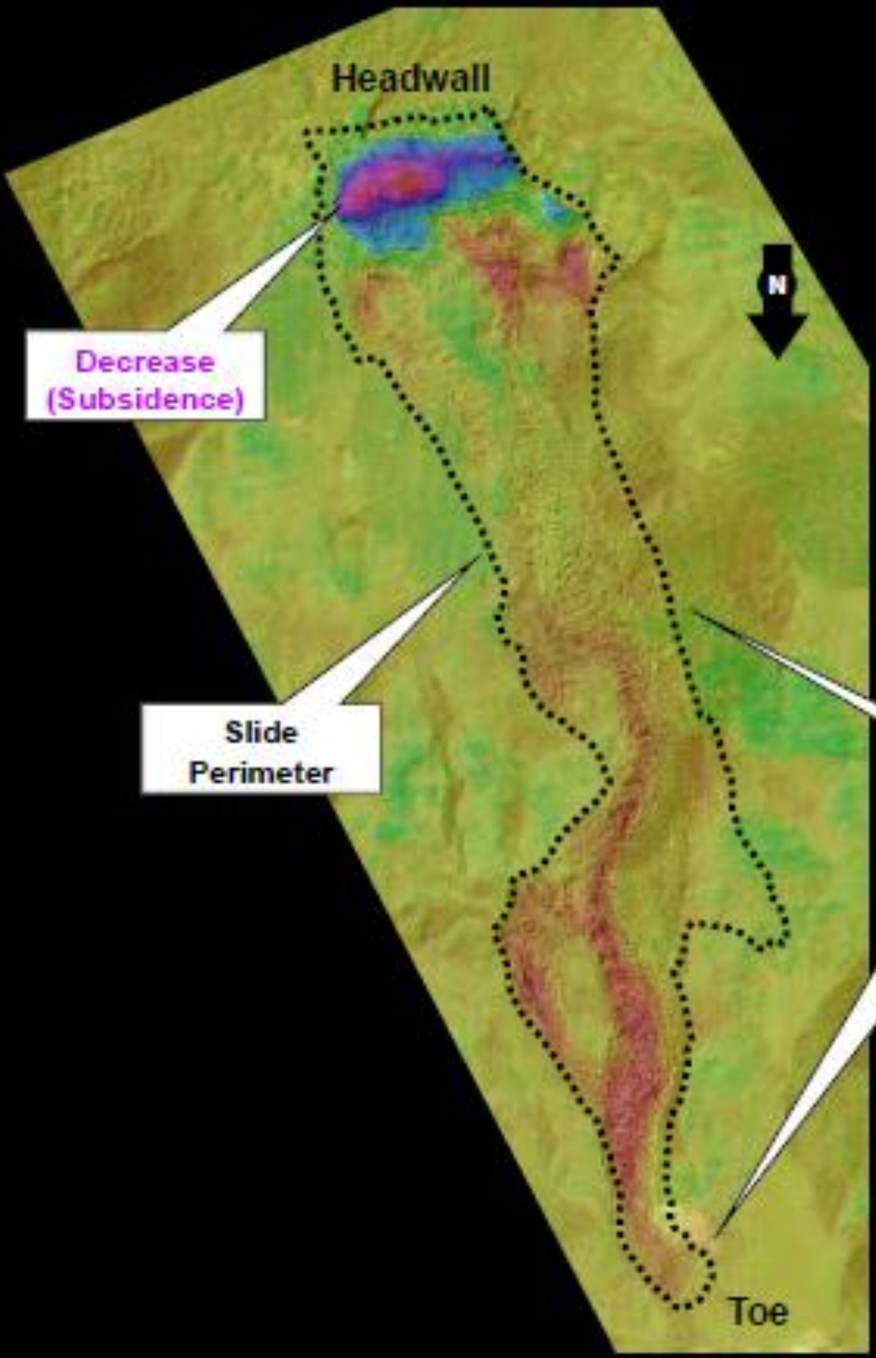
- Uinta Fm. and/or Goodenough Deposits
- Parachute Creek Mbr. of Green River Fm.
- Anvil Points Mbr. of Green River Fm.
- Wasatch Fm.



Seismic Signal at Orchard Mesa



Elevation Changes



LiDAR Data from Colorado Geol. Survey;
Image Created by Verner Johnson.

Headwall Scarp and Slump Block

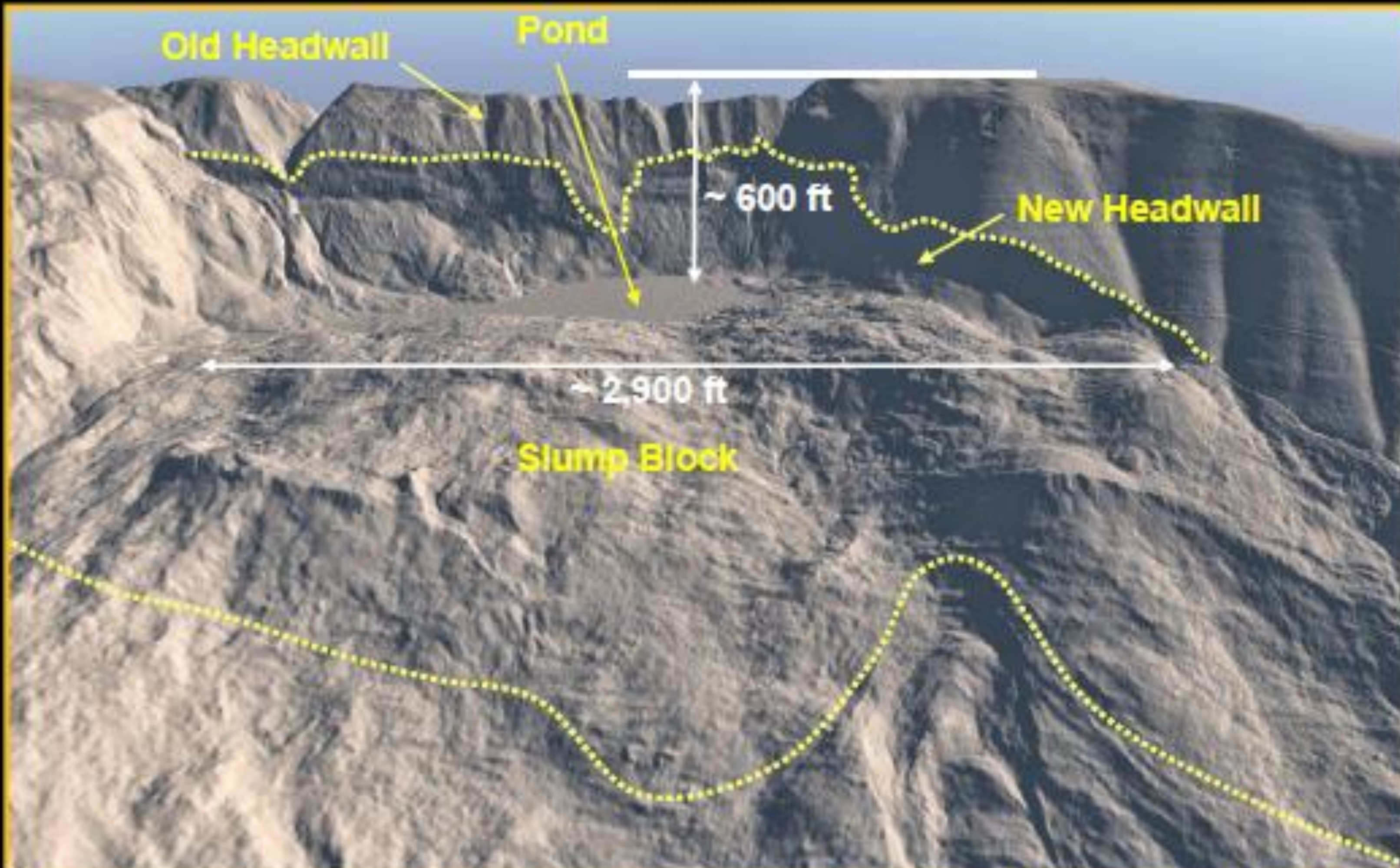
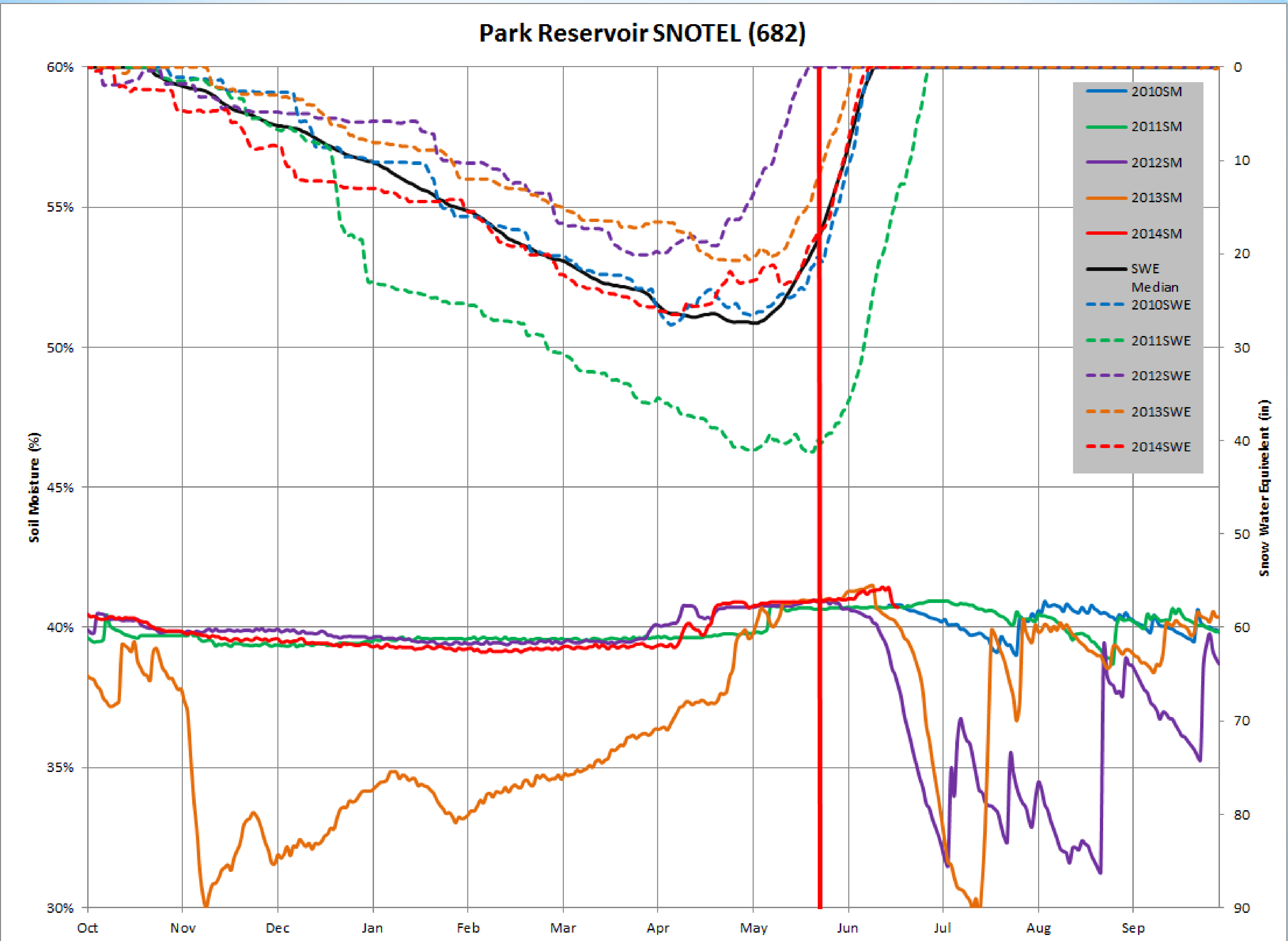
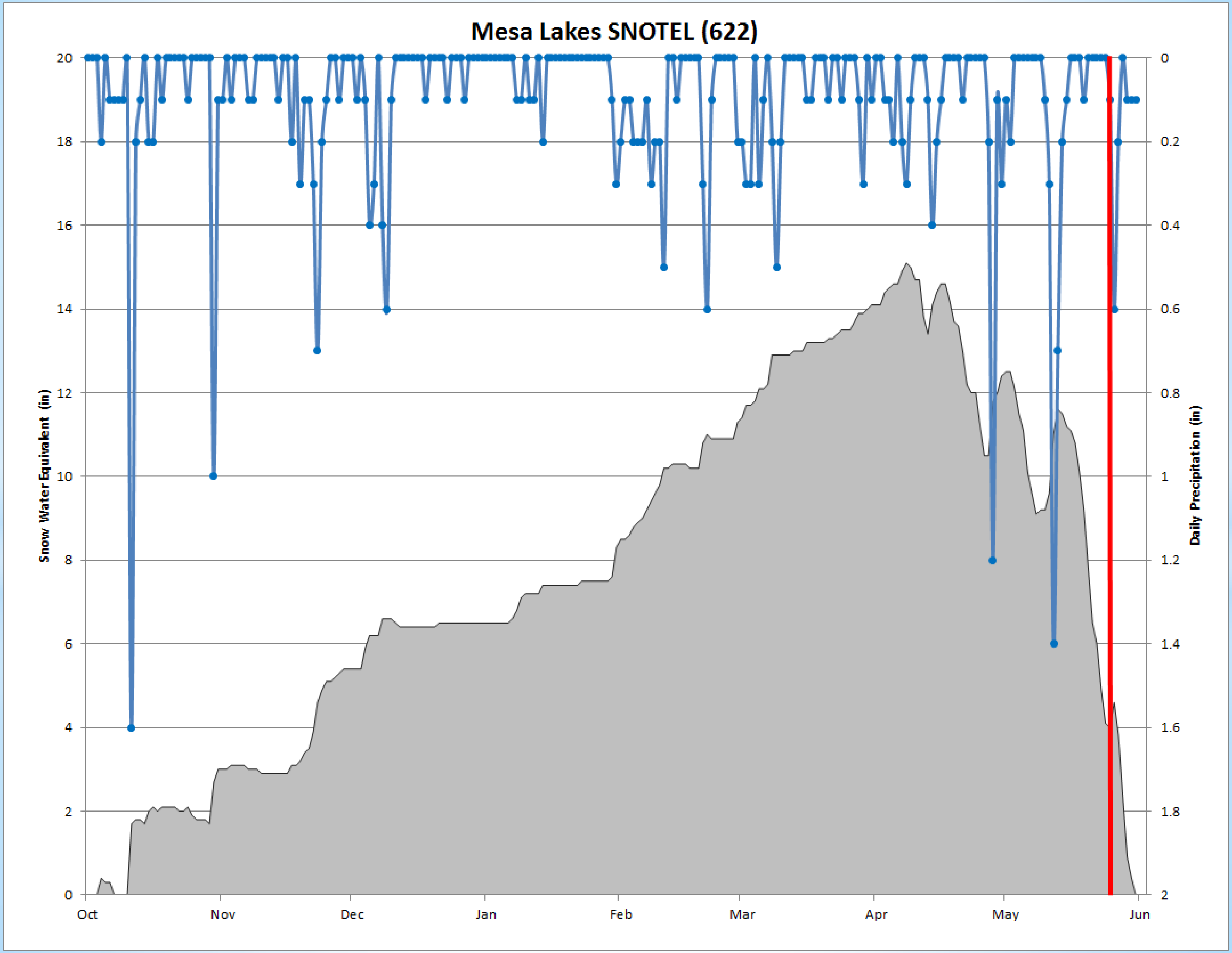


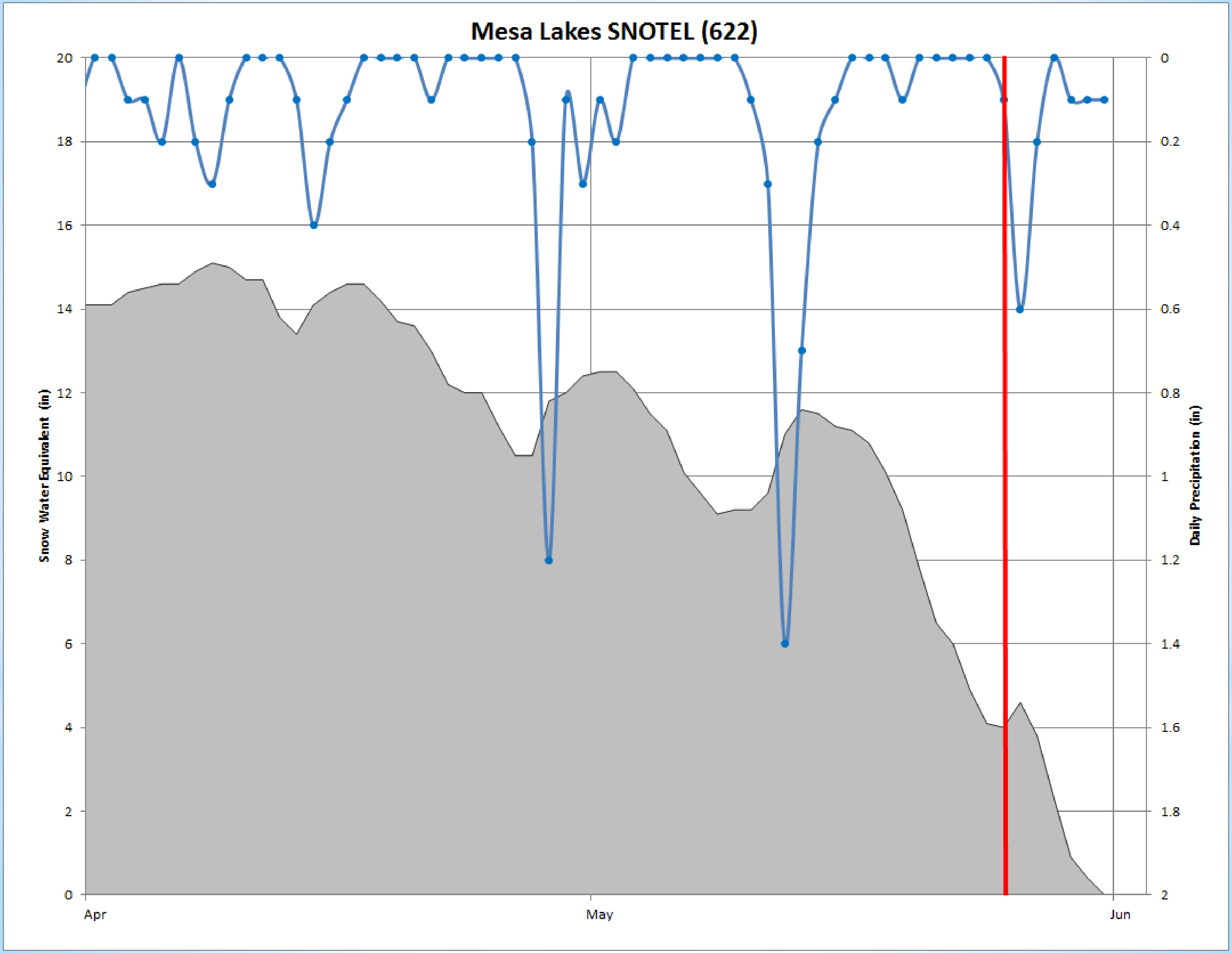
Image from Mesa County (http://www.mesacounty.us/Landslide-Model-Images/) based on LiDAR data from the Colorado Geological Survey



Park Reservoir SNOTEL (682)
Soil Moisture (%)
Snow Water Equivalent (in)
60%
55%
50%
45%
40%
35%
30%
0
10
20
30
40
50
60
70
80
90
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
2010SM
2011SM
2012SM
2013SM
2014SM
SWE Median
2010SWE
2011SWE
2012SWE
2013SWE
2014SWE



Mesa Lakes SNOTEL (622)
Snow Water Equivalent (in)
Daily Precipitation (in)
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun



Mesa Lakes SNOTEL (622)
Snow Water Equivalent (in)
Daily Precipitation (in)
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Apr
May
Jun

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

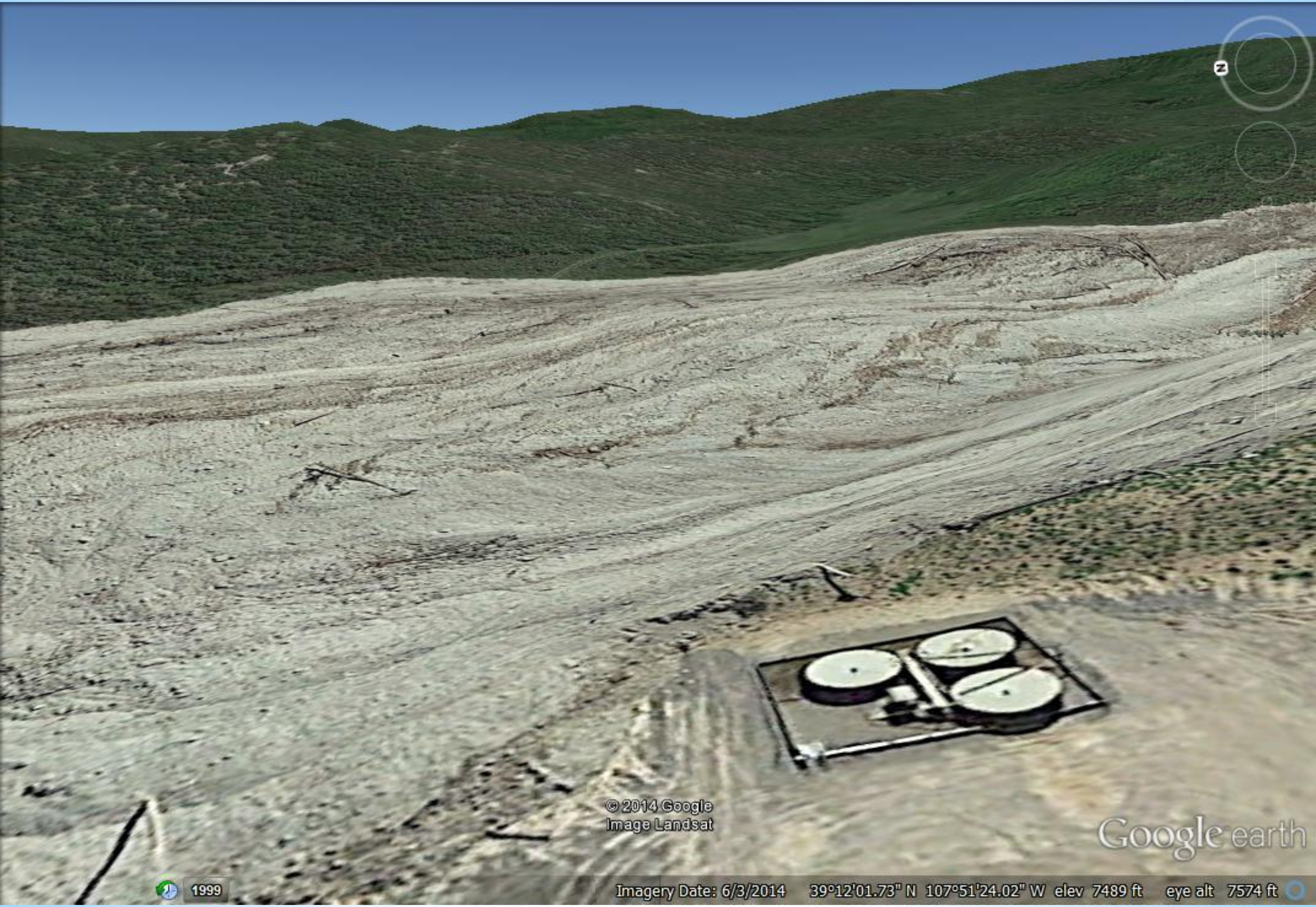
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.193** (0.154-0.247)	**0.208** (0.165-0.266)	**0.255** (0.202-0.327)	**0.316** (0.249-0.408)	**0.435** (0.348-0.629)	**0.553** (0.423-0.795)	**0.694** (0.510-1.02)	**0.861** (0.604-1.30)	**1.12** (0.749-1.73)	**1.34** (0.859-2.05)
10-min	**0.283** (0.226-0.362)	**0.304** (0.242-0.389)	**0.373** (0.296-0.479)	**0.463** (0.365-0.598)	**0.637** (0.510-0.920)	**0.81** (0.620-1.16)	**1.02** (0.746-1.49)	**1.26** (0.884-1.90)	**1.64** (1.10-2.53)	**1.96** (1.26-3.00)
15-min	**0.345** (0.275-0.442)	**0.371** (0.295-0.474)	**0.455** (0.361-0.584)	**0.565** (0.445-0.729)	**0.777** (0.622-1.12)	**0.988** (0.756-1.42)	**1.24** (0.910-1.82)	**1.54** (1.08-2.32)	**2** (1.34-3.08)	**2.4** (1.53-3.66)
30-min	**0.413** (0.329-0.528)	**0.486** (0.387-0.622)	**0.637** (0.505-0.818)	**0.792** (0.624-1.02)	**1.05** (0.817-1.46)	**1.28** (0.964-1.79)	**1.54** (1.12-2.22)	**1.83** (1.27-2.72)	**2.27** (1.51-3.46)	**2.64** (1.69-4.03)
60-min	**0.502** (0.400-0.641)	**0.601** (0.478-0.769)	**0.788** (0.625-1.01)	**0.966** (0.761-1.25)	**1.24** (0.961-1.71)	**1.48** (1.11-2.06)	**1.75** (1.26-2.50)	**2.04** (1.41-3.00)	**2.46** (1.63-3.73)	**2.8** (1.79-4.28)
2-hr	**0.59** (0.475-0.745)	**0.716** (0.576-0.905)	**0.939** (0.752-1.19)	**1.14** (0.908-1.45)	**1.44** (1.12-1.93)	**1.69** (1.27-2.30)	**1.95** (1.42-2.73)	**2.24** (1.56-3.23)	**2.64** (1.77-3.93)	**2.97** (1.93-4.46)
3-hr	**0.672** (0.544-0.842)	**0.797** (0.645-1.00)	**1.02** (0.821-1.28)	**1.22** (0.976-1.54)	**1.51** (1.18-2.02)	**1.76** (1.34-2.38)	**2.02** (1.49-2.81)	**2.31** (1.62-3.30)	**2.71** (1.83-3.99)	**3.03** (1.98-4.51)
6-hr	**0.842** (0.690-1.04)	**0.979** (0.800-1.21)	**1.21** (0.989-1.51)	**1.42** (1.15-1.77)	**1.72** (1.36-2.25)	**1.97** (1.51-2.61)	**2.23** (1.65-3.03)	**2.5** (1.78-3.51)	**2.88** (1.97-4.17)	**3.18** (2.11-4.67)
12-hr	**1.08** (0.897-1.32)	**1.23** (1.02-1.51)	**1.49** (1.23-1.82)	**1.71** (1.40-2.11)	**2.04** (1.63-2.63)	**2.32** (1.80-3.02)	**2.6** (1.95-3.49)	**2.91** (2.09-4.02)	**3.33** (2.31-4.75)	**3.67** (2.47-5.30)
24-hr	**1.38** (1.15-1.66)	**1.55** (1.30-1.88)	**1.86** (1.55-2.25)	**2.13** (1.76-2.59)	**2.52** (2.03-3.19)	**2.84** (2.23-3.65)	**3.17** (2.41-4.19)	**3.53** (2.58-4.80)	**4.02** (2.82-5.64)	**4.41** (3.01-6.27)
2-day	**1.72** (1.45-2.04)	**1.96** (1.65-2.33)	**2.36** (1.99-2.82)	**2.71** (2.27-3.25)	**3.2** (2.60-3.98)	**3.59** (2.85-4.54)	**3.99** (3.07-5.17)	**4.41** (3.25-5.88)	**4.97** (3.53-6.84)	**5.41** (3.75-7.56)
3-day	**1.97** (1.68-2.33)	**2.27** (1.93-2.68)	**2.75** (2.33-3.26)	**3.16** (2.67-3.77)	**3.74** (3.06-4.61)	**4.19** (3.35-5.24)	**4.65** (3.60-5.97)	**5.13** (3.81-6.77)	**5.76** (4.13-7.84)	**6.25** (4.37-8.65)
4-day	**2.2** (1.88-2.58)	**2.53** (2.16-2.98)	**3.08** (2.62-3.63)	**3.54** (3.00-4.19)	**4.18** (3.43-5.12)	**4.68** (3.76-5.81)	**5.18** (4.03-6.61)	**5.7** (4.26-7.49)	**6.4** (4.61-8.65)	**6.93** (4.87-9.52)
7-day	**2.81** (2.42-3.26)	**3.2** (2.76-3.73)	**3.86** (3.31-4.50)	**4.4** (3.76-5.16)	**5.16** (4.27-6.23)	**5.74** (4.65-7.04)	**6.33** (4.97-7.96)	**6.92** (5.23-8.96)	**7.72** (5.62-10.3)	**8.32** (5.92-11.3)
10-day	**3.33** (2.89-3.84)	**3.77** (3.27-4.35)	**4.48** (3.87-5.19)	**5.08** (4.37-5.91)	**5.9** (4.92-7.07)	**6.54** (5.33-7.95)	**7.17** (5.67-8.95)	**7.82** (5.95-10.0)	**8.67** (6.37-11.5)	**9.32** (6.69-12.5)
20-day	**4.75** (4.17-5.40)	**5.29** (4.64-6.02)	**6.16** (5.39-7.04)	**6.89** (5.99-7.90)	**7.88** (6.65-9.29)	**8.64** (7.14-10.3)	**9.4** (7.53-11.5)	**10.2** (7.84-12.8)	**11.2** (8.32-14.5)	**11.9** (8.68-15.7)
30-day	**5.9** (5.22-6.66)	**6.57** (5.80-7.42)	**7.63** (6.72-8.64)	**8.5** (7.45-9.67)	**9.67** (8.21-11.3)	**10.6** (8.78-12.5)	**11.4** (9.22-13.9)	**12.3** (9.55-15.3)	**13.4** (10.1-17.2)	**14.2** (10.4-18.6)
45-day	**7.36** (6.55-8.24)	**8.23** (7.32-9.22)	**9.61** (8.52-10.8)	**10.7** (9.46-12.1)	**12.2** (10.4-14.0)	**13.2** (11.1-15.5)	**14.3** (11.6-17.1)	**15.3** (12.0-18.8)	**16.5** (12.5-20.9)	**17.4** (12.9-22.5)
60-day	**8.6** (7.69-9.57)	**9.69** (8.66-10.8)	**11.4** (10.2-12.7)	**12.8** (11.3-14.3)	**14.5** (12.4-16.6)	**15.8** (13.2-18.3)	**16.9** (13.8-20.1)	**18.1** (14.2-22.0)	**19.4** (14.8-24.4)	**20.4** (15.2-26.1)


Sag pond
Top of slide block
2 JUN 2014
W:107 50' 35.77"
N:039 10' 00.03"

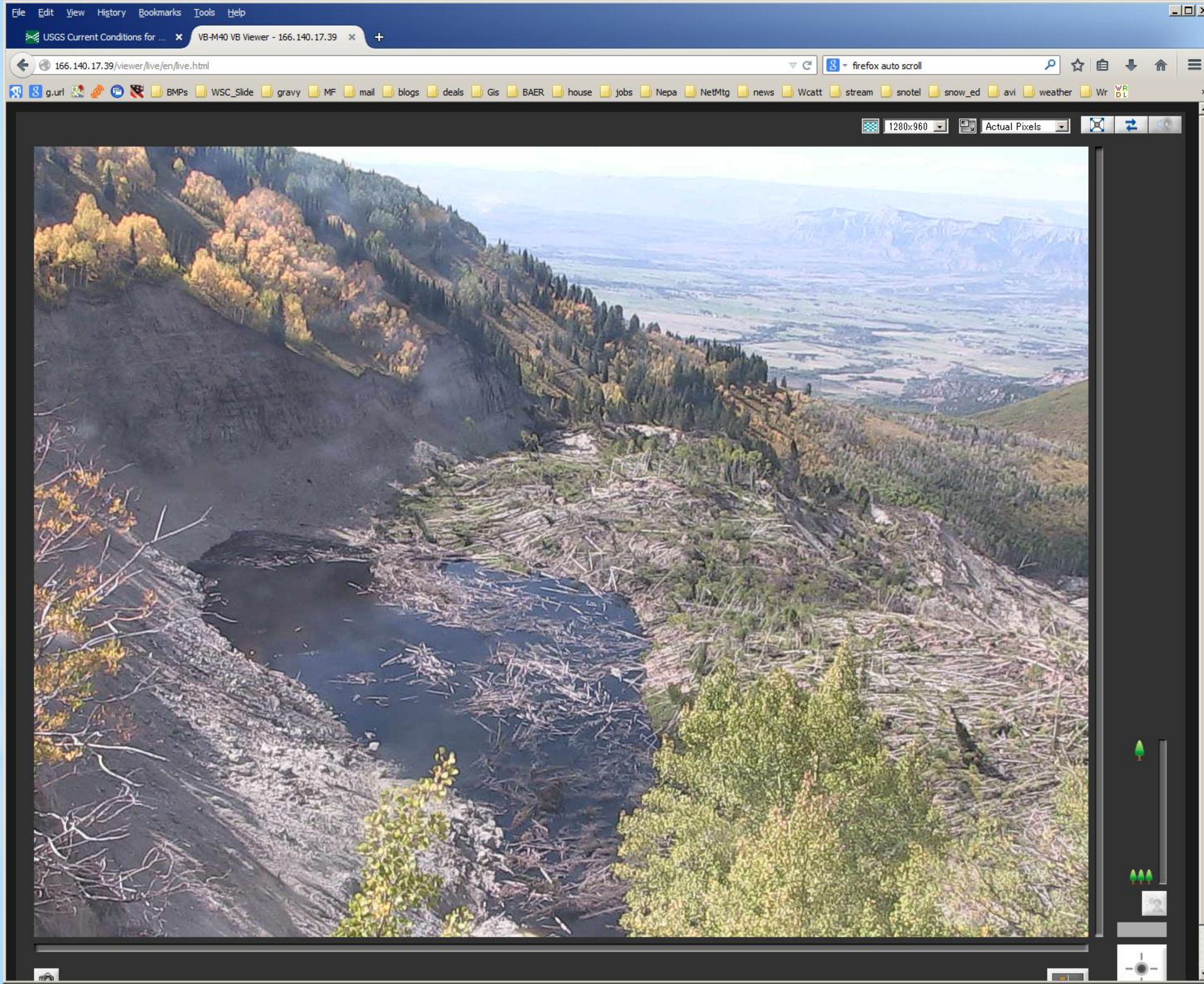

Total Inflow ≈ 30cfs (60 acre-ft/day)

Block Pond:
Surface ≈ 1 acre
Depth:
Wednesday ≈ 7’
Friday ≈ 15’

Existing end of the stock Driveway


© 2014 Google
Image Landsat
Google earth
1999
Imagery Date: 6/3/2014 39°12'01.73" N 107°51'24.02" W elev 7489 ft eye alt 7574 ft


2 JUN 2014


File Edit View History Bookmarks Tools Help
USGS Current Conditions for ...
VB-M40 VB Viewer - 166.140.17.39
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WSC_Slide
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MF
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blogs
deals
Gis
BAER
house
jobs
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Wcatt
stream
snotel
snow_ed
avi
weather
Wr
1280x960
Actual Pixels

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USGS Current Conditions for ... | MESOWEST STATION INTERFACE

waterdata.usgs.gov/co/nwis/uv?cb_00045=on&cb_00065=on&format=gif_default&site_no=09096570&period=&begin_date=2014-06-10&end_date=2014-09-19

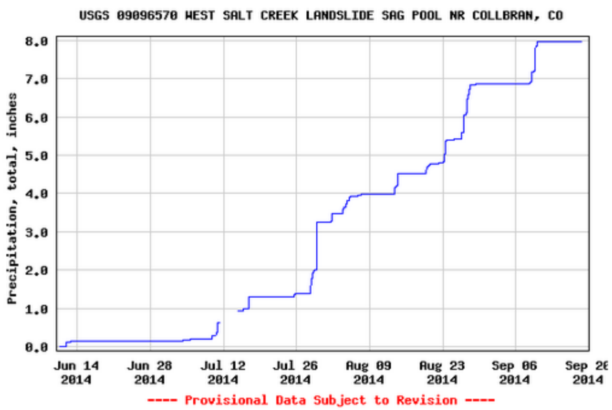
firefox auto scroll

g.url BMPs WSC_Slide gravy MF mail blogs deals Gis BAER house jobs Nepa NetMtg news Wcatt stream snotel snow_ed avi weather Wr

[Summary of all available data for this site](#)
[Instantaneous-data availability statement](#)

Precipitation, total, inches

Most recent instantaneous value: 0.00 09-18-2014 14:30 MDT



Add up to 2 more sites and replot for "Precipitation, total, inches"

Add site numbers Note

Enter up to 2 site numbers separated by a comma. A site number consists of 8 to 15 digits

GO

Create presentation-quality / stand-alone graph. Subscribe to WaterAlert

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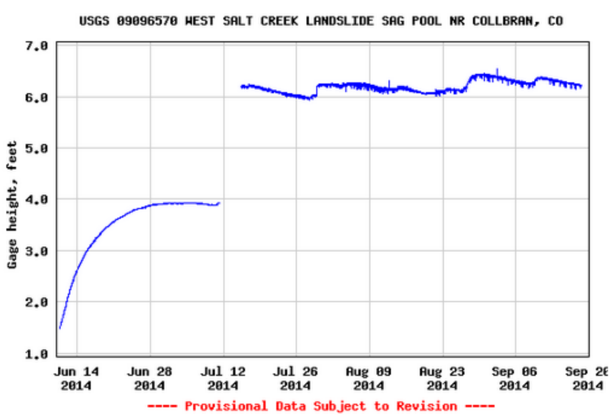
Gage height, feet

Most recent instantaneous value: 6.22 09-18-2014 14:30 MDT



Add up to 2 more sites and replot for "Gage height, feet"

Add site numbers Note

Enter up to 2 site numbers separated by a comma. A site number consists of 8 to 15 digits

GO

Create presentation-quality / stand-alone graph. Subscribe to WaterAlert

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LiDAR – What is LiDAR?

LiDAR is a Portmanteau

Portmanteau is a blend of two words in linguistics.

Some common Portmanteaus are Brunch or Smog

In this case, LiDAR's root words are the combination of Light and Radar

Lidar (also written LIDAR or LiDAR) is a remote sensing technology that measure distance by illuminating a target with a laser and analyzing the reflected light.

Lidar is popularly used as a technology to make high-resolution maps, with applications in geomatics, archaeology, geography, geology, geomorphology, seismology, forestry, remote sensing, atmospheric physics, airborne laser swath mapping (ALSM), laser altimetry, and **contour mapping**.

Lidar was developed in the early 1960s, shortly after the invention of the laser.

In 1971, Lidar was used during Apollo 15 mission to map the surface of the moon.

Lidar uses ultraviolet, visible, or near infrared light to image objects. It can target a wide range of materials, including non-metallic objects, rocks, rain, chemical compounds, aerosols, clouds and even single molecules. A narrow laser-beam can map physical features with very high resolution.

Wavelengths vary to suit the target: from about 10 micrometers to the UV (approximately 250 nm). Typically light is reflected via **backscattering.** Different types of scattering are used for different lidar applications.

Airborne lidar sensors are used by companies in the remote sensing field. It can be used to create **DEM (digital elevation models);** this is quite a common practice for larger areas as a plane can acquire 3-4 km wide swaths in a single flyover.

Greater vertical accuracy of below 50 mm can be achieved with a lower flyover, even in forests, where it is able to give you the height of the canopy as well as the ground elevation.

Lidar data must be interpreted. The lowest reading would be considered the ground. Canopy's and rock formations will also reflect back higher (in elevation) readings.

Even stream pebble counts (of dry streams) could be extracted from Lidar data.

Canopy heights are often found using Lidar data.

The following is Lidar data from the West Salt Creek Landslide.

West Salt Creek Landslide
Flow Pond Extent Analysis of LiDAR Data

0 100 200 300 400 500 Feet

1 inch = 60 feet
1:720

The Information on this map or in this document is based on map products from the Colorado Geological Survey with support from the Colorado Office of Emergency Mangement.

ATTENTION

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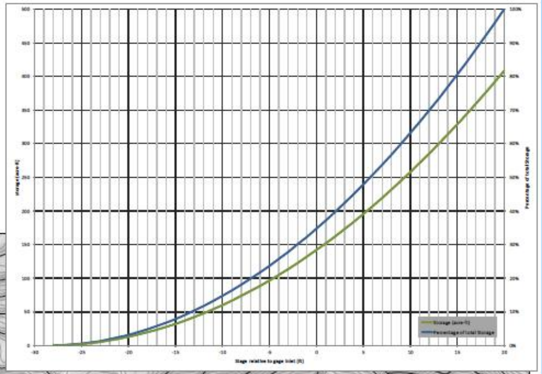
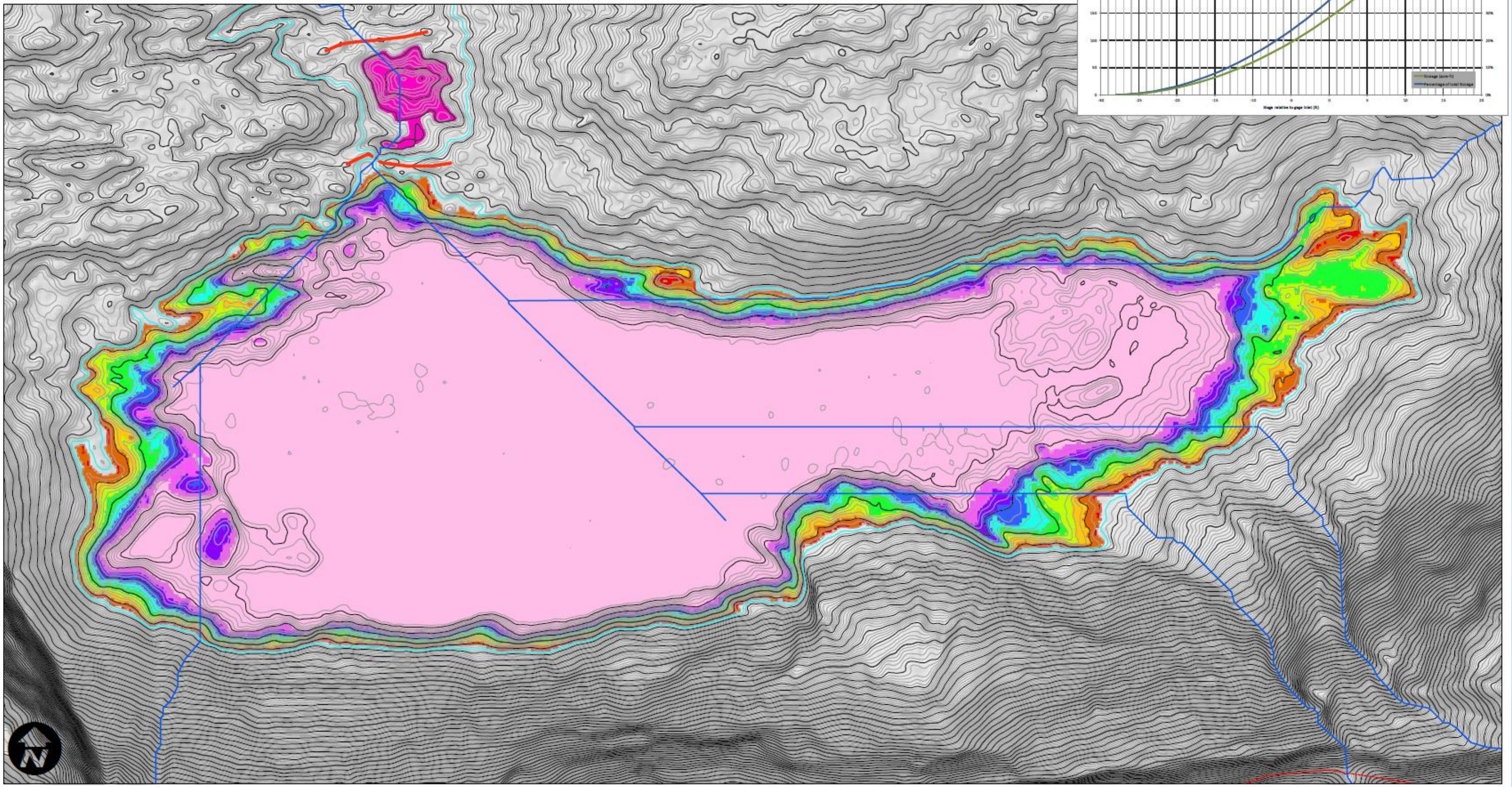
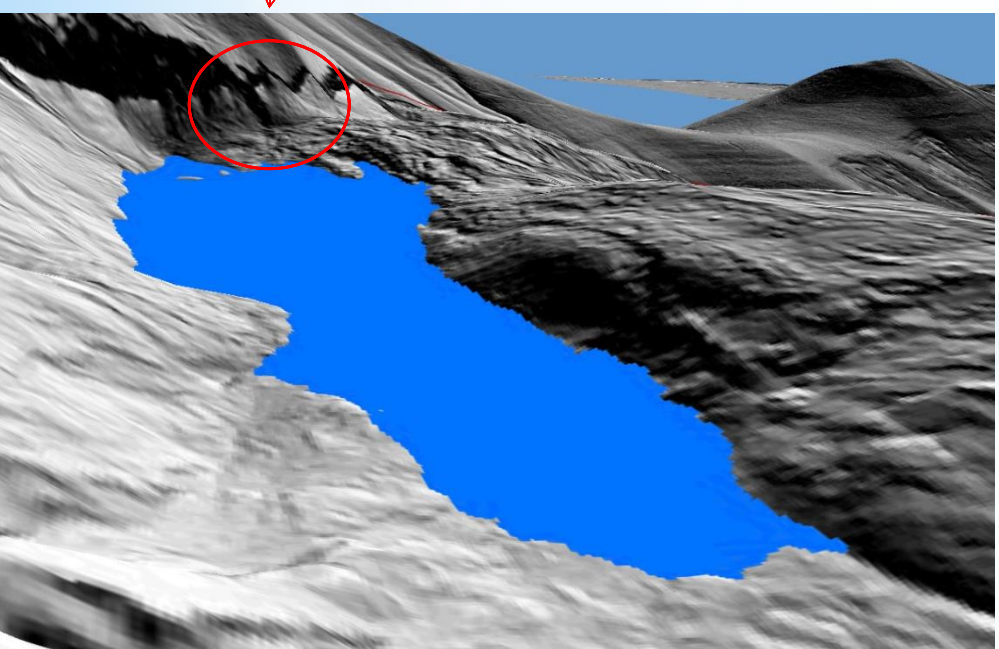
Flow Accumulation from LIDAR DEM
Slide Perimeter
Dams
contour_40ft
countour_5ft
countour_ft
2nd Pond Extent

gage_DEM
Elevation Relative to Gage 0
<2
2-4
4-6
6-8
8-10
10-12
12-14
14-16
16-18
>18

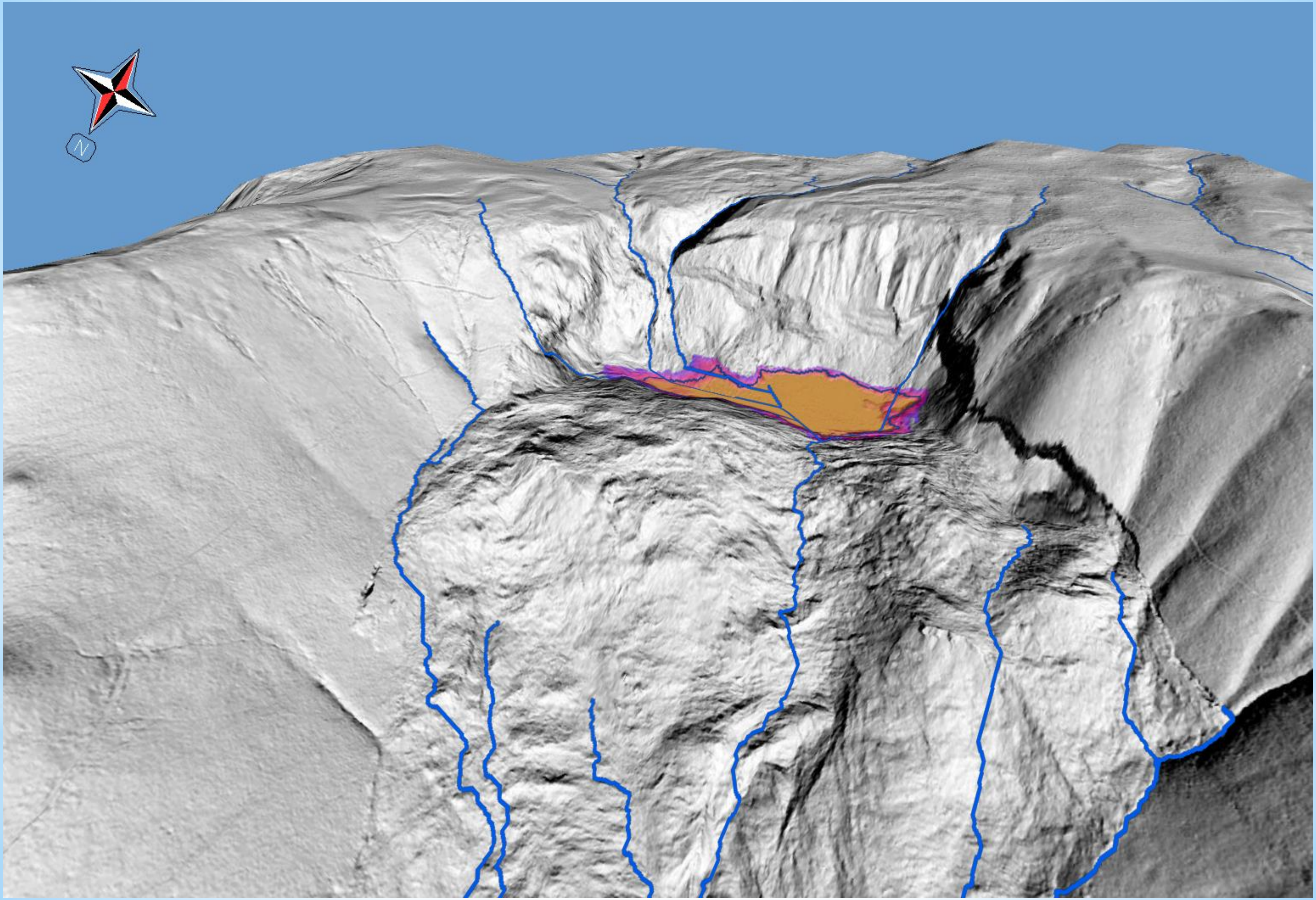


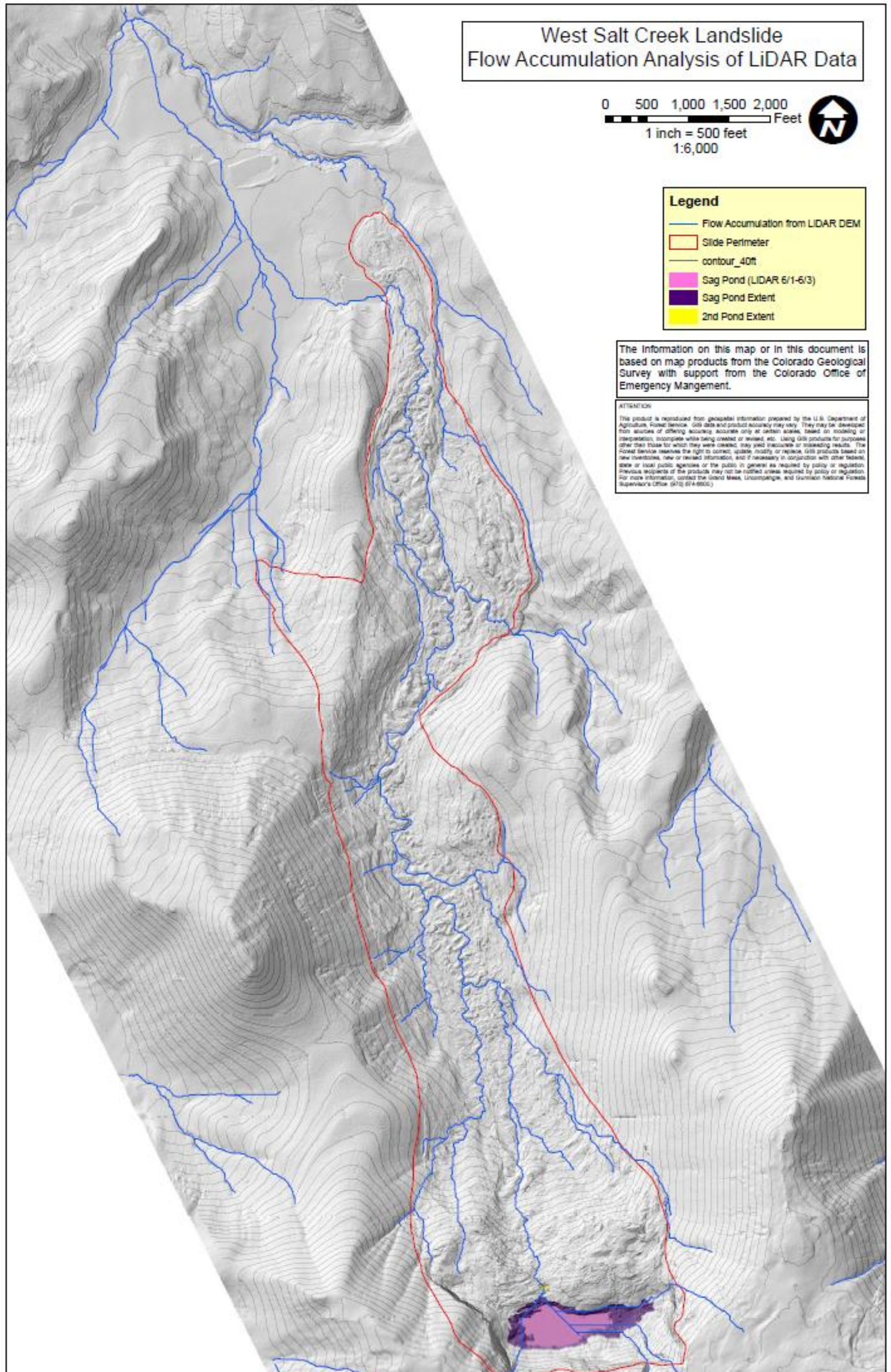


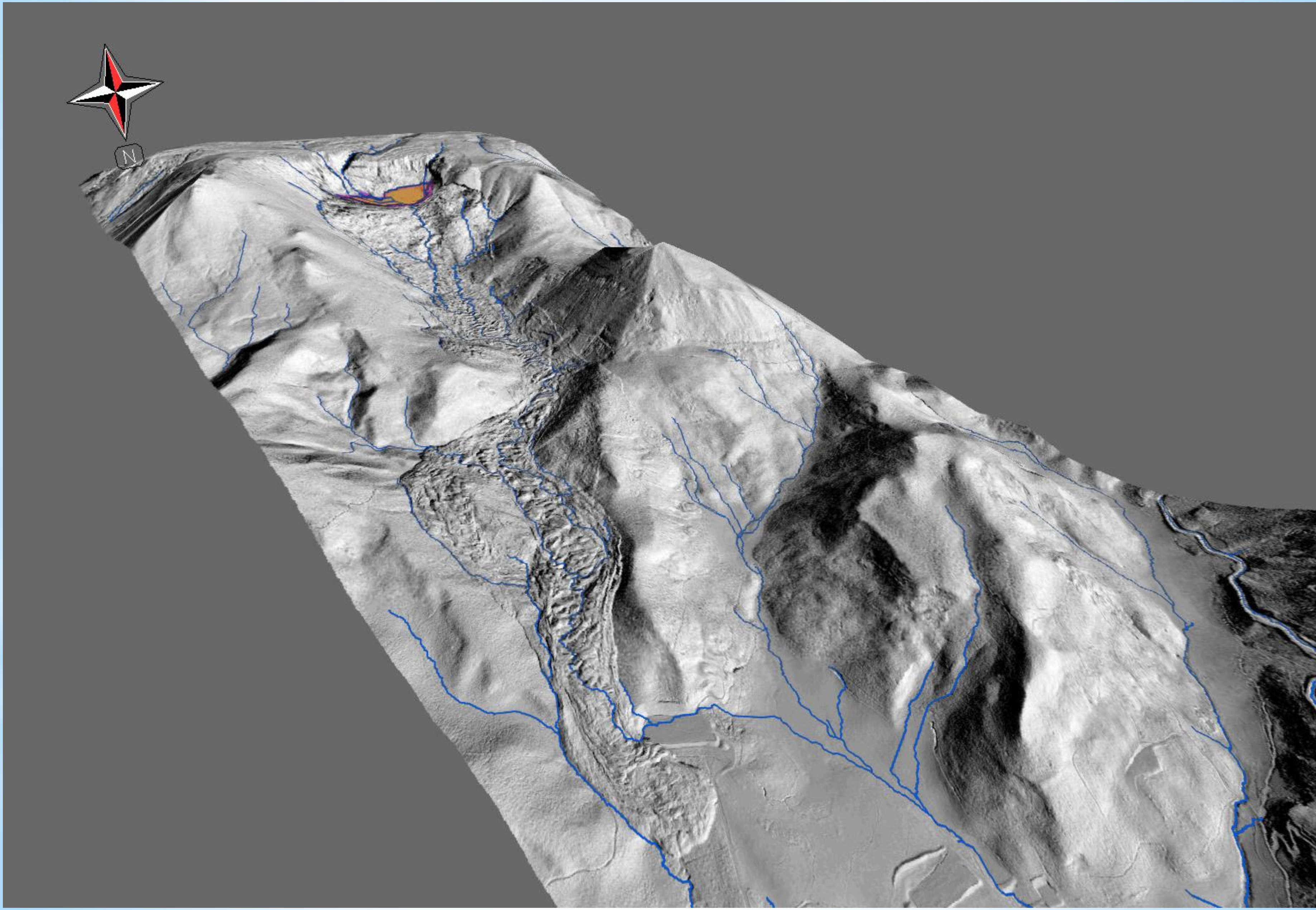


Pond DEM at gage Height of 3.91’ at 0800 on 6/30/2014 With photo at same time

- Both islands in upper left of pond modeled well

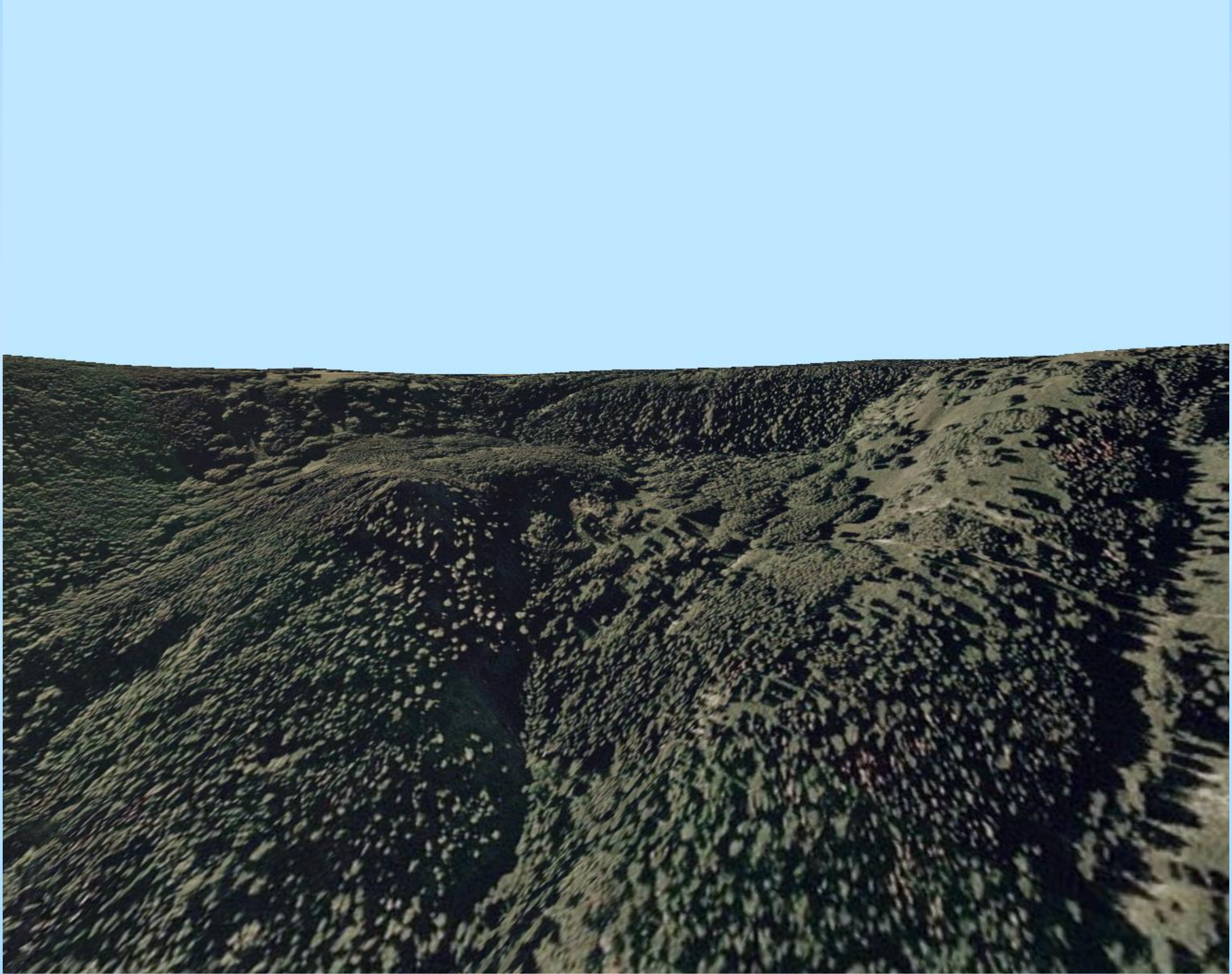

N

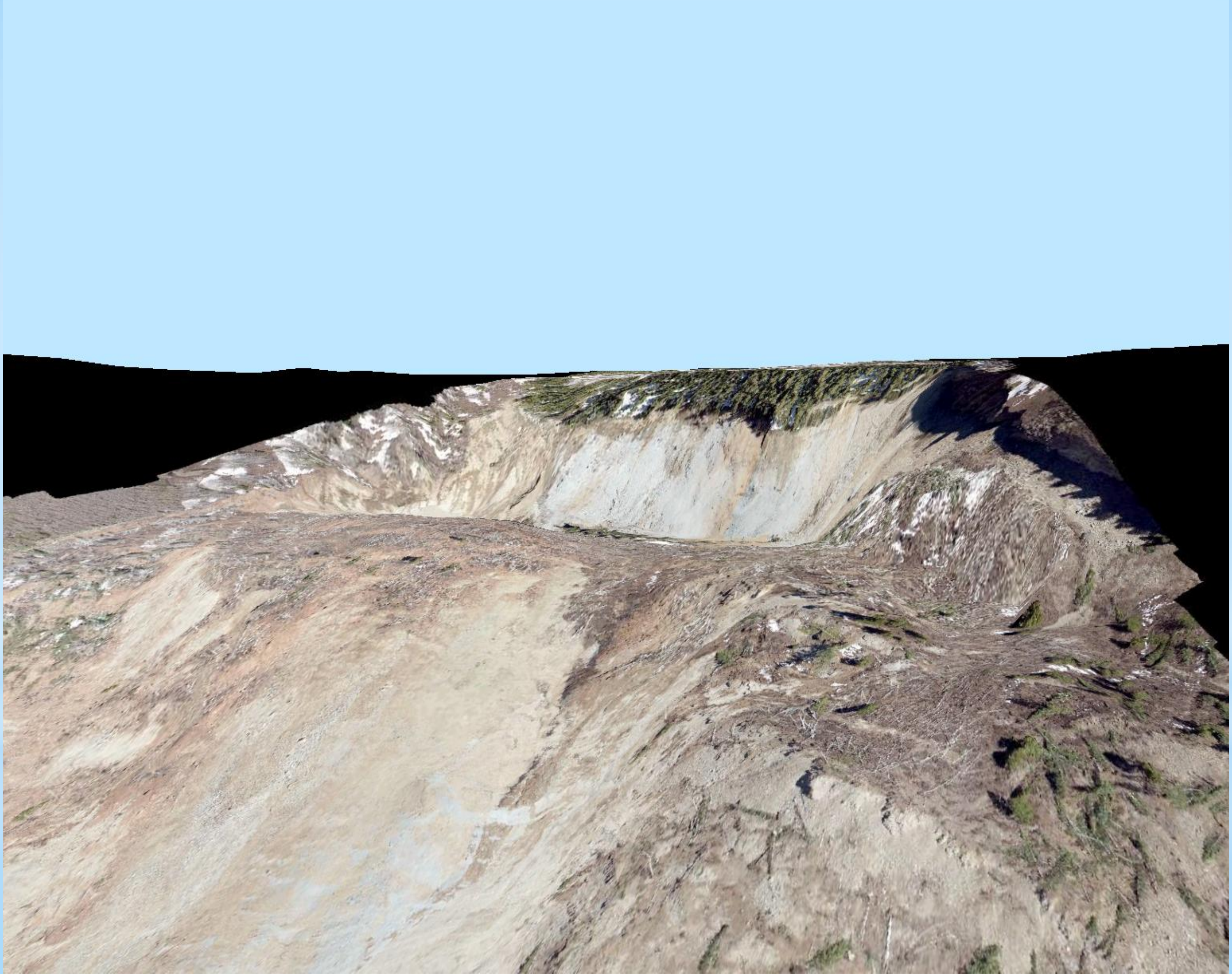

West Salt Creek Landslide
Flow Accumulation Analysis of LiDAR Data
0 500 1,000 1,500 2,000
Feet
1 inch = 500 feet
1:6,000
N
Legend
Flow Accumulation from LIDAR DEM
Slide Perimeter
contour_40ft
Sag Pond (LIDAR 6/1-6/3)
Sag Pond Extent
2nd Pond Extent
The information on this map or in this document is based on map products from the Colorado Geological Survey with support from the Colorado Office of Emergency Mangement.


N

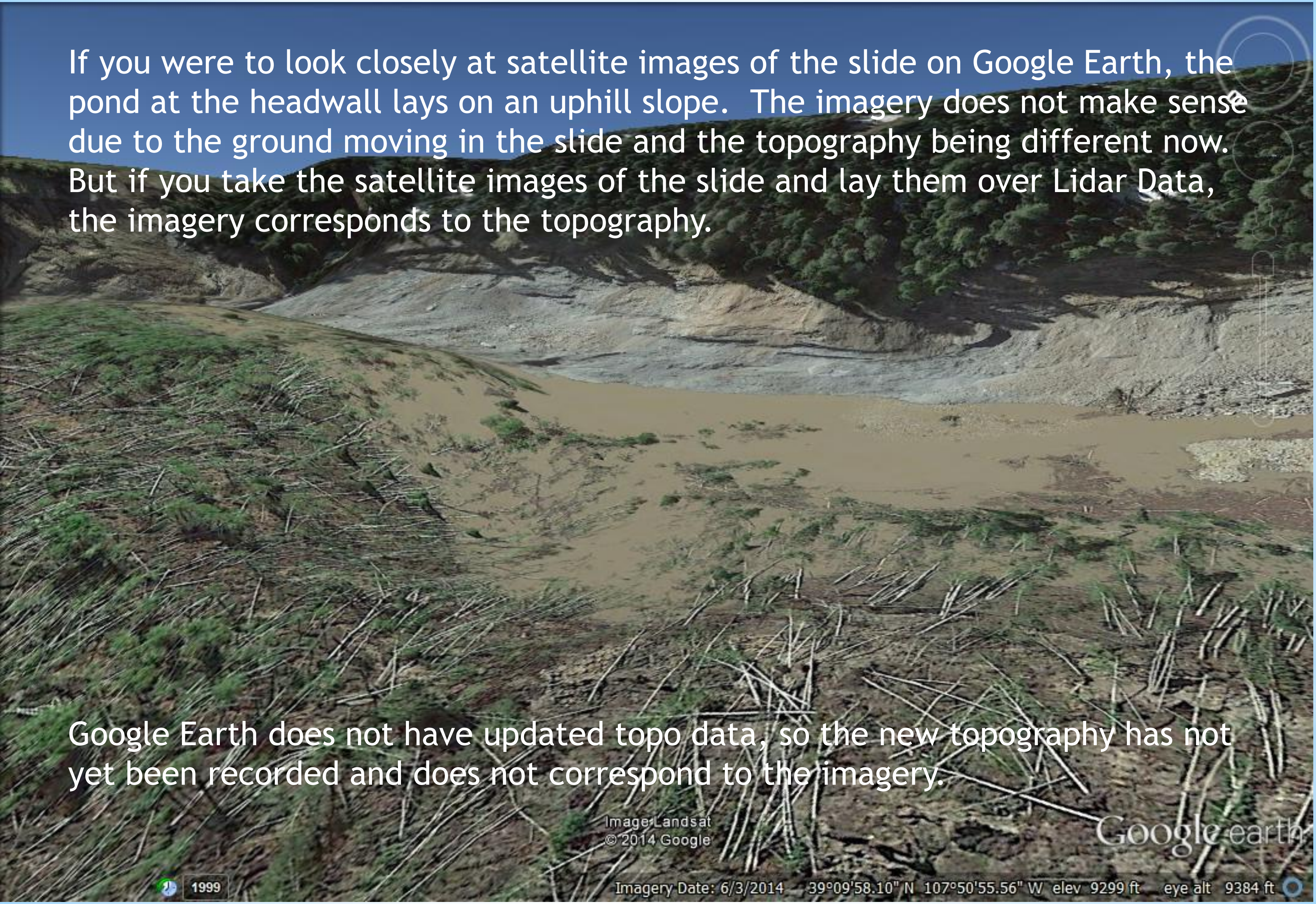
Notice the stream going through the well pads

Notice the old slide to the left of the new slide and the stream paths that resulted.

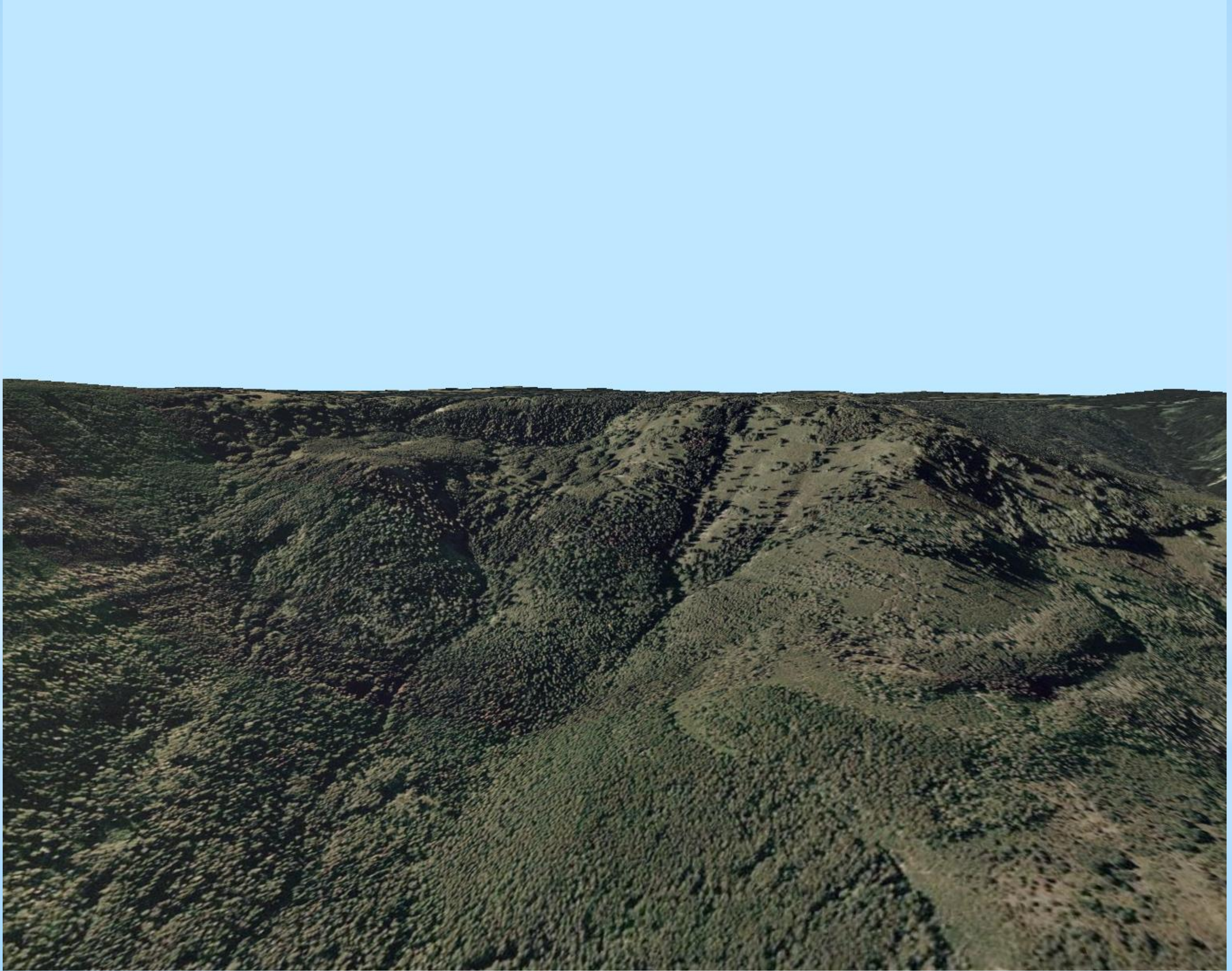


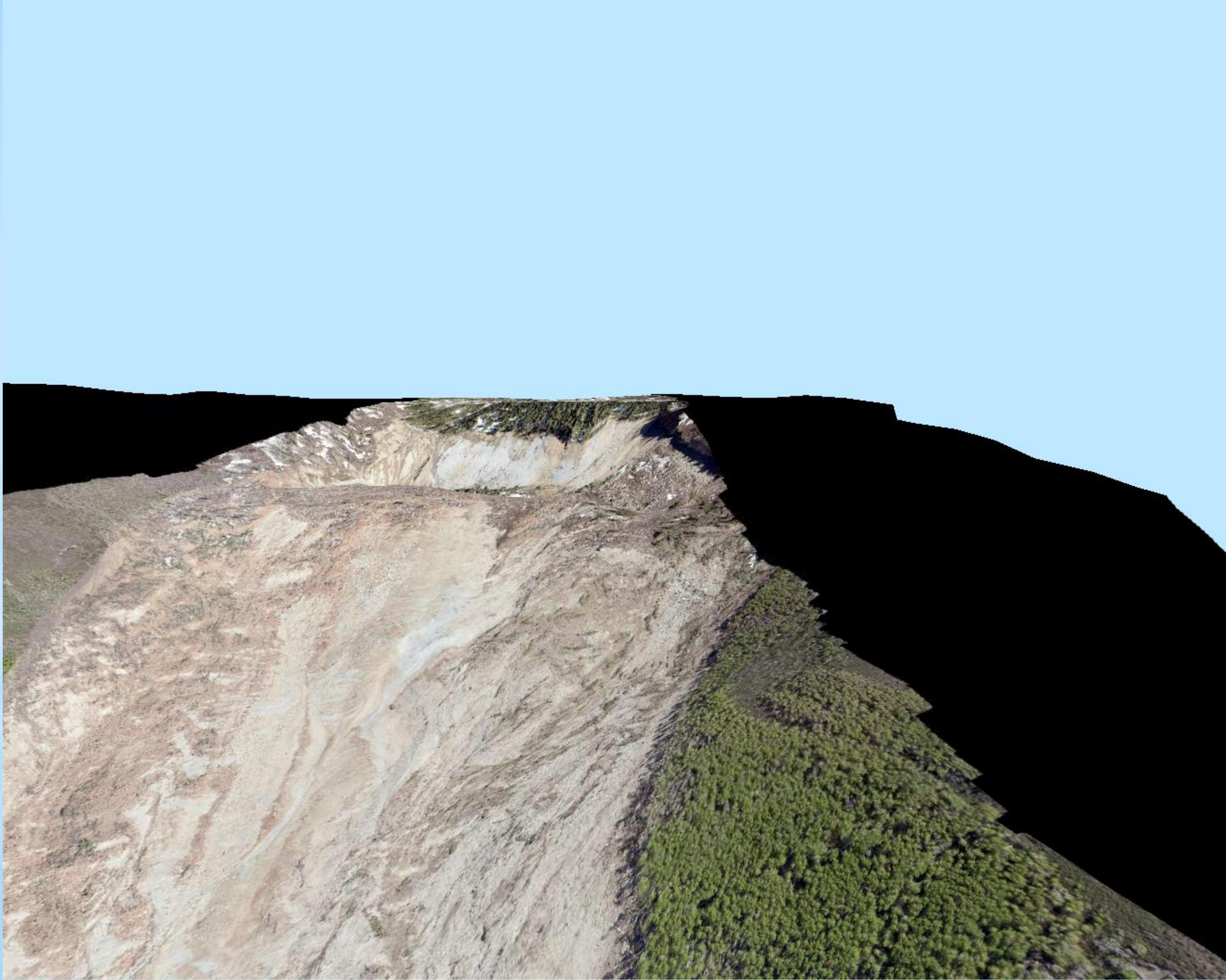


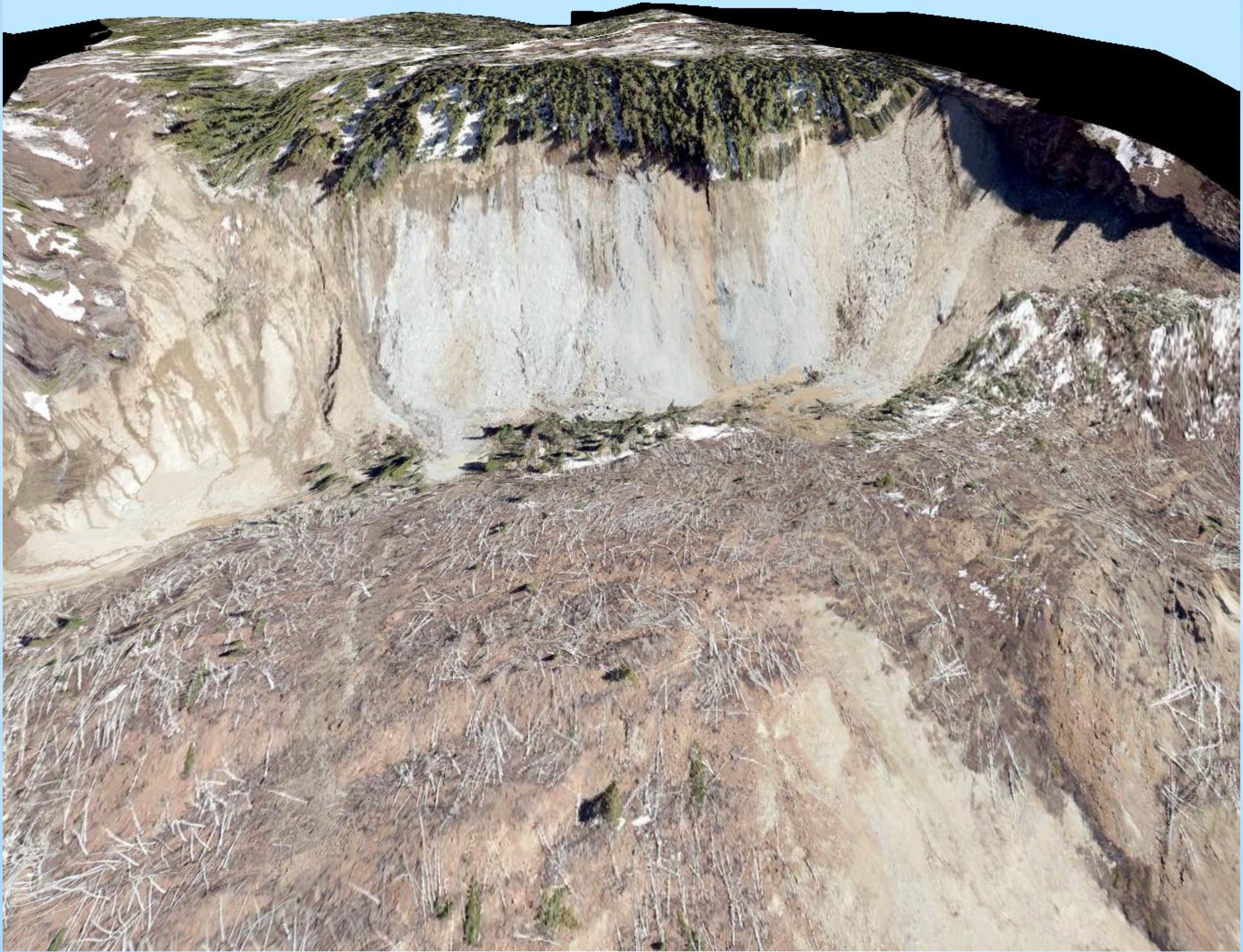
If you were to look closely at satellite images of the slide on Google Earth, the pond at the headwall lays on an uphill slope. The imagery does not make sense due to the ground moving in the slide and the topography being different now. But if you take the satellite images of the slide and lay them over Lidar Data, the imagery corresponds to the topography.

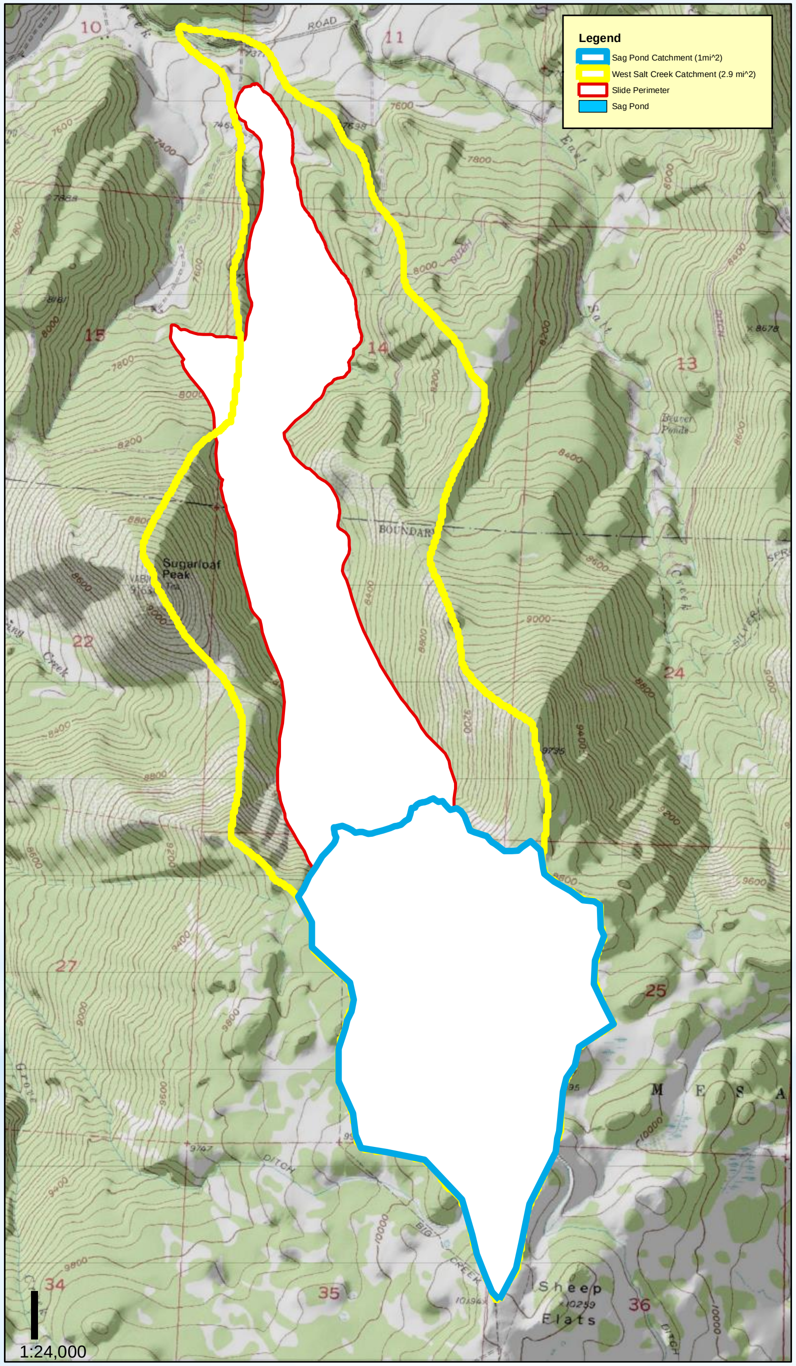


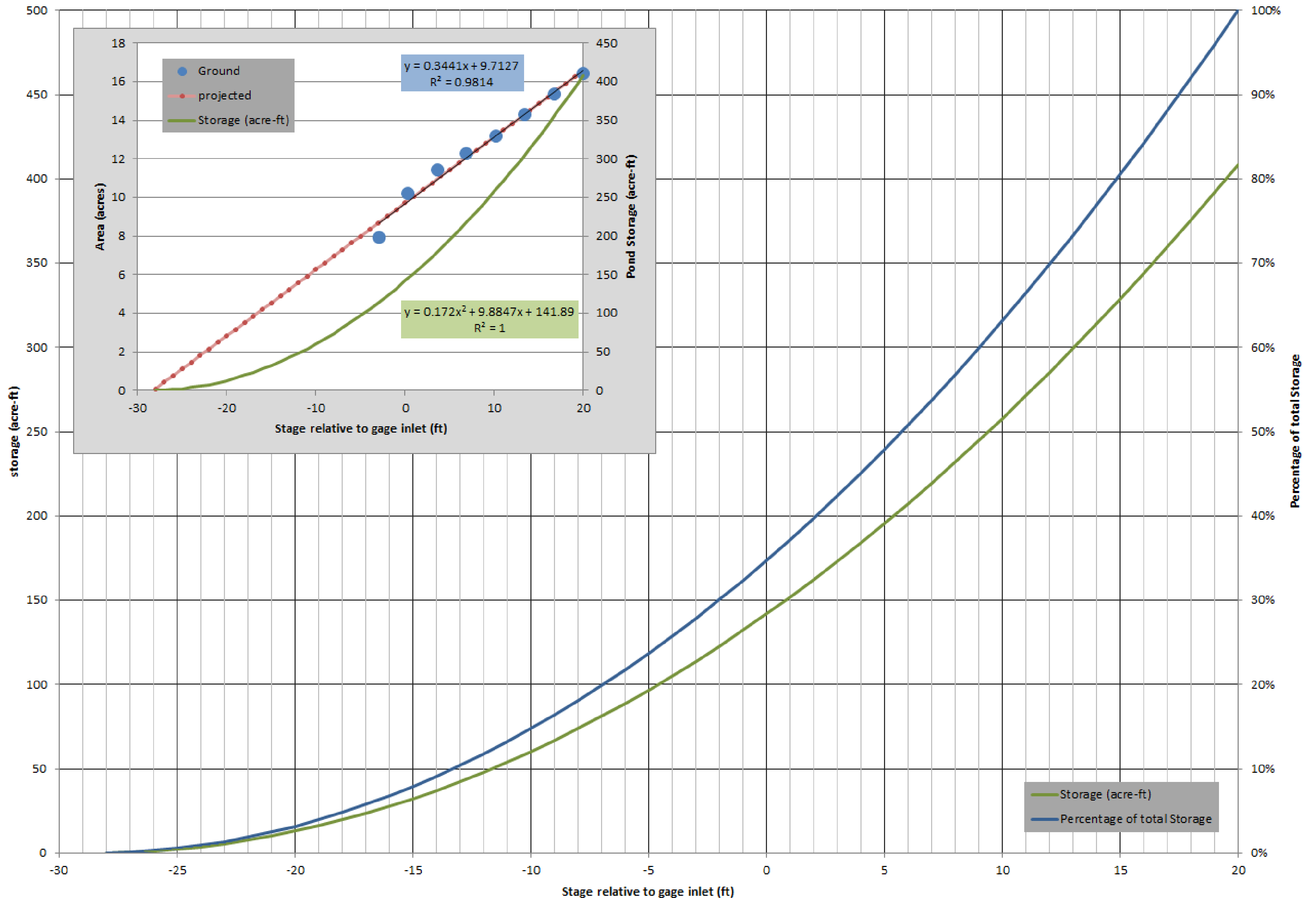
Google Earth does not have updated topo data, so the new topography has not yet been recorded and does not correspond to the imagery.



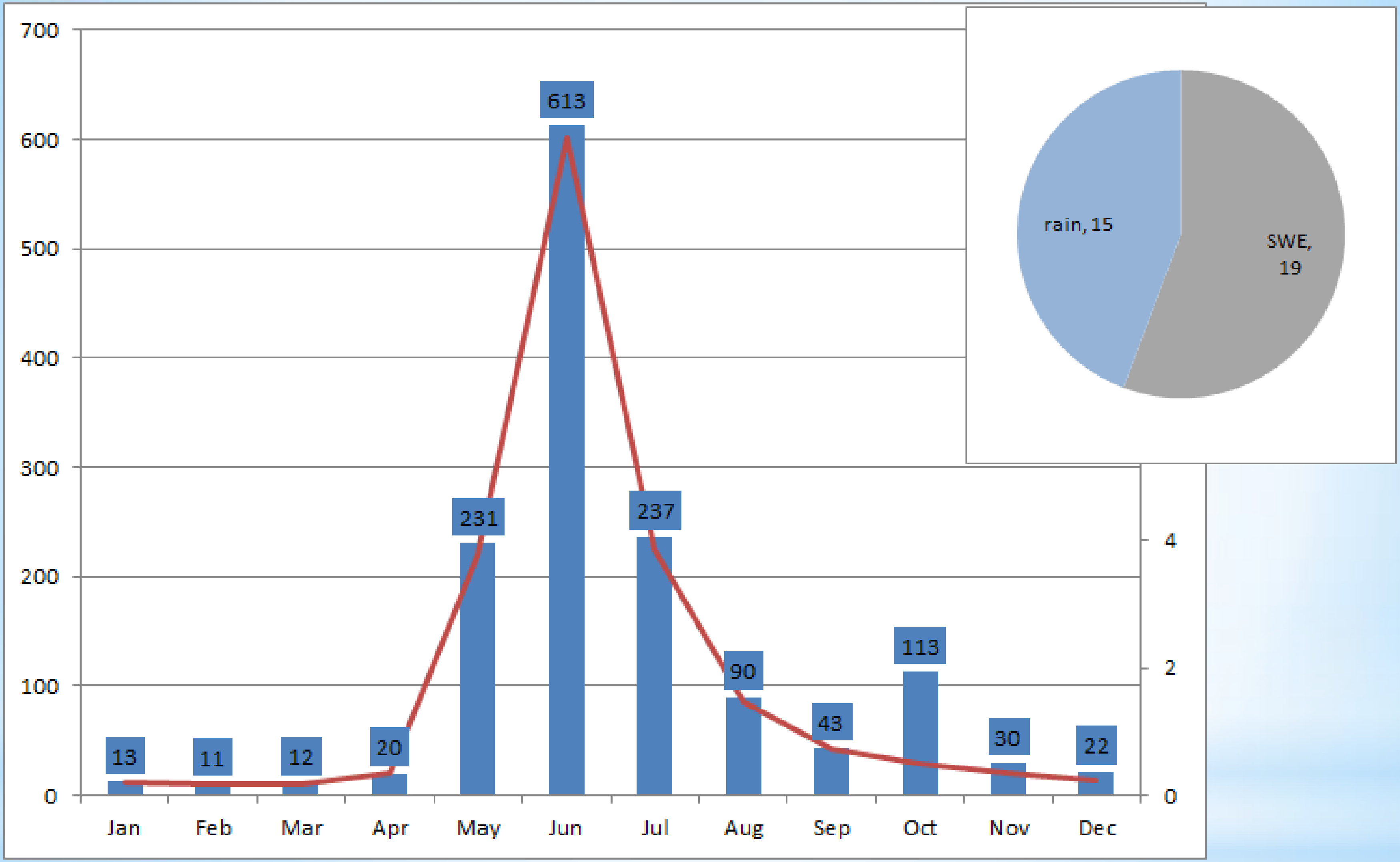





Legend
Sag Pond Catchment (1mi^2)
West Salt Creek Catchment (2.9 mi^2)
Slide Perimeter
Sag Pond
Sugarloaf Peak
BOUNDARY
Sheep Flats
M E S A
1:24,000

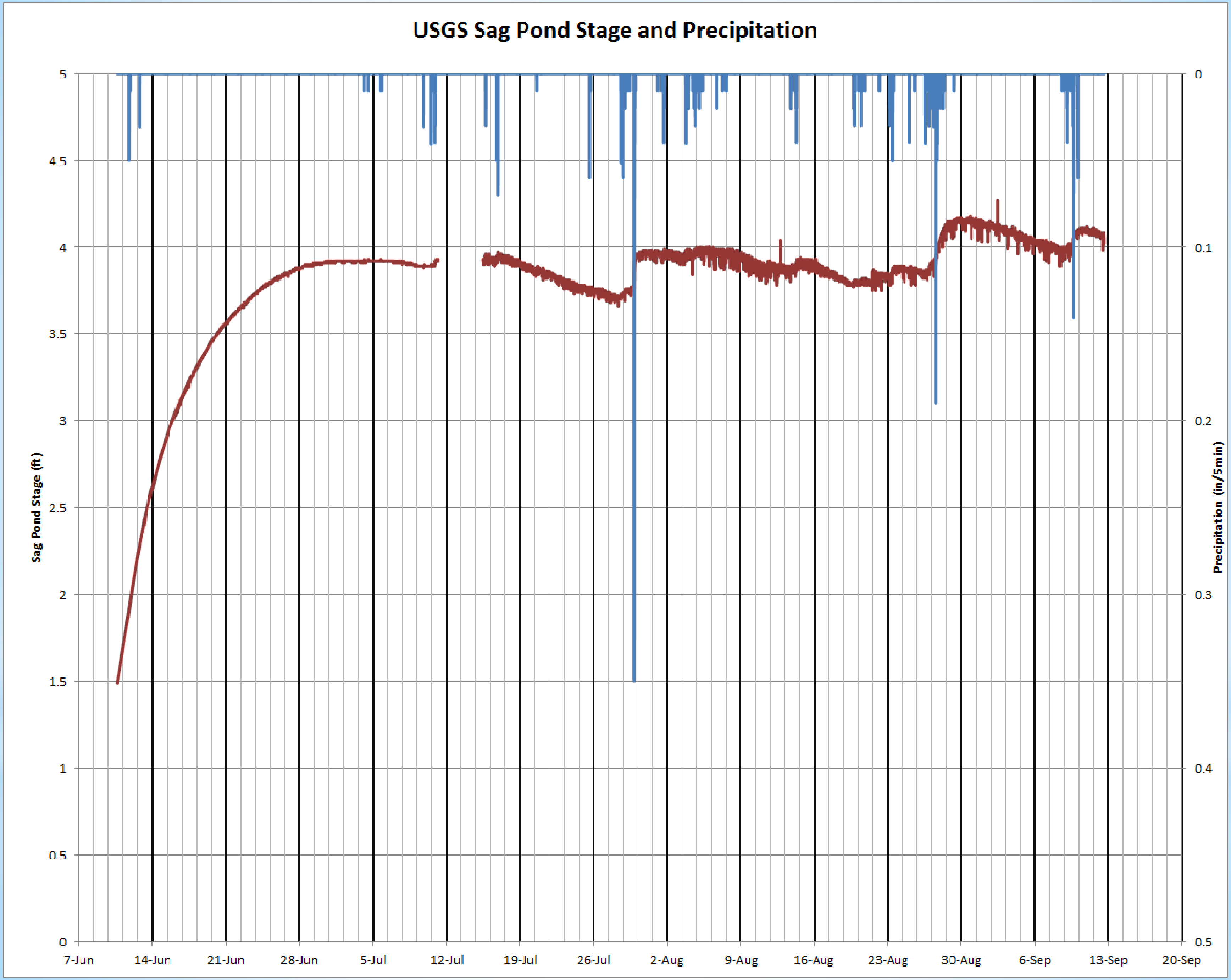


Ground
projected
Storage (acre-ft)
y = 0.3441x + 9.7127
R² = 0.9814
y = 0.172x² + 9.8847x + 141.89
R² = 1
Area (acres)
Pond Storage (acre-ft)
Stage relative to gage inlet (ft)
storage (acre-ft)
Percentage of total Storage
Storage (acre-ft)
Percentage of total Storage
Stage relative to gage inlet (ft)

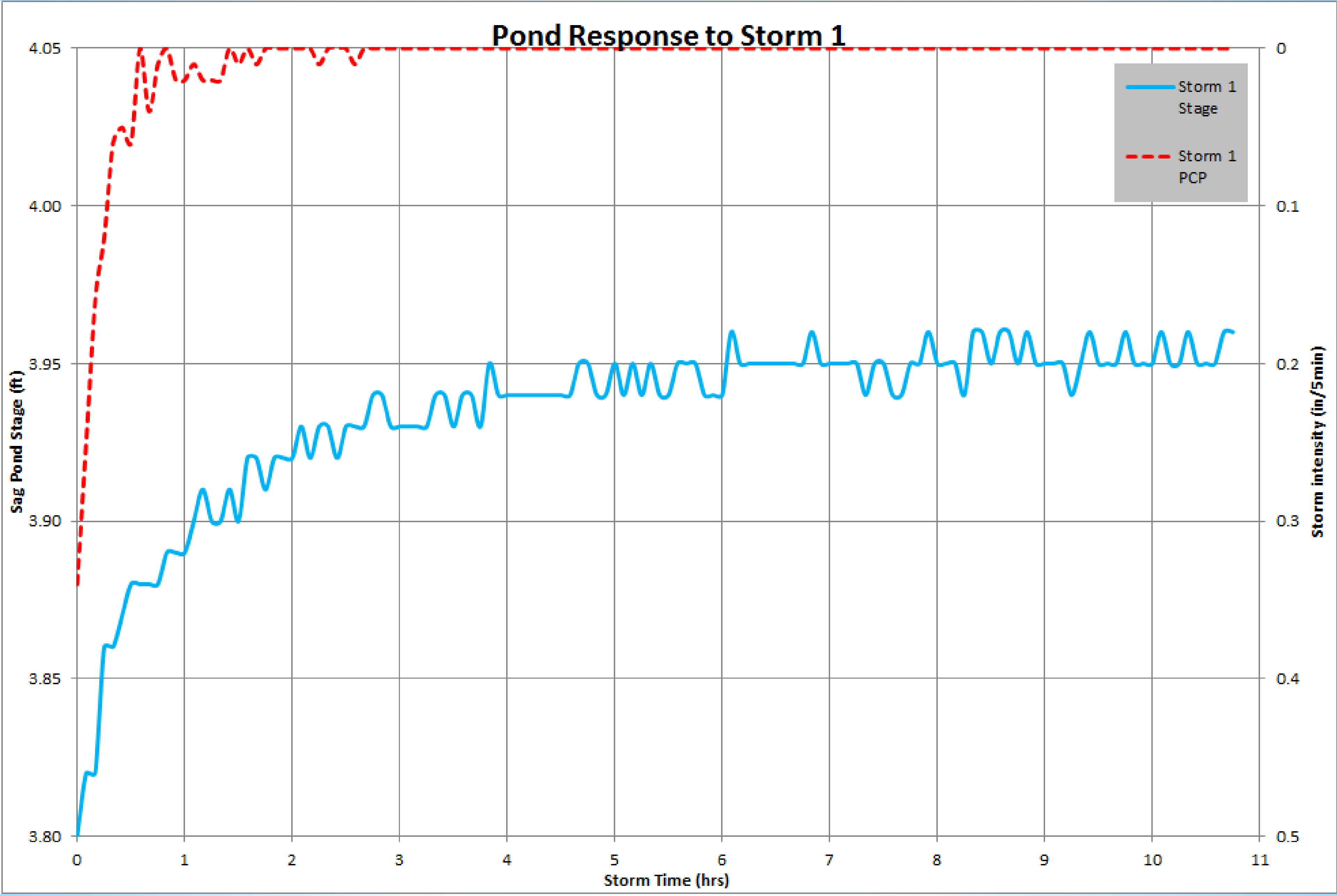


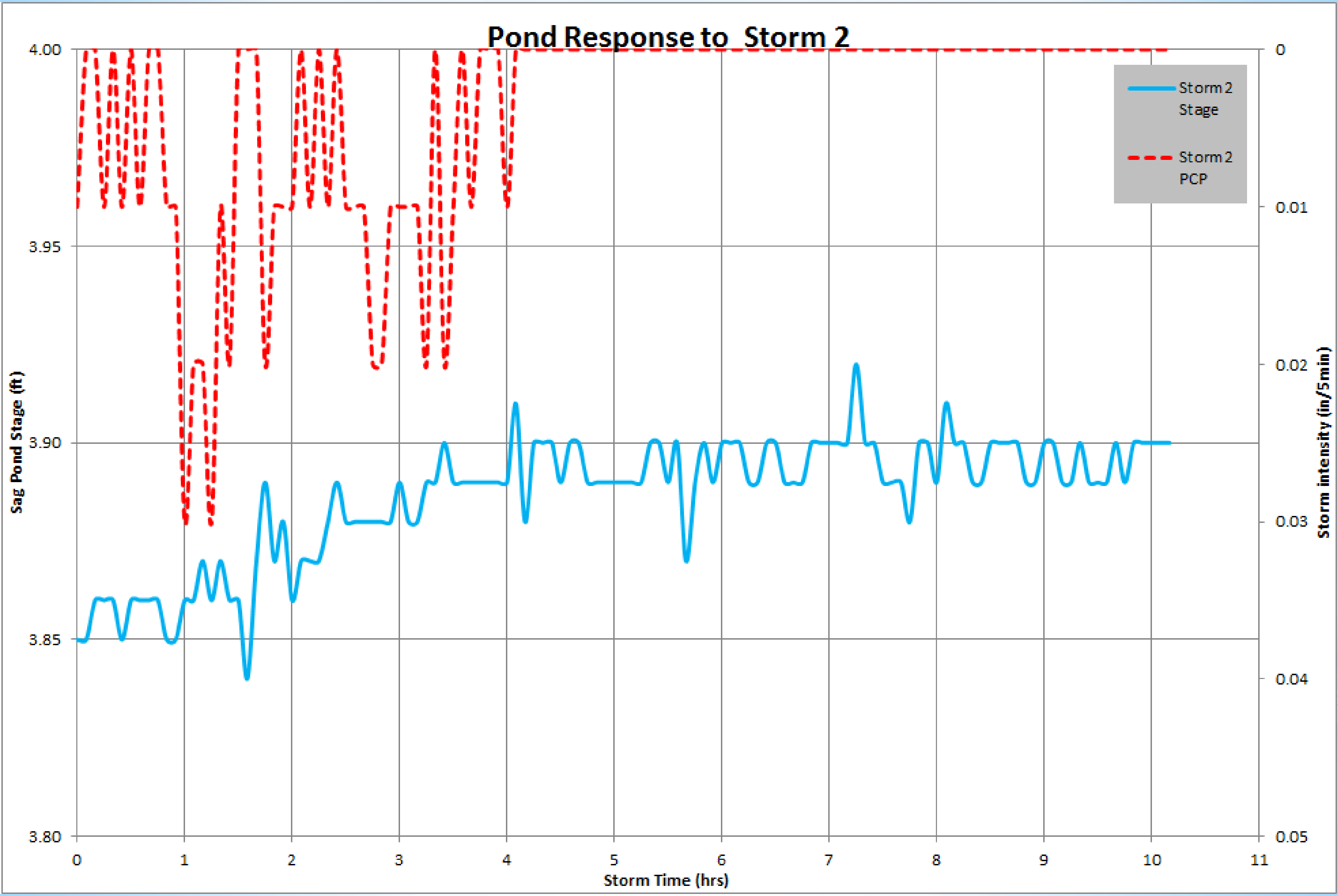
area	640 acres
SWE vol	1000 acre-ft
precip vol	1800 acre-ft
stream Stats	1400 acre-ft

Pond storage is only 400 acre feet, 2cfs for a day is an acre-ft. The storage pond should overtop during spring runoff in May/June. Pond should be silted in by then and hold water better.

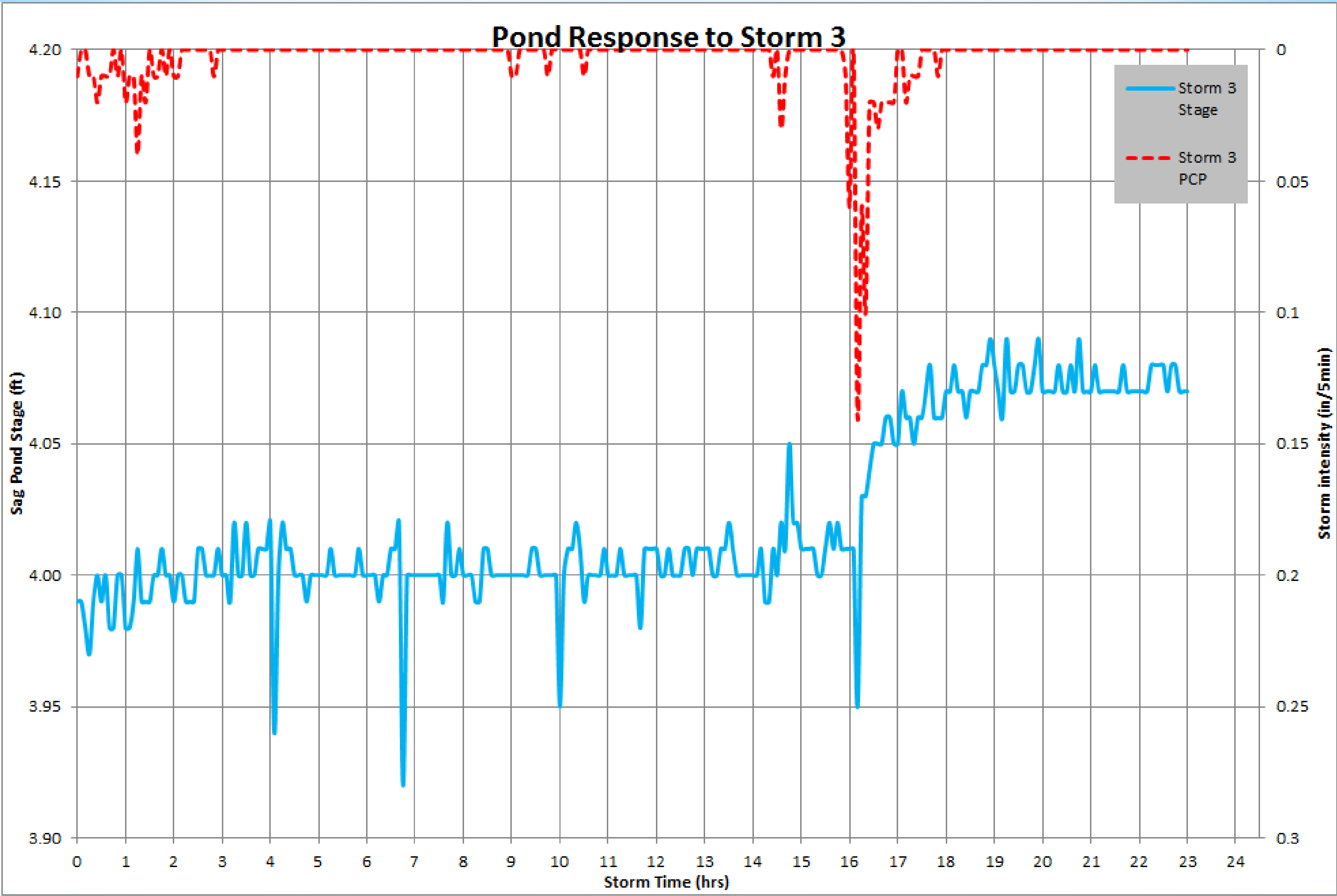


USGS Sag Pond Stage and Precipitation
Sag Pond Stage (ft)
Precipitation (in/5min)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.1
0.2
0.3
0.4
0.5
7-Jun
14-Jun
21-Jun
28-Jun
5-Jul
12-Jul
19-Jul
26-Jul
2-Aug
9-Aug
16-Aug
23-Aug
30-Aug
6-Sep
13-Sep
20-Sep


Pond Response to Storm 1
Storm 1 Stage
Storm 1 PCP
Sag Pond Stage (ft)
4.05
4.00
3.95
3.90
3.85
3.80
Storm intensity (in/5min)
0
0.1
0.2
0.3
0.4
0.5
0
1
2
3
4
5
6
7
8
9
10
11
Storm Time (hrs)



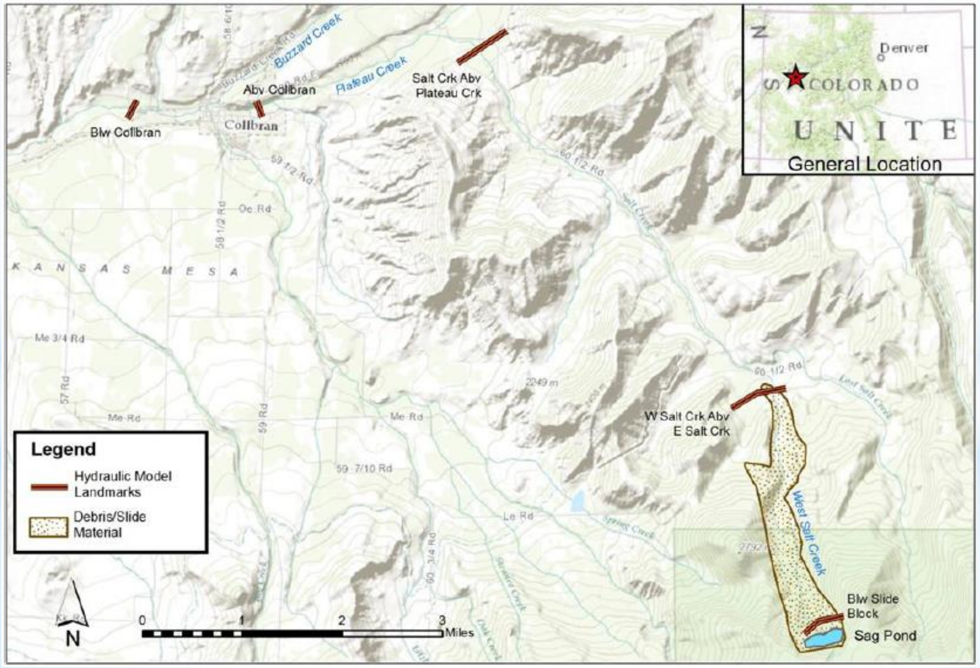
Pond Response to Storm 2
Storm 2 Stage
Storm 2 PCP
Sag Pond Stage (ft)
4.00
3.95
3.90
3.85
3.80
Storm intensity (in/5min)
0
0.01
0.02
0.03
0.04
0.05
0
1
2
3
4
5
6
7
8
9
10
11
Storm Time (hrs)



Pond Response to Storm 3
Storm 3 Stage
Storm 3 PCP
Sag Pond Stage (ft)
4.20
4.15
4.10
4.05
4.00
3.95
3.90
Storm intensity (in/5min)
0
0.05
0.1
0.15
0.2
0.25
0.3
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Storm Time (hrs)

Army Corp of Engineers used FLO-2D software modeling and concluded:

Location	Time to first flow from breach (hr)	Time to peak flow (hr)
Toe of landslide	1.0 – 1.5	2.0 – 2.5
Salt Creek at new USGS gage	2.0 – 3.0	2.5 – 3.5
Plateau Creek upstream of Collbran	2.5 – 4.0	3.0 – 5.0
Plateau Creek downstream of Collbran	3.0 – 5.0	3.0 – 5.5



Hydrologically, there is little consequence of the sag pond overtopping the block and creating a flood event. There is so much topography and roughness and infiltration capacity of the slide debris that as long as we don't some how move the block again it could move towards a flow in=flow out situation.

Since a catastrophic release of the sag pond producing “a wall of water” is not expected, the focus has been shifted to studying the potential for a second movement of the block due to increased pore pressure in the bock as a result of a higher pond level.