Peak Discharges of July 20, 2014; Buckeye Creek and Johnson Wash Crest-Stage Stage (CSG) Sites, Douglas County, Nevada

USGS Nevada Water Science Center

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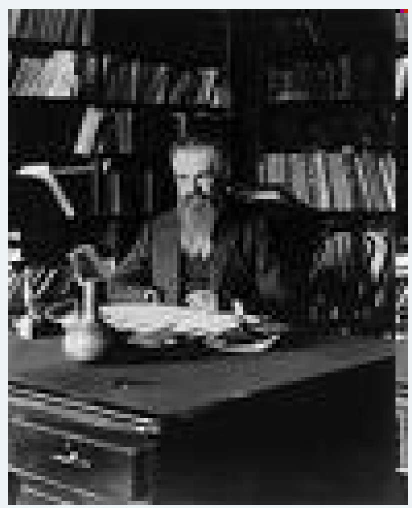
Objectives

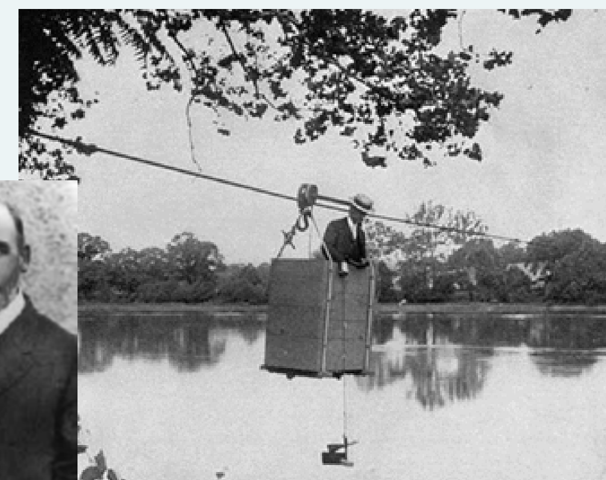
- Quickly describe USGS database (NWIS)
- Describe July 20, 2014 peak flow indirect measurements at Johnson Wash and Buckeye Creek gages.
- Describe estimated frequency characteristics of the peak discharges.
- Describe USGS Nevada Water Science Center crest-stage gage program.

We’ve come a long way

- Streamgaging: 1889 at Embudo, NM
- Frederick H Newell led development with direction from John Wesley Powell
- 1895: began sharing cost with the States (Kansas State Engineer)







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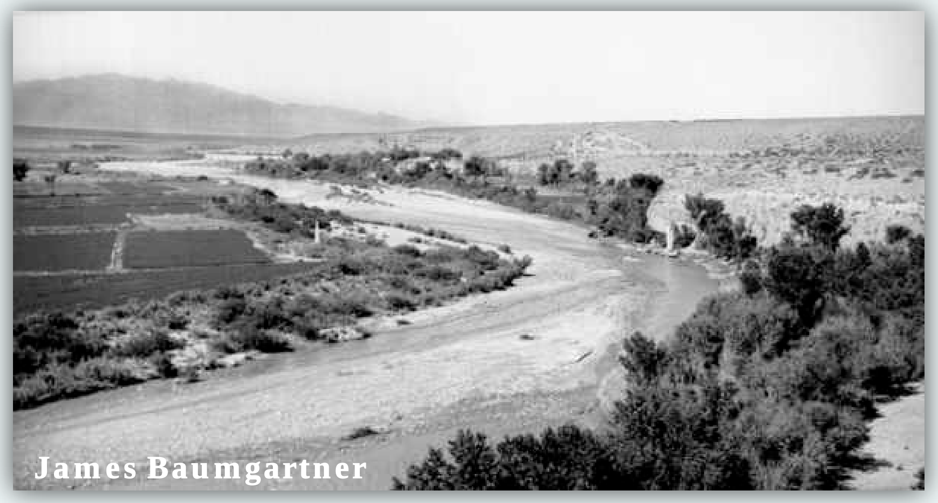
Long History of measuring water in Nevada

- East Fork Carson River near Gardnerville (1890)
- West Fork Carson River at Woodfords (1900)
- Truckee River at Tahoe City (1895)
- Humboldt River at Palisade (1902)
- Truckee River below Derby Dam (1909)
- Virgin River at Littlefield (1929)



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http://waterdata.usgs.gov/

Provides access to select USGS data

- Current Conditions (Real-time)
- Site information
- NWIS Mapper – Map interface
- Current and historical data
  - Surface Water
    - Daily means
    - Daily, monthly, and annual statistics
    - Peak flows
    - Field Measurements including channel geometry
  - Groundwater levels
  - Water Quality
  - Water Use

**Does not include all data stored in NWIS

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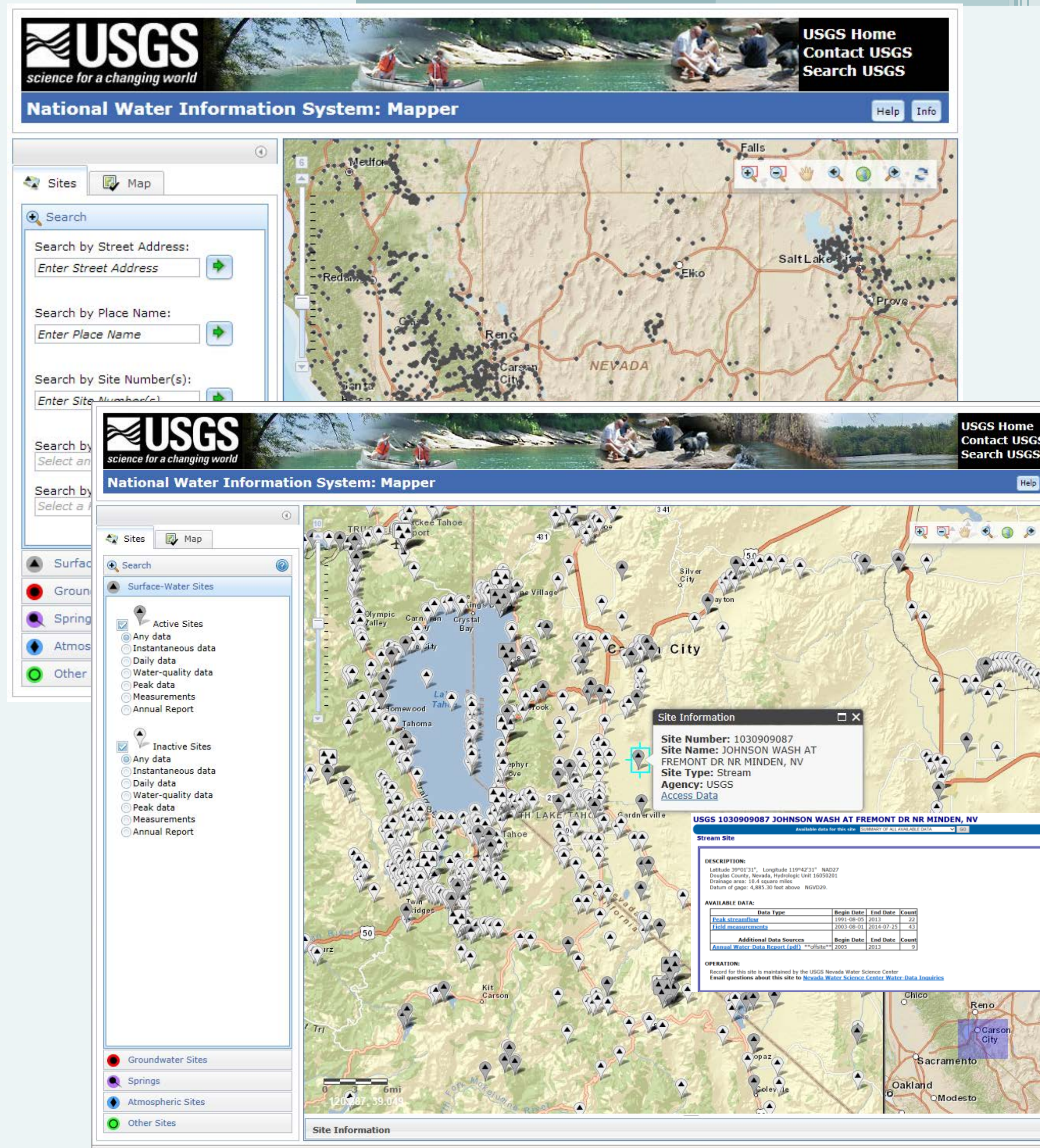
NWIS Mapper

- Select any data collection site by ‘point and click’ function
- Sites can be active or historic discontinued
- Entire period of record is available including measurements and unit values (spotty before 1985)
- Can zoom and pan
- Sites become clickable at certain zoom levels
    - Site lists available
    - KML for Google Maps
- Sites can be viewed by
    - Active
    - Inactive
    - Realtime
    - Site Type



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Crest-Stage Gages

Buckeye Creek

- To record and verify highest water levels. Stick housed in pipe records highest water level between visits
- Less expensive than continuous recording streamflow gages
- Uses:
  - Peak verification at continuous recording streamflow gages
  - Record peaks at ephemeral washes/creeks or at locations where peaks rather than continuous flow records meet program objectives

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Crest-Stage Gages

- Visits every six weeks
  or more often if warranted.

- Discharge measurements made
  or zero flow documented made
  each visit

- Stage-discharge relationship
  (rating) developed, if possible

- Peak event discharges
  determined by rating or indirect
  methods (using channel
  characteristics and hydraulic
  principles)

- Crest stage gage program:
  NDOT: 25 throughout Nevada
  USACE: 4 in S. Nevada

Johnson Wash

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Crest-Stage Gages

- Records published in Site Data Sheets (previously called Annual Data Report)
- Manuscript includes information on location, period of record, and extremes
- Collected data quality assured and published in peak discharge and discrete measurement tables

Site Data Sheet

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Water-Data Report 2013

10309075 Buckeye Creek At East Valley Road Near Gardnerville, NV

Carson Basin
Upper Carson Subbasin

LOCATION.--Lat 38°57'53", long 119°42'13" referenced to North American Datum of 1927, in SW ¼ NE ¼ sec.26, T.13 N., R.20 E., Douglas County, NV, Hydrologic Unit 16050201, at culvert on East Valley Road, 2.9 mi northeast of Gardnerville, Nevada

DRAINAGE AREA.--73.8 mi².

SURFACE-WATER RECORDS

PERIOD OF RECORD.--Annual maximums, 1992, 1994-1995, 1997, Aug. 1998 to current year.

GAGE.--Crest-stage gage.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 1000 ft³/s, Sept 14, 2013, gage height, 10.36 ft.

EXTREMES OUTSIDE PERIOD OF RECORD.--Maximum discharge, 3,000 ft³/s, July 14, 1992, gage height, unknown.

MAXIMUM PEAK DISCHARGE
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013

Date	Discharge, in ft³/s	Discharge qualification code	Gage height, in ft	Gage height qualification code
Sep 14, 2013	1,000	---	10.36	---

DISCHARGE MEASUREMENTS
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013

Date	Discharge, in ft³/s	Gage height, in ft
Oct 16, 2012	0.0	---
Nov 29, 2012	0.0	---
Dec 2, 2012	13.0	5.35
Dec 4, 2012	0.0	---
Jan 8, 2013	0.0	---
Feb 21, 2013	0.0	---
Mar 26, 2013	0.0	---
May 14, 2013	0.0	---
Jun 25, 2013	0.0	---
Aug 7, 2013	0.0	---
Sep 14, 2013	1,000	10.36

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Peak Streamflow Files

Johnson Wash
520 cfs

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1991	Aug. 05, 1991		350[2]
1992	Jul. 14, 1992		1,200[2]
1993	1993		0.0
1994	Jul. 22, 1994		1,400[2]
1995	Mar. 10, 1995		15[2]
1996	1996		0.0
1997	Jan. 02, 1997		30[2]
1999	1999		0.0
2000	2000		0.0
2001	2001		0.0
2002	2002		0.0
2003	Jul. 20, 2003	15.89	19[2]
2004	2004		0.0
2005	Jul. 29, 2005	17.38	210
2006	Dec. 31, 2005		1[2]
2007	Feb. 12, 2007		1.0[2]
2008	Jan. 04, 2008	[4]	0.410[2]
2009	Jun. 03, 2009	15.09[4]	27[2]
2010	Jan. 13, 2010	[4]	2[2]
2011	Jul. 30, 2011	15.98	66
2012	Jul. 23, 2012	16.90	400[2]
2013	2013		0.0

Buckeye Creek
2,800 cfs

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1992	Jul. 14, 1992		3,000[2,7]
1994	Jul. 22, 1994		1,300[2]
1995	Mar. 10, 1995		500[2]
1997	Jan. 02, 1997		200[2]
1998	Sep. 26, 1998		80[2]
1999	1999		0.0
2000	2000		0.0
2001	2001		0.0
2002	2002		0.0
2003	Jul. 20, 2003	5.80	140[2]
2004	Jul. 03, 2004	6.10	990[2]
2005	2005		0.0
2006	Dec. 31, 2005	6.07	120
2007	2007		0.0
2008	2008		0.0
2009	Jun. 08, 2009	4.85	1.0[2]
2010	Jan. 13, 2010	[4]	2[2]
2011	Jul. 30, 2011	5.49	67
2012	Jul. 23, 2012	5.33	60
2013	Sep. 14, 2013	10.36	1,000

Indirect Measurements of Peak Discharge

USGS New Mexico Water Science Center

Albuquerque, New Mexico

July 30 to August 2, 2013

Agenda for Course

for_Mike	8/28/2014 1:07 PM	File folder	
1-Overview	2/2/2014 11:00 PM	Microsoft PowerP...	1,998 KB
2-HWMs	2/2/2014 11:00 PM	Microsoft PowerP...	1,789 KB
3-Field Procedures	2/2/2014 11:00 PM	Microsoft PowerP...	5,127 KB
4-Subdivision of Cross Sections	2/2/2014 11:00 PM	Microsoft PowerP...	639 KB
5-ManningsRoughnessCoefficient	2/2/2014 11:00 PM	Microsoft PowerP...	1,951 KB
6-Exercise_nvalues_Barnes	2/2/2014 11:00 PM	Microsoft PowerP...	20,103 KB
7-SurveyEquipmentAndMethods	2/2/2014 11:00 PM	Microsoft PowerP...	20,925 KB
8-SAC_GUI_Field - Copy	2/2/2014 11:00 PM	Microsoft PowerP...	2,179 KB
8-SAC_GUI_Field	2/2/2014 11:00 PM	Microsoft PowerP...	2,179 KB
Extra_Surveying_Information	2/2/2014 11:00 PM	Microsoft PowerP...	738 KB
Indirect_survey_reference_FIELDBOOK	2/2/2014 11:00 PM	Adobe Acrobat D...	108 KB
Indirect_survey_reference_FIELDBOOK	2/2/2014 11:00 PM	Microsoft PowerP...	63 KB
MC_UT_CSV_HWMs_Field	2/2/2014 11:00 PM	Microsoft Excel C...	2 KB
Survey_notes_TS.mes_130731	2/2/2014 11:00 PM	Adobe Acrobat D...	3,019 KB
Surveying.notes050504	2/2/2014 11:00 PM	Microsoft Word 9...	177 KB
9-General Office Procedures	2/2/2014 11:00 PM	Microsoft PowerP...	2,822 KB
10-Office Procedures For Slope Area	2/2/2014 11:00 PM	Microsoft PowerP...	1,442 KB
11-SAC_GUI_Office	2/2/2014 11:00 PM	Microsoft PowerP...	5,743 KB
Analysis Template_NM.MES 080930	2/2/2014 11:00 PM	Microsoft Word 9...	55 KB
Evaluate.Results.S-A.060730	2/2/2014 11:00 PM	Microsoft Word 9...	31 KB
Measurement_Summary_Outline.MES_13...	2/2/2014 11:00 PM	Microsoft Word 9...	36 KB
NM08386505 S-E.MES version 110115	2/2/2014 11:00 PM	Microsoft Excel 97...	58 KB
Rio Ruidoso at Ruidoso Analysis.July 200...	2/2/2014 11:00 PM	Microsoft Word 9...	2,754 KB

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Indirect Measurement of Discharge

- During floods, it is frequently is impossible or impractical to measure peak discharge directly. Consequently, many peak discharges must be determined after the passage of the flood by indirect methods.
- Indirect determinations of discharge make use of the **energy equation** for computing stream flow.

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Indirect Measurement of Discharge

- Indirect methods involve these general factors:
  1. Physical characteristics of the channel; that is dimensions and conformation of the channel within the reach used and boundary conditions.
  2. Water-surface elevations at time of peak stage (high-water marks, or HWMs) to define the upper limit of the cross-sectional areas and the difference in elevation between two or more significant cross sections.
  3. Hydraulic factors based on physical characteristics, water-surface elevations, and discharge, such as roughness coefficients and discharge coefficients.

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Slope-Area Method

- The slope-area method is the most commonly used technique of indirect discharge determination.
- Discharge is computed on the basis of a uniform-flow equation involving channel characteristics, water-surface profiles, and a roughness or retardation coefficient. The drop in water-surface profile for a uniform reach of channel represents energy losses caused by bed and bank roughness.

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Reach selection

- No significant inflow or outflow
- Insignificant channel storage
- Not affected by scour and fill
- As straight as possible
- Consistent channel shape and roughness
- Near to point where peak discharge value is desired

In the end, what is most critical?

- Site selection – It is nearly impossible to get a good result from a bad site
- Profile definition – Fall through the reach drives everything
- Cross-section location – The validity of the result depends on friction slope being uniform between sections

July 20 Precipitation: High Intensity over a Few Hours

- National Weather Service, Nevada Appeal:

  Base of Hot Springs Mtn: 1.21 inches in 2 hours

- Weather Underground:

  Top of Johnson Lane: 1.15 inches in 2 hours

  Gardnerville: 0.62 inches in 2 hours

NEVADA APPEAL

50¢ | Vol. 150 · No. 60

Your Life. Your Community. Your News. | Friday

High: 92 Low: 55
Page A19

BLAZING TRAIL
Volunteers needed to work on Tahoe Rim Trail.
Page A6

RAIDER NATION

Fish Springs Volunteer Fire Department first responders block Jo Lane on Sunday.

SPECIAL TO THE RECORD-COURIER

Douglas officials: Flood was once in a century

Record-Courier staff report

of rainfall had a 1 percent chance of being exceeded or that it was 99 percent greater than typical storms," officials said.

The National Weather Service reported 1.21 inches of rain fell at the base of Hot Springs Mountain in less than two hours on Sunday.

That water rushed down a wash on the south side of the mountains sending water rushing into homes along the base.

Residents in Buckbrush Estates reported mud wiped out their yard, filled pools, entered garages and otherwise damaged their homes.

FLOOD, A6

stops in Silver Springs

start his senior year at Nevada

1:49 PM	65.3 °F	54.2 °F	66 %	SE	33 mph	44 mph	29.48 in	0.02 in	0.02 in
1:54 PM	61.3 °F	54.4 °F	78 %	SE	17 mph	44 mph	29.55 in	0.06 in	0.07 in
1:59 PM	58.7 °F	52.2 °F	79 %	ESE	18 mph	41 mph	29.50 in	0.27 in	0.3 in
2:04 PM	56.4 °F	51 °F	82 %	SSE	9 mph	36 mph	29.58 in	0.63 in	0.65 in
2:09 PM	56.7 °F	53.5 °F	89 %	South	13 mph	23 mph	29.56 in	0.84 in	0.86 in
2:14 PM	58 °F	55.1 °F	90 %	South	19 mph	29 mph	29.57 in	0.95 in	0.96 in
2:19 PM	58.8 °F	56 °F	90 %	SSE	14 mph	29 mph	29.58 in	0.98 in	0.98 in
2:24 PM	59.6 °F	56 °F	88 %	SSE	7 mph	21 mph	29.59 in	0.99 in	0.99 in
2:29 PM	59.7 °F	56.1 °F	88 %	SE	11 mph	19 mph	29.59 in	1.03 in	1.03 in
2:34 PM	59.9 °F	56.3 °F	88 %	South	8 mph	21 mph	29.58 in	1.05 in	1.05 in
2:39 PM	60.3 °F	56.4 °F	87 %	SE	16 mph	21 mph	29.58 in	1.07 in	1.07 in
2:44 PM	60.3 °F	56.4 °F	87 %	SE	19 mph	25 mph	29.58 in	1.09 in	1.1 in
2:49 PM	60.3 °F	56.1 °F	86 %	SSE	13 mph	25 mph	29.58 in	1.1 in	1.12 in
2:54 PM	60.4 °F	56.2 °F	86 %	SSE	11 mph	24 mph	29.58 in	1.05 in	1.13 in
2:59 PM	60.5 °F	56 °F	85 %	South	11 mph	24 mph	29.58 in	0.81 in	1.14 in
Time	Temperature	Dew Point	Humidity	Wind	Speed	Gust	Pressure	Precip. Rate.	Precip. Ac
3:04 PM	60.6 °F	55.7 °F	84 %	South	8 mph	21 mph	29.59 in	0.45 in	1.15 in
3:09 PM	60.6 °F	55.7 °F	84 %	South	7 mph	16 mph	29.59 in	0.27 in	1.15 in
3:14 PM	60.6 °F	56.4 °F	86 %	WSW	0 mph	12 mph	29.6 in	0.18 in	1.15 in
3:19 PM	60.4 °F	56.5 °F	87 %	WSW	0 mph	10 mph	29.6 in	0.17 in	1.15 in
3:24 PM	60.3 °F	56.7 °F	88 %	WSW	0 mph	9 mph	29.6 in	0.16 in	1.15 in
3:29 PM	60.1 °F	56.5 °F	88 %	WSW	0 mph	1 mph	29.6 in	0.12 in	1.15 in
3:34 PM	60 °F	56.4 °F	88 %	WSW	0 mph	1 mph	29.6 in	0.09 in	1.15 in
3:39 PM	60.1 °F	56.8 °F	89 %	NNE	2 mph	5 mph	29.61 in	0.08 in	1.15 in
3:44 PM	60.1 °F	56.8 °F	89 %	NNE	3 mph	6 mph	29.6 in	0.05 in	1.15 in
3:49 PM	60.2 °F	57.3 °F	90 %	NNE	4 mph	9 mph	29.6 in	0.03 in	1.15 in

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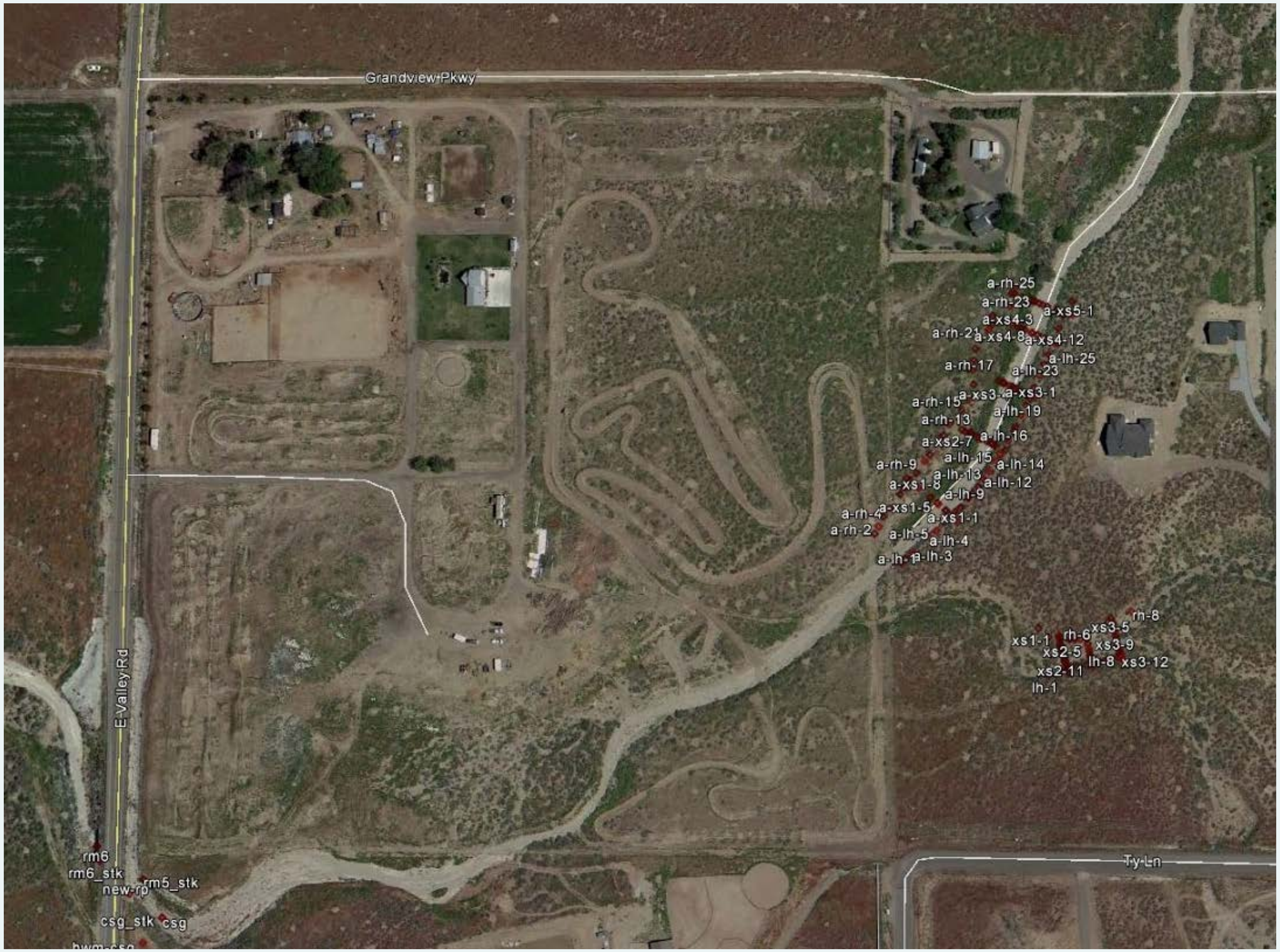
Buckeye Creek Plan View



Buckeye Creek Site Conditions

- Complex culvert doesn't lend itself to culvert computation.
- Slope-Area indirect computation procedure applied

Buckeye Creek Site Conditions

- Primary and tributary channels about 0.3 miles upstream from gage

- Primary channel relatively straight with clear high-water marks

- Tributary channel had short straight reach with clearer high-water marks on right bank

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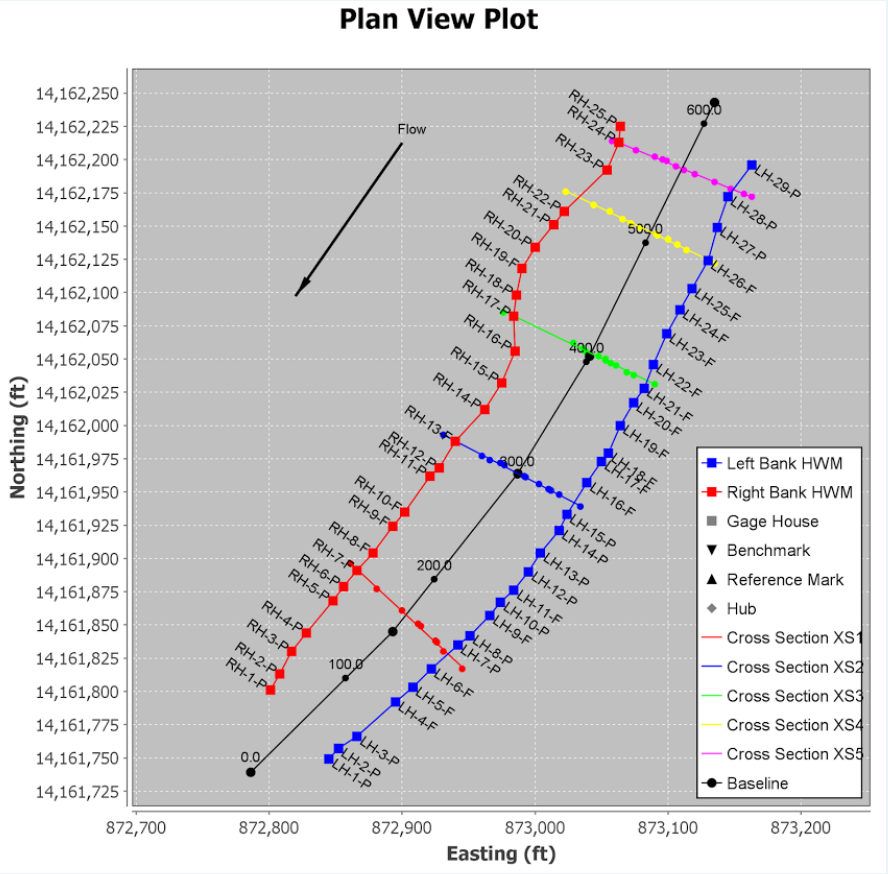
Buckeye Creek: Plan View, High-Water Marks, Slope, Channel Geometry, and Roughness

- <u>High-water mark information defines</u>:
  - Left and right banks
  - Water level at cross sections
  - slope
- <u>Cross-section information defines</u>:
  - Channel geometry through survey reach
  - Channel roughness



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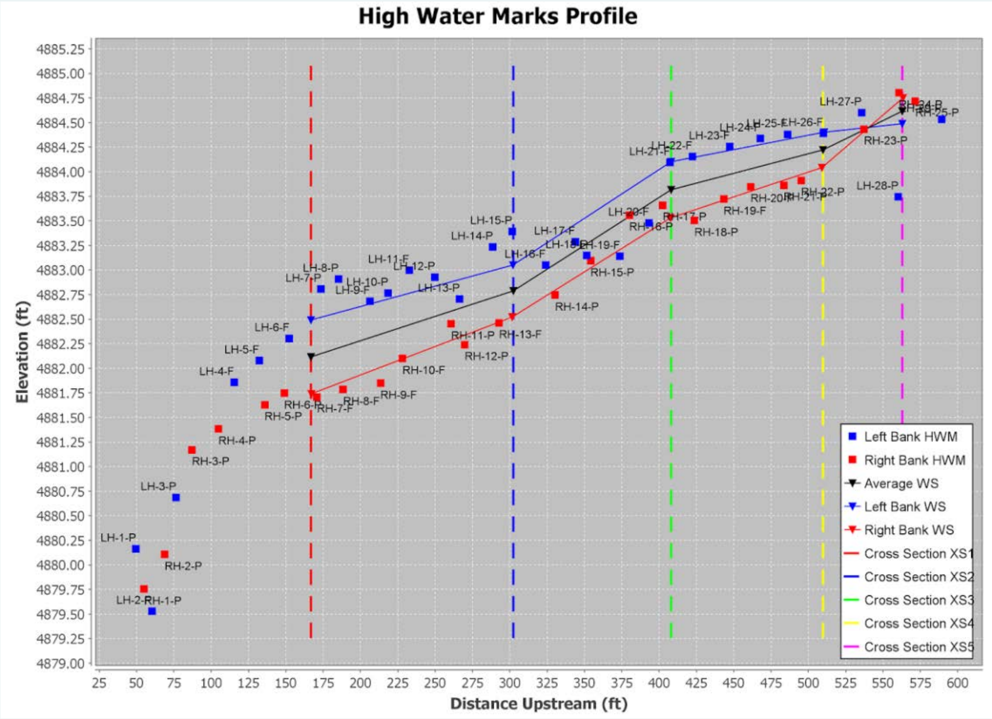
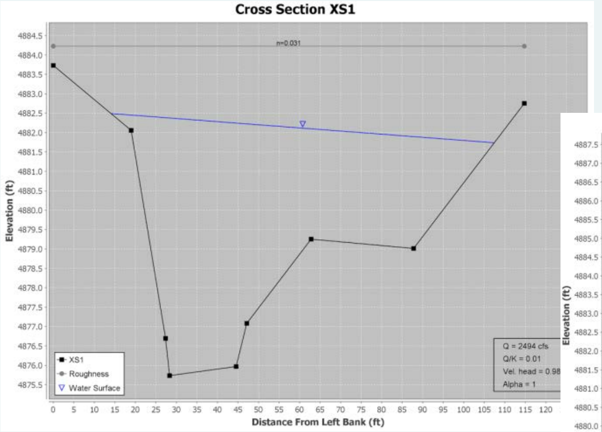
Buckeye Creek: Plan View, High-Water Marks, Slope, Channel Geometry, and Roughness

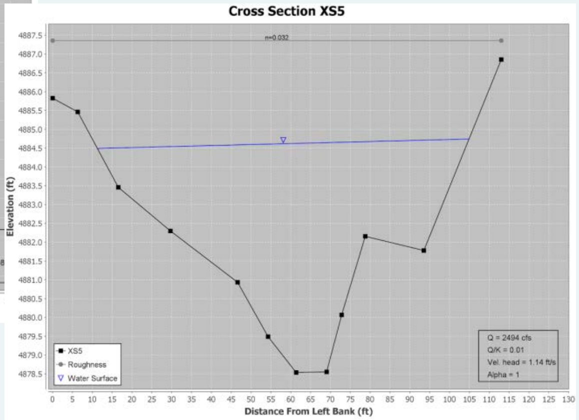
- High-water mark profiles define:
  - Slope
  - Cross section locations



Buckeye Creek: Plan View, High-Water Marks, Slope, Channel Geometry, and Roughness

- <u>Cross Sections define</u>:
  - Channel geometry
  - Roughness





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Buckeye Creek: Documentation

- <u>Measurement Analysis includes</u>:
  - Type of Measurement
  - Location of Site
  - Discharge and Gage Height
  - Drainage Area
  - Unit Discharge
  - Nature of Flood
  - Field Conditions inc.
    - site selection
    - survey conditions
    - profiles
    - cross sections
    - roughness values
  - Computations
  - Discharge Determination
  - Evaluation of Results inc sensitivity analysis
  - Previous Computations
  - Archival Information
  - Remarks
  - Information on personnel who worked, checked and reviewed the measurement

10309075 BUCKEYE CK AT E VALLEY RD NR GARDNERVILLE, NV
Peak flow event of 07/20/2014

TYPE OF MEASUREMENT: 5 section and 3 section (two channels) slope area measurement.

LOCATION OF SITE: Lat 38°57'53", Long 119°42'13" referenced to North American Datum of 1927. Surveyed first cross-section of primary channel located approximately .3 miles upstream and surveyed first cross section of secondary channel located .25 miles upstream.

SURVEY OF SITE:

- HWM flagged by S.N. Berris, M.L. Gipson, and K.M. Schmidt on 07/22/2014.
- Site surveyed by K.M. Schmidt (Instrument, notes, rover) and D.M. Sawyers (rover); survey conducted 07/24/2014.
- Survey Datum: UTM 11 North (ft)
- Instrument: Topcon GR3 444-0858 (base) and Topcon GR3 (rover) 444-0856

DISCHARGE AND GAGE HEIGHT: 2800 CFS at 13.20 ft. Gage height d
near location of new csg. Mark surveyed during levels run on 07/30/2014.

DRAINAGE AREA: 73.8 mi²

UNIT DISCHARGE: 37.9 CFS/ mi²

NATURE OF FLOOD: Peak caused by monsoonal type storm. Approximat
rain fell within 2 hours in the region (Nevada Appeal article). Other gages i
rainfall amount at 1.1 inches (Knox RAWS and Marlette Lake SNOTEL).

FIELD CONDITIONS:

- Site Selection: Above and below the gage the channel conditions
to survey. Below the gage the channel is sinuous and had multiple
above the gage is expanding through much channel as it approache
a site upstream approximately upstream 0.3 miles was selected. Th
confluence of Buckeye creek and an unnamed drainage. There was
from this unnamed drainage that contributed to the total flow at the
channels were surveyed. It is assumed that both the primary an
peaked around the same time.

- Survey Conditions: A static survey was set up on a RP established on the day of the survey. The static was not set up on a RM due to all RM being located on wing-walls or not possessing a good point to set up the fixed 2.0 meter tripod on. The static survey was run for 6 hrs, 96% of the observations were used with 97% of ambiguities fixed. Overall RMS was 0.013 meters. For the RTK survey RM's and the CSG were staked out using 30 second observations and different antenna height (1.60m and 1.80m). Stakeout points varied from -.026 to .022 ft (horizontal Northing and Easting) and -.013 to .024 ft in vertical. For the channels surveyed 30 second observations were used for all high water marks and cross section points.
- Profiles: The primary channel was fairly straight with a minor bend towards the right. Marks were composed of debris lines and occasionally wash lines. Marks were mostly fair with a significant amount of marks being rated poor. Generally left bank marks were rated higher than right bank marks in the field. Left bank high water marks (HWM) were generally higher than right bank HWMs. This could be due to the slight curvature of the channel. Even though left bank marks were rated in the field better than the right marks, once the data was plotted the right bank marks plotted in smoother more consistent manner. This might be due to the left bank being steeper than the right and some of the marks slumping on the left. When individual sides are viewed on their own both display a definable water profile. HWMs for both the left and right appear good when viewed in the plan view plot. Since both sides looked good in plan view, had definable water surfaces, a consistent trend of higher water surface elevation on the left, and a bend in the channel; a slopped water surface elevation was used for the final computation.
  The secondary channels HWMs were not nearly defined as well as the primary channel. Marks were rated fair to poor and had a bit of scatter. An average water profile was formed by defining both left and right water profiles and averaging the two. There was not a great deal of difference between the left and right water profiles for the secondary channel. The reach is fairly short due to above the reach multiple drainages coming together and below the reach surveyed the channel becomes very sinuous.
- Cross Sections: For the primary channel bottom material was fairly smooth and was composed of a mixture of sand, fine gravel and silt. The main part of the channel was free of obstruction. The left bank was generally steep and had moderate to heavy sagebrush, though most of the flow would have been out of the brush on the left. It was generally much less steep and wider than the left bank. The right bank generally had large amounts of sage brush and grass interspersed.
  The secondary channel bottom material was fairly smooth and was composed of a mixture of sand, fine gravel and silt. The channel contained sage brush throughout the banks and main part of the channel.
- Roughness Values: Previous indirects and slope conveyances Manning's N values ranged from 0.02 to 0.0494

Table 1

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Buckeye Creek: Documentation and Quality Assurance

- <u>All indirect measurements are checked and reviewed</u>:
  - Measurement returned if mistakes found or needs additional work
  - Compliments and constructive criticism provided for continual improvement
  - Items to address are provided
  - Worker required to address comments

Review of 10309075 Buckeye Creek at E Valley Rd nr Gardnerville, NV
Flood of 7/20/2014

I have reviewed the indirect computation by the slope-area method at 10309075. My comments are included below. Good job to the worker and checker for their discussion on the correct water surface profile at this site. Indirects can sometimes be worked many different ways when a channel presents less than ideal circumstances.

This indirect is rated poor due to a +/- 20% variation in the final discharge as computed during the sensitivity analysis, a poorly-defined secondary channel, and some uncertainty as to the water surface profiles during the peak.

I liked your idea of varying the rod height on your stake outs for the closing shots on the RMs. It looks like your closure error was good for the survey. Nice job locating the cross sections at breaks in slope in the water surface profile. The baseline goes through the middle of the reach. The HWMs show the same trends even though they do not have the best agreement. Froude numbers appear to be reasonable. Overall you did a good job with a very interesting slope-area reach.

I agree with using the average of the right and left HWMs to compute this indirect. There was clearly some influence of the bend, and it makes more sense to account for that in the computation. Using just the right HWMs may make for a cleaner computation from a statistics standpoint, but it masks problems with the reach as a whole. Plus, the left bank was clearly higher than the right bank. It shows a pretty strong trend with the left marks being about a 0.5-1 ft higher than the right marks. If anything, I would have chosen a sloping water surface rather than the averaged water surface; however, the results of the sloping water surface are within the error bars of this computation.

We chatted briefly about doing a superelevation in bend computation to help verify the numbers. It'll be rough since the computation isn't great non-uniform channels, but it should increase your confidence in the slope-area. Once you finish it, please add the spreadsheet to Other Analysis folder and write it up briefly in the Analysis document. It will have a pretty large error potential since you only have a slight curve and the computation is very sensitive to all of the geometry you measure, but it is better than nothing. **I ended up not including this computation since I could not get it to compute a Q (K was negative and K has to be positive to compute a Q). This is most likely due to non-uniform channel conditions. Terry Kenney had previously discouraged me from using super elevation computations on natural channels.**

Since this indirect is rated poor and the results will be within 10% either way you do it, I will leave the decision for averaged water surface or sloping water surface to you.

Please address the following comments and/or add to the Analysis as needed:

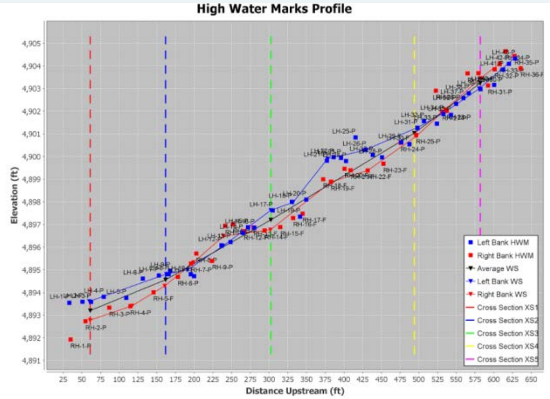
1) Where is the original data as it was pulled from the GPS? It's usually just an Excel spreadsheet. It is good to see that in addition to your SAC input files. You also don't have to remove RMs from the SAC input file unless they're very far from the surveyed reach and are altering the

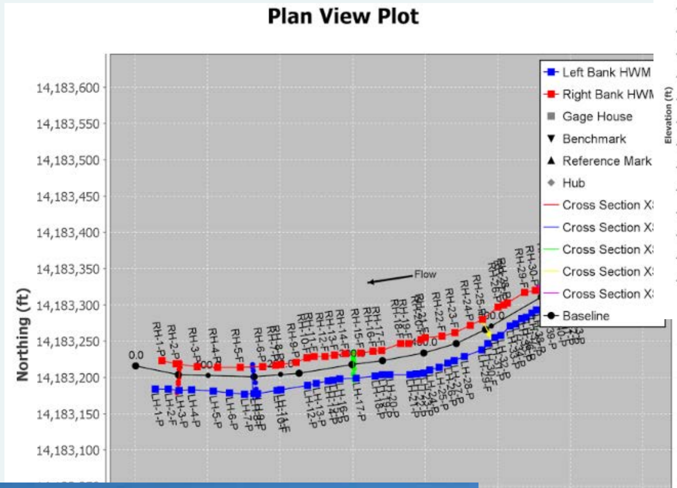
Johnson Wash: Short Video Clip

Johnson Wash Plan View

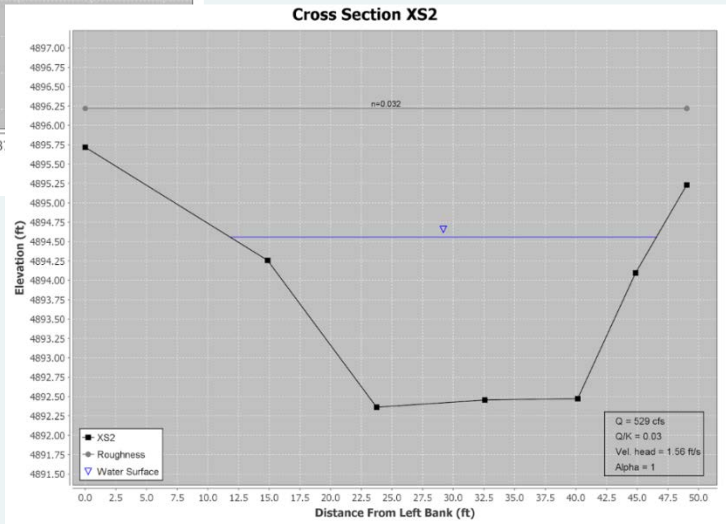
Johnson Wash: Plan View, High-Water Marks, Slope, Channel Geometry and Roughness

- Similar to Buckeye Ck
  - Plan view, high-water mark , and cross section plots






Looking upstream towards XS5, viewed from in-between XS4 and XS5.



CONCEPTS OF FREQUENCY ANALYSIS

Introduction

Frequency analysis is a statistical procedure by which the needed streamflows can be estimated.

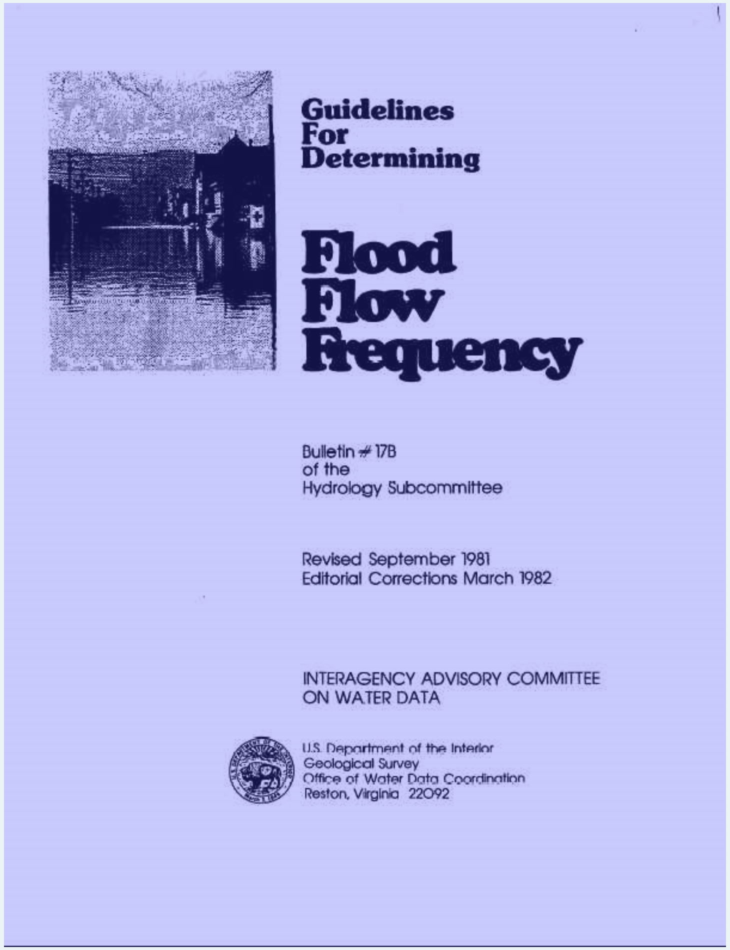
Estimates of the magnitude and frequency of hydrologic extremes, such as floods and droughts, are needed to:

- Define flood hazard areas
- Design flood-control structures such as dams and levees
- Design bridges and culverts
- Design water treatment facilities and water-supply reservoirs

The types of streamflow data typically used for frequency analysis include annual maximum instantaneous peak discharge and annual n-day low flows.

Annual data are used in the frequency analysis to ensure that the data are random and independent, an essential assumption of frequency analysis.

Flood Frequency Analyses Based on Long-Established Interagency Approach



B17B Statistical Approach:

- Log-Pearson Type 3 Distribution
- Fit by Method of Moments
- Weighted Skew
- Cookbook procedures
    - Weighted moments (Historical information)
    - Conditional Probability Adjustment (Low outliers, zero flows)

Bulletin 17B Approach Recently Updated:
Expected Moments Algorithm (EMA)

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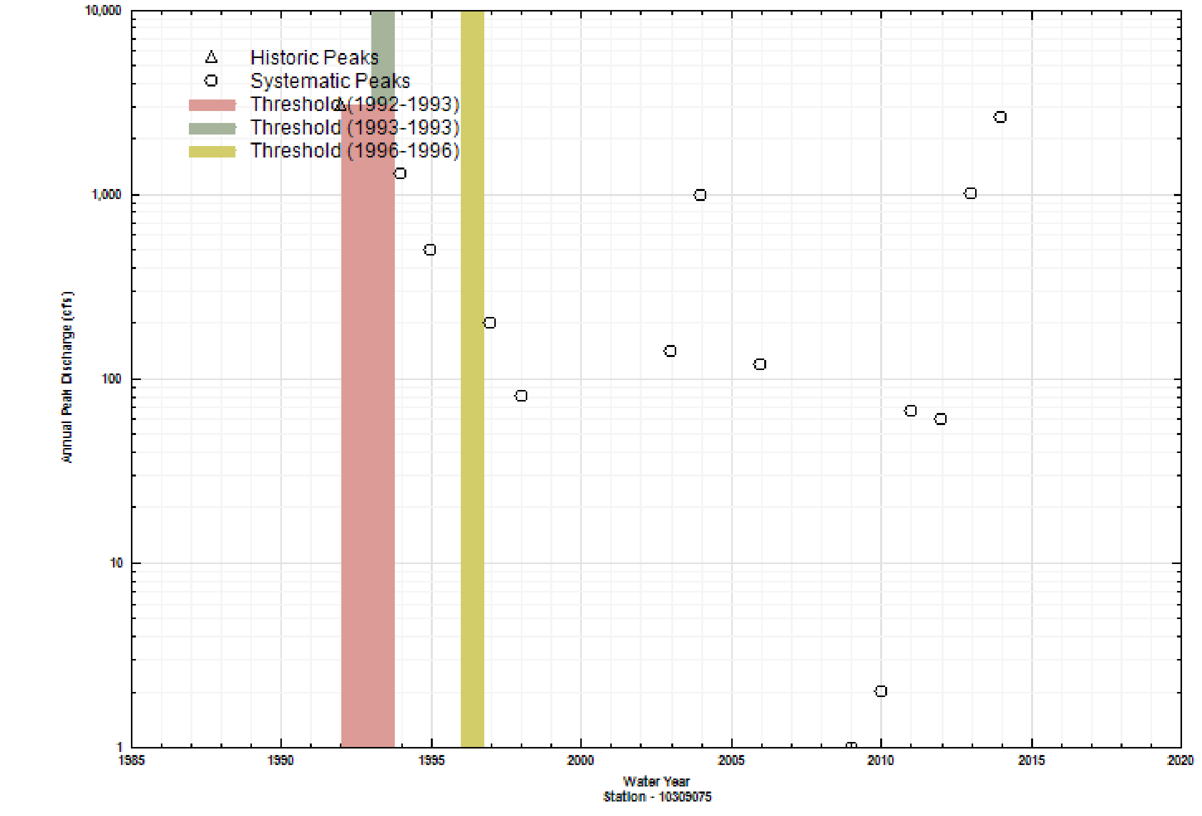
Annual Peak Input to PeakFQ

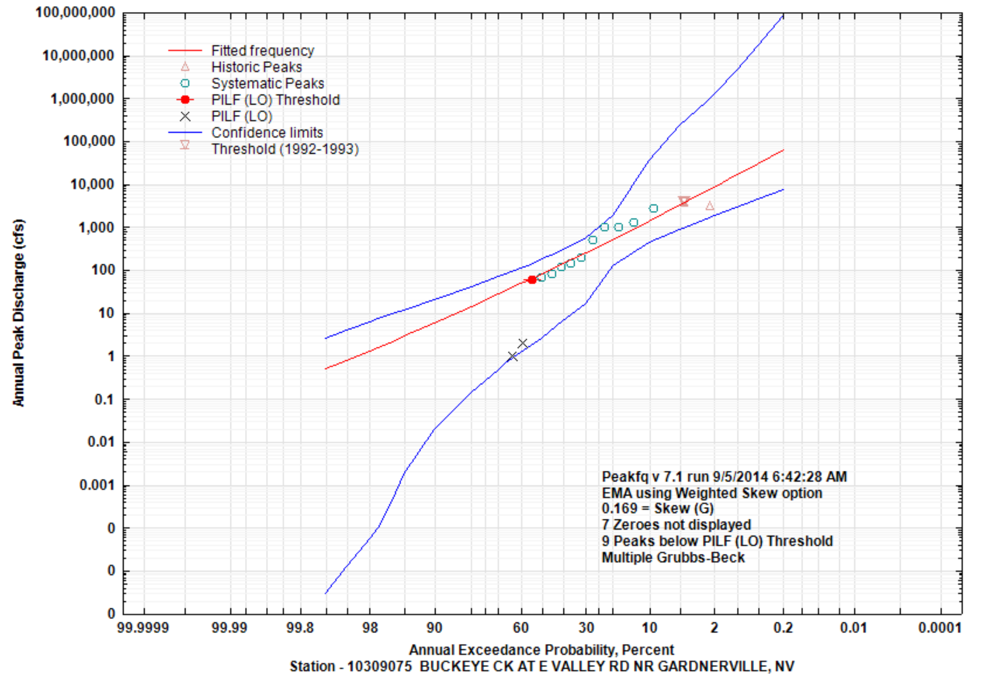
Buckeye Creek

WATER YEAR	PEAK VALUE	
-1992	3000.0	H
1994	1300.0	
1995	500.0	
1997	200.0	
1998	80.0	
1999	0.0	
2000	0.0	
2001	0.0	
2002	0.0	
2003	140.0	
2004	990.0	
2005	0.0	
2006	120.0	
2007	0.0	
2008	0.0	
2009	1.0	
2010	2.0	
2011	67.0	
2012	60.0	
2013	1000.0	
2014	2800.0	



PeakFQ Output: Buckeye Creek

Discharge: 2,800 cfs
Annual Exceedence Probability: 0.0907
Recurrence Interval: 11 years



Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001
Version 7.1 Annual peak flow frequency analysis Run Dat
3/14/2014 08/28/2

Station - 10309075 BUCKEYE CK AT E VALLEY RD NR GARDNERVILLE, I

EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	EMA ESTIMATE	INTERVALS LOW	HIGH
-1992	3000.0	0.0227		
2014	2800.0	0.0907		
1994	1300.0	0.1362		
2013	1000.0	0.1817		
2004	990.0	0.2271		
1995	500.0	0.2726		
1997	200.0	0.3181		
2003	140.0	0.3636		
2006	120.0	0.4090		
1998	80.0	0.4545		
2011	67.0	0.5000		
2012	60.0	0.5455		
* 2010	2.0	0.5909		
* 2009	1.0	0.6364		

* DENOTES PILF (LO)

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	EMA W/ REG INFO ESTIMATE	EMA W/O REG INFO ESTIMATE	<------ FOR EMA ESTIMATES -------> VARIANCE OF EST.	95% CONFIDENCE INTERVALS LOWER	UPPER
0.5000	81.4	81.4	0.0897	2.5	179.3
0.4292	119.4	119.0	0.0720	5.0	251.9
0.2000	512.7	508.0	0.0518	127.0	1886.0
0.1000	1389.	1381.	0.0796	450.1	34960.0
0.0400	4125.	4150.	0.1495	1047.0	366500.0
0.0200	8456.	8604.	0.2197	1832.0	1265000.0
0.0100	16290.	16780.	0.3017	2940.0	4616000.0
0.0050	29930.	31260.	0.3944	4476.0	16720000.0
0.0020	63200.	67320.	0.5317	7382.0	88130000.0

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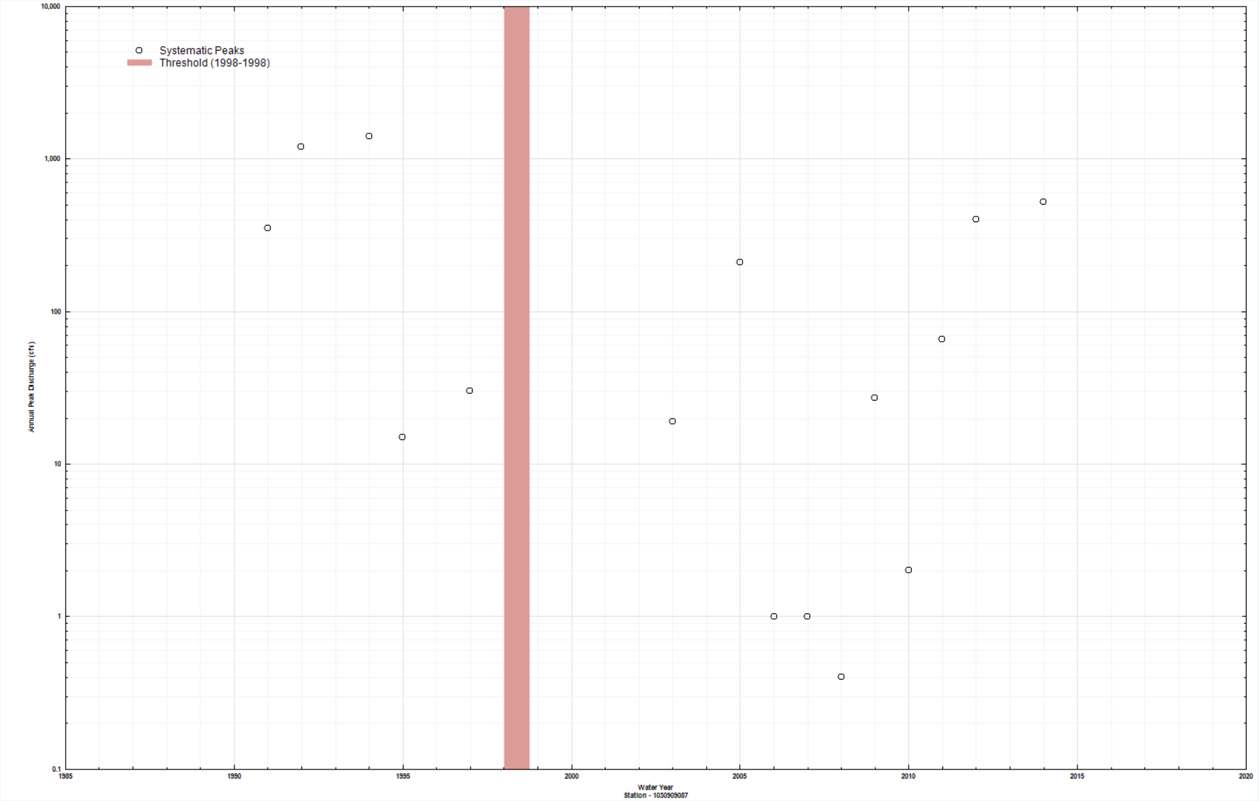
Annual Peak Input to PeakFQ

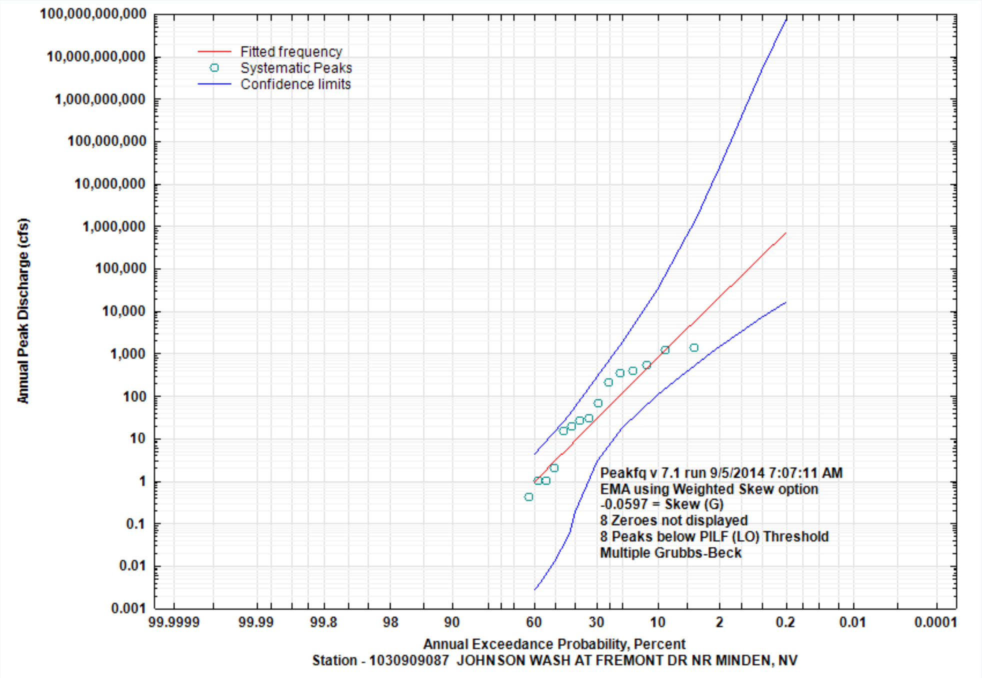
Johnson Wash

WATER YEAR	PEAK VALUE
1991	350.0
1992	1200.0
1993	0.0
1994	1400.0
1995	15.0
1996	0.0
1997	30.0
1999	0.0
2000	0.0
2001	0.0
2002	0.0
2003	19.0
2004	0.0
2005	210.0
2006	1.0
2007	1.0
2008	0.4
2009	27.0
2010	2.0
2011	66.0
2012	400.0
2013	0.0
2014	520.0



PeakFQ Output: Johnson Wash

Discharge: 520 cfs
Annual Exceedence Probability: 0.1249
Recurrence Interval: 8 years



Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.00
Version 7.1 Annual peak flow frequency analysis Run Date /
3/14/2014 09/05/2014

Station - 1030909087 JOHNSON WASH AT FREMONT DR NR MINDEN, NV

EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	EMA ESTIMATE	INTERVALS LOW	HIGH
1994	1400.0	0.0415		
1992	1200.0	0.0832		
2014	520.0	0.1249		
2012	400.0	0.1665		
1991	350.0	0.2082		
2005	210.0	0.2499		
2011	66.0	0.2916		
1997	30.0	0.3333		
2009	27.0	0.3750		
2003	19.0	0.4166		
1995	15.0	0.4583		
2010	2.0	0.5000		
2006	1.0	0.5834		
2007	1.0	0.5417		
2008	0.4	0.6250		

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	EMA W/ REG INFO ESTIMATE	EMA W/O REG INFO ESTIMATE	<------ FOR EMA ESTIMATES -------> VARIANCE OF EST.	95% CONFIDENCE INTERVALS LOWER	UPPER
0.5000	2.9	3.2	0.2100	0.0	14.2
0.4292	6.4	7.1	0.1868	0.1	36.7
0.2000	116.4	126.1	0.2117	18.1	1816.0
0.1000	784.2	753.7	0.3192	104.3	31580.0
0.0400	5884.	4589.	0.5235	530.8	1383000.0
0.0200	21420.	13970.	0.7161	1424.0	23950000.0
0.0100	67980.	36700.	0.9398	3315.0	384700000.0
0.0050	194600.	86290.	1.1950	6915.0	4553000000.0
0.0020	690900.	234500.	1.5800	16040.0	70260000000.0

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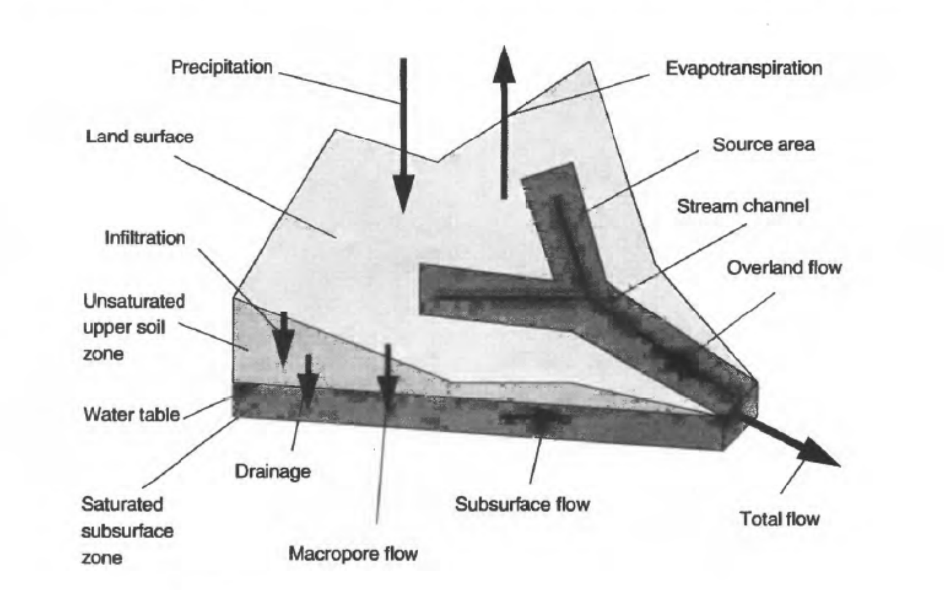
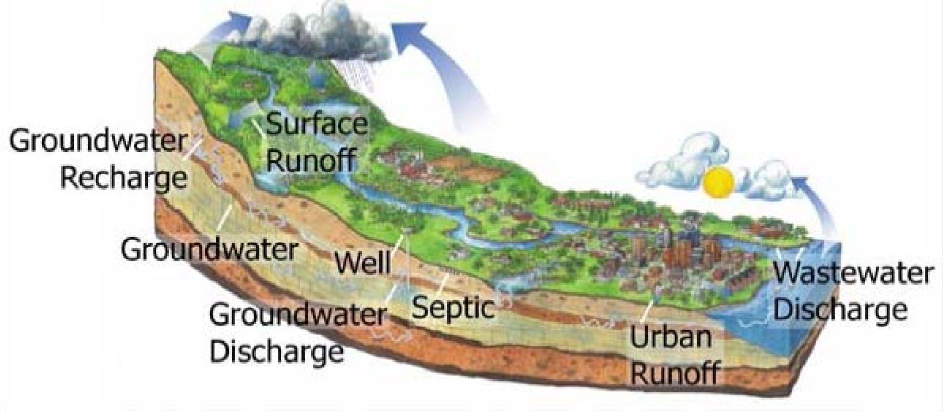
Only a 10-percent (10-year) flow event for a 1-percent (100-year) precipitation event?

Frequency of Precipitation event does not directly translate to flood frequency.

Total precipitation is significant input to generate flows, but not only factor:

- Variability and intensity of precipitation over basin
- Shape of basin and its relation to storm path
- Basin infiltration, recharge
- Basin storage
- Channel geometry and bed characteristics, and bed storage
- Antecedent conditions i.e. soil moisture, water level of saturated zone





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Flood Frequency Analyses based on Statistical Procedures

- Documented annual peaks represent the dataset
- Dataset is unbiased and represents entire population
- Dataset is only a sample of the entire population.
- Assumes the past will represent the future
- Missing annual peaks
- Measurement errors
- Output (answers) are estimates with confidence intervals
- Short period of data record

"Flood-frequency analysis for single stations is subject to large errors because of the brevity of most records, the inherent variability of floods, and the difficulty of fitting theoretical frequency distributions to the sample record." – Thomas Dunne and Luna Leopold, 1978

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Crest-Stage Gage Program: Collection of Actual Discrete Water Level Data

-Longer periods of record result in increasing certainties with flood frequency analyses
- Shorter periods of record result in larger uncertainties
- No periods of record result in guessing

Cooperative Program between NDOT and USGS funds 25 crest-stage gages throughout Nevada. Period of record getting longer at both Carson Valley gages. Included are:

- Johnson Wash: 22 annual peaks; 1998 to current year
-Buckeye Creek: 20 annual peaks; 1992, 1994-1995, 1997, Aug 1998 to current year

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Crest-Stage Gage Program: Collect the Data, Characterize the Flood Hazards

Crest-Stage Gage Program

- 6-week visits
  - O&M
  - Make flow measurements
  - If significant peak recorded at CSG, flag HWM's and compute indirect measurements
  - Run levels every year for five years. If stable, run levels every three years
- If significant flow, visit as conditions warrant
  - Best to flag high-water marks as soon as possible after high-water events
  - Make indirect measurements

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Crest-Stage Gage Program: Collect the Data, Characterize the Flood Hazards

- Records published in Site Data Sheets (previously called Annual Data Report)
- Manuscript includes information on location, period of record, and extremes
- Collected data quality assured and published in peak discharge and discrete measurement tables
- **Actual data** used to characterize flood hazard and can be used for calibration/ verification of hydrologic models.

Water-Data Report 2013

1030909087 Johnson Wash At Fremont Dr Near Minden, NV

Carson Basin
Upper Carson Subbasin

LOCATION.--Lat 39°01'31", long 119°42'31" referenced to North American Datum of 1927, in NE ¼ NW ¼ sec.2, T.13 N., R.20 E., Douglas County, NV, Hydrologic Unit 16050201, at bridge on Fremont Drive, 6 mi northeast of Minden, Nevada

DRAINAGE AREA.--10.4 mi².

SURFACE-WATER RECORDS

PERIOD OF RECORD.--Jul. 1998 to current year.

GAGE.--Crest-stage gage.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 1,400 ft³/s, Jul. 22, 1994, gage height, unknown.

MAXIMUM PEAK DISCHARGE
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013

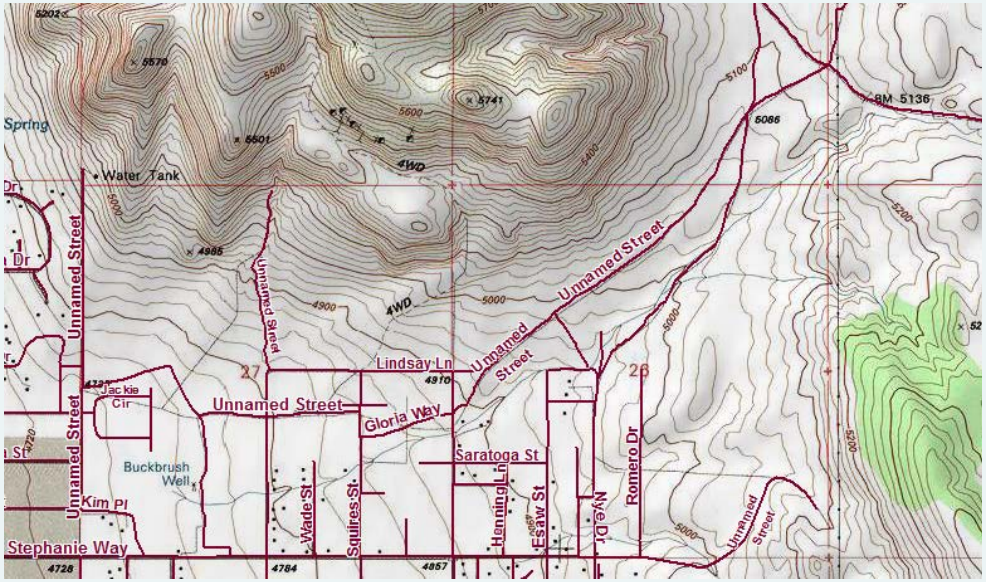
Date	Discharge, in ft³/s	Discharge qualification code	Gage height, in ft	Gage height qualification code
2013	0.0	---	---	---

DISCHARGE MEASUREMENTS
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013

Date	Discharge, in ft³/s	Gage height, in ft
Oct 16, 2012	0.0	---
Nov 29, 2012	0.0	---
Dec 4, 2012	0.0	---
Jan 8, 2013	0.0	---
Feb 21, 2013	0.0	---
Mar 26, 2013	0.0	---
May 14, 2013	0.0	---
Jun 25, 2013	0.0	---
Aug 7, 2013	0.0	---
Sep 17, 2013	0.0	---

Potential Crest-Stage Gage Sites to Collect Data for Characterization of Carson Valley Flood Hazards

- Buckbrush Wash
- Sunrise Pass Wash
- Annual Costs for CSG with USGS Cooperative Water Program Funds:
  - $6,000 partner
  - $6,000 USGS



Questions, Comments, Discussion

USGS Nevada Water Science Center

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NWISWeb – How can I see the data?

- Retrieval Options include
  - Graphs
    - Real-time stream flow, water levels, and water quality
  - Tables
    - HTML and ASCII tab-delimited files
  - Automated retrievals
    - http://waterdata.usgs.gov/nwis/?automated_retrieval_info

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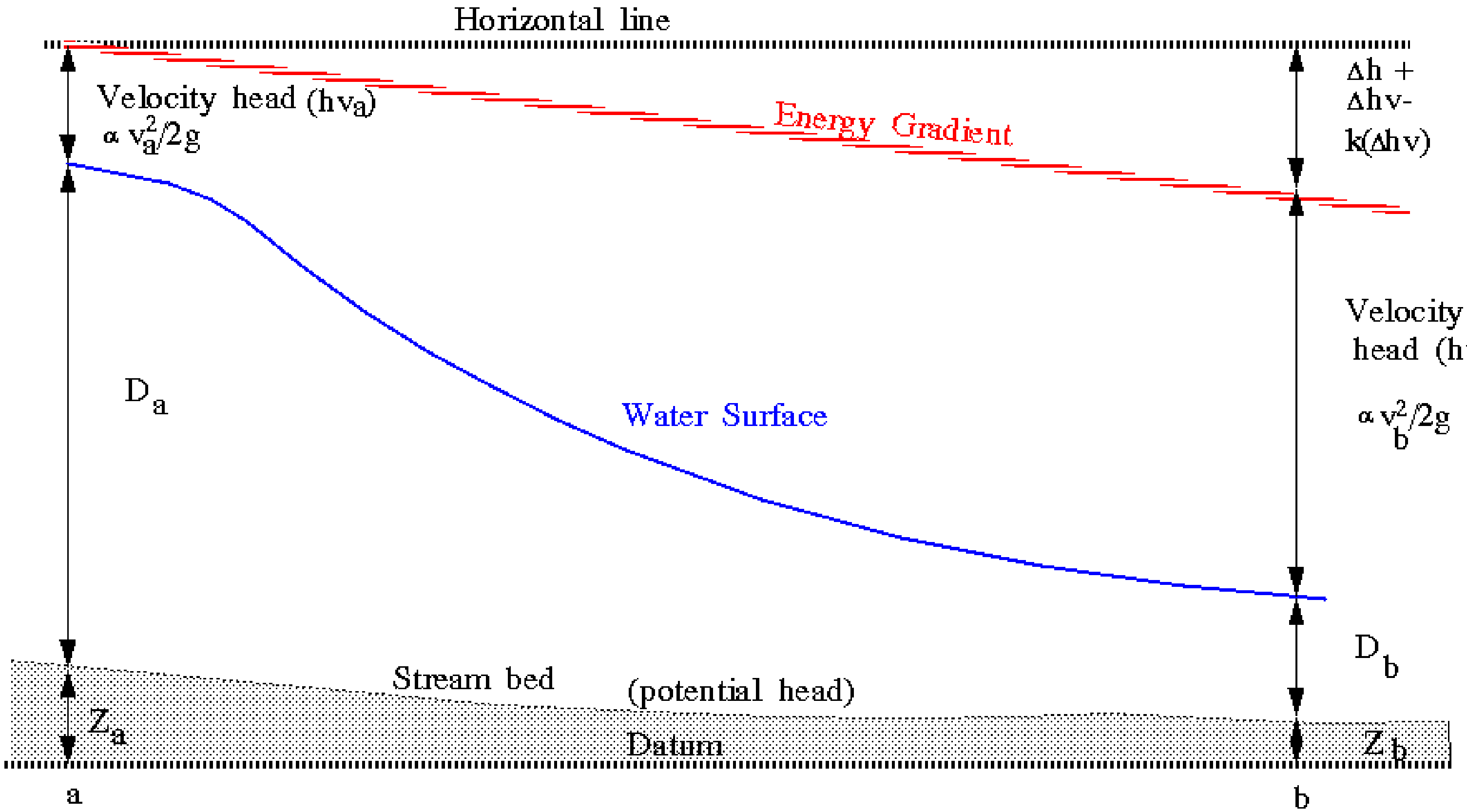
Energy Equation- Real fluids

Shows energy losses due to friction and entrance losses due to expansion and contraction

$$\text{Energy slope} = \frac{\Delta h + \Delta hv - k(\Delta hv)}{L}$$



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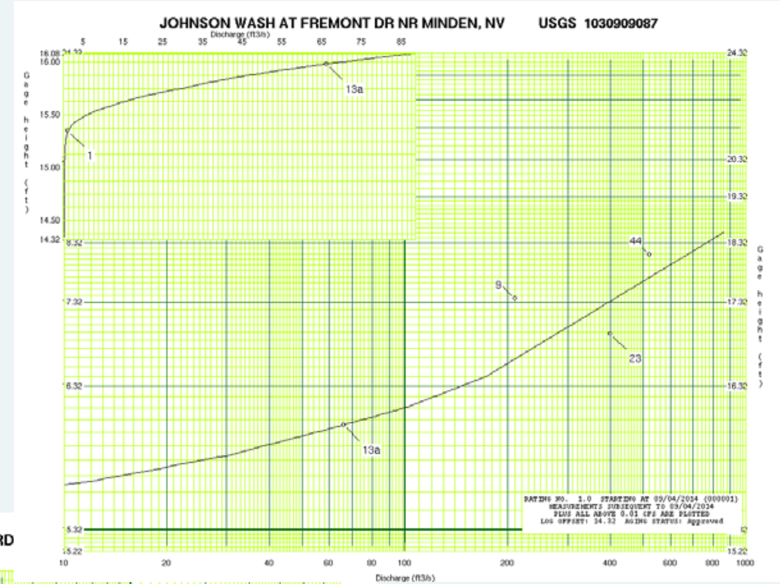
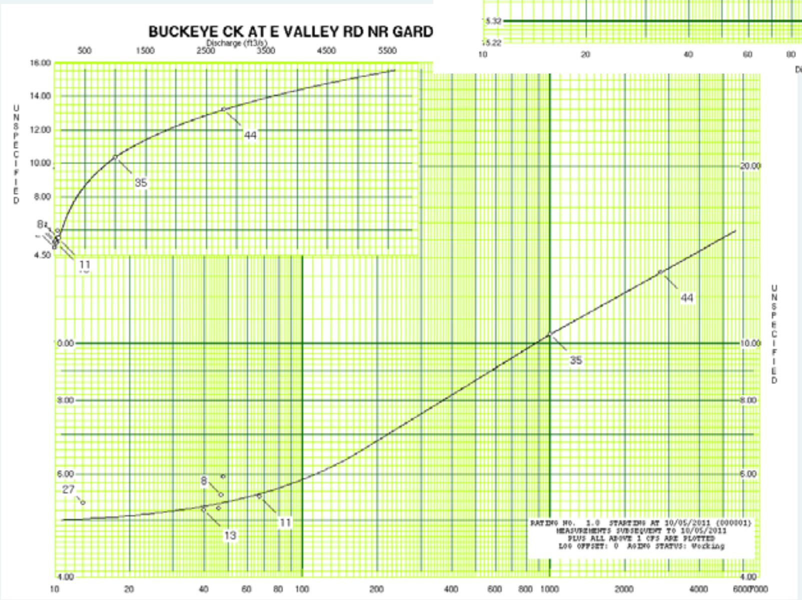
Rating Curves provide Stage-Discharge Relations

- Reliable with stable channel
- Measurements required for evaluation and verification
- Measurements required for unstable channels





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BASIC Assumptions of Frequency Analysis

- Observations of past events are indicative of future possibilities
- Questions that can be answered by knowledge of fraction of events greater than any specified magnitude
- Prediction of magnitude or timing of <u>specific</u> events is not a goal
- Corollary -- Time-order of data is not relevant –
  - trends - cycles - clusters
- Cause or source of event is not important
  - rainfall vs snowmelt vs hurricane etc.
- User/analyst is responsible for verifying whether these assumptions are appropriate in any particular application

More Assumptions of Frequency Analysis

- Hydrologic events can't be forecasted as to magnitude and time of occurrence on time scales relevant to engineering/economic planning and design.
- Planning & design must be based on estimates of magnitude and likelihood or frequency of occurrence of critical events.
- There is a "**population**" of potential events.
- All that is available to us is **samples** from the population. We infer magnitudes and frequencies of events from the sample.
- Assume that the samples are "**representative**"
- Different samples will yield different estimates -- "**random**"

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Bulletin 17B Procedures Recently Updated

Why EMA Is More Efficient than B17B Historic Data Procedure:

- Observed magnitudes are treated **identically** by B17B and EMA
- Both B17B and EMA define moments for below-threshold observations
- B17B employs only the below-threshold systematic data to estimate moments of below-threshold data
- EMA exploits all of the data available to estimate moments of below-threshold data

=> EMA takes advantage of information at hand

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