

“In Search of CFS’ers”

Or

“How in Heck does the USGS Measure Streamflow”

Presented to

Canadian Basin Advisory Committee

by

Mick Baldys

U.S. Geological Survey
North Texas Program Office

March 19, 2013

Field to the Office

How do you go from this: 



To this:

Station Number	Station name	Date/Time	Gage height, feet	Dis-charge, ft ³ /s
● Arkansas River Basin				
07227420	Cramer Ck at US Hwy 54 nr Dalhart, TX	03/07 10:30 CST	2.90	0.00
07227500	Canadian Rv nr Amarillo, TX	03/07 10:15 CST	1.53	12
07227890	Big Blue Ck nr Fritch, TX	03/07 10:15 CST	6.77	1.4
07227900	Lk Meredith nr Sanford, TX	03/07 10:30 CST	--	--
07233500	Palo Duro Ck nr Spearman, TX	03/07 10:30 CST	2.37	0.00
07233550	Palo Duro Res nr Spearman, TX	03/07 10:45 CST	--	--
07235000	Wolf Ck at Lipscomb, TX	03/07 09:45 CST	4.01	0.82

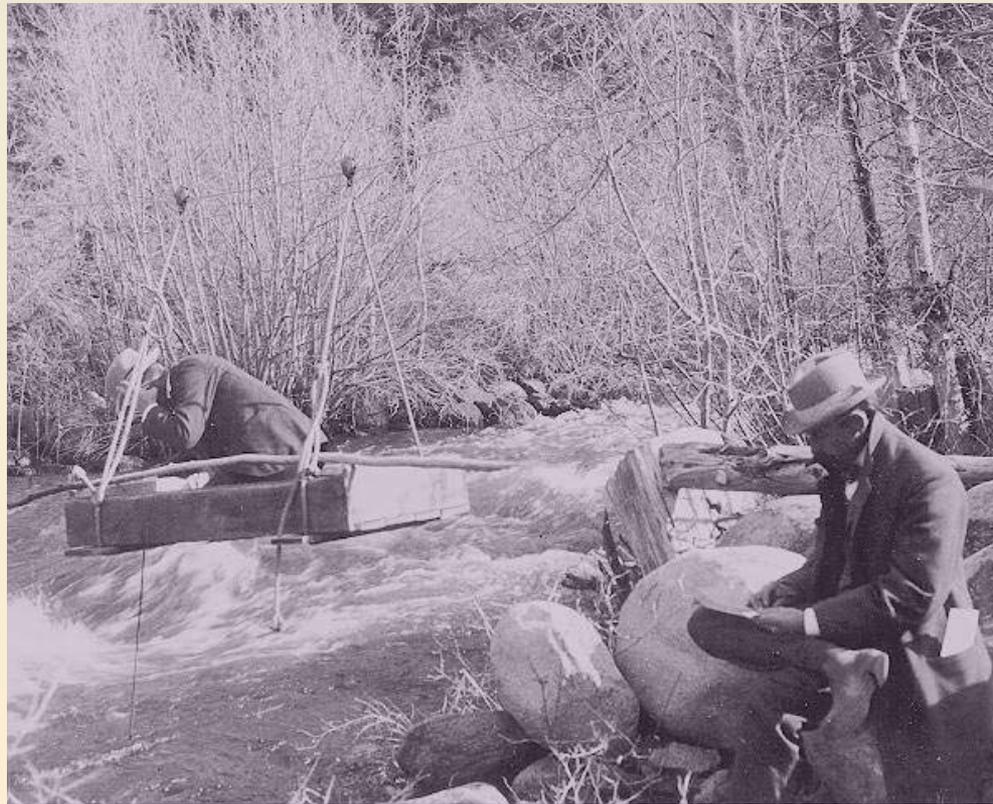
Presentation Objectives

- Relate USGS units to water provider units
- Describe how the USGS measures streamflow in the field
- Show the calculation methods used
- Describe how the data is presented and how the data can be obtained/used

What is a cfs???

- cfs stands for cubic feet per second (ft^3/s)
- 1 cfs contains 7.48 gallons
- 1 cfs for one day = 1.98347 ac-ft
- 1 cfs for one day = 646,317 gallons
- 1 cfs/day = 0.6463 million gallons per day (mgd)
- 1 mgd = 1.55 cfs/d

Streamgaging in 1901



More recent times



Typical USGS gaging station



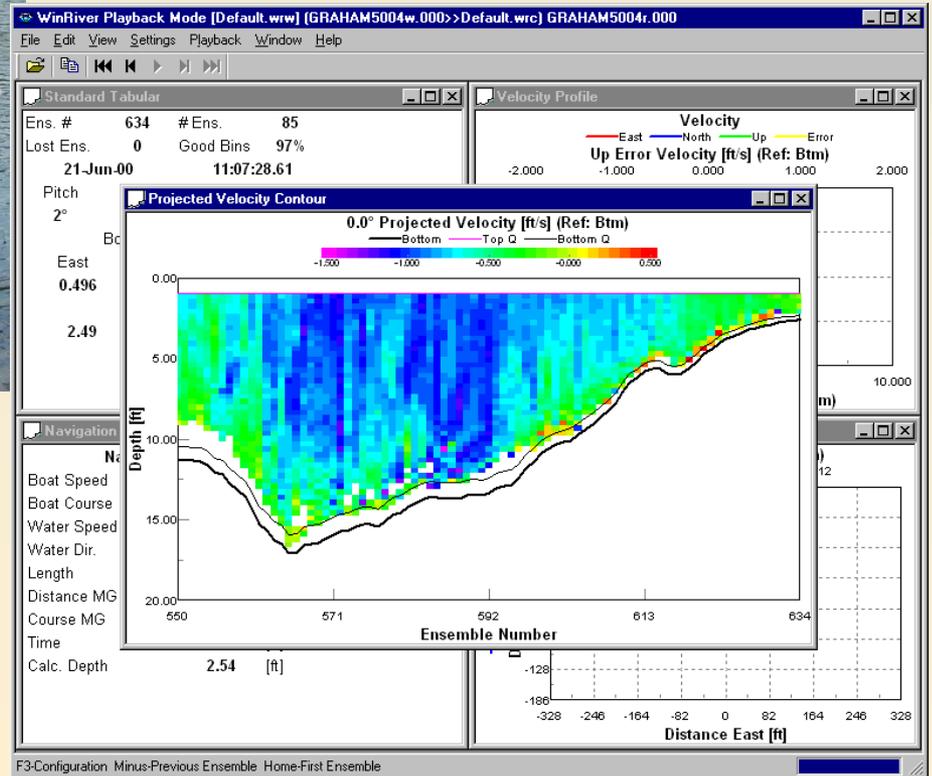
- Senses water level
- Records data 15 min.
- Transmits hourly
- Adjusted automatically
- Available on internet

Discharge monitoring

Conventional River Discharge Measurements



Acoustic Doppler Current Profiler



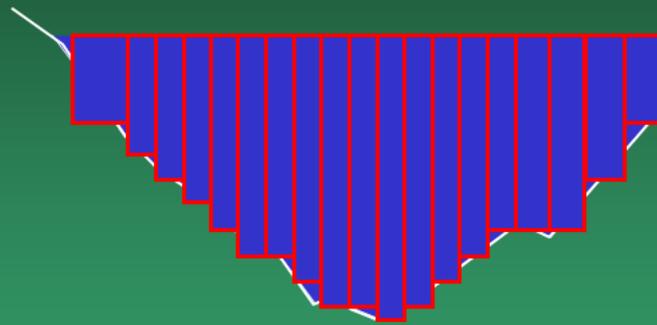
Computation method

THE VELOCITY-AREA METHOD

Discharge = (Area of water in cross section) x (Water velocity)



Channel cross section is divided into numerous sub sections



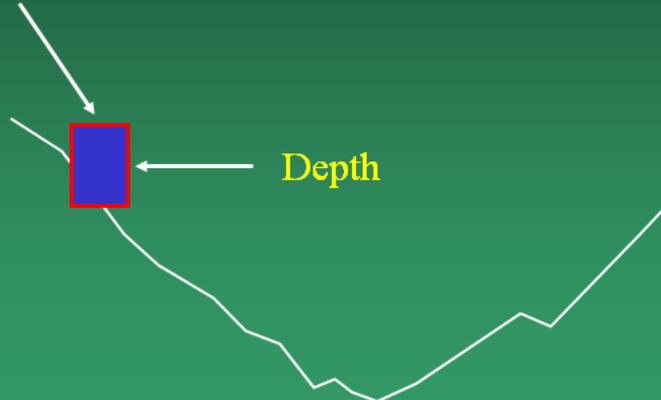
Discharge of each sub-section = Area x Average Water Velocity

Area of each sub-section determined by directly measuring width and depth

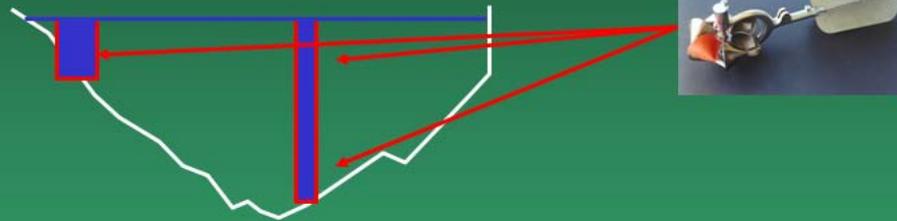
Width

Area = Width x Depth

Depth

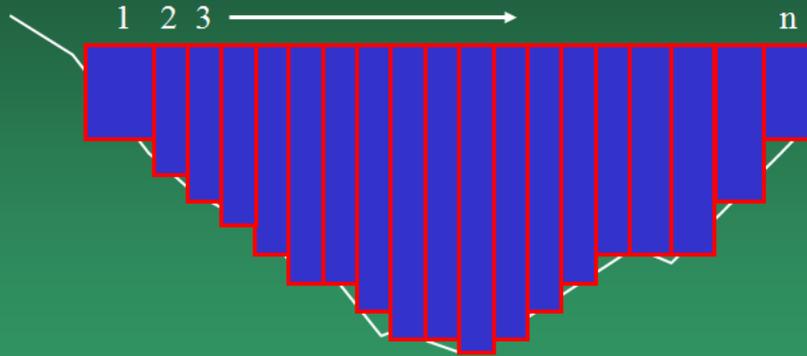


Water velocity in each sub-section is estimated using a current meter to measure water velocity at selected locations



Stream discharge is sum of discharges in all sub-sections

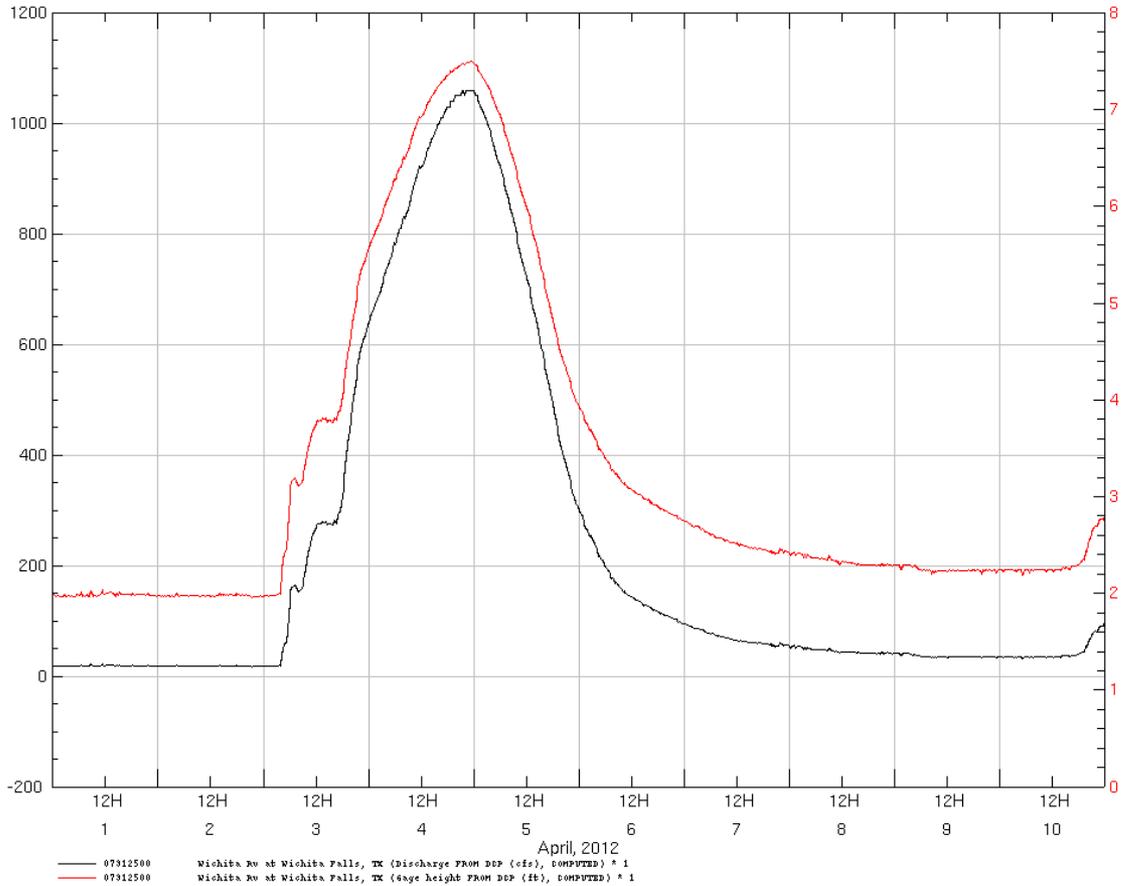
$$\text{Total Discharge} = ((\text{Area}_1 \times \text{Velocity}_1) + (\text{Area}_2 \times \text{Velocity}_2) + \dots (\text{Area}_n \times \text{Velocity}_n))$$



What is gage height?

- Gage height is the water-surface elevation, in feet above the gage datum (vertical datum)
- Datum is referenced to North American Vertical datum of 1988 (preferred) or National Geodetic Datum of 1929





- Gage datum at site is 924.26 above NGVD 1929

Streamflow data is available on the web!

USGS Current Conditions for selected River Basins in Texas - Windows Internet Explorer

http://waterdata.usgs.gov/tx/nwis/current?type=flow_res&site_no_list=&office_wch.rdb&group_key=basin_cd

USGS Home
Contact USGS
Search USGS

National Water Information System: Web Interface

USGS Water Resources (District Access) Data Category: Current Conditions Geographic Area: Texas GO

Combined Texas Streamflow and Lakes Table -- 42 site(s) found
[PROVISIONAL DATA SUBJECT TO REVISION](#)

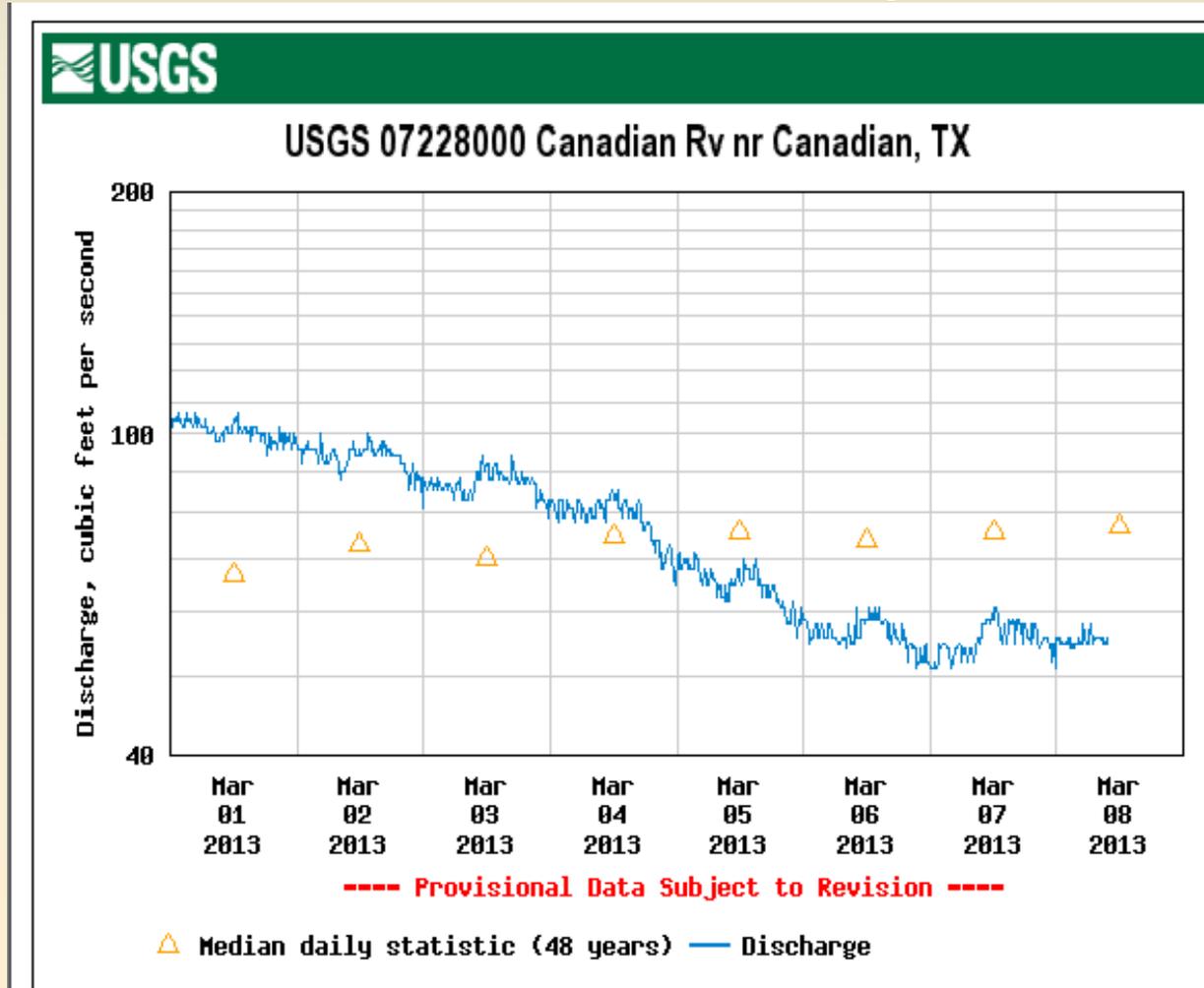
--- Predefined displays ---
 TX Streamflow / Lake Table Group table by: Major River Basin Select sites by number or name: [] go show sites on a map

[Customize table to display other current-condition parameters](#)

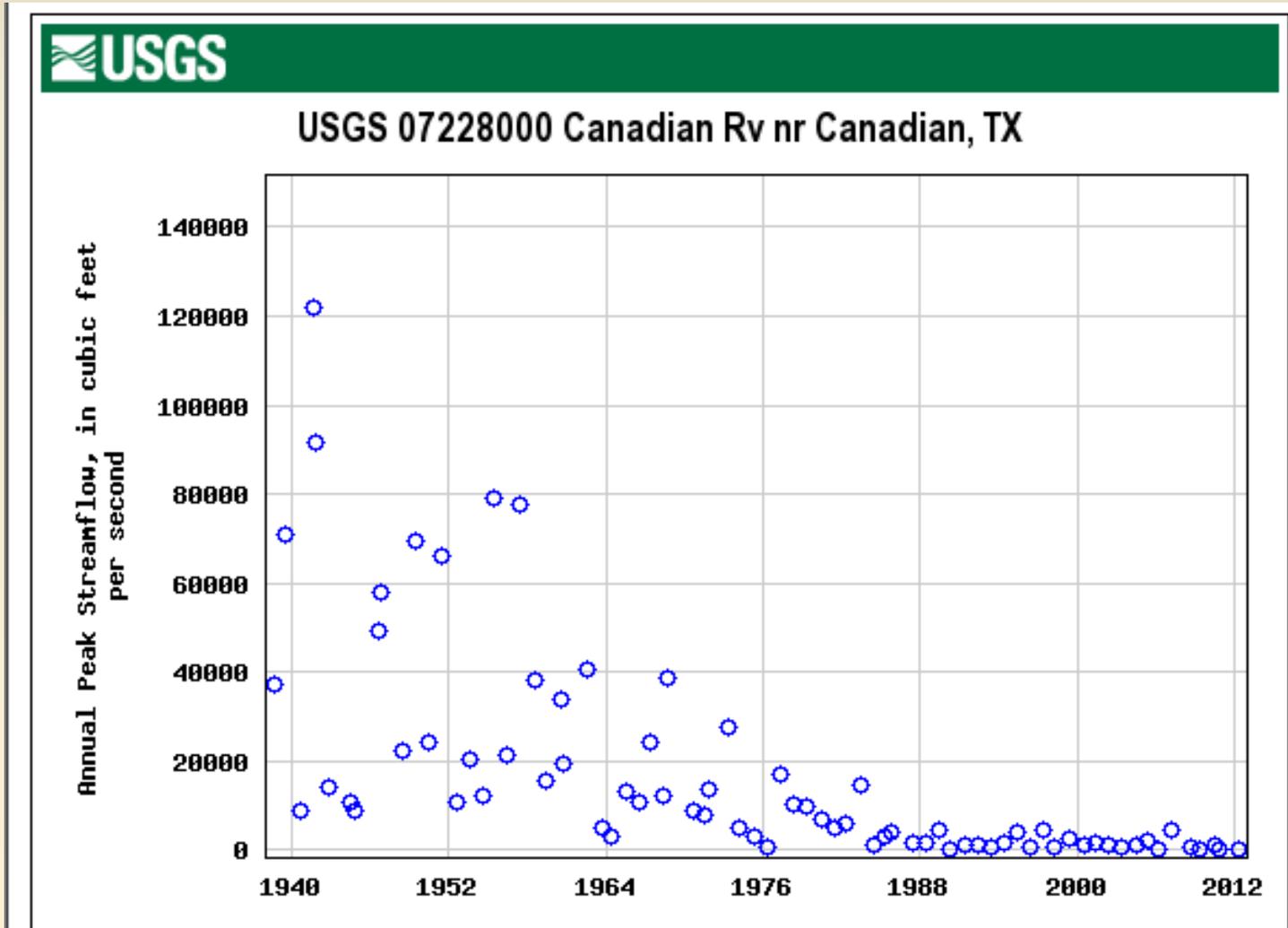
Station Number	Station name	Date/Time	Gage height, feet	Dis-charge, ft ³ /s	Reser-voir elevation above datum, feet	Elev-ation, Reser-voir above storage NGVD	acre-ft
● Arkansas River Basin							
07228000	Canadian Rv nr Canadian, TX	03/08 09:45 CST	2.25	55	--	--	--
● Red River Basin							
07299540	Pr Dog Twn Fk Red Rv nr Childress, TX	03/08 09:45 CST	7.41	0.85	--	--	--
07299670	Groesbeck Ck at SH 6 nr Quanah, TX	03/08 10:00 CST	7.08	8.5	--	--	--
07300000	Salt Fk Red Rv nr Wellington, TX	03/08 09:45 CST	3.23	24	--	--	--
07301300	N Fk Red Rv nr Shamrock, TX	03/08 09:45 CST	0.85	39	--	--	--
07301410	Sweetwater Ck nr Kelton, TX	03/08 09:45 CST	6.50	7.3	--	--	--
07308200	Pease Rv nr Vernon, TX	03/08 10:00 CST	5.24	2.5	--	--	--
07308500	Red Rv nr Burkburnett, TX	03/08 09:30 CST	3.05	82	--	--	--
07311600	2~N Wichita Rv nr Paducah, TX	03/08 09:45 CST	3.01	0.02	--	--	--
07311630	2~Middle Wichita Rv nr Guthrie, TX	03/08 09:45 CST	7.06	3.0	--	--	--
07311700	N Wichita Rv nr Truscott, TX	03/08 09:45 CST	6.14	8.5	--	--	--

Local intranet 100%

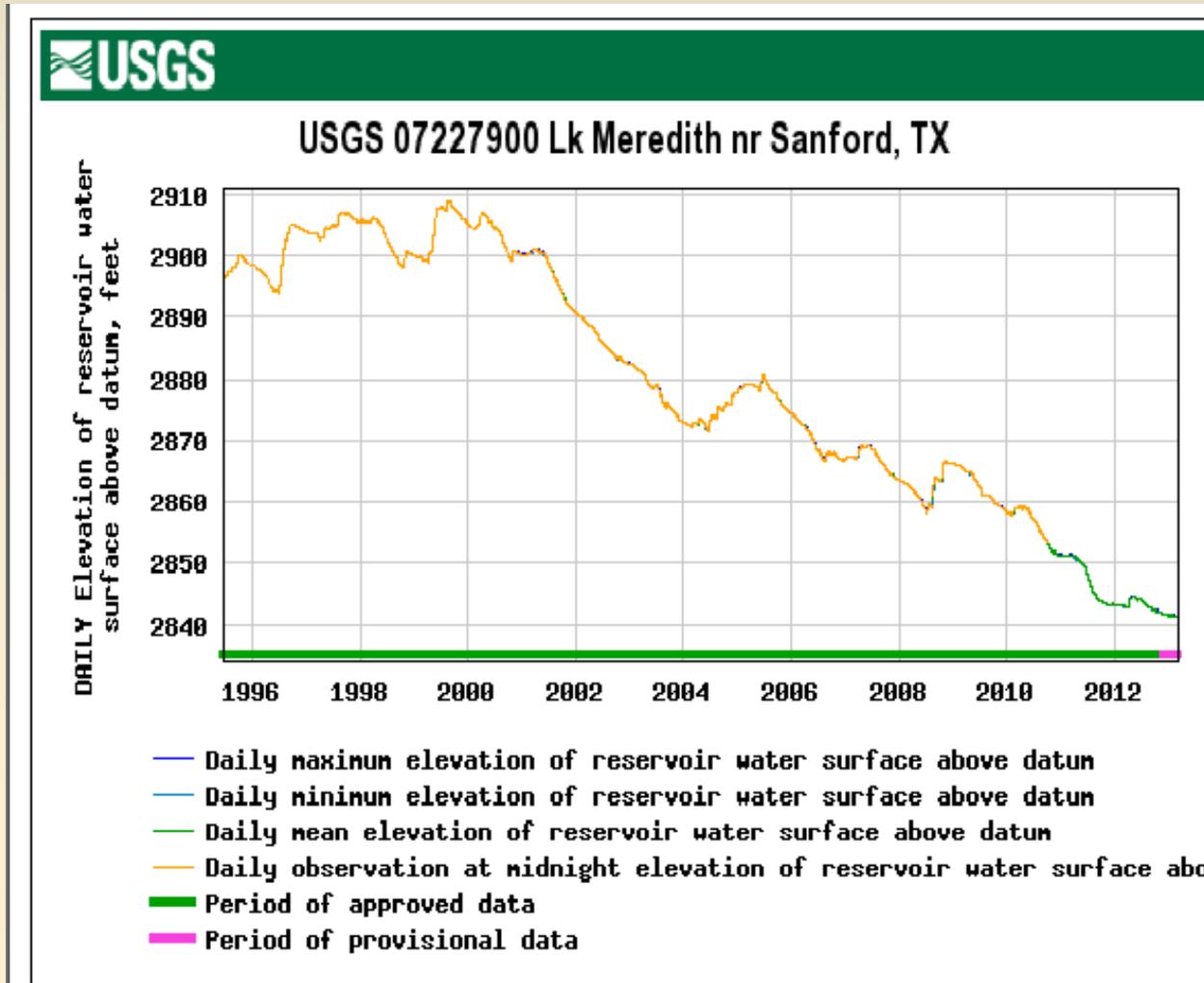
Instantaneous Discharge (and gage height) data are available for 120 days



Long term peak-flow data are also available



Historical data for reservoirs



Uses for streamflow data

- Flood studies
- Availability
- Quality
- Future planning
- Recreation
- Many other uses

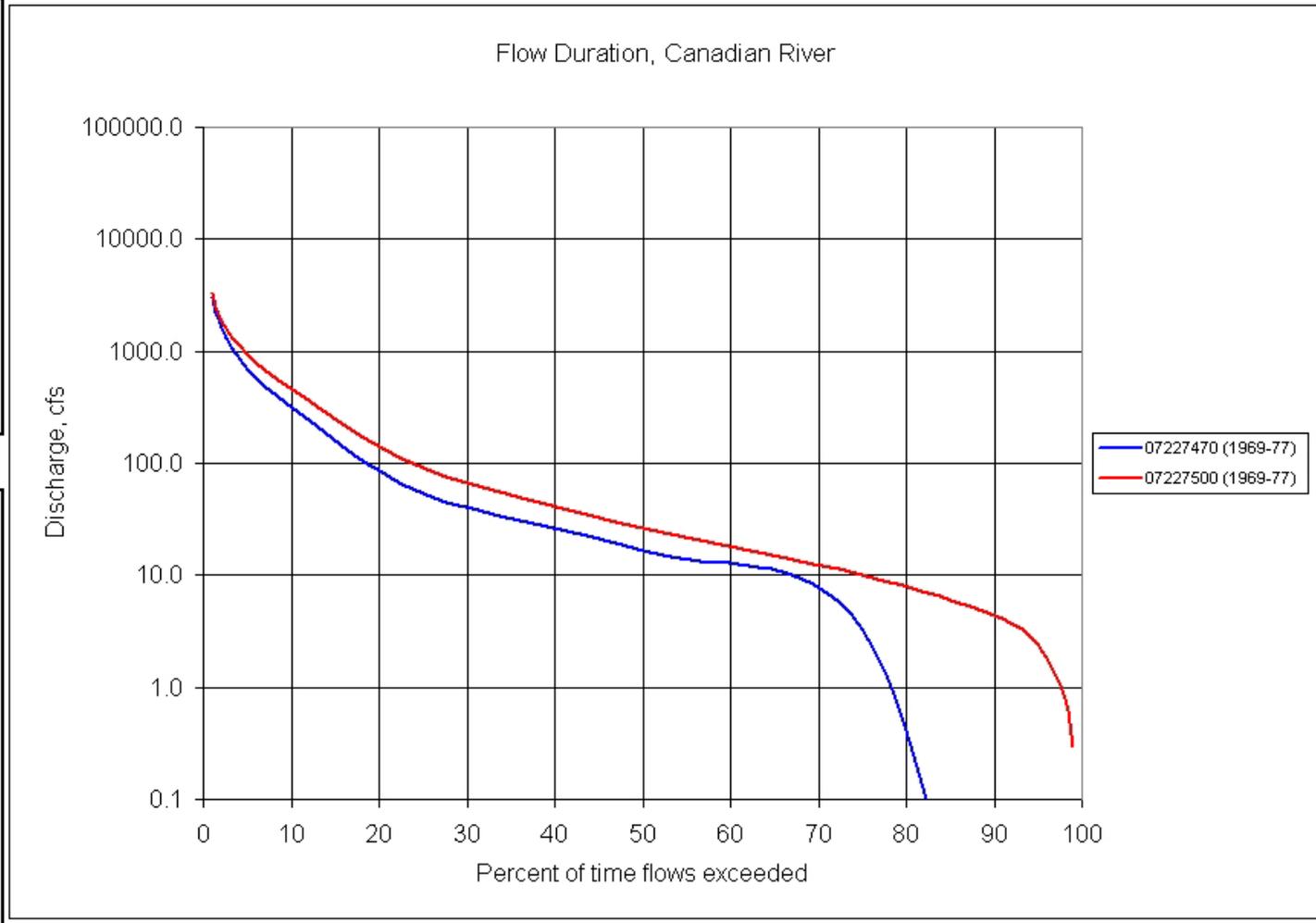
Flow Duration Curves for Canadian R. at Tascosa and nr Amarillo (Hwy 287)

07227470 Canadian River at Tascosa, TX

	Percent of time flows exceeded	Discharge (cfs)
(1969-77)	99	0.0
	98	0.0
	95	0.0
	90	0.0
	75	3.3
	50	16.4
	25	54.4
	10	313.8
	5	686.6
	2	1609.5
	1	3057.5

07227500 Canadian River near Amarillo, TX

	Percent of time flows exceeded	Discharge (cfs)
(1969-77)	99	0.3
	98	0.8
	95	2.4
	90	4.4
	75	10.2
	50	26.3
	25	90.8
	10	459.3
	5	928.7
	2	1867.3
	1	3292.1



Headlines in the Wichita Falls Time Record News

PROGRESS 2008

61. ■ Sunday, February 24, 2008 Times Record News

Ray Queen and Avery Scruggins, left, of Purcellan haul out debris as they work to get the molature out of a home in the Horseshoe Bend area in Wichita County. Floodwaters rose about a foot inside the home.



A Red Cross disaster services van passes over the Wichita River at FM 366 as the river swells underneath. The neighborhoods of the Horseshoe Bend and Wranglers Retreat, both located just off FM 366, were under a mandatory evacuation order from Wichita County Judge Woody Gossom as the water rose in late June.



Flood one for record books

Wichita River notched its highest-ever level of 24.4 feet

Lara N. Richards
Times Record News

It was more water than the Wichita River had ever seen. . . . Rains started falling in late June 2007 and they fell day after day after day, pushing the river further over its banks. . . . The 2007 flood was one for the record books as the river notched its highest-ever level of 24.4 feet. . . . It was an event that sent waves of water into many neighborhoods in Wichita County and the city of Wichita Falls, forcing evacuations and causing millions of dollars in damage. . . . "It was a major undertaking," said Dave Clark, city of Wichita Falls director of community development. "Two rivers been through that degree of disaster before. We did what we had to do and got through it." . . . The Tanglewood and East Side neighborhoods in Wichita Falls were under water. Wranglers Retreat and Horseshoe Bend in Wichita County spilled over so well. . . . Hundreds of homes sustained flood damage, with around 100 or so receiving



than it could have been. Our emergency personnel, both volunteers and on-call people, really rose to the occasion. The city and county worked well together." . . . Although the flooding happened several months ago, Bourgoin said recovery is still continuing. . . . The county is still waiting on word from state and federal officials about a disaster mitigation grant program, which would give the county funds to purchase and then demolish three homes in Wranglers Retreat that suffered the most damage. . . . The county is also working on public assistance funds from FEMA to work on repairing roads and bridges that were damaged in the flood. . . . "It's still ongoing for the county and will be for a few more months," Bourgoin said. . . . Recovery continues to progress steadily in the city as well, Clark said. . . . "People have moved ahead and are doing repairs," he said. "There's a couple of cases where they have actually elevated the house above the flood plain. There is re-

Tom Halley/Times Record News

Overview of flood events Wichita Falls

June 30, 2007 Flood:

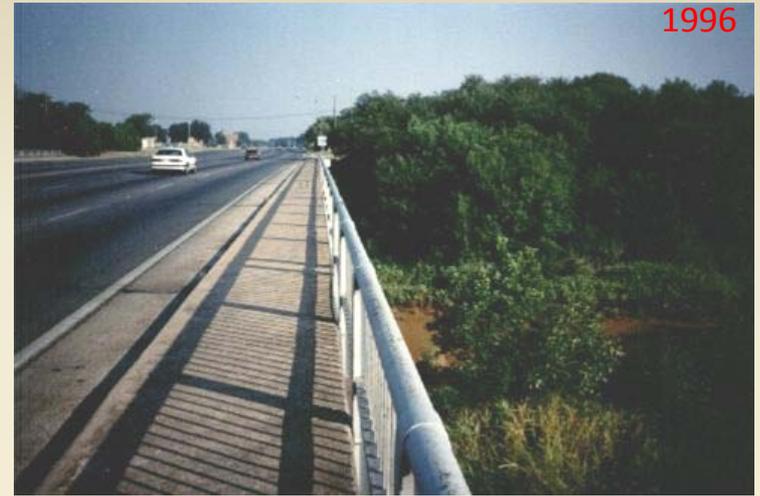
Stage 24.40 ft , $Q=10,100$ cfs, Mean Velocity = 2.03 ft/sec



Oct. 3, 1941 flood: Stage 24.00 ft,
 $Q=17,800$ cfs,
Mean velocity = 3.60 ft/sec



Wichita River at Loop 11; 1950, 1961, 1996, and 2009



Contest Time!!!!!!!



How much
water is there?



**Brazos River near
Dennis June 28, 2007**

Water reached the floodplain



**Acoustic doppler was
used to measure the
stream**

Brazos River nr Dennis June 28, 2007 streamflow information

- Gage Height: 26.78
- Width: 584 ft
- Max depth: 29.8 ft
- Max Velocity: 13.3 ft/s
- 30 cfs ght 1.25 ft



Discharge Measurement Results

Station No.: 08090800 Meas. No: 337
 Station Name: Brazos River nr Dennis, TX Date: 06/28/2007

Party: DAB/JDB	Width: 584 ft	Processed by: DAB
Boat/Motor: Tethered #599	Area: 10,500 ft ²	Mean Velocity: 4.70 ft/s
Gage Height: 26.78 ft	G.H.Change: 0.01	Discharge: 49,200 ft ³ /s

Area Method: Avg. Course	ADCP Depth: 0.40 ft	Index Vel.: 0.00 ft/s	Rating No.: 8.1
Náv. Method: Bottom Track	Shore Ens.: 10	Adj. Mean Vel: 0.00 ft/s	Qm Rating: F
MagVar Method: None (0.0°)	Top Est: Power (0.1667)	Rated Area: 0.000 ft ²	% Diff: 0.0%
Depth Sounder: Not Used	Bottom Est: Power (0.1667)	Control: Unspecified	

Screening Thresholds:	ADCP:	
BT 3-Beam Solution: ON	Type/Freq.: Rio Grande / 600 kHz	
WT 3-Beam Solution: OFF	Serial #: 6794	Firmware: 10.15
BT Error Vel.: 0.33 ft/s	Bin Size: 50 cm	Blank: 25 cm
WT Error Vel.: 3.50 ft/s	BT Mode: 5	BT Pings: 1
BT Up Vel.: 1.00 ft/s	WT Mode: 1	WT Pings: 1
WT Up Vel.: 15.00 ft/s	ADCP Temp.: 75.4 °F	WV: 286
Max. Vel.: 13.3 ft/s		
Max. Depth: 29.8 ft		
Mean Depth: 17.9 ft		
% Meas.: 69.62%		

Diag. Test: 6794.070628095443.txt Filename Prefix: 08090800_0628
 Moving Bed Test: 08090800_0628000r.000 Software: 10.06.00
 Compass Test:
 Meas. Location: approx. 100ft ds of bridge/300ft ds of gage.

Tr.#	Edge D.		#Ens	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens	Bins	
002	L	180	120	435	4428	32474	4023	4193	1910	47027	604	10816	10:20	10:23	1.96	4.35	26	1
003	R	140	120	313	4434	32459	4072	2967	1071	45003	525	9587	10:24	10:26	2.46	4.69	35	1
004	L	180	120	391	4436	32928	4087	7083	1348	49882	597	10734	10:26	10:29	2.19	4.65	28	3
005	R	180	120	503	4854	34459	4471	6565	346	50695	577	10466	10:29	10:33	1.71	4.84	22	2
006	L	180	120	366	4426	32893	4130	3717	1846	47013	592	10249	10:34	10:37	2.22	4.59	25	1
007	R	180	120	328	4848	35837	4265	4207	1329	50487	584	10364	10:37	10:39	2.38	4.87	30	1
008	L	180	120	308	5119	38163	4675	5666	2009	55632	602	10886	10:40	10:42	2.66	5.11	29	1
009	R	180	120	335	4735	34967	4170	3222	1014	48106	591	10651	10:42	10:44	2.60	4.52	30	2
Mean		175	120	372	4660	34272	4237	4702	1359	49231	584	10469	Total	00:23	2.27	4.70	28	2
SDev		14	0	68	267	2012	226	1547	560	3252	26	420			0.32	0.24		
R/M%		23	0	52.4	14.9	16.6	15.4	87.5	122.3	21.6	13.6	12.4			41.42	16.22		

Discharge = 49,200 cfs

Presentation review

- Relate USGS units to water provider units
- Describe how the USGS measures streamflow in the field
- Show the calculation methods used
- Describe how the data is presented and how the data can be obtained/used

Thank You!!!!!!!!!!

sbaldys@usgs.gov

