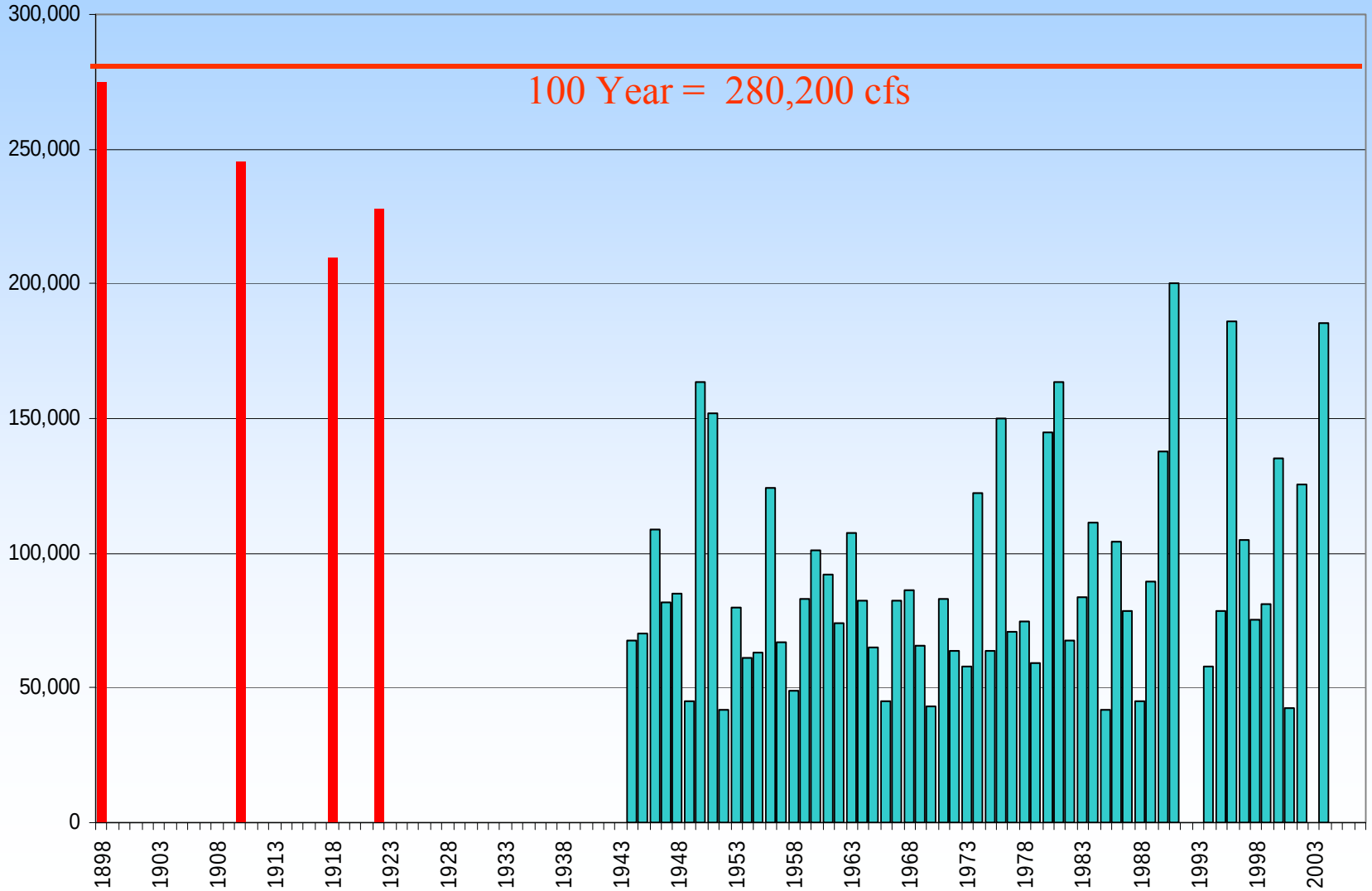
Update

Skagit River Hydrology Issues

Presented to the
Burlington City Council
July 24, 2008

Slide 1 of 823

Winter Unregulated Annual Peak Flows Skagit River Near Concrete: Corps of Engineers Data Set (November 2005)



timeline

- November 2005 – COE Hydrology Report
  - Unregulated peak flow 280,200 cfs @ Concrete
- December 2005 – PI Engineering Hydrology Report
  - Unregulated peak flow – 246,300 cfs @ Concrete
- February 2007 – COE Flood Insurance preliminary release (incorrect Flo-2d)
- April 2007 – "Smith" house investigation
- April 2007 – NHC "Independent Technical Review" of Skagit hydrology
- August 2007 – USGS slight revision, historic flood estimates
- August 2007 – PI Engineering draft amended hydrology report
  - Unregulated peak flow – 227,200 cfs @ Concrete
- September 2007 – PI Engineering competing base flood maps (correct Flo-2d)
- November 2007 – NHC review of PI Engineering amended hydrology
- November 2007 – NHC review of COE Flo-2d model
- January – June, 2008 – Concrete Crofoot's Addition investigation
  - Extension of Hydraulic Model from the Dalles to Concrete
- June 2008 – COE 2nd FIS map release (correct Flo-2d)

At Hamilton


Highway 20
Old School House
Smith House
CAP: Western WA Flooding

At Hamilton | Nov 27 1922

	12.73	12.73		00.00	W.S. 10 AM
TP			4.36	8.37	
	10.68	19.05			
			2.27	16.78	RP nail in 14" maple on river edge of old levee
					Nov 28
	2.94	96.84		93.90	Top of GN rail in front of Hamilton Depot. Elev from USGS Bulletin 670?
TP			2.40	94.44	
	4.21	98.65			
			3.03	95.62	1917 HW
TP			4.95	93.70	
	3.40	97.10			
TP			4.49	92.61	
	5.87	98.48			
			1.59	96.89	R.P. described above

.55 above 17 = 1909 HW
.84 above 17 = 1921 HW

At AJ Jacobin cigar store. Bldg may have settled 10 or 12 in. lost 1971

95.62
.55
96.17 = 1909

95.62
.84
96.46 = 1921

95.62
80.11
15.51 = 1917 HW above stage 11/27/22

96.17
80.11
16.06 = 1909 HW above stage 11/27/22

96.46
80.11
16.35 = 1921 HW above 11/27/22 stage

96.89
16.78
80.11 Elev of WS Nov 27

Magnus Miller says 1897 flood came to door knob of James Smiths drug store (door later note drug store raised since then)
Hine across from Hamilton may have 1897 mark


GNRR Depot
93.90 Top of GN Rail
A. J. Jacobin
1921 HWM
96.46 feet
"Smith" House
2003 HWM 100.83
N
0
502ft
Includes material © Space Imaging LLC.

“Smith” House, built in 1908, Hamilton WA

Smith House, 1917?

Smith House Exterior Flood Mark, 1995 / 2003

Hamilton Flood Elevations then and now

Year	Water Level in Hamilton, A. J. Jacobin Cigar Store And Smith House
1897	(no data)
1909	96.17
1917	95.62
1921	96.46
1995	101.00
2003	100.83

Issue: Was channel capacity much greater back then?

- Answer: probably – but not all that much
- Argument: **if 1921 flood discharge was 228,000 cfs (USGS) and did not flood the Smith House, then how could the flood of 1932 (147,000 cfs) cover "nearly the whole of Hamilton at the height of the flood** (Concrete Herald, March 3rd, 1932)"
- PI Engineering conclusion: 188,000 was the peak for 1909, 1917 and/or 1921 events at Hamilton
- FEMA / USGS / COE position: inconclusive

Taken as a Whole. . .

- “Smith” house investigation added new, useful information but was not enough to sway USGS / FEMA / COE

Concept

Investigation of the Historic Floods in the Crofoot's Addition to Concrete

- Build on Stewart's observed and documented high water marks of the historic floods (1922 field notes)
- Combine Stewart's 1922 interview/survey data with today's hydraulic modeling methods to determine the historic discharges
- Supplement the hydraulic modeling with a forensic investigation

At Concrete, Crofoot's Addition

Levels at Concrete

BS	HI	FS	Elev	
.40	230.91		230.51	BM USGS
			225.57	
		5.34	214.33	
1.31	215.64			
		8.30	207.34	
7.45	214.79			
		0.47	214.32	
2.96	217.28			
		12.82	204.46	
1.92	206.38			
		12.73	193.65	
0.91	194.56			
		12.33	182.23	
4.40	186.63			
		2.08	184.55	

Dec 21 1922

	BS	HI	FS	Elev	
	10.5	20.5		10.00	1897 flood crest on stump at old Bar by bridge 5' to 1 Est. by means Mother That H W was 4½ below top of stump
TP			11.2 rod 4.6 top 15.8	4.7	
	4.7	9.4			
			3.0	6.4	1921 H W

These are relative figures only at a ... stump and Washington Cement Plant. The ... are a configuration of straight and ... during ...

Nov 28

See pages 18 and 30 also

Measured down 11.24' from this point on freight car to rail below (about 300 ft below depot)

Ground surface 4.9 ft below line of sight at this point. Note pt of zero flow for old channel Coll low pt Elev 210 ft

1921 flood mark at Wolfs Residence

(McDaniels near Washington Cement plant can give 1909 flood)

Leonard Everett says 1897 flood about 9" lower than 1909, says that log jam in Dalles raised water 10 ft in 2 hrs, He says 1897 about highest midnight
1909 highest after midnight possibly 12:30
1921 highest about 1 am
considerable distance and some slope between 1897 and 1909 mks. Est max at 0.2 ft ... Coll 1897 1.4 ft higher than 1909 and 3.4 ft higher than 1921

1897	10.00
1909	9.4
1921	6.4

Found line at 1909 HW 2.0' above 1921 at Washington cement plant machine shop today

He is wrong probably see bottom half of page 141 Day 3/24/23

See bottom of page 19 for comparison of 1909 and 1921


P70645
P70866
Crofoot's
P70647
P70771
off Map
P70913
PARCELS OWNED
BY L.E. WOLFE
1921
Sources
1) 1921 Real Property Tax Roll
And Assessment, State
Archives, Bellingham
2) Skagit County on-line
Assessor Database
3) Assessor Parcel Map
Section 11 Township 35
Range 08
Research conducted by
Josef Knazler and Curt Martin
20 Mar 08
Copyright ©2007 Pictometry

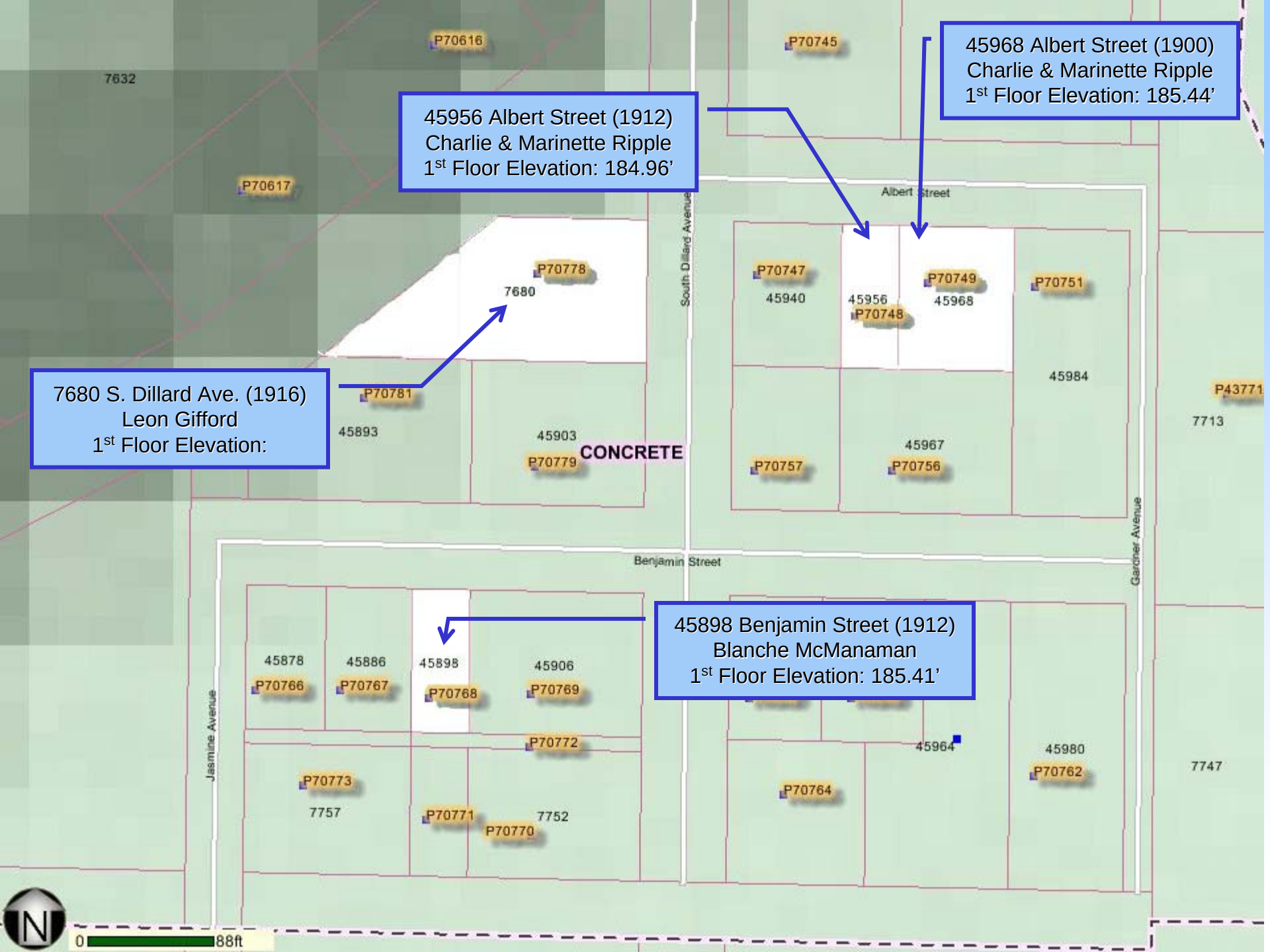
L.E. Wolfe Residence, 1922

1921, Concrete Herald Newspaper

"About three o'clock in the afternoon it went over the banks in Crofoot addition and the residents of that part of town began to move out … The waters also crept up around some of the dwellings in East Concrete, and some of the residents moved out for the night. **In Crofoot addition** only three residences remained above the high water mark, **the water being to a depth of an inch to 14 inches in the others**. No particular damage was done, except for small articles outside being washed away, and the job of cleaning out the mud left by the flood. … **In East Concrete practically no damage was done.**" *Dec. 17, 1921 Concrete Herald "Skagit River Goes On Wild Rampage; Light Damage Here"*

Part I: Forensic Investigation

- Would it be possible to investigate houses in Crofoot's Addition built prior to 1921 and determine if they had been flooded above the first floor by the 1921 flood?


45968 Albert Street (1900)
Charlie & Marinette Ripple
1st Floor Elevation: 185.44'
45956 Albert Street (1912)
Charlie & Marinette Ripple
1st Floor Elevation: 184.96'
7680 S. Dillard Ave. (1916)
Leon Gifford
1st Floor Elevation:
45898 Benjamin Street (1912)
Blanche McManaman
1st Floor Elevation: 185.41'
Albert Street
South Dillard Avenue
Benjamin Street
Gardner Avenue
Jasmine Avenue
CONCRETE
P70616
P70745
P70617
P70778
7680
P70747
45940
45956
P70748
P70749
45968
P70751
45984
P43771
7713
P70781
45893
45903
P70779
45967
P70757
P70756
45878
P70766
45886
P70767
45898
P70768
45906
P70769
P70772
P70773
7757
P70771
7752
P70770
45964
45980
P70762
P70764
7747
0
88ft

Ripple House, Built 1900
First Floor Elevation 185.44
(1921 Stewart mark at Wolfe residence 183.55)
1909 Theoretical Water Level – 193.4)


04/03/2008 11:22


D10
04/03/2008 11:45

2nd Ripple house, Built 1912
First Floor elevation 184.96


04/03/2008 12:07


S2
04/03/2008 12:17


S5
S4
S1
04/03/2008 12:17


M8
M7
M6
M5
M4
M3
M2
M1
04/03/2008 15:12


7680
04/03/2008

Approach to Forensic Evidence

Table 3 – R Samples from Ripple Residence #1 45968 Albert Street Taken April 3, 2008

R-4	Wood chip	Board sheathing West ext. wall opening	Moderate deposits of silt-size siliceous mineral grains, insect parts, and other biological materials
R-5	Wood chip	Board sheathing West ext. wall opening	Traces of dust to silt-size mineral grains and biological materials
R-6	Wood chip	Board sheathing West ext. wall opening	Moderate deposits of insect parts and other biological materials, traces of dust-size mineral grains
R-7	Wood chip	Board sheathing West ext. wall opening	Moderate deposits of insect parts and other biological materials, traces of dust-size mineral grains

Approach to Forensic Evidence

Table 3 – R Samples from Ripple Residence #1 45968 Albert Street Taken April 3, 2008

Sample ID	Sample Type	Location	Description
D-10	Debris	Sill plate West ext. wall opening	Wood fragments, insect parts, rodent fecal pellets, various plant debris, **small amounts of siliceous minerals (mostly coarse),** paint flakes, mortar
R-1	Wood chip	Sill plate, first floor West ext. wall opening	Heavy deposits of silt-size siliceous mineral grains, insect parts, and other biological materials
R-2	Wood chip	Sill plate, first floor West ext. wall opening	Heavy deposits of silt-size siliceous mineral grains, insect parts, and other biological materials
R-3	Wood chip	Sill plate, first floor West ext. wall opening	Moderate to heavy deposits of silt-size siliceous mineral grains, insect parts, and other biological materials

Preliminary Conclusion:
Possibly flooded above FF, but unsure if house was elevated and also, forensic evidence is inconsistent (see sample D10)

Approach to Forensic Evidence

Sample ID	Sample Type	Location	Description
S-1	Wood chip	Base of wood stud, 1st floor East ext. wall	**Light deposits** of silt-size siliceous mineral grains and biological material
S-2	Wood chip	Base of wood stud, 1st floor East ext. wall	Light deposits of biological materials, possible **traces of dust-size mineral grains**
S-3	Wood chip	Base of wood stud, 1st floor East ext. wall	Light deposits of biological materials, possible traces of dust-size mineral grains

Preliminary Conclusion:
Not Flooded above FF

Preliminary Synopsis of Forensic Information, Crofoot's Addition to Concrete

Home	Year Built	FF Elevation	Elevated ?	Indication of Flooding above FF?	Max Silt	Corresponding Flood Discharge
Ripple #1	1900	185.44	Unsure	Possible	186.11	190,000 cfs
Ripple #2	1912	184.96	No	Unlikely	184.96	182,000 cfs
McManaman	1912	185.41	Unsure	Possible	185.58	186,500 cfs
Gifford	1916	186.74	No	Not Consistent	N/A	N/A

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Gifford	1916	186.74	No	Not Consistent	N/A	N/A

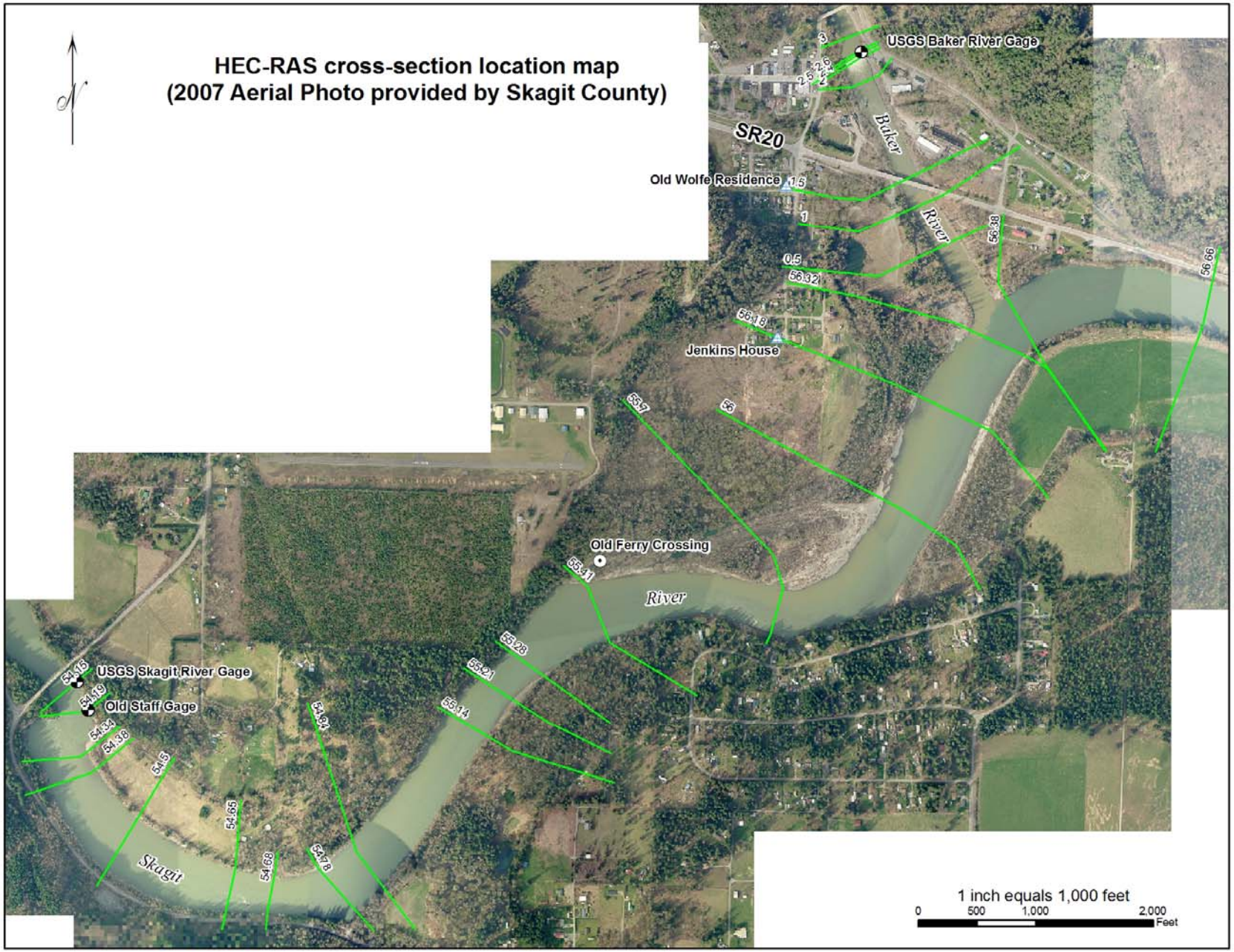
Part II: Hydraulic Modeling

- Could we start with known stage/discharge information from the 2003 flood event at the Dalles gage, develop a hydraulic river model from that point up to Crofoot's Addition; and, based on Stewart's surveyed high water marks for the 1921 flood, determine the peak discharge of the 1921 flood?

Answer

Yes, and we believe this information is very compelling.

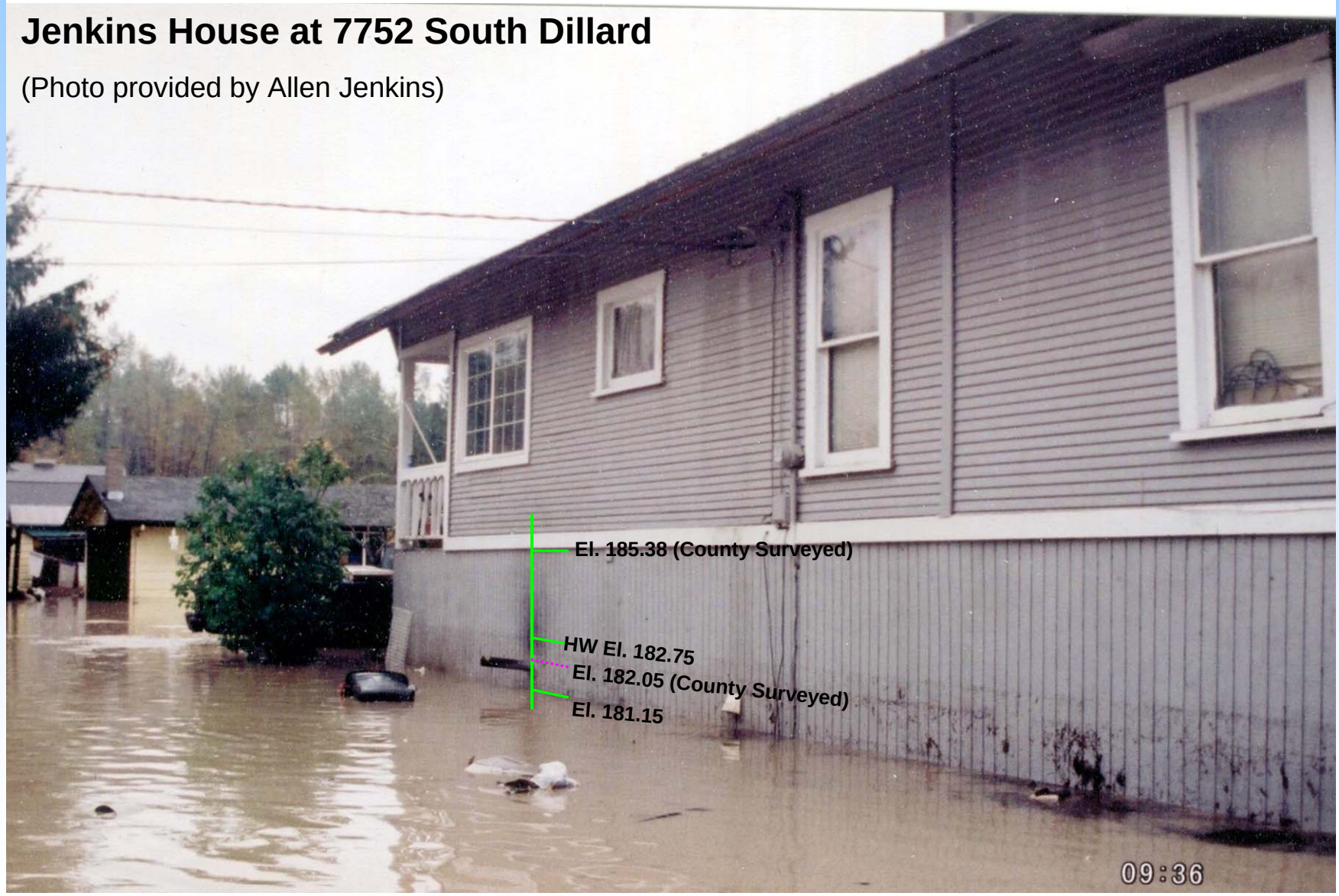

N
0
0.4mi
Includes material © Space Imaging LLC.


HEC-RAS cross-section location map
(2007 Aerial Photo provided by Skagit County)
USGS Baker River Gage
SR20
Baker
River
Old Wolfe Residence
Jenkins House
Old Ferry Crossing
River
USGS Skagit River Gage
Old Staff Gage
Skagit
1 inch equals 1,000 feet
0
500
1,000
2,000
Feet

October 2003 Flood

Jenkins House at 7752 South Dillard

(Photo provided by Allen Jenkins)



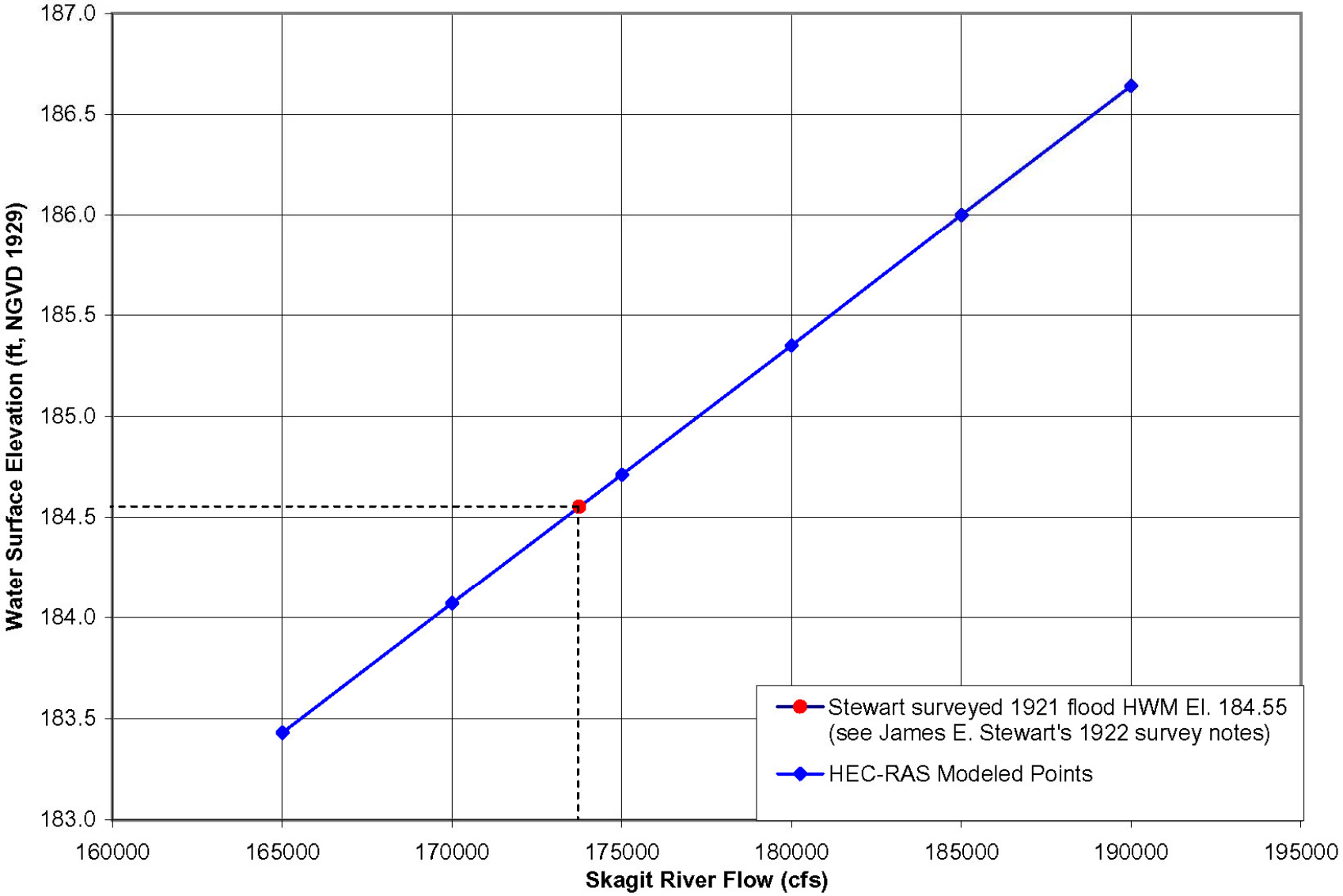
Comparison of Modeled and Observed 2003 Flood Elevations (NGVD-29)

Date of Flood	Time	Skagit River Flow* (cfs)	Baker River Flow** (cfs)	High Water Mark Location	Source of Data	Observed (ft)	Modeled (ft)	Difference (ft) btw. Modeled and observed flood elev.
21-Oct-03	6:15 AM	165,655	4,647	Baker River gage	USGS gage record	183.49	183.70	0.21
21-Oct-03	6:30 AM	164,169	4,655	Baker River gage	USGS gage record	183.48	183.50	0.02
21-Oct-03	7:15 AM	162,602	4,710	Baker River gage	USGS gage record	183.32	183.29	-0.03
21-Oct-03	7:30 AM	162,342	4,747	Baker River gage	USGS gage record	183.22	183.25	0.03
21-Oct-03	9:30 AM	150,956	4,822	Baker River gage	USGS gage record	181.77	181.70	-0.07
21-Oct-03	9:45 AM	151,538	4,822	Baker River gage	USGS gage record	181.54	181.78	0.24
21-Oct-03	6:15 AM	165,655	4,647	Jenkins House	Resident provided photo	182.75	182.78	0.03
21-Oct-03	6:30 AM	164,169	4,655	Jenkins House	Resident provided photo	182.75	182.57	-0.18
21-Oct-03	9:30 AM	150,956	4,822	Jenkins House	Resident provided photo	181.15	180.74	-0.41
21-Oct-03	9:45 AM	151,538	4,822	Jenkins House	Resident provided photo	181.15	180.82	-0.33
21-Oct-03	6:15 AM	165,655	4,647	Old staff gage at the Dalles	USGS 2004 survey	173.30	173.39	0.09
21-Oct-03	6:30 AM	164,169	4,655	Old staff gage at the Dalles	USGS 2004 survey	173.30	173.21	-0.09

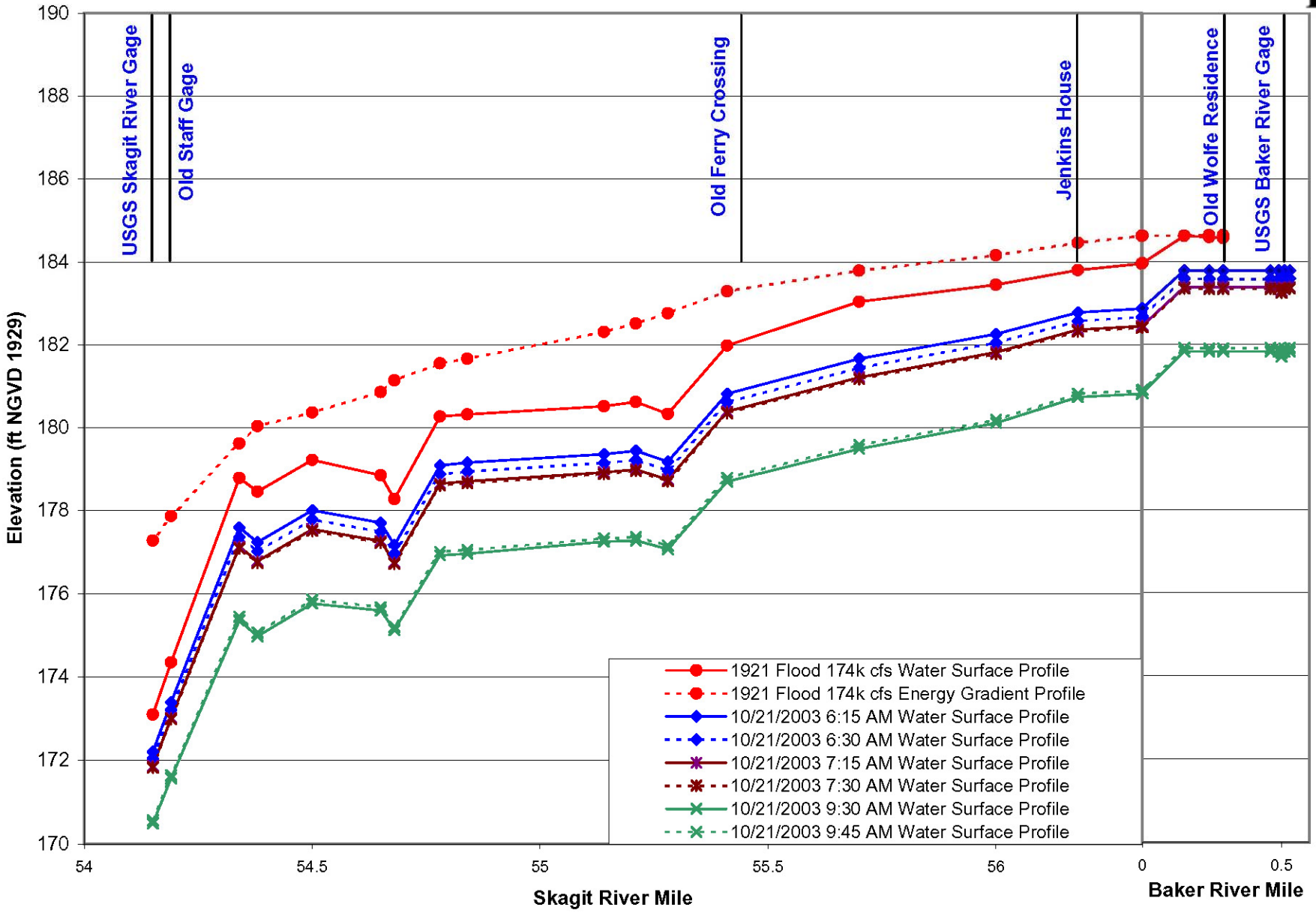
***USGS provided flow data (15-minute interval) at the Skagit River gage near Concrete**

****PSE provided hourly flow data (interpolated for 15-minute interval) below Lower Baker Dam and powerhouse**

Flood Stage-Discharge Curve at Wolfe Residence in Concrete



HEC-RAS Modeled Flood Profiles



(7) 8 8

Nov 25 1922

At The Dalles
The man who lives at The Dalles showed the highest point 1921 flood reached. This point was 0.44 above sand we found in maple tree. We will use our levels on sand however as they are comparable with other points

Later levels show his marks nearer right. We found (Mar 8 that H.W. mk. was .57 above sand in maple (See bottom page 175) J.H.B. 3/9/23

on R side of River above The Dalles and a short distance above BM 956 on opposite side of River

1.15	101.15		100.00	Assumed 1921 flood at elev 100.00
		7.08	94.07	
0.84	94.91			
		12.15	82.76	
0.78	83.54			
		11.42	72.12	WS today.

100.00
72.12
27.88 1921 above W.S. today

1620 from 1856 flood down to axehelve
10.25 rod on axe helve
5.95 1856 flood above line of sight
1.15 1921 flood below line of sight
7.10 1856 above 1921 flood

This is much too low: doubtless did not reach HW mark

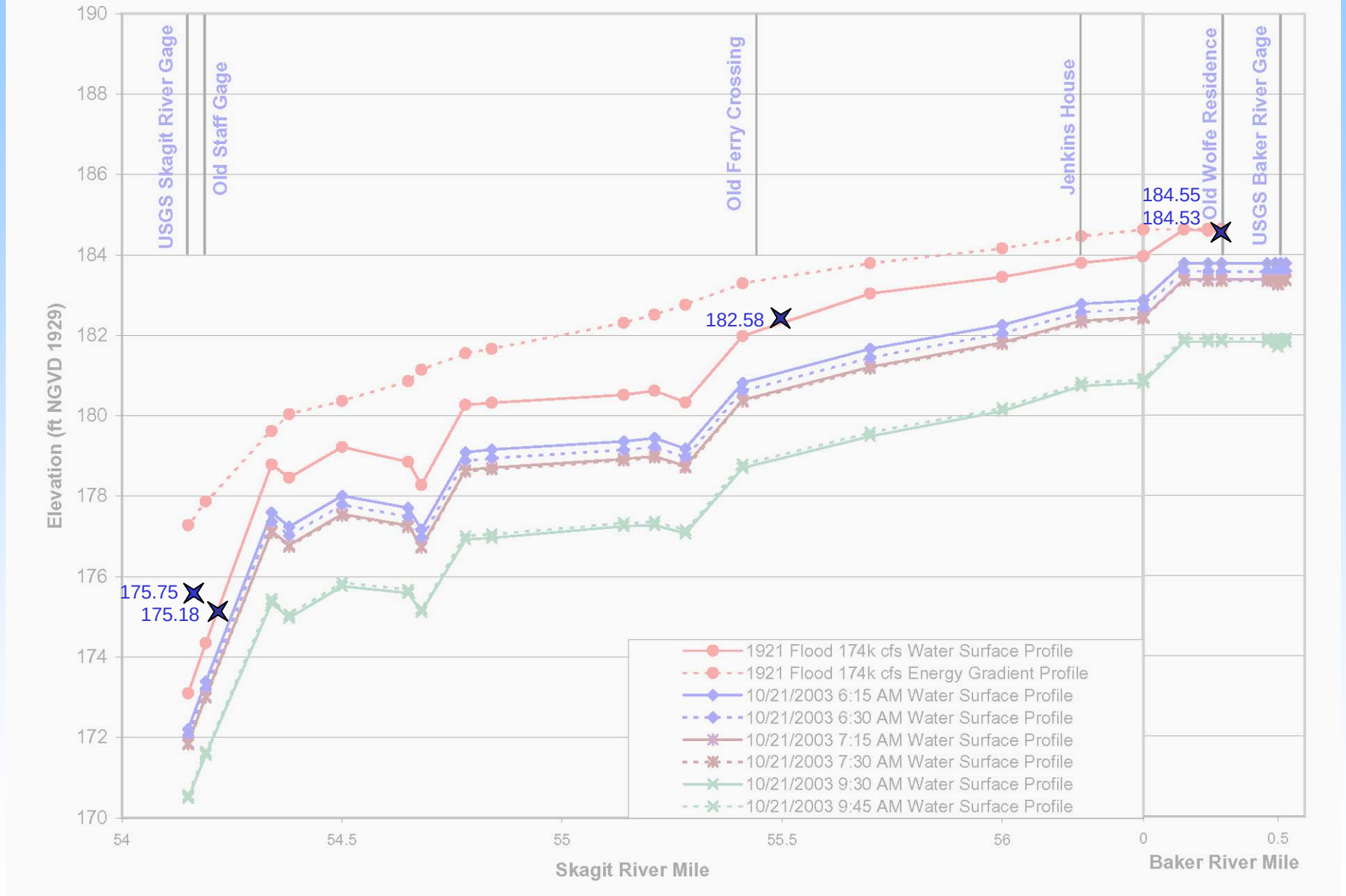
"27.88 seemed small so ran level back"

			00.00	
11.41	11.41			
		.70	10.71	This indicates .5 error in previous level. This elev still looks low
11.80	22.51	+ 5.9	28.40	

measured up from line of sight

Use 28.4 as 1921 above low water today. Assuming pt on other side of river at BM 956 was 1909 flood To make this 28.4 comparable with other side of river we must add 0.7 for fall over riffle (see top of page 5) 28.4 + .7 = 29.1

Stewart Surveyed 1921 High Water Marks



Preliminary Conclusion

- Hydraulic model shows a peak discharge for the 1921 flood of 174,000 cfs, based on Stewart's survey notes from 1922 – peak flood elevation of 184.55 feet

BS	HI	FS	Elev	
.40	230.91		230.51	BM USGS
			225.57 / 11.24	Measured down 11.24' from this point on freightcar to rail below (about 300 ft below depot)
		5.34	214.33	
1.31	215.64			
		5.30	207.34	
7.45	214.79			Ground surface 4.9 ft below line of sight at this point. Near pt at zero flow for old channel. Call low pt Elev 210 ft
		0.47	214.32	
2.96	217.28			
		12.82	204.46	
1.92	206.38			
		12.73	193.65	
0.91	194.56			
		12.33	182.23	
4.40	186.63			
		2.08	184.55	1921 flood mark at Wolfs Residence

(McDaniels near Washington Cement plant can give 1909 flood)

Dec 21 1922

	BS	HI	FS	Elev	
	10.5	20.5		10.00	1897 flood crest on stump at old bridge site. Est. by Messrs. Wilder & Ness H W was 8½' below top of stump
TP			11.2 rod / 4.6 top / 15.8	4.7	
	4.7	9.4			
			3.0	6.4	1921 H W

These are relative figures only. [...] stump and Washington Cement Plant. The g[...] are a combination of 5 [...]

Leonard Everett says 1897 flood about 9" lower than 1909, says that log jam in Dalles raised water 10 ft in 2 hrs. He says 1897 about highest midnight
1909 highest after midnight possibly 12:30
1921 highest about 1 am

Considerable distance and some slope between 1897 and 1909 mks. Est max at 0.2 ft. Call 1897 1.4 ft higher than 1909 and 3.4 ft higher than 1921

{1897 10.00
1909 8.4
1921 6.4

Found line of 1909 H W 2.0' above 1921 at Washington cement plant machine shop

Fig is wrong proba[bly] see bottom [of] p[age] ... left at Dec 1921 ... 3/24/23

See bottom of page 19 ... the true comparison of ... 1921

Preliminary Synopsis of Forensic Information, Crofoot's Addition to Concrete

Home	Year Built	FF Elevation	Elevated ?	Indication of Flooding above FF?	Max Silt	Corresponding Flood Discharge
Ripple #1	1900	185.44	Unsure	Possible	186.11	190,000 cfs
Ripple #2	1912	184.96	No	Unlikely	184.96	182,000 cfs
McManaman	1912	185.41	Unsure	Possible	185.58	186,500 cfs
Gifford	1916	186.74	No	Not Consistent	N/A	N/A
Jenkins					182.75	166,000 cfs
	Stewart's High Water Mark 1921, translated to Ripple vicinity				**183.8**	**174,000 cfs**

Summary

- USGS Peak Discharge Estimate, 1921 flood at Concrete = 228,000 cfs
- Worst case, Ripple residence #1 would indicate peak discharge = 190,000 cfs
- Stewart surveyed high water mark from 1921 flood = 174,000 cfs

Question

- That was 1921. What methodology are you using to estimate the peak discharge of the 1897, 1909, and 1917 floods?

26

At Savage Ranch
(directly across from Old Birdsview School)
Jan 20 1923

16.62	116.62		100.00	W.S. [illegible]
		2.92	113.70	1917 [illegible] Approx. [illegible] of rose bush)
		2.24	114.38	1921 Flood [illegible] side of top step)
		1.57	115.05	1909 Flood [illegible] of porch next to wall)

1909 .7' above 1921

See page 17 (bottom) for levels on opposite side of river

At Kemerick Ranch

3.37	103.34		100.00	1897 [illegible] floor in granary
			99.22	
		4.12	~~99.22~~ 99.10	1921 [illegible] probably correct within .2 or .3
T.P.		1.49	101.85	
0.59	102.44			
T.P.		11.26	91.18	
4.85	96.03			
		16.53	79.50	W.S. [illegible] day at 4:30 PM

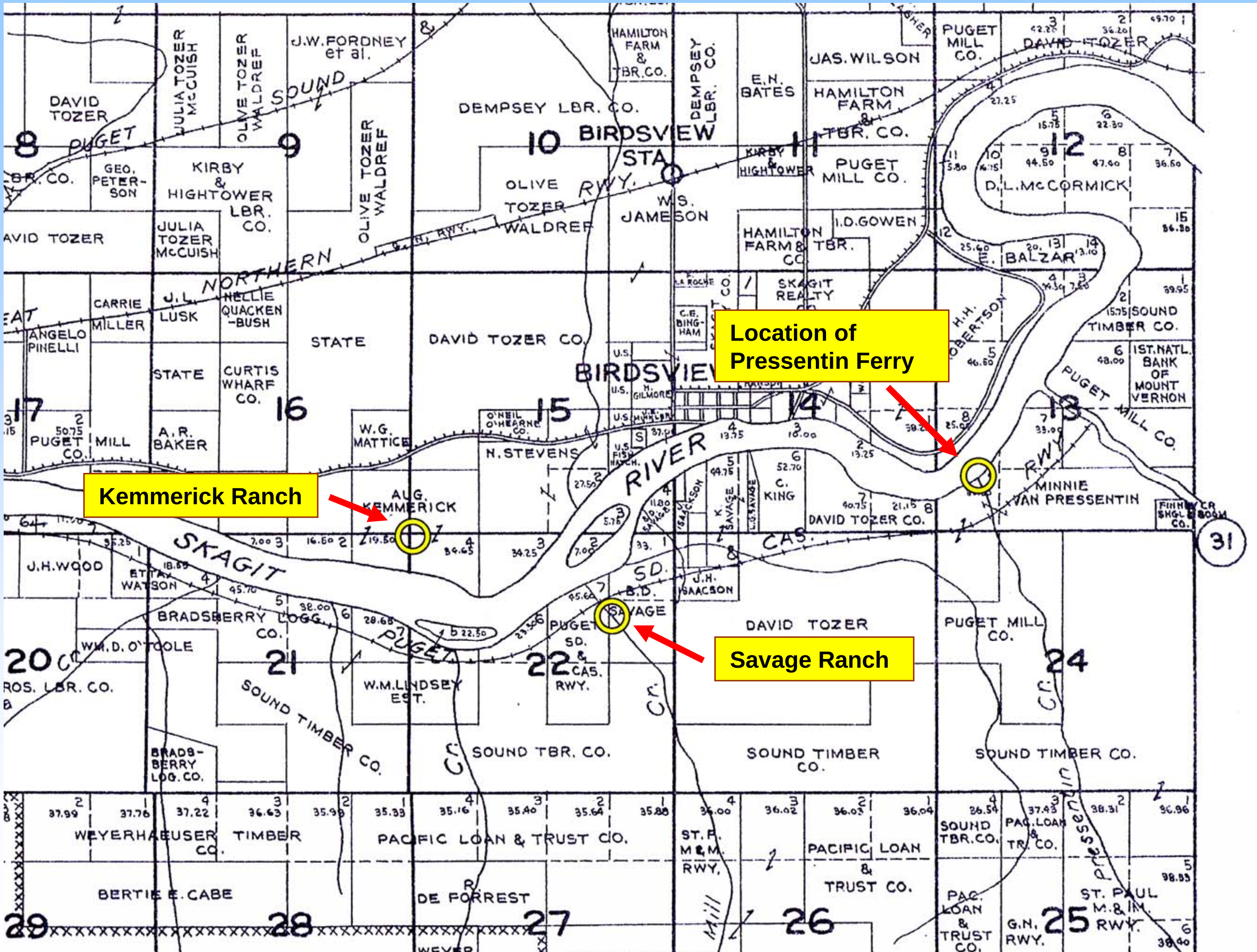
1897 about 0.8' above 1921

Kemerick Ranch about 1 mile below Savage Ranch

Comparison of levels of the two places indicates 1897 about the same as 1909

Feb 2 At Savage Ranch

11.91	111.91		100.00	W.S. today
T.P.		1.55	110.36	By Robert Knapp
1.04	120.40			
		3.60	116.80	1909 [illegible]
		4.11	116.29	1921 [illegible]



Location of Pressentin Ferry
Kemmerick Ranch
Savage Ranch
SKAGIT RIVER
BIRDSVIEW
BIRDSVIEW STA.
GREAT NORTHERN
PUGET SOUND
DEMPSEY LBR. CO.
DAVID TOZER CO.
DAVID TOZER
SOUND TIMBER CO.
PUGET MILL CO.
PACIFIC LOAN & TRUST CO.
WEYERHAEUSER TIMBER CO.
AUG. KEMMERICK
MINNIE VAN PRESSENTIN
D. L. McCORMICK
JAS. WILSON
HAMILTON FARM & TBR. CO.
KIRBY & HIGHTOWER LBR. CO.
OLIVE TOZER WALDREF
JULIA TOZER McCUISH
BRADSBERRY LOGG. CO.
W. M. LINDSEY EST.
J. H. WOOD
WM. D. O'TOOLE
BERTIE E. CABE
DE FORREST
STATE
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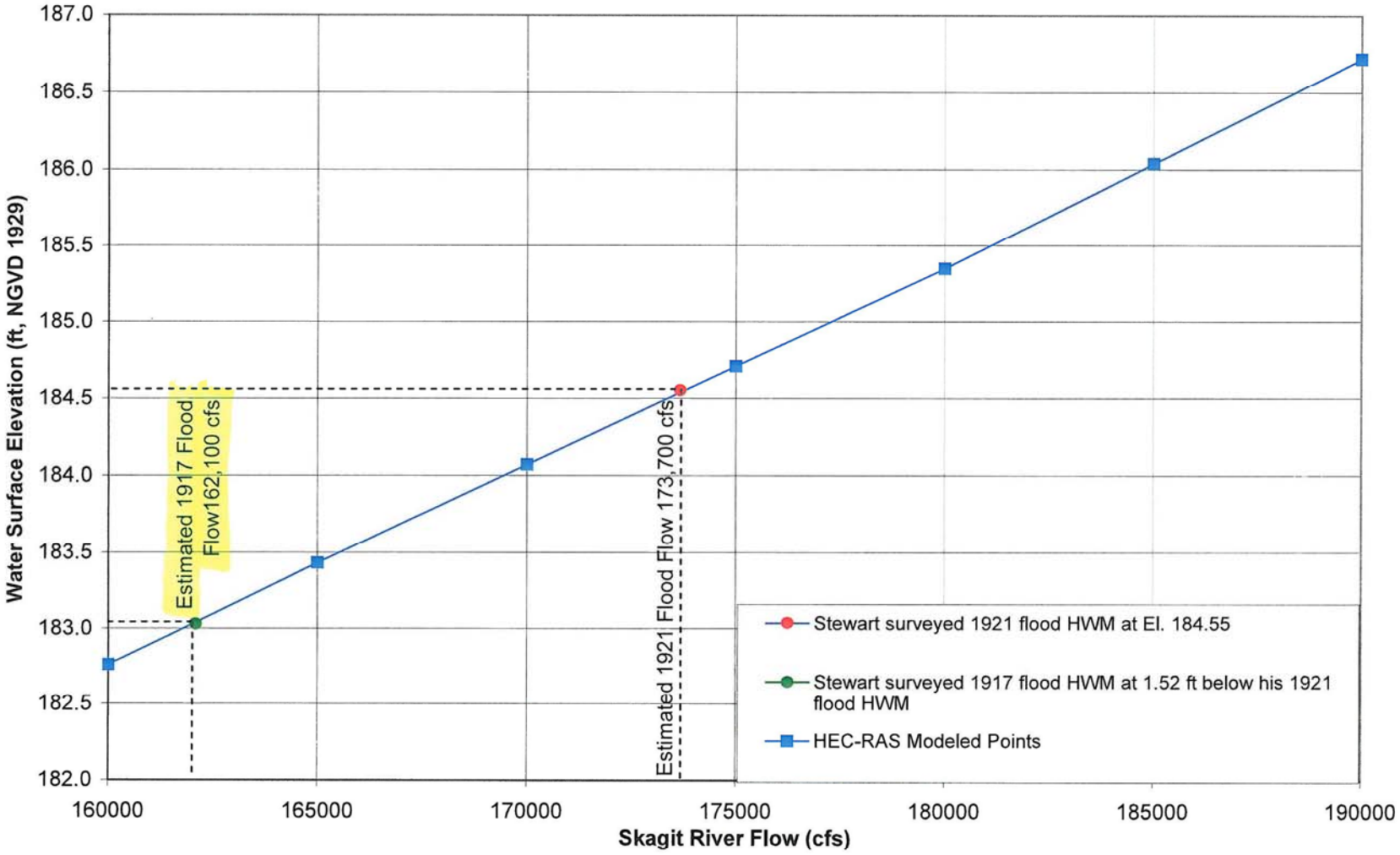
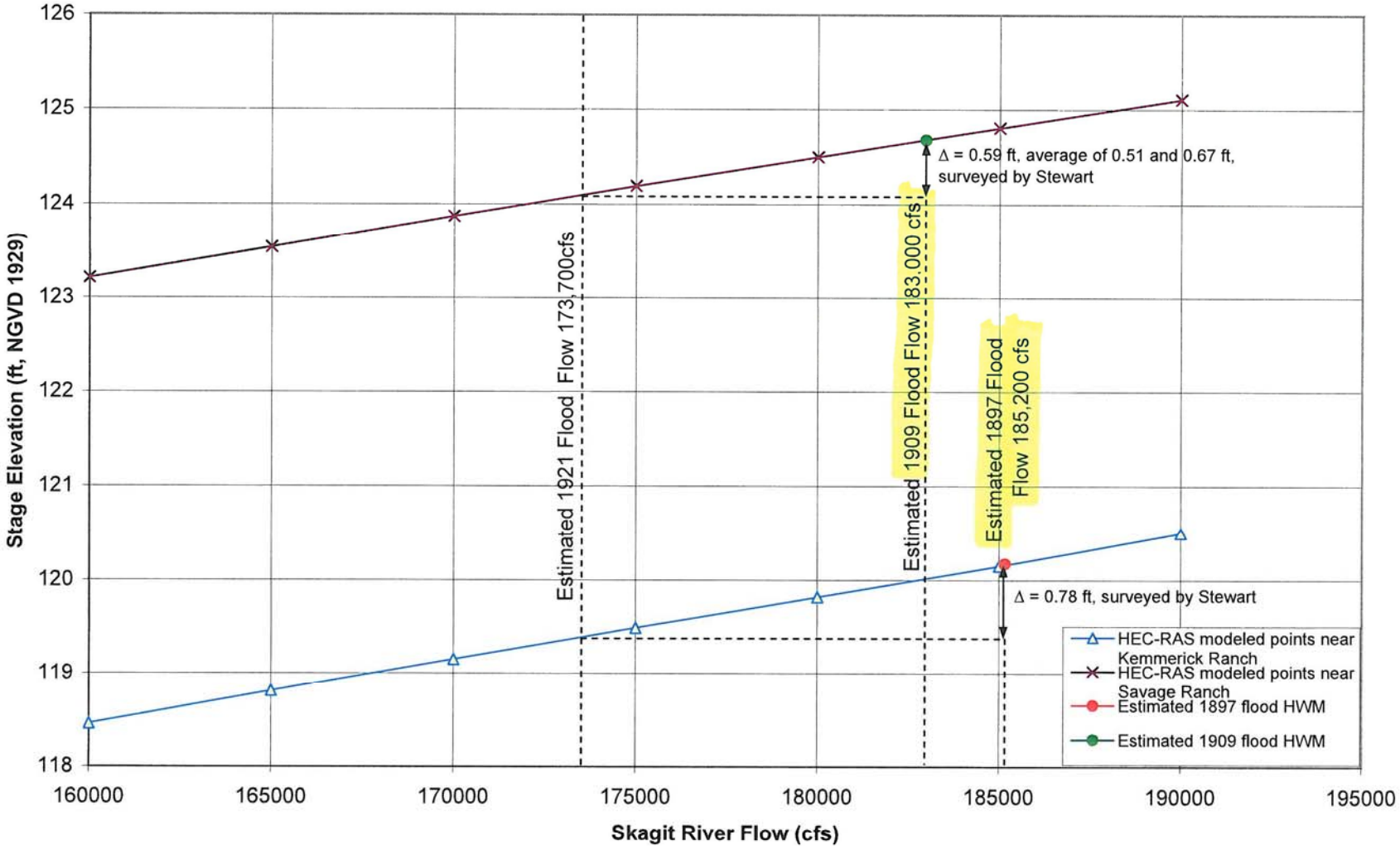
Flood Stage-Discharge Curve at Wolfe Residence in Concrete



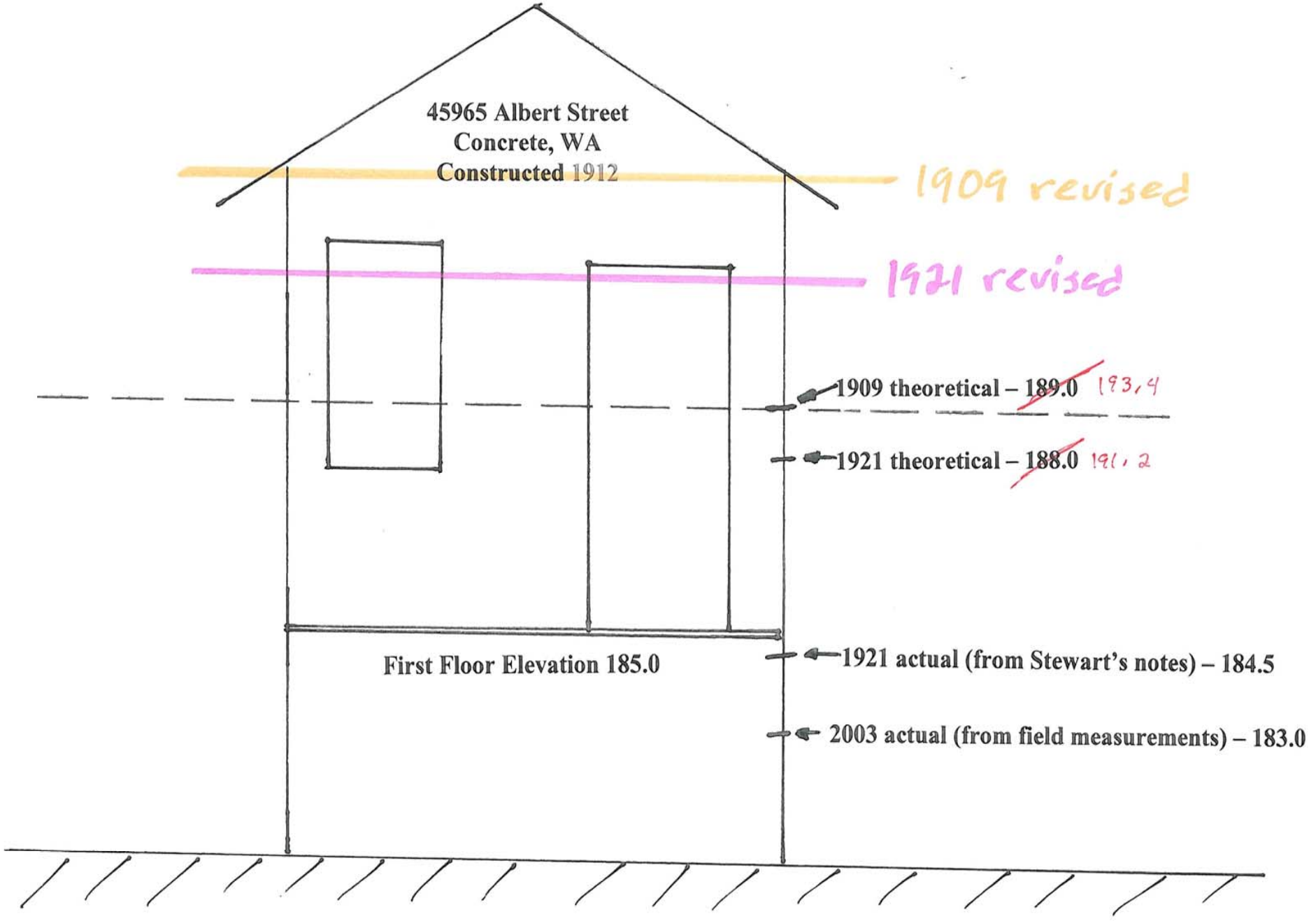
Flood Stage - Discharge Curves at Kemmerick and Savage Ranches near Birdsview



PI Engineering methodology to determine peak discharges of the historic events

- Extend hydraulic model from a known stage/discharge at Concrete (2003 – 166,000 cfs)
- Dial Stewart's actual 1922 survey marks into the hydraulic model to obtain the discharge of the 1921 and 1917 events
- Use existing model and Stewart's surveyed high water marks to determine the 1897 and 1909 flood discharges

- Results:
- 1921: 173,700 cfs
- 1917: 162,100 cfs
- 1909: 183,000 cfs
- 1897: 185,200 cfs


45965 Albert Street
Concrete, WA
Constructed 1912
1909 revised
1921 revised
1909 theoretical – 189.0 193.4
1921 theoretical – 188.0 191.2
First Floor Elevation 185.0
1921 actual (from Stewart's notes) – 184.5
2003 actual (from field measurements) – 183.0

What benefits does the extension of the hydraulic model bring to the issue?

- Fewer assumptions – the model starts with a relatively accurate estimate at the Dalles
- Uses objective, foundational data of the time – Stewart's own survey notes
- Applies modern techniques, unavailable to Stewart, to the foundational data Stewart generated

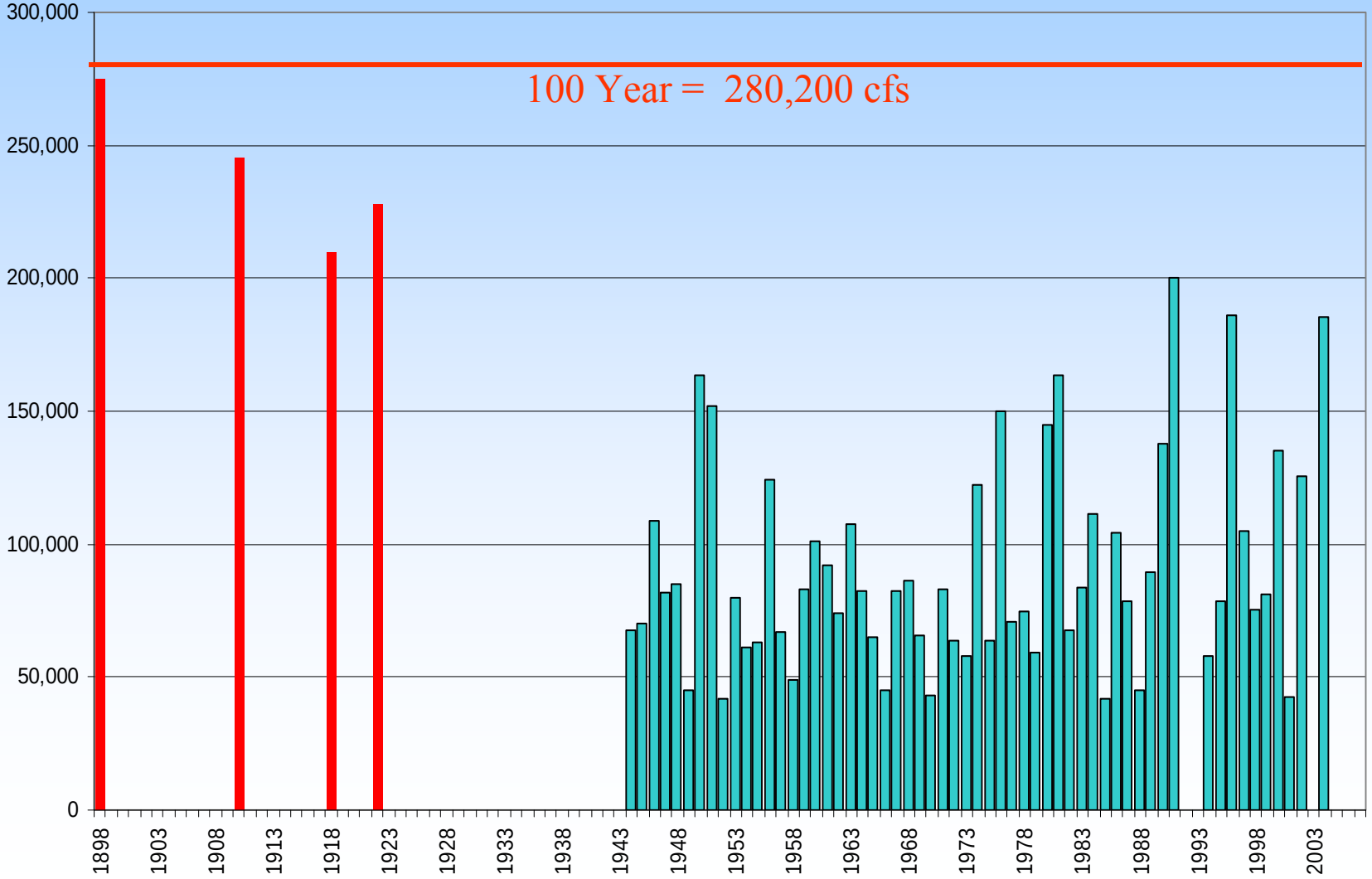
Question

- How does this new information compare with current Corps of Engineers work on the hydrology and the Flood Insurance Study?

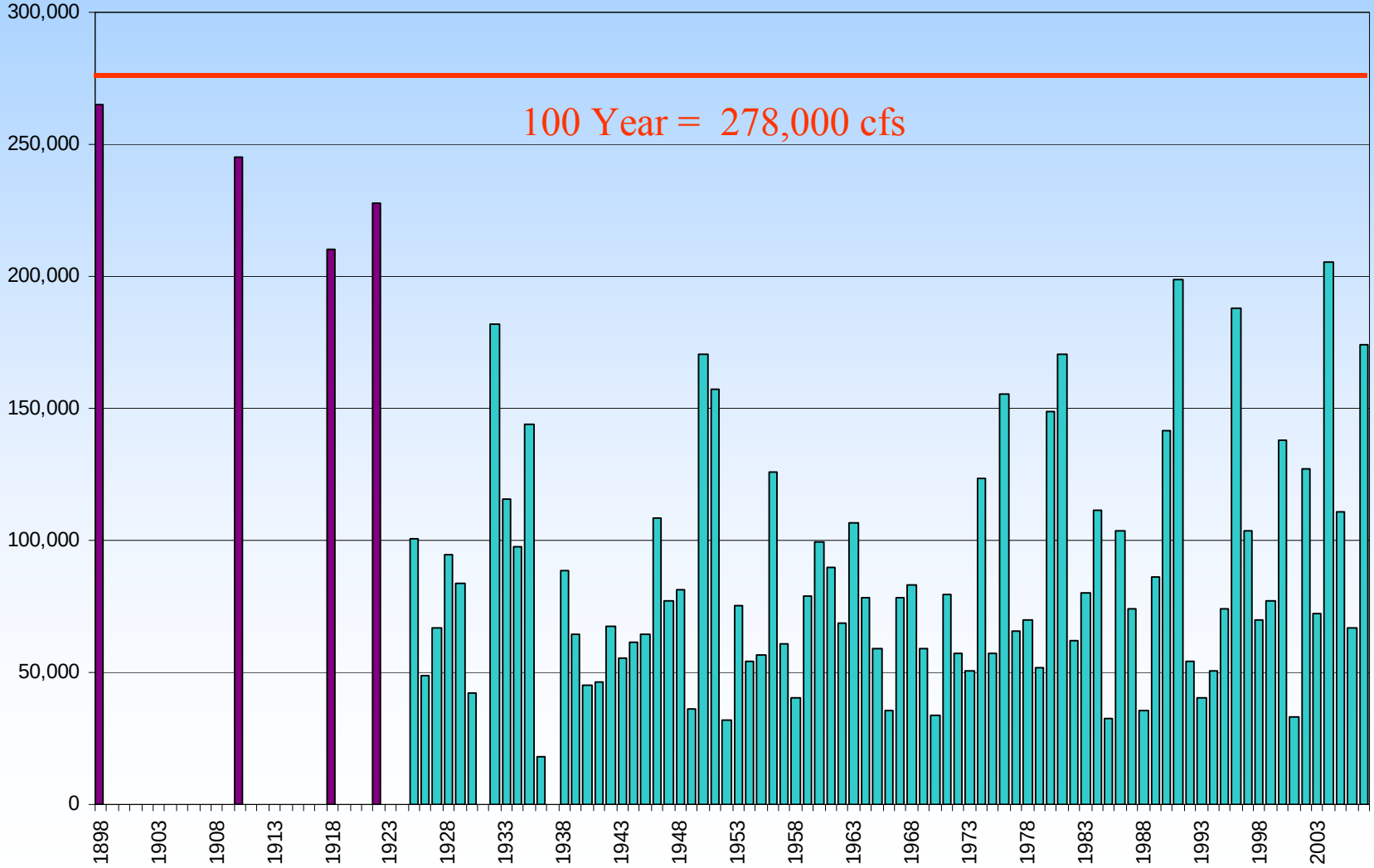
Updated COE Flood Frequency Data Set

- Old COE flood frequency data set contained 58 years of data, ignoring gage information from 1923-1944.
- Recently, the Corps located work previously done that "unregulated" the floods that occurred during this interval, and are now including this data.
- Additionally, the Corps has updated the unregulated information for the more recent floods, and included those in its flood frequency data set
- Also, the Corps has reduced the historic flood events by a few percentage points, consistent with the USGS 2007 study

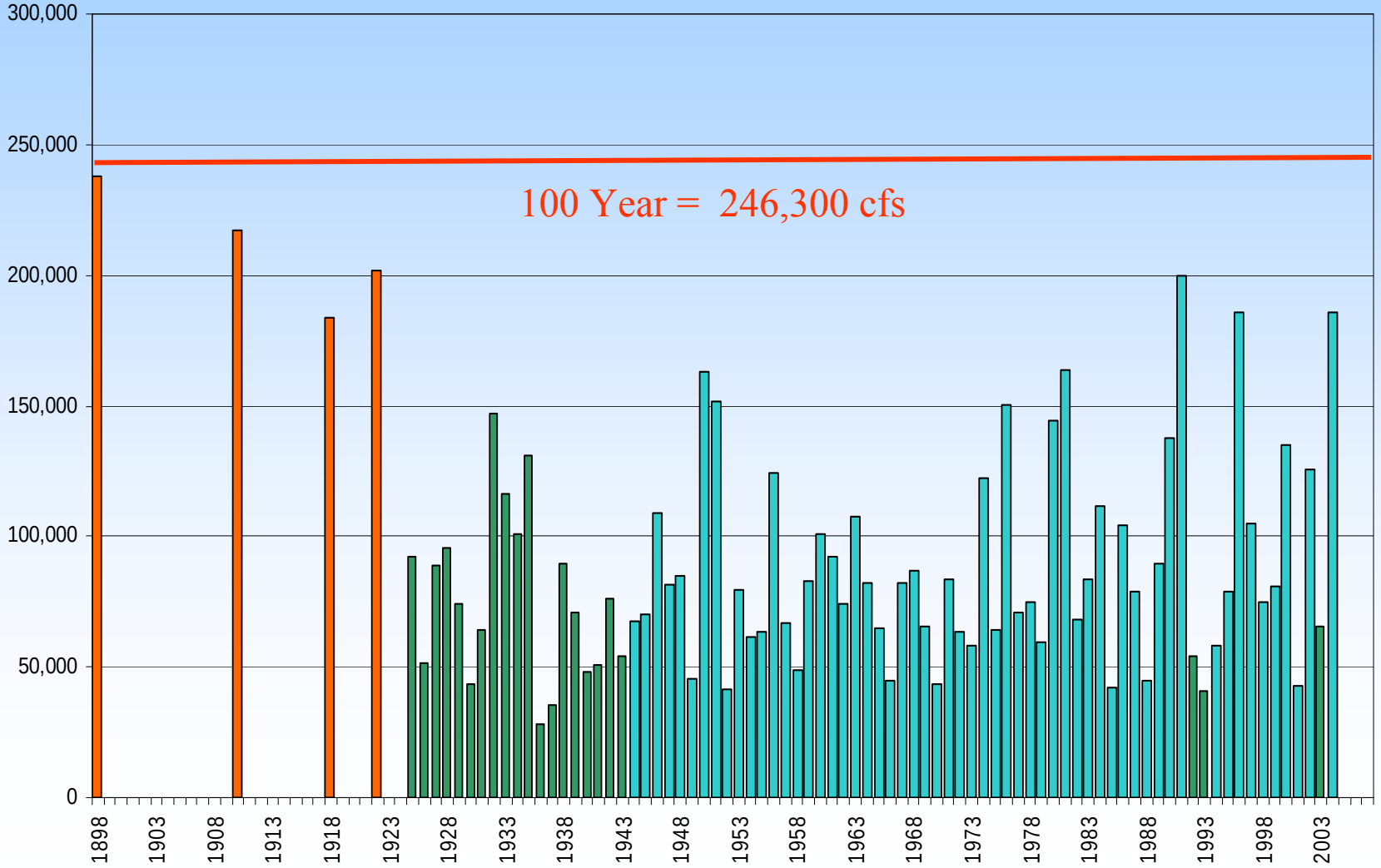
Winter Unregulated Annual Peak Flows Skagit River Near Concrete: Corps of Engineers Data Set (November 2005)



Skagit River Winter Unregulated Annual Peak Flows
Concrete – COE Frequency Distribution (April 2008)

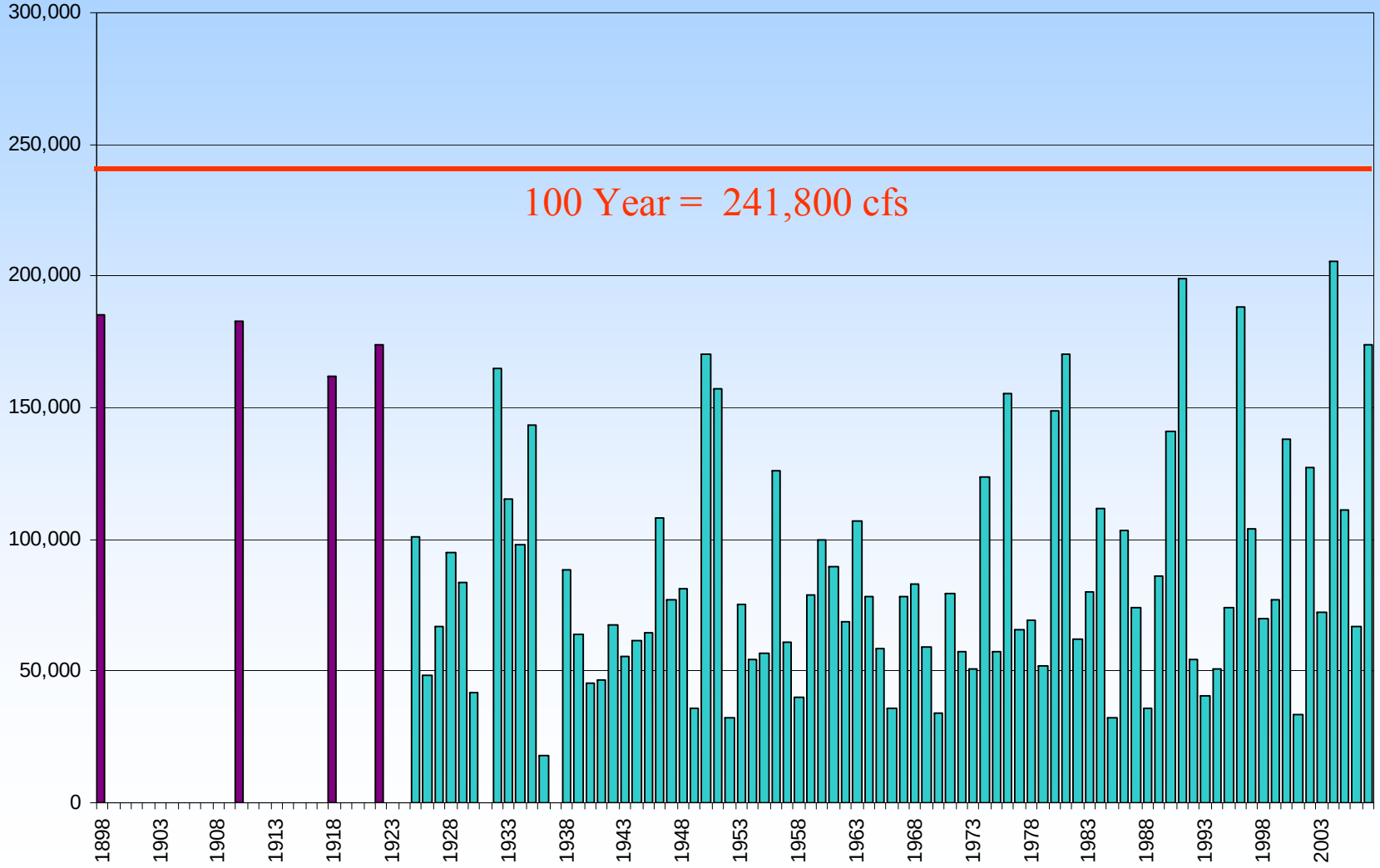


Winter Unregulated Annual Peak Flows Skagit River Near Concrete: PI Engineering Data Set (December 2005)

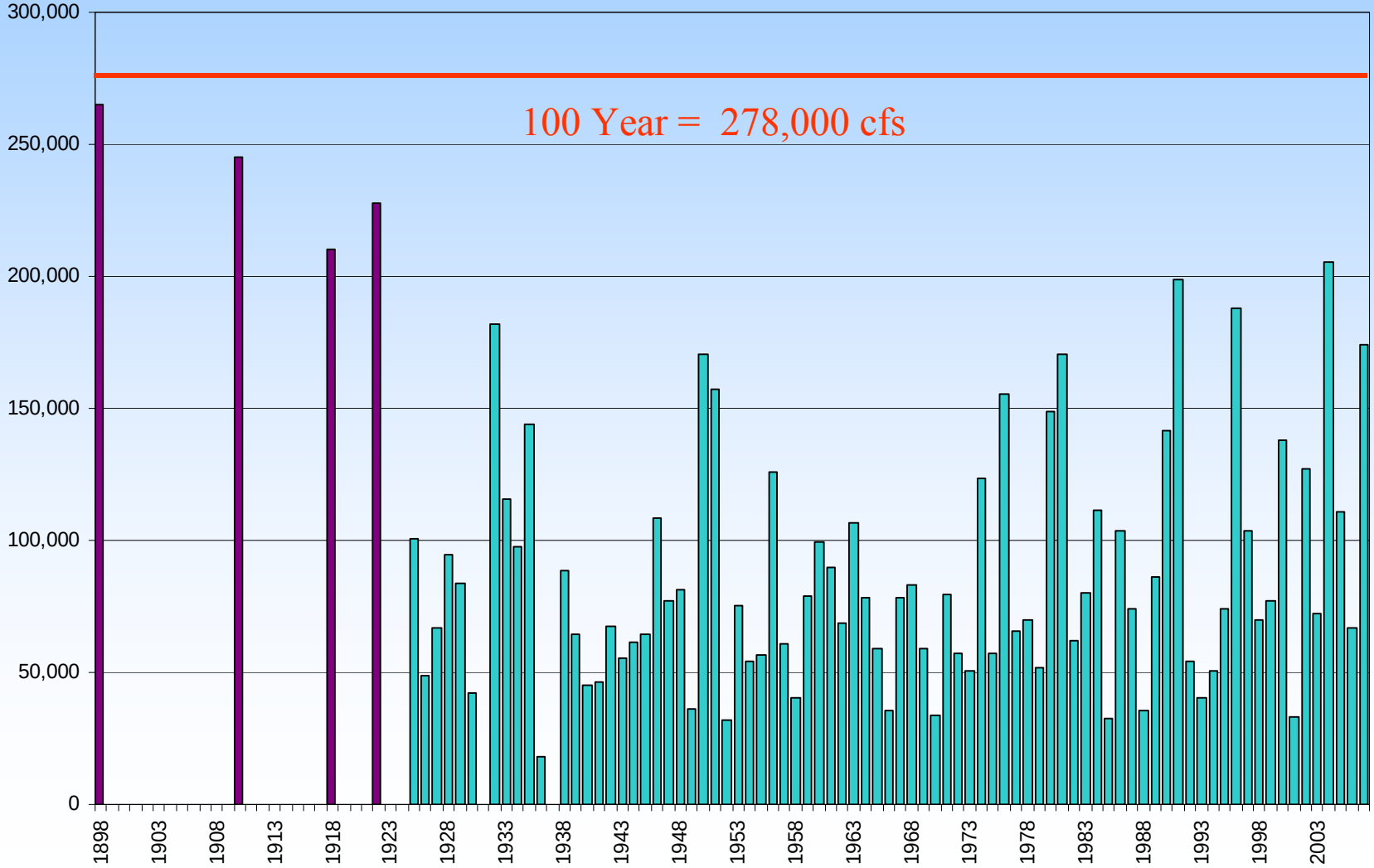


Winter Unregulated Annual Peak Flows Skagit River Near Concrete:

Draft PI Engineering July 2008



Skagit River Winter Unregulated Annual Peak Flows
Concrete – COE Frequency Distribution (April 2008)



Differences

- Historic peak flows
  - 1921: 173,700 (maybe 170,000)
  - 1917: 162,100
  - 1909: 183,000
  - 1897: 185,200
- 1932 165,000 (not 182,000)
- Peak to 1-day flow ratio 1.21 instead of COE's 1.18

Regulated Flows

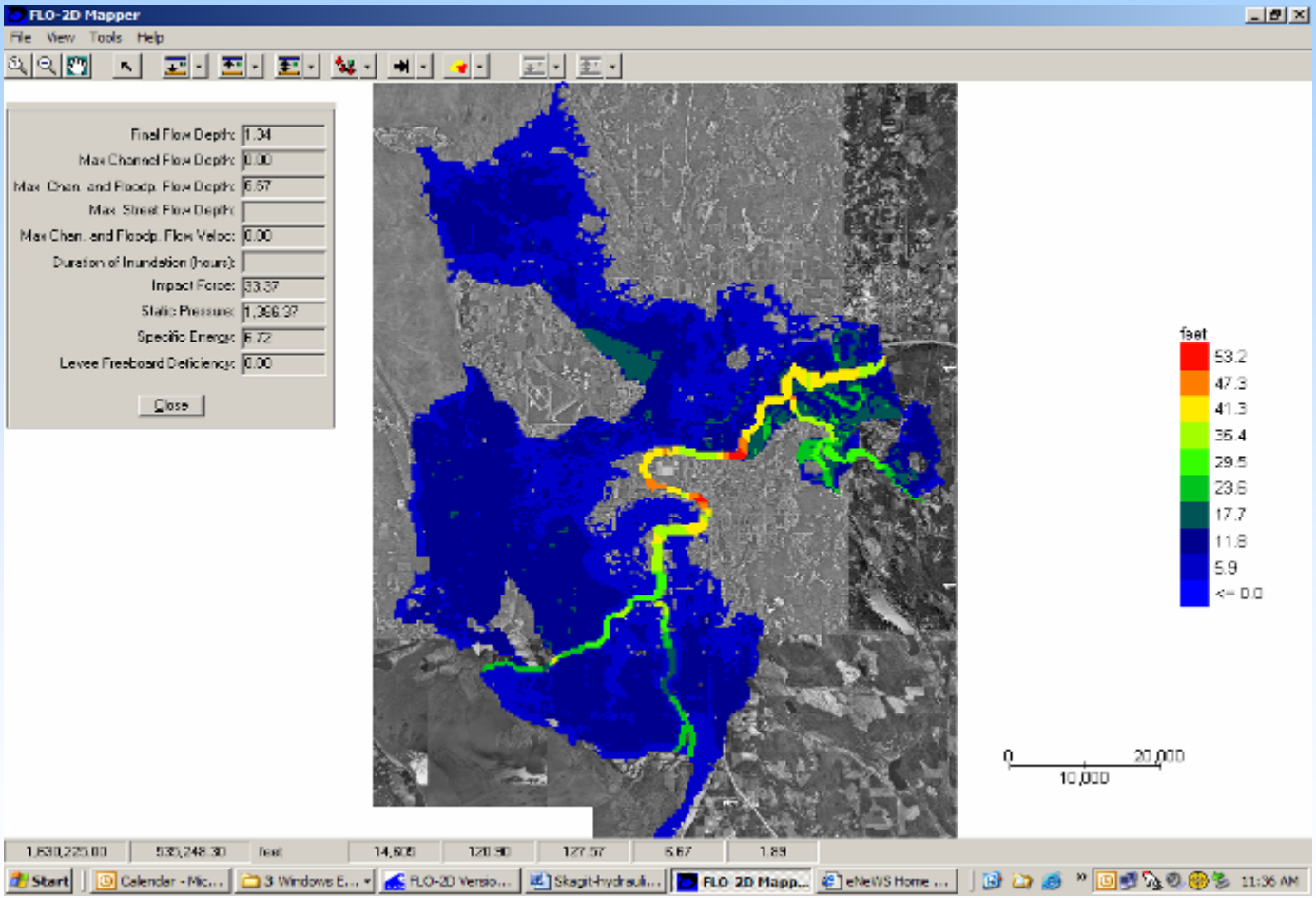
(COE Nov 05; PI Engineering Aug 07)

	Concrete	Sedro	MV
COE	226,400	234,820	221,510
PI Eng.	178,700	180,900	162,100

Note: COE numbers are expected to decrease slightly; PI Engineering numbers are expected to increase slightly

U.S. Army Corps of Engineers
Seattle District

SKAGIT RIVER BASIN, WASHINGTON
REVISED FLOOD INSURANCE STUDY
HYDRAULICS SUMMARY



SKAGIT COUNTY, WA

Prepared For: Federal Emergency Management Agency

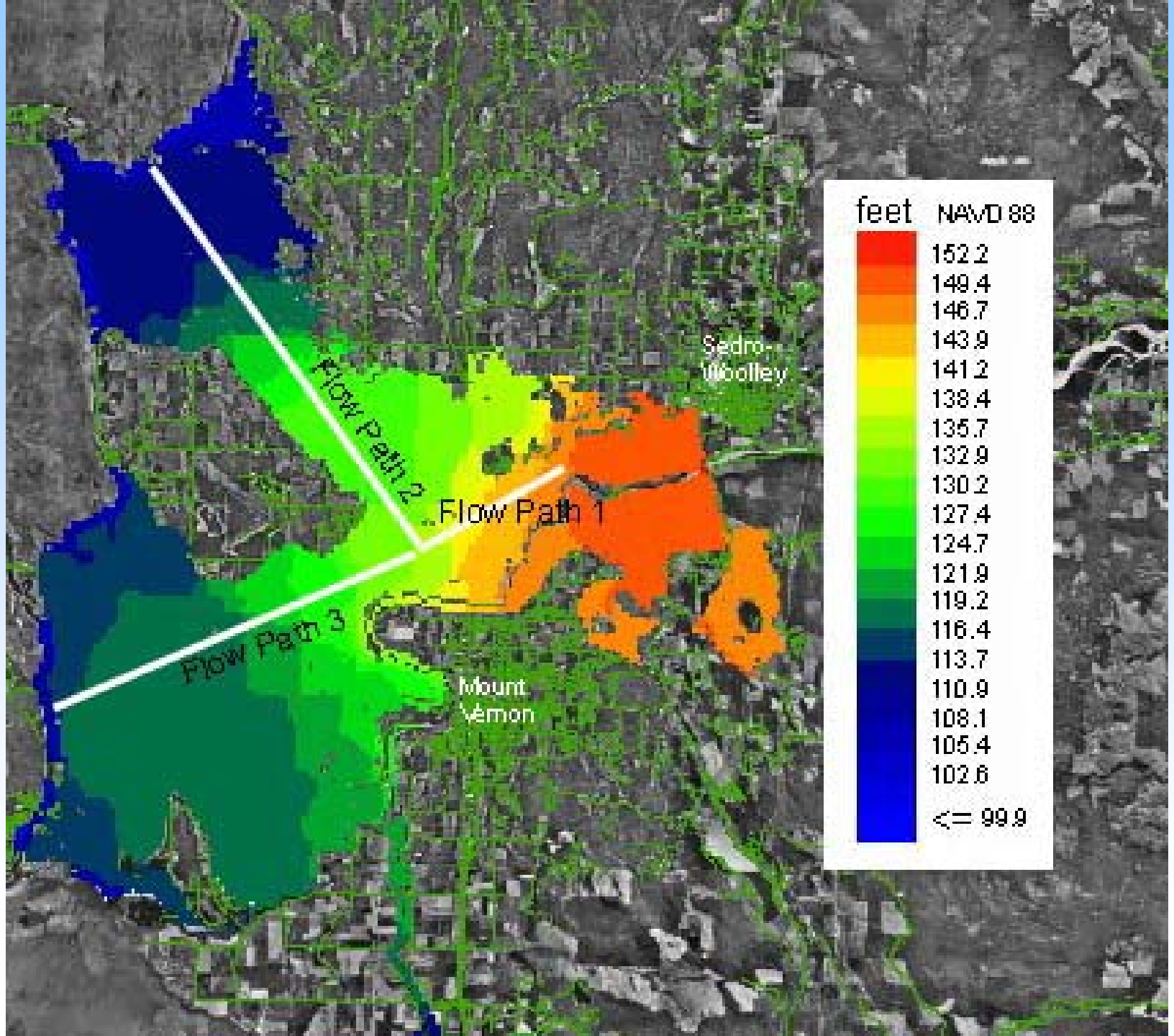
1 MAY 2008

The 1984 study did not finalize a floodway on the Skagit River downstream of Sedro-Woolley. A reason for this is the complexity in determining the proper positioning and methodology for this downstream floodway when using a one-dimensional model when flows can head north to Samish Bay, south to Skagit Bay and West to Swinomish Slough and Padilla Bay. With the development of the two-dimensional FLO-2D model for this study, a floodway analysis is possible.

There are two approaches that will initially be attempted for the floodway analysis. The first is similar to the upstream methodology where an attempt will be made to do an equal conveyance floodway surrounding the existing river channel. A second approach will look at routing the water through the most logical overbank flow paths and determine the level of encroachments that can be made around these. This work will be done in the next phase and is not a part of this release.

C. Floodplain Flow Paths

There are 5 floodplain flow paths that are used to develop water surface profiles in the overbank areas in the lower basin below Sedro-Woolley. Figures 24, 25, and 26 show the locations of these flow paths. These flow paths are delineated by attempting to follow the quickest drop to the sea which defines the most likely path the overbank flows will follow.


feet NAVD 88
152.2
149.4
146.7
143.9
141.2
138.4
135.7
132.9
130.2
127.4
124.7
121.9
119.2
116.4
113.7
110.9
108.1
105.4
102.6
<= 99.9
Flow Path 1
Flow Path 2
Flow Path 3
Sedro-Woolley
Mount Vernon

Next Steps

- Finalize hydrology report, based on current investigatory effort
- Finalize our work product (including the new base flood elevation maps based on the correct hydrology)
- Prepare for appeal of the FEMA flood maps

Questions?