Summary of the Skagit River Hydrology Technical Meeting
March 17, 2010
Alexandria, Virginia

A meeting was held on March 17, 2010 at the office of Michael Baker, Jr. in Alexandria, Virginia to discuss issues related to the estimation of four historic floods (November 1897, November 1909, December 1917 and December 1921) for the Skagit River near Concrete, Washington (station 12194000). Computations for the December 1921 flood were used to estimate the other three historic peak discharges so this meeting centered primarily on the peak discharge for the 1921 flood. The agenda for the meeting is given in the attachment.

The attendees at the meeting were as follows:

John Doyle, Town of La Conner, Washington
John Hunter, U.S. Army Corps of Engineers (USACE), Washington, DC
Steve Sexton, City Council Member, Burlington, Washington
Robert Mason, U.S. Geological Survey (USGS), Reston, Virginia
Siamak Esfandiary, Federal Emergency Management Agency (FEMA), Washington, DC
Kevin Long, Federal Emergency Management Agency (FEMA), Washington, DC
Lorna Ellestad, Skagit County Public Works Department, Mount Vernon, Washington
Albert Liou, Pacific International Engineering (PIE), Edmonds, Washington
Dan Berentson, Skagit County Public Works Department, Mount Vernon, Washington
Malcolm Leytham, Northwest Hydraulic Consultants (NHC), Seattle, Washington
Chal Martin, City of Burlington, Washington
Zhida Song-James, Michael Baker, Jr., Alexandria, Virginia
Ted Perkins, Federal Emergency Management Agency (FEMA), Bothell, Washington
Will Thomas, Michael Baker, Jr., Manassas, Virginia
Ray Martinez, Michael Baker, Jr., Alexandria, Virginia
Adam Lemieux, Congressman Rick Larsen's staff, Washington, DC

The attendee list with telephone numbers and email addresses is given in the attachment.

Approach for the Meeting

The approach for the meeting was for Skagit County, the City of Burlington and their consultants (NHC and PIE) to give presentations and this led to questions and discussion on the various issues. Prior to the meeting, PIE provided a Technical Memorandum titled "Review and Reevaluation of Skagit River 1921 Flood Peak Discharge" and NHC provided a report titled "Re-

evaluation of the Magnitude of Historic Floods on the Skagit River near Concrete – Revised Final Report". These documents were the basis for the presentations by PIE and NHC and supplemented previous reports provided by PIE and NHC namely:

- "Skagit River Basin Hydrology Report – Existing Conditions" dated October 2008 by PIE,
- "Re-evaluation of the Magnitude of Historic Floods on the Skagit River near Concrete – Final Report" dated October 2008 by NHC.

The presentations were very detailed and the discussions were extensive and it is not feasible to describe the presentations in detail. The objective of this summary is to define the new information that was presented and to summarize any decisions.

Presentation by Chal Martin, City of Burlington

Chal began the meeting by giving a brief history of the investigations undertaken by Skagit County and the City of Burlington for determining the peak discharges for the four historic floods and the roles played by PIE and NHC. Chal gave an overview of why the County and City think the USGS estimates of the four historic floods are too high. Peak discharges for the four historic floods were determined by James Stewart, USGS, in 1923, published by USGS in 1961, and revised by USGS in 2007.

Presentation by Albert Liou, PIE

Albert determined lower discharges for the four historic floods than those published by USGS in 2007 and he discussed several reasons why he felt his estimated discharges were more accurate. PIE's approach was to calibrate a HEC-RAS model to high water marks from the October 2003 flood and then to use this hydraulic model to estimate peak discharges for the historic floods using flood elevations determined by Stewart in 1922-23.

<u>Datum Issue</u>

The datum for the Upper Dalles Gage and the current gaging station is 142.69 feet (NGVD) as used by USGS and this is 1.8 feet higher than the datum (140.89 feet) used by Stewart during his 1922-23 field survey. Albert thinks the datum used by Stewart is correct and is using elevations of the high water marks as determined by Stewart in his HEC-RAS model. Albert presented a comparison of low-flow water surface elevations as surveyed by Stewart to similar events determined by a USACE survey in 1911 and low-flow water surface elevations as surveyed by Skagit County in 2008 and PIE in 2004. Based on information presented by Albert, the water-surface elevations determined by Stewart, based on a datum of 140.89 feet, agreed more closely with water-surface elevations as determined by others. Albert's conclusion was that the datum used by Stewart was correct and the USGS datum was 1.8 feet too high.

Comments on Stewart's Slope-Area Measurement

Stewart surveyed three cross sections and identified several high water marks in 1923 for the December 1921 flood and used these data in a slope-area measurement for a reach downstream of the current Concrete gaging station. Stewart's computations are given in Exhibit B of a report titled "Stage and Volume of Past Floods in Skagit Valley and Advisable Protective Measures Prior to the Construction of Permanent Flood Controlling Works", dated November 16, 1923. This report, as well as Stewart's 1922 field notes and Stewart's 1918 report, are on Larry Kunzler's web site under USGS Documents at http://www.skagitriverhistory.com/DirectoryV2.htm#USGS_Documents.

Albert provided comments on Stewart's slope-area measurement with respect to:

- Use of the incomplete energy equation that ignored the variation in velocity head between cross sections,
- Possible incorrect flow area for cross section 3,
- Unsupported water surface slope for the upper slope-area reach (cross section 1 to 2),
- Unknown quality of high water marks and the effect of surging on the high water marks.

Reevaluation of the 1921 Flood Peak Discharge

Albert described a re-computation of the slope area measurement using the complete energy equation, revised flow area for cross section 3, a revised water-surface slope for the upper slope-area reach, corrections to the high water marks for surging by subtracting 0.0 to 2.0 feet, and two different estimates of Manning's n value (0.033 and 0.0315). Using a surge adjustment of -0.5 feet, the December 1921 peak discharge ranged from 177,000 to 184,000 cfs as compared to 228,000 cfs as published by USGS in 2007.

Albert also estimated the December 1921 peak discharge using the stage-discharge relation at the Concrete gaging station by transferring Stewart's high water marks to the current gaging station and using stages or elevations inside the gage well. He estimated the December 1921 peak discharge as 178,000 cfs using this approach.

Albert also described his HEC-RAS analysis and development of a rating curve at the Wolfe Residence upstream of the Concrete gaging station. Using the HEC-RAS model and the high water mark determined by Stewart in 1923 based on the datum used for Stewart's survey , a peak discharge of 169,700 cfs was determined for the December 1921 flood. Notwithstanding the issue of the correct datum for Stewart's Dalles high water marks, this determination is independent of Stewart's slope-area study of the Dalles reach in 1922-23, because it is based on Stewart's twice-surveyed Wolfe residence high water mark near Concrete's Crofoot's Addition, compared to the stage-discharge relationship returned by the hydraulic model in the

Crofoot's vicinity. Albert considers this the best estimate of the December 1921 flood discharge for two reasons:

1. The two high water marks (1917 and 1921) surveyed by Stewart are in the Skagit River backwater area at the Wolfe Residence. These high water marks are not affected by the Baker River flow, not associated with any effects of flood flow surging, and are not associated with the Dalles gage datum.
2. The Baker River gage, located in the same backwater area less than a half mile from Stewart's high water marks, and the Dalles gage, located two miles downstream, provided stage and flow records to use in calibrating the hydraulic model. Due to a 10-hour time lag between the Baker and the Skagit River flood peaks, the Baker River gage readings include not only the Baker River flood stages, but also the backwater elevations of the Skagit River flood peaks.

Therefore, Albert considers the Wolfe residence stage-discharge rating developed by the HEC-RAS model to be very accurate.

Presentation by Malcolm Leytham, NHC

Malcolm also described sources of uncertainty in the Stewart/USGS slope-area measurement. His comments centered on the quality of the high water marks and the water-surface profile used by USGS. Malcolm provided the following comments:

- There is no clear tie between the field-surveyed high water marks and the actual slope-area computations used by Stewart and later by others,
- No data are available to provide absolute high water elevations between cross sections 2 and 3,
- The slope-area calculations are sensitive to WS profiles and there are other alternative water-surface profiles that could be drawn through the available high water marks in addition to the one used by USGS,
- High water marks from the November 2006 flood show a break in water-surface slope just downstream of cross section 2 and at the end of the gravel bar/island,
- Uncertainty in the slope-area measurement suggests that alternative approaches should be used to estimate the peak discharge for the December 1921 flood.

NHC also developed a HEC-RAS model for the Skagit River and calibrated this model to data from the October 2003 flood. NHC's modeling approach explicitly addressed the issue of uncertainty in head-loss through The Dalles. The HEC-RAS model was used to develop a rating curve at a Crofoot Addition residence. Using a high water mark determined from a newspaper account of the December 1921 flood, a peak discharge of 195,000 cfs was determined for this flood as compared to 228,000 cfs as published by USGS in 2007.

General Discussion

Extensive discussions occurred during the presentations noted above and after them. The following pertinent comments were made near the end of the meeting:

- Robert Mason, USGS, indicated that he would discuss the new issues with the Washington Water Science Center in Tacoma (particularly Mark Mastin) and determine if any new analyses were warranted. He made no promises that USGS would revise the historic peak discharges. He commented that FEMA and USACE can use any values for the historic peak discharges they think are reasonable. Robert also commented that USGS will request the PIE and NHC HEC-RAS models if they want them.
- John Hunter, USACE, commented that USACE uses a risk-based approach that considers the uncertainty in the 1-percent annual chance discharge. The flood frequency curve is just one input to their economic analysis. Uncertainty in the stage-discharge relation is also considered in the risk-based analyses.
- Will Thomas, Michael Baker, expressed surprise that Stewart's notes didn't identify more HWMs for the December 1921 flood particularly between cross sections 2 and 3. Participants also noted that the water surface profile used by Stewart "missed" all of the available HWMs as presented in the plot provided by NHC.
- Lorna Ellestad, Skagit County, mentioned that the County has a cooperative agreement with the USGS and asked if this agreement could be used to provide funding to USGS for the review of the hydraulic models developed by PIE and NHC. Robert Mason commented that USGS would request the hydraulic models if they decided to review them.
- Chal Martin, City of Burlington, asked if there was a process to get USGS to accept the PIE and/or NHC analyses for the historic peak discharges. Robert Mason commented that he was not aware of any process.
- Siamak Esfandiary, FEMA, commented that it was difficult to determine which approach, slope-area measurement or HEC-RAS modeling, is more accurate.
- Kevin Long, FEMA, agreed that FEMA would review the HEC-RAS models developed by PIE and NHC. Zhida Song-James, Michael Baker, will be the person performing these reviews.
- In response to comments from Ted Perkins about the occurrence of large floods on other rivers in the Pacific Northwest in the late 19th century and early 20th century, Malcolm Leytham asked whether Michael Baker, Jr. would be considering such regional information in its review of the revised estimates of the Skagit River historic floods presented by PIE and NHC. Will Thomas responded that this was something that had been looked into previously and it had been concluded that there was insufficient data to support a regional analysis.

- Lorna Ellestad, Skagit County, indicated the County had asked FEMA several questions about the H&H modeling for the Skagit River study and about the topography and LIDAR data. She indicated that the County would like responses to all previously submitted questions and issues documented in the PIE and NHC reports.
- Ted Perkins, FEMA, indicated that a Technical Memorandum was being prepared with responses to questions raised by the County and the City of Burlington. This Technical Memorandum will be provided with revised copies of the Preliminary FIRM. Ted also indicated that release of the revised Preliminary FIRM was held up pending the outcome of the March 17 meeting.
- Dan Berentson, Skagit County, commented that in December 2009 the Press Release about the Preliminary FIRM was received before the maps. He asked that the County get an opportunity to review the maps before they were distributed to the public.
- Ted indicated that a meeting will be held with community officials (without the public) to discuss the Technical Memorandum and the revised Preliminary FIRM.
- Lorna Ellestad and Chal Martin asked if the review period for the revised Preliminary FIRM could be extended to six months.

Skagit County and the City of Burlington offered to provide copies of all presentations given at this meeting. Several people commented that the meeting was worthwhile and there was a good exchange of information. Skagit County and Burlington thanked FEMA for hosting the meeting and for providing the wonderful homemade treats; and thanked all for attending and participating.

Will Thomas
Michael Baker, Jr.
March 30, 2010 – Revised April 5, 2010
Reviewed and supplemented by Skagit County and Burlington April 16, 2010
Final revisions accepted by meeting participants May 5, 2010

Attachment - Draft Agenda

Skagit River Hydrology Tech Conference
March 17, 2010
Washington, D.C.

Approach/Background

The purpose of this technical conference is to review analyses related to the historic Skagit River flood events, and find a consensus regarding the peak discharge of the 1921 flood.

The proposed approach will be to look in detail at three methods of estimating the 1921 flood peak:
1) the slope-area method as used in Stewart's original 1922-23 field work and subsequently reevaluated by the USGS and Pacific International Engineering;
2) extension of the stage-discharge rating at the current gage; and
3) a hydraulic modeling approach developed by both Northwest Hydraulic Consultants and Pacific International Engineering.

Time	Topic	Presenter
8:00 a.m.	Introductions and material handouts	Long/Martin
8:15 a.m.	Background: - indicators that historic peak estimates were too high - current position of USGS, Corps of Engineers, and FEMA	Martin
8:45 a.m.	Questions / Discussion about the Background topics	All
9:00 a.m.	Stewart / USGS Slope Area Discharge Estimates - Stewart's original approach (field surveys and calculations) - Mastin's reevaluation - Evaluation of uncertainty o Reliability and interpretation of high water marks o Datum of Stewart's high water marks o Manning's "n" value o Geometry of lower slope section o Incomplete energy equation o Hydraulic grade line o Surge - Conclusions / uncertainty regarding likely range of 1921 peak discharge based on slope/area methodology	Liou/Leytham
9:45 a.m.	Using stage/discharge rating to reevaluate the 1921 peak discharge - Transfer of Stewart's 1921 high water marks - Surge estimate - Plotting on stage/discharge extension - Conclusions / uncertainty regarding likely range of 1921 peak discharge based on stage/discharge rating	Liou
10:00 a.m.	Questions / Discussion regarding slope/area and stage/discharge methodologies	All

10:20 a.m. Break

10:45 a.m. Hydraulic Modeling methodology to estimate 1921 flood peak — Leytham / Liou

- Basis of hydraulic models; calibration
- Crofoot's information
- Newspaper accounts / Stewart's high water marks
- Conclusions / uncertainty regarding likely range of 1921 peak discharge estimates using HEC-RAS models and Crofoot's information

11:15 a.m. Other data points

- Spill channel above The Dalles
- Others? 1921 HWMs in Hamilton reported by Stewart, GNRR, County, etc.

11:30 a.m. Questions / Discussion regarding hydraulic modeling methodology to estimate 1921 flood peak/Other data points — All

12:00 p.m. Lunch

1:00 p.m. Discussion: reducing uncertainty, element-by-element. Catalog discussion. Results to include specific areas of agreement or disagreement; whether agreement could be reached if additional information was available; and, if so, what additional information is needed. — All

- Slope/Area study
  - Reliability of high water marks.
  - Datum issue: what is the datum of Stewart's high water marks?
  - Surge
- Extension of the stage/discharge rating
  - Transfer of Stewart's high water marks – head loss through the Dalles
  - Surge
- HEC-RAS model and Crofoot's investigation
  - Hydraulic model(s) acceptability
  - Approaches to characterize uncertainty in hydraulic models.
  - High water marks to use for 1921 event?
  - Relative merits of hydraulic modeling and slope/area methodology
- Other approaches to handling uncertainty (EMA)

3:00 p.m. Break

3:20 p.m. Continued discussion; develop strawman list of elements of agreement/consensus

4:00 p.m. Continued discussion and list of elements of agreement / disagreement

4:30 p.m. Next steps, possible additional discussion agenda for smaller work group on Thursday

5:00 p.m. Adjourn

Skagit River Meeting
March 27, 2020

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