United States Department of the Interior

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Mr. Larry Kunzler
[redacted]

Dear Mr. Kunzler,

First, we want to offer you sincere thanks for all the thoughtful work and study you have put into your evaluation of the historic flood peaks along the Skagit River, Washington. It is always important to be reminded of the significance and importance of these kinds of data, and we are happy to review our current thinking about these flood peaks.

The work situation of Stewart is worth mentioning, as it is unusual in the USGS–an employee who was working on a project, then left the organization but continued to work on that project, and the fact that the work would go unpublished for such a long time. It is important to realize that the USGS does not have the resources under the cooperative streamgaging program to carry out extensive historic investigations of streamflow data without having additional funding through a partner cost-share. This may have been the reason the original investigations remained unpublished for so long.

The “Stewart Reports” of 1918, 1923, and any others prior to U.S. Geological Survey Water-Supply Paper (WSP) 1527 (Stewart and Bodhaine, 1961) are drafts of the final Skagit River floods report. As such they reflect the changing thoughts, ideas, and interpretations of a hydrologist as new data and evidence became available. This is the life history of any USGS report–drafts, colleague review, revisions, reinterpretations, final reviews, then publication. It is not unusual for interpretative data, such as flood magnitudes, to evolve throughout this process. As drafts, these documents are not subject to FOIA and should not have been included in the archived materials. First and second drafts of reports are rarely saved. USGS WSP 1527 is the official USGS document concerning the flood history of the Skagit River and states the USGS position as understood in 1961. Data in this document are the only data which the USGS supports.

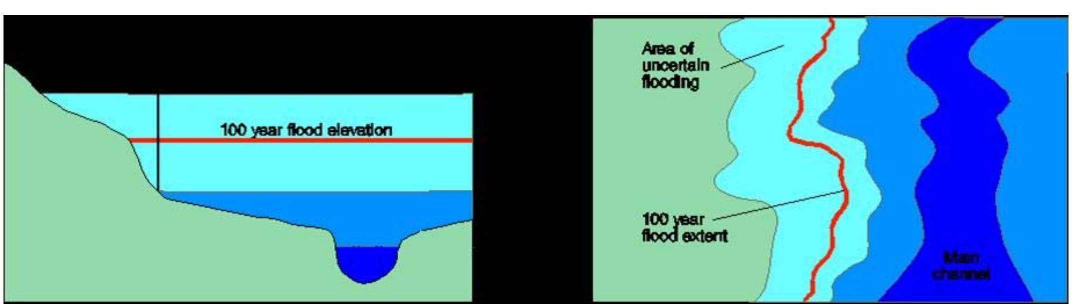
Below, we’ll try to follow the Conclusions section of your report with information and comments that we hope will be helpful.

1. Estimates of flood frequency can change over time as more data are collected. This may be the case in the Skagit River. In 1918, Stewart estimated that floods approaching the magnitude of the 1897, 1909, and 1917 floods—which ranged from 220,000 to 275,000 cubic feet per second (cfs) in the Skagit River near Concrete—could be expected on an average of once in 10 years. However, using the current (2004) flood frequency analysis computed by the U. S. Army Corps of Engineers for unregulated flows at Concrete (Ted Perkins, USACE, written communication), the same magnitude of floods would have a recurrence interval ranging from 30 to 75 years. The current flood-frequency analysis includes an additional 59 flood peaks that have been recorded since 1918, when Mr. Stewart derived his estimates. The occurrence of flooding of a given magnitude is affected by several processes, including changes in climate, land use, and streamflow regulation. Streamflow in the Skagit River Basin, including peak flood flows, has been affected by regulation since 1926, when a dam was constructed on the Baker River. On the main-stem Skagit River, Diablo Dam has been in place since 1930 and Ross Dam since 1940.

2. Flood hydrology is not an exact science and results cannot be viewed as absolute numbers. Precise solutions for individual flood peaks, or flood frequencies, are not possible because it is impossible to measure all the variables that contribute to peak discharge in natural systems. These variables include estimates of flow roughness, lateral variations in velocity head, stability of cross sections, surges in unsteady flows, occurrence and non-occurrence of debris dams, and the presence and accuracy of high-water marks. All directly measured and computed flood peaks have error bars associated with them, which reflect the uncertainty in the data. A difference of 30,000 cfs in a flood peak that is estimated or measured to be 200,000 cfs is about 15 percent. In the USGS all flow measurements and computations are assigned an estimated accuracy rating, depending on how difficult the field conditions or uncertain the assumptions (Benson and Dalrymple, 1967). Those estimated ratings are:

   Good – reported value expected to be within 10 percent of the real value
   Fair – reported value expected to be within 15 percent of the real value
   Poor – reported value may be a least 25 percent different than the real value

   A rating of poor does not reflect the quality of work done but is simply a descriptive term that we use to describe estimates that have a 25 percent uncertainty or greater. We do not refrain from reporting flood data because the measurement is difficult or has uncertainty–we try to provide the best number possible under existing conditions, within a probable error. See the figure below. The light blue area on either side of the 100-year-flood elevation is the area of uncertain flooding bracketing the number reported.



3. The flood frequency for different locations along the Skagit River is computed by the U.S. Army Corps of Engineers with data from the USGS. Their most recent frequency curves do not use the USGS peaks for 1815 and 1856, so much of your concern about those peaks seems moot. But we will say that the USGS rating curve for the Skagit River at Concrete reflects a very stable bedrock channel in which extrapolation of the rating to Stewart's reported stages of the earliest floods would produce discharge estimates very close to the reported values in WSP 1527.

4. Please see the third paragraph of this letter.

5. If one looks at the historical flood series for the Skagit River near Concrete, WA, there are six historical floods (1815, 1856, 1897, 1909, 1917, 1921) prior to systematic streamgaging that began in 1924.

   Based on uncertainty in the timing of the 1815 and 1856 flood events and the fact that neither settlers nor USGS employees were present to document these events shortly after their occurrence, all discharges for the 1815 and 1856 events in WSP 1527 are now rated poor and indicated as estimates in the USGS Peak Flow File.

   The basis for the remaining flood peaks at Concrete–1897, 1909, 1917, and 1921—are recounted here. From reading some of the memoranda at the time that WSP 1527 was written and from looking at the current rating for Skagit River near Concrete, it appears that the discharges for the 1897, 1909, and 1917 floods were determined by extending the current rating at the time through the 1921 measurement computed by Stewart using standard practices of indirect-discharge measurements: the contracted-opening method and the slope-area method. In 1952, an n-verification computation for the same flood computed a discharge that was 6.2 percent less than the discharge computed by Stewart. The n-verification value adds credibility to Stewart's computation, that it is a good computation of discharge. Revisions of peak flows are made when a proposed revised discharge is more than 10 percent different from the original value; therefore, no revision was made based on the n-verification study nor is there now a good reason to revise it or the other peaks. The current rating for the Skagit River near Concrete is based on more recent discharge measurements and extended by a straight-line. One could argue that the current rating should go through the 1921 measurement or the revised n-verification computation. However, since the current rating has been constructed, the highest flow has only reached 166,000 cfs, with recent current-meter measurements as high as 138,000 cfs; therefore, a straight-line extension of the current rating is a reasonable method to determine peak flows. Using the current rating, the 1921 peak discharge is 10.4 percent less than the published value, and the other peaks have nearly the same percent differences (differences range from 9.5 to 11.9 percent less).

6. The occurrence of log jams during large floods along the upper Skagit River is certainly possible. Even if debris jams impact the reported peak discharges, they are considered a recurring natural process uncontrolled by humans and regularly reflected in the size of floods downstream. You can't subtract the impacts of events that may or may not occur

from flood to flood. The USGS integrates the impacts of upstream recurring natural processes by reporting the actual stages and related discharges that are recorded at streamgaging stations.

7. We have long recognized that tributaries of the Skagit River drain Glacier Peak and Mount Baker, two Cascade Range volcanoes. We actively monitor and study the Cascade Range volcanoes at the USGS Cascades Volcano Observatory in Vancouver, WA. There is no record of volcano-generated flows from Glacier Peak reaching the Skagit River in the last 5,000 years (Waitt and others, 1995; Beget, 1982). Kevin Scott, a research scientist at the Cascades Volcano Observatory, presented a paper at the annual meeting of the Geological Society of America last fall (Scott and Tucker, 2003). In this abstract, he reports that Sherman Crater, an active vent below the summit of Mt. Baker, generated small hydrovolcanic eruptions in 1843, 1858, and 1859. Highly altered rock from the crater rim failed and generated volcanic debris flows (lahars) that inundated the Baker River valley. Kevin Scott believes these lahars may have temporarily dammed the Baker River; however, he does not believe the lahars could have caused the magnitude of flooding suggested by high marks found downstream along the Skagit River.

8. It is not common practice for qualified hydrologists and engineers to have another person follow them into the field and verify routine measurements. This would make much of surface-water hydrology prohibitively expensive. That said, the lack of documentation does not mean that it was not done. Field trips with colleagues to show progress and results are the rule in the USGS, and these trips are not logged or documented anywhere where they would be archived.

9. The field estimation of Manning's n is very important for indirect discharge calculations and one of the largest sources of uncertainty. In the review of flood records, it is not unusual for other reviewing hydrologists to adjust or alter a roughness coefficient based on their own experiences. As large floods are measured directly by current meter, as was done at the Skagit River near Concrete gage in 1932, the n-values for the channel can be further refined.

10. In WSP 1527, the November 1949 flood is used as an example of a "short-duration" flood event where the flood crest or peak discharge is reduced as it moves downstream. During the November 1949 flood, the peak discharge at Concrete was 154,000 cfs, and further downstream at Mount Vernon the peak was only 114,000 cfs. The USGS has never reported a November 1949 flood peak discharge for Sedro Woolley, located between Concrete and Mount Vernon, most likely because the gage was not in operation in 1949.

11. We do not think there is any dilemma concerning the rainfall data for the November 1990 floods. The reported rainfall data are point data, but floods integrate rainfall from the entire basin plus any snowmelt. It could well have rained much harder in the hills around Reflector Bar in 1921 than at the point where the rain was recorded. This would not be unusual.

12. Hand levels were a common instrument of the day; and, even if Stewart's readings were in error by 6 inches (a very large error, even for a hand level), a stage of 56.6 or 56 feet for the Skagit River at Concrete would not change the flood peak discharge significantly. He was not leveling a building but was trying to measure the height of flood stains on trees. He is very likely correct to a few inches; certainly within 6 inches. Remember there is an error bar around all flood estimates, which could be as large as 25 percent or more.

13. Given that there is a limitation to fiscal and technical resources for any scientific investigation, it is common practice for USGS scientists to try and complete reports within set deadlines. In order to complete a report limited by fiscal and time restraints, the USGS may reduce the scope of a report, but it does not condone the lowering of research standards in order to stay within deadlines. The high quality of USGS data, analysis, and publications is paramount and must be upheld.

James Stewart did far more work on the flood history of the Skagit River basin than was required or that would have been done by most hydrologists or engineers of the day. He continued to work on the flood history, without pay, even after he moved to the other end of the country. As late as 1950, he was trying to get data to verify his estimates of flow roughness for the 1921 flood at Concrete. The USGS would find it difficult to label his efforts as sloppy or not careful, since it was something in which he had invested so much time and effort. He applied some approaches that were novel during his time to extend the flood record and improve the estimates of flood frequency, but these methods are certainly are not inappropriate or novel today. He was one of the first hydrologists to realize that the natural system around a river preserves evidence of the past history of the river. This evidence includes botanical as well as sedimentological data. The science of paleoflood hydrology has evolved in the last few decades to use these kinds of data. Stewart's work was among the earliest, but certainly not the last. A good history of the use of "more than just flow data from gaging stations" is "A History of Paleoflood Hydrology in the United States 1800-1970" by John E. Costa and published by American Geophysical Union (1986). Costa cites Stewart's work on the Skagit River as an early example of the application of this approach. The National Research Council recognizes the use of paleoflood hydrology in their report "Estimating probabilities of extreme floods" (1988). Paleoflood hydrology is defined by the National Research Council as "…the study of the movements of water and sediment before the time of continuous measurement by modern hydrologic procedures." (p. 105).

Taken in context of the time, James Stewart was ahead of the field and upheld the highest standards of effort, commitment, and creativity that define the U.S. Geological Survey.

Sincerely,

Cynthia Barton

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