Skagit Levee Failure Scenarios

- Challenges of Defining Levee Failures
- FEMA Regulations
- Implementation of Regulations
- Comparison to Actual Observations
Past Skagit River Levee Failures
Isolated Levee Failures
Systemwide Levee Failures
General FEMA Levee Failure Policy

Guidelines and Specifications for Flood Hazard Mapping Partners

Appendix H: Guidance for Mapping of Areas Protected by Levee Systems

http://www.fema.gov/library/viewRecord.do?id=2206
General FEMA Levee Failure Policy

- If the subject levee does not meet the requirements stated in Section 65.10 of the NFIP regulations, as verified by the RPO, the Mapping Partner shall recompute the 1-percent-annual-chance flood elevations as if the levee did not exist.

(page H-11)
One Levee System

WITHOUT LEVEE

WITH LEVEE

SINGLE LEVEE
General FEMA Levee Failure Policy

- The above procedures for the determination of BFEs and regulatory floodways also apply to the conditions where levees exist on both sides of the stream. In these cases, the evaluation shall include the possibility of simultaneous levee failure, failure of only the left side, and failure of only the right side, and shall consider simultaneous levee failure for both the BFE and regulatory floodway computations. The Mapping Partner shall contact the RPO for guidance on the evaluation of levee systems under these circumstances.

(page H-12)
Levees on Both Sides of the River

WITH LEVEE

WITHOUT LEFT LEVEE

TWO LEVEES

WITHOUT RIGHT LEVEE
Levees Inundated

WITHOUT LEVEES

LEVEES INUNDATED
General FEMA Levee Failure Policy

• For levee systems where an area of land may be totally or partially surrounded by levees or where two or more flooding sources join that have levees on both sides of the stream, the Mapping Partner that is performing the analysis shall contact the RPO before proceeding with any analyses for levee failures. For these complex situations, the flood hazard in the area that would have been protected by the non-failed levee(s) must be based on selection of failure scenarios that yield the highest BFE or flood hazard.

(page H-12)
Surrounded by Levees
Chosen Scenarios for Skagit River Floodplain Mapping

Scenario
- All Levees Intact (Figure 3)
- Left Bank Levees Removed (Figure 4)
- Fir Island Levees Removed (Figure 5)
- South Fork Right Bank Levee Removed (Figure 6)
- North Fork Left Bank Levee Removed (Figure 7)
- Right Bank Levees Removed Except South Fork (Figure 8)
- Left Bank Levees Removed Except North Fork (Figure 9)
All Levees Intact

Grid Element Max Combined Channel and Floodplain Flow Depth
Right Bank Levees Removed
Burlington to Samish and Padilla Bays
Dark Blue Area
Right Bank Levees on Mainstem and North Fork Skagit River Removed While All Other Levees Remain Intact
Right Bank Levees on Mainstem and North Fork Skagit River Removed While All Other Levees Remain Intact
Flowpath 1 Burlington Area (Page 60)
Levee Failures 1917

Major Dike Failures
Lower Skagit River Basin
Washington

LEGEND:
- [Legend items]

DATA SOURCE:
[Data source details]

100 YEAR FLOOD:
[100 Year Flood information]

[Map showing major dike failures in the Lower Skagit River Basin, Washington]
Levee Failures 1917
Burlington 1917
Levee Failures 1909 and 1921
Levee Failures 1909
Newspaper Documentation
Burlington

- Concrete Herald 12/17/1921
  “The entire city of Burlington was flooded to a depth of from three to five feet”
  Concrete Flow = 240,000 cfs

- Skagit County Courier 12/2/1909
  “The water broke the dykes guarding Burlington and almost the entire town was flooded. In the residence districts the water was over eight feet deep in places.”
  Concrete Flow = 260,000 cfs
Flowpath 2 Samish Area (Page 61)
Newspaper Documentation
Samish

• Mount Vernon Argus 12/15/1921

“In some of the houses in the Samish flats, water was 6 or 7 feet and the occupants were forced to move to the second story.”

Concrete Flow = 240,000 cfs
Left Bank Levees Removed
Mount Vernon to Stanwood
Brown Area

Chosen Scenarios for Skagit River Floodplain Mapping

- All Levees Intact (Figure 3)
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- Fir Island Levees Removed (Figure 5)
- South Fork Right Bank Levee Removed (Figure 6)
- North Fork Left Bank Levee Removed (Figure 7)
- Right Bank Levees Removed Except South Fork (Figure 8)
- Left Bank Levees Removed Except North Fork (Figure 9)
Left Bank Levees on Mainstem and South Fork Skagit River Removed While All Other Levees Remain Intact.
Left Bank Levees on Mainstem and South Fork Skagit River Removed While All Other Levees Remain Intact
Left Bank Levees on Mainstem and South Fork Skagit River Removed While All Other Levees Remain Intact
Levee Failures 1951
Mount Vernon Argus 12/15/1951

“Conway residents declared the 1951 flood was two feet, 10 inches below the 1921 inundation in their community…”

Concrete Flow = 139,000 cfs
Mount Vernon Flow = 144,000 cfs
Fir Island
Red, Pink and Light Blue Areas

Chosen Scenarios for Skagit River Floodplain Mapping

<table>
<thead>
<tr>
<th>Scenario</th>
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<tbody>
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<td>All Levees Intact (Figure 3)</td>
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Fir Island Levees Removed While All Other Levees Remain Intact
Fir Island Levees Removed While All Other Levees Remain Intact
South Fork Skagit River Right Bank
Levee Removed While All Other Levees Remain Intact
South Fork Skagit River Right Bank Levee
Removed While All Other Levees Remain Intact

Grid Element Maximum Flow Depth
North Fork Skagit River Left Bank
Levees Removed While All Other
Levees Remain Intact
North Fork Skagit River Left Bank Levees Removed While All Other Levees Remain Intact

Grid Element Maximum Flow Depth
Fir Island Flowpath
Flowpath 4 Fir Island Area (Page 65)
Fir Island 1949 Flood
Fir Island 1990 Flood

Major Dike Failures
Lower Skagit River Basin
Washington

LEGENDS
- Dike
- Flood of Unknown Elevation
- River Valleys
- Delta

DATA SOURCE
- USGS
- Washington Department of Ecology

100 YEAR FLOOD
- 100-Year flood elevations were derived from a combination of FEMA flood insurance rate maps (FIRMs) and USGS stage data.
- Fir Island dike elevations were derived from Fir Island topographic maps.

1000 YEAR FLOOD
- 1000-Year flood elevations were derived from a combination of FEMA flood insurance rate maps (FIRMs) and USGS stage data.
- Fir Island dike elevations were derived from Fir Island topographic maps.

10000 YEAR FLOOD
- 10000-Year flood elevations were derived from a combination of FEMA flood insurance rate maps (FIRMs) and USGS stage data.
- Fir Island dike elevations were derived from Fir Island topographic maps.

GEODETIC CONTROL
- All flood elevations were computed using a 2003 Alaska-Kansas StatePlane Coordinate System (ASPC) with the 1983 World Geodetic System (WGS) ellipsoid.

REFERENCES
- FEMA: Flood Insurance Rate Maps (FIRMs)
- USGS: Topographic Maps
- Washington Department of Ecology: Flood Insurance Rate Maps (FIRMs)
Workers have punched a hole in a dike to drain flooded Fir Island but water from the raging North Fork of the Skagit River is filling the island faster than the water can leave...Water is reportedly as deep as 10 feet...That break sent a wall of water 10 feet high over fertile farm land...Waves were 8 to 10 feet high...He estimates he has 9 to 10 feet of water at his house.”

Concrete Flow = 149,000 cfs
Mount Vernon Flow = 142,000 cfs
Big Bend Area
Yellow Area

Chosen Scenarios for Skagit River Floodplain Mapping

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- Right Bank Levees Removed Except
  - South Fork (Figure 8)
  - Left Bank Levees Removed Except
  - North Fork (Figure 9)
All Left Bank Levees Removed with Right Bank Levees Intact
1917 Levee Failures
Newspaper Documentation
Big Bend – North Mount Vernon

• Burlington Journal 1/4/1918
  “The Riverside district south of the river on the Pacific highway to Mt. Vernon’s limits suffered...The highway was under from **two to ten feet** of water...”

• Mount Vernon Herald 1/3/1918
  “The Riverside section was badly hit, in some places as much as **fifteen feet** of water covered the ranch property.”

Concrete Flow = 220,000 cfs
Questions/Comments/Concerns?

[Image of people standing in floodwater, flooded street with houses and power lines in background, text '10, ca. 19-1921']