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# Skagit River Flood Damage Reduction Study



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## Preliminary Measures Presentation *Aug. 18, 2008*



Floodwater 1921 Fairhaven Looking East  
1921 Flood 02 - Fairhaven.jpg

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# Introduction

- Preliminary measures are required by the Corps planning guidance - ER-1105-2-100.
- Six-Step Planning Process:
  1. Problems and Opportunities (Needs)
  2. Baseline conditions
  3. **Measures - small stand-alone projects**
  4. Alternatives - combinations of measures
  5. Optimization of Alternatives - level of protection, total costs
  6. Recommended plan (35% design)



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# Presentations

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- Hydrology/Hydraulics Measures Presentation 2007.
- Measures Evaluation August 2008.
- Alternatives Evaluation 2009.
- Other: environmental scoping, workshops for public/stakeholder input, tribal/agency meetings, diking district meetings.



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# Corps Guidance



- 
- Engineering Regulation ER-1105-2-100.
  - Executive Order 11988 - not encourage development of floodplains; protect natural floodplains.
  - Water Resources Development Act (WRDA) 1986, Section 204 - Requires local sponsor to be in conformance with federal flood programs (insurance, floodplain management plans).
  - WRDA 2007 - Revised Corps guidelines to protect floodplains, prevent imprudent use of floodplains, fully mitigate for impacts, consider basin-wide solutions — not just levees and dams.



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# Purpose of Screening



- Identify projects by most protection and least cost (based on very general information).
- Prioritize projects based on costs, environmental and social issues.
- Focus money, resources and time on most likely solutions.
- Identify needs for further technical analysis.

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# Screening of Measures



- 
- Big price items – construction costs, real estate.
  - Damages each would prevent.
  - Benefits–to–cost ratio (B/C).
  - Environmental, risk/safety and engineering issues.



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# Not Included

- 
- In depth environmental analysis of impacts.
  - Social and cultural impacts.
  - Operation and maintenance costs.
  - Mitigation requirements (environmental, flooding).
  - Modifications to infrastructure (i.e. bridges, roads, relocations, pump plants).
  - Real estate for ring dikes.
  - Relocations
  - Optimization of level of protection.

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# Source of Measures



- 
- Workshops, Flood Control Meetings
  - Diking districts, tribes, agencies, stakeholders
  - Historic (2001 studies)
  - General public
  - Engineers and consultants
  - County



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# Categories of Measures



1. Hold back flood water - dams
2. Get floodwater out of river- bypass
3. Enlarge channel - dredging, natural valley storage and setbacks
4. Keep river in bounds - levees
5. Let river flood, remove damages - relocations, floodproofing and evacuation plans



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# Previously Screened Out Measures



- New dam(s) on the Sauk River:
  - National designation as Wild and Scenic.
- Dredging:
  - 60 million cubic yards (cy) of material would have to be removed from mouth to Sedro-Woolley.
  - Initial dredging cost would be ~\$300 million (based on \$5/cy estimate).
  - Re-dredge every three years at 100% local cost.
  - Impacts to endangered species.



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# Measures



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## Modifications to Existing Dams

### *Operational Changes*

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# Measure 1 Upper Baker Dam



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# Measure 1

## Upper Baker Dam



- Description: All Upper Baker measures address changes in operation of the existing project. Major structural changes (i.e. building a new dam with more storage) was not economically or environmentally feasible.
- Measures assume closing off flow from dam to 0 cubic feet per second (cfs) during peak of storm event. Variations are based on size of reservoir storage area behind existing dam.
- Current authorized flood project is for 74,000 acre feet of storage, with 5,000 cfs of outflow during flood event.
- Flood control authority starting in November.



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# Measure 1 Upper Baker Dam



- Preliminary Construction Costs: \$0
  - Does not account for any structural changes that may be necessary.
  - Does not include maintenance or mitigation costs.
  - Any additional dam maintenance would be a 100% local sponsor cost.
  - Compensation for hydropower losses are a local sponsor responsibility.
  - B/C ratio will be developed when the Federal Energy Regulatory Commission (FERC) issues are resolved.



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# Measure 1 Upper Baker Dam



- Sub-measures:
  - Measure 1A – 74,000 acre-feet with 0 cfs outflow
    - Damages prevented\*: \$6 million
  - Measure 1B – 85,000 acre-feet with 0 cfs outflow
  - Measure 1C – 100,000 acre-feet with 0 cfs outflow
    - Damages prevented\*: \$9 million
  - Measure 1D – 110,000 acre-feet with 0 cfs outflow
    - Damages prevented\*: \$9 million

*\*Annual expected damages*



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# Measure 1

## Upper Baker Dam



### Potential Advantages

- Reduces flood flows for more frequent, smaller flood events.

### Potential Disadvantages

- Increases flood flows for larger flood events (i.e. Sedro-Woolley).
- Impacts to endangered species.
- Hydropower losses.
- Must meet new Corps HQ structure and design requirements.
- Issue resolution of FERC Probable Maximum Flood (PMF) required for Corps HQ to consider this measure (may take years).
- Only reduces flows from 15% of total inflow to mainstem).



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# Measure 2 Lower Baker Dam



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# Measure 2

## Lower Baker Dam



- Description:
  - Evaluated changes in operation of the existing project. Major structural changes (i.e. building a new dam with more storage) are not economically or environmentally feasible.
  - Measures assume closing off flow from dam to 0 cfs during peak of storm event. Variations based on size of reservoir storage area behind existing dam. Existing condition is all inflow passes its outflow.
  - Measure not feasible for Corps implementation. Cannot predict floods with high enough certainty to qualify for authorization.



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# Measure 2

## Lower Baker Dam



### Potential Advantages

- Can be done under informal basis by Puget Sound Energy in appropriate flood events on case-to-case basis.

### Potential Disadvantages

- Limited storage capacity.
- Limited outflow capacity.
- Hydropower losses.
- Must meet new Corps HQ structure and design requirements (not likely).
- Requires perfect ability to predict timing and magnitude of storm events to be Federally authorized. State of the art for forecasting not adequate.



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# Measure 3 Ross Dam



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# Measure 3 Ross Dam



- Description:
  - All Ross Dam measures address changes in operation of the existing project. Major structural changes (i.e. building a new dam with more storage) are not economically or environmentally feasible.
  - Measures assume closing off flow from dam to 0 cfs during peak of storm event. Variations based on size of reservoir storage area behind existing dam. Current outflow during peak is 0-5,000 cfs.
  - The Corps has authorization for flood control storage of 120,000 acre-feet.
  - Authorized timing is for full storage Dec. 1. Measure assumes full storage available Oct. 15.



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# Measure 3 Ross Dam



- Preliminary Construction Costs: \$0
  - Does not account for any structural changes that may be necessary.
  - Does not include maintenance or mitigation costs.
  - Any additional dam maintenance would be a 100% local sponsor cost.
  - Compensation for hydropower losses are a local sponsor responsibility.



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# Measure 3 Ross Dam



- Sub-measures:
  - Measure 3A – 150,000 acre-feet with 0 cfs outflow
    - Damages prevented\*: \$2 million
  - Measure 3B – 180,000 acre-feet with 0 cfs outflow
    - Damages prevented\*: \$3 million

*\*Annual expected damages*



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# Measure 3 Ross Dam



## Potential Advantages

- Reduces flows for events greater than the 10-year event.

## Potential Disadvantages

- Impacts to endangered species.
- Hydropower losses.
- Would require reopening FERC license.
- Impacts to Seattle City Light facilities.
- May require negotiations with Canada.



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# Measures

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## Additional Storage

*small-scale storage*

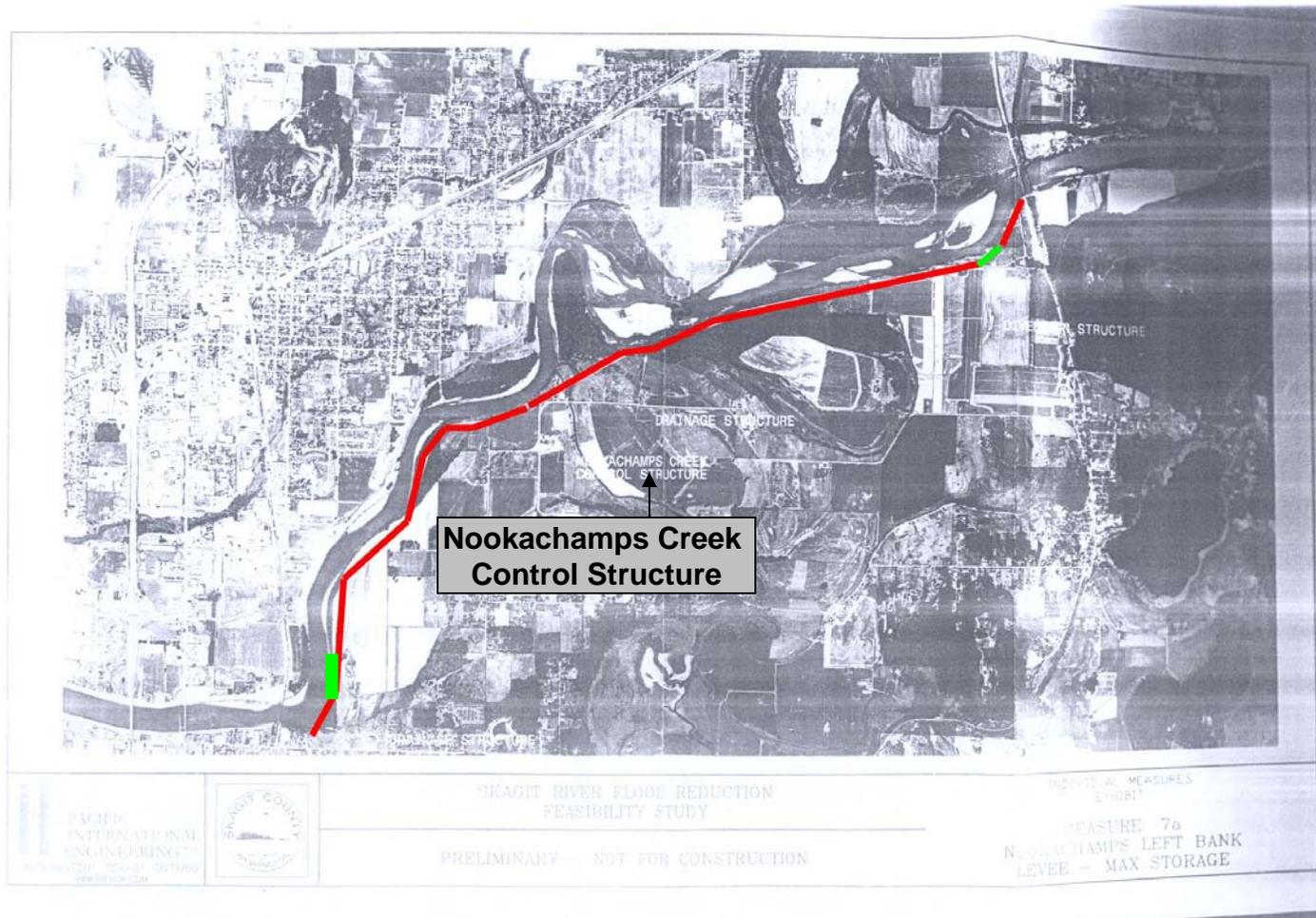


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# Measure 4

# Nookachamps Storage



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# Measure 4

## Nookachamps Storage

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- Description:
  - Dams off the mouth and available natural storage of the Nookachamps; so it does not fill early in a Skagit flood event.
  - Includes levee on left bank from Highway 9 bridge to 3 bridge corridor. Gate at upstream end of levee.
- Preliminary Construction Costs: ~\$90 million
  - Derived from PIE report (2006). Costs do not include operation and maintenance (O&M), access to structures, flowage easements and relocations, environmental mitigation or flood mitigation.



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# Measure 4

## Nookachamps Storage

### Potential Advantages

- Reduces peak flow for large flood events.

### Potential Disadvantages

- Does not meet Corps requirements (i.e. high O&M costs, risks in operating properly).
- Requires perfect ability to predict timing and magnitude of storm events to be federally authorized.
- Induces flooding upstream and downstream of project and increases duration of small, frequent flood events on nearby levees.
- Significant impacts to fish and wetlands.
- May significantly impact local residents (relocations).
- Environmental and flooding impacts would need to be mitigated and costs attributed to overall project cost.
- May require significant construction costs to entire levee system.

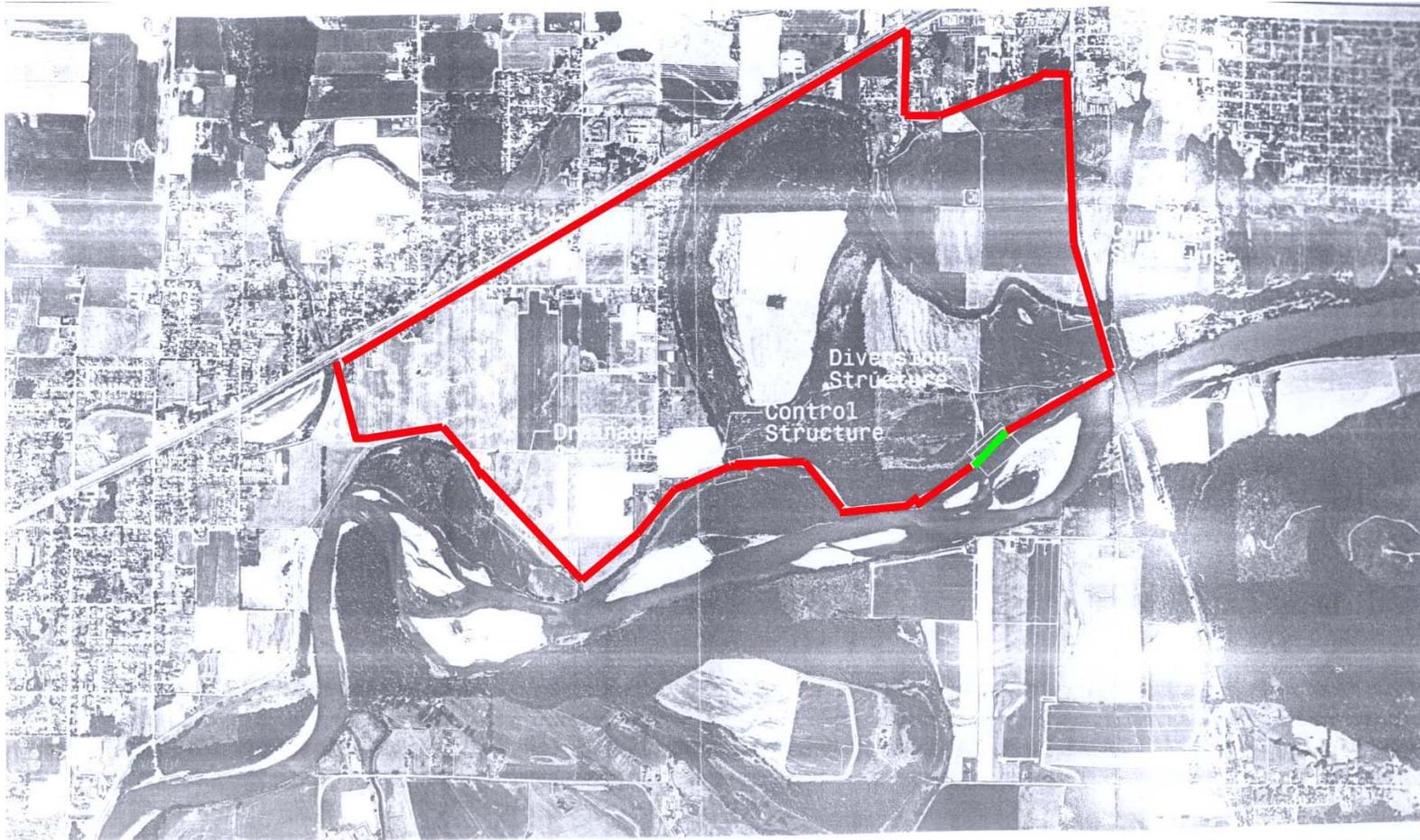


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# Measure 5

## Hart's Slough Storage



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# Measure 5

## Hart's Slough Storage

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- Description:
  - Dams off the available natural valley storage area of Hart's Slough.
  - Levee on right bank from Highway 9 to River Mile (RM) 21.6 with gate at upstream end
- Preliminary Construction Costs: ~\$52 million
  - Derived from PIE report (2006). Costs do not include O&M, access to structures, flowage easements and relocations, environmental mitigation, or flood mitigation.



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# Measure 5

## Hart's Slough Storage

### Potential Advantages

- Reduces peak flow for large flood events.

### Potential Disadvantages

- Does not meet Corps requirements (i.e. high O&M costs, high operation failure risk).
- Measure requires perfect ability to predict timing and magnitude of storm events to be federally authorized.
- Induces flooding upstream and downstream.
- Significant environmental impacts (i.e. loss of wetlands).
- May require relocations.
- Measure would require significant mitigation for induced flooding and environmental impacts.



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# Measures



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## Levees

### *Modifications, Setbacks and Flood Walls*



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# Generic Issues

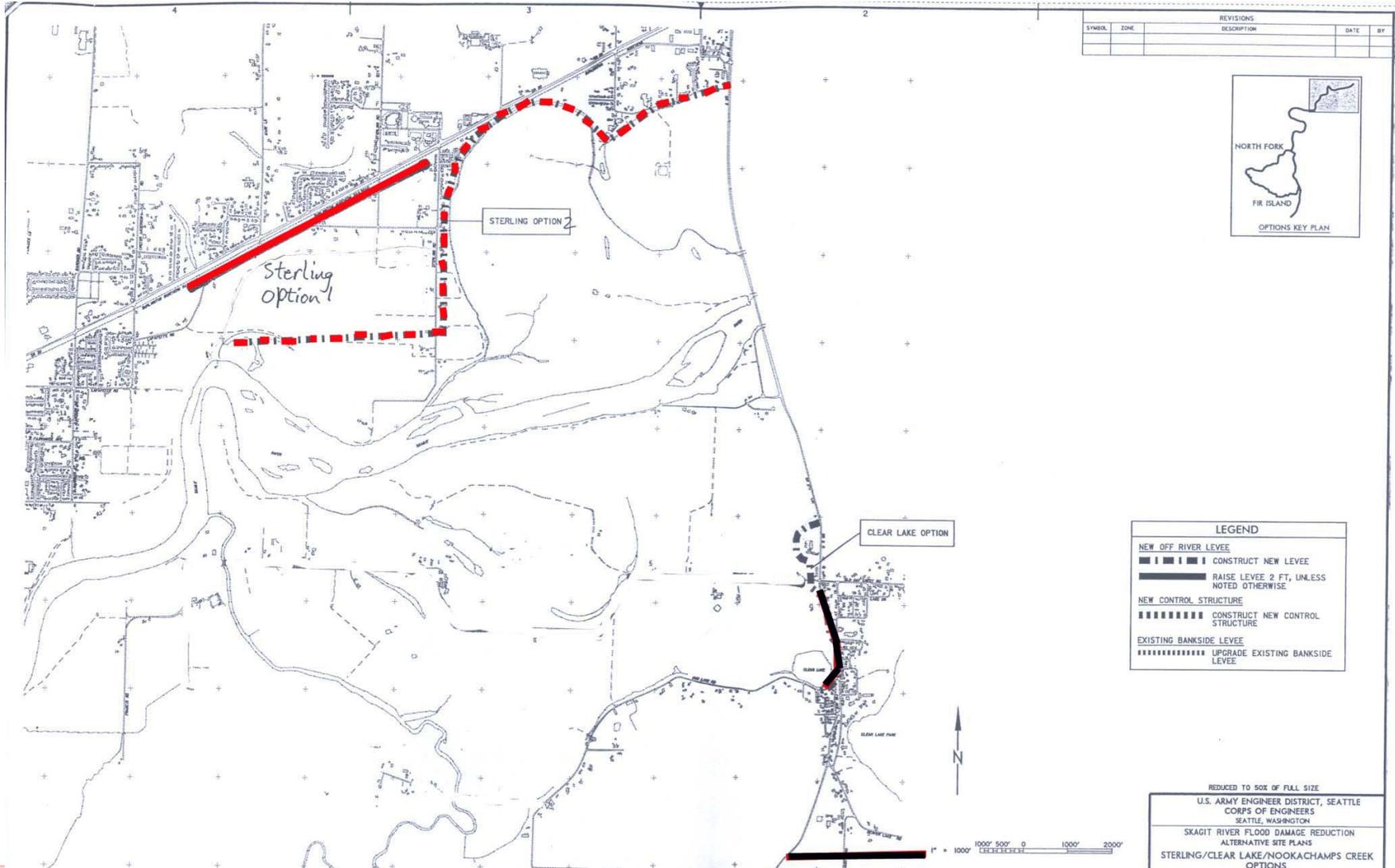


- Levees along river:
  - Impacts to riparian habitat.
  - Promotes development in floodplain (against Corps policy) in rural areas if significant protection.
  - Setback levees lower impacts and can keep rural, undeveloped areas riverward of levee



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# Measure 6 Sterling Levee





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# Measure 6

## Sterling Levee



- Description:  
There are two versions of the design for this area.
  - 6A - Ties in the levee at the upstream side at Sedro-Woolley and the downstream side at the existing levee system. It also encompasses most of the houses that are found in this area.
  - 6B - Raises the ground elevation for the low spot only to match what is upstream and downstream.
  - Project does not “stand alone”- needs to be combined with other measures
- Preliminary construction costs will be developed in alternatives analysis



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# Measure 6 Sterling Levee



## Potential Advantages

- Will be considered in conjunction with a larger levee system during alternatives analysis.
- A setback option to this measure would have less environmental impacts.

## Potential Disadvantages

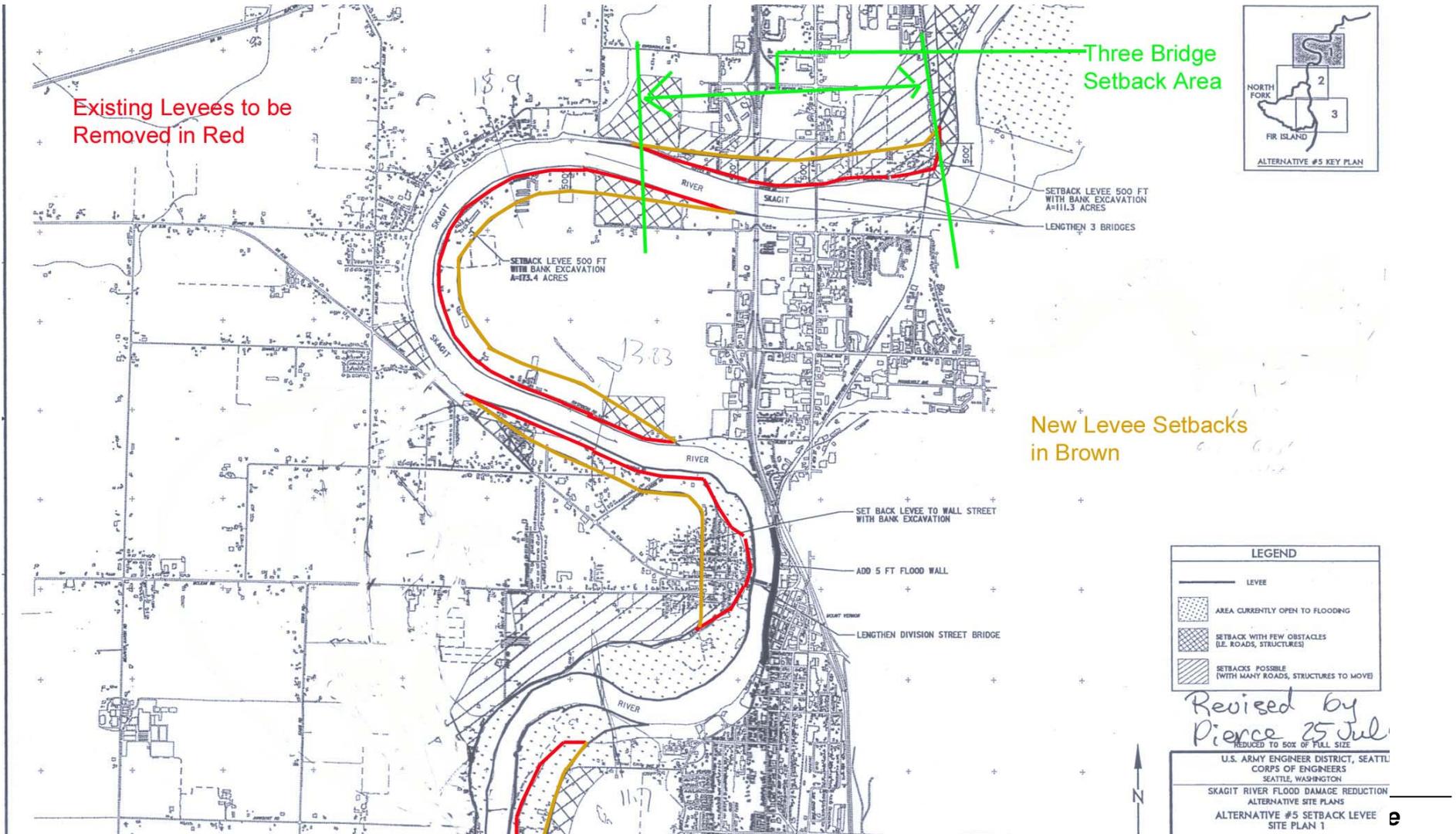
- Does not provide significant flood protection as a stand-alone project.
- 6B limited to protection between 10- and 20-year events.
- Environmental impacts have not been evaluated.
- With a setback option, any structures riverward may have to be relocated.



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# Measure 7 Levee Setback

## Downstream of 3-Bridge Corridor





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# Measure 7

## Levee Setback



### Downstream of 3-Bridge Corridor

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- Description:
  - 500-foot setback on the mainstem from below 3 Bridge Corridor to the Forks, the North Fork from the mainstem to its mouth, and the South Fork from the mainstem to its mouth.
  - Setback widens the channel to handle more flows; assumes setback levee elevations will be the same as existing elevations.
  - Further evaluation would determine the optimum levee elevations and level of protection.
  - Does not include modifications to the 3-Bridge Corridor.
- Preliminary Construction Costs: ~\$424 mil
  - Includes real estate, costs to modify North and South Fork and Mount Vernon bridges.
  - Does not include mitigation or O&M costs.



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# Measure 7

## Levee Setback



# Downstream of 3-Bridge Corridor

### Potential Advantages

- Setback levees may potentially reduce induced flooding and required levee height.
- Setting back levees generally minimizes environmental impact and provides opportunity for riparian improvements.

### Potential Disadvantages

- Would require significant modifications to the Mount Vernon, North Fork and South Fork bridges.
- Difficult to raise a levee on one side and not on the other – induced flooding issue
- Increased sediment transport and localized erosion
- Will require purchasing a great deal of property and replacing a large portion of existing infrastructure (i.e. West Mount Vernon).
- Impacts to agricultural land.
- Structures riverward of levee or in footprint need to be relocated.
- Potential toxic contamination.

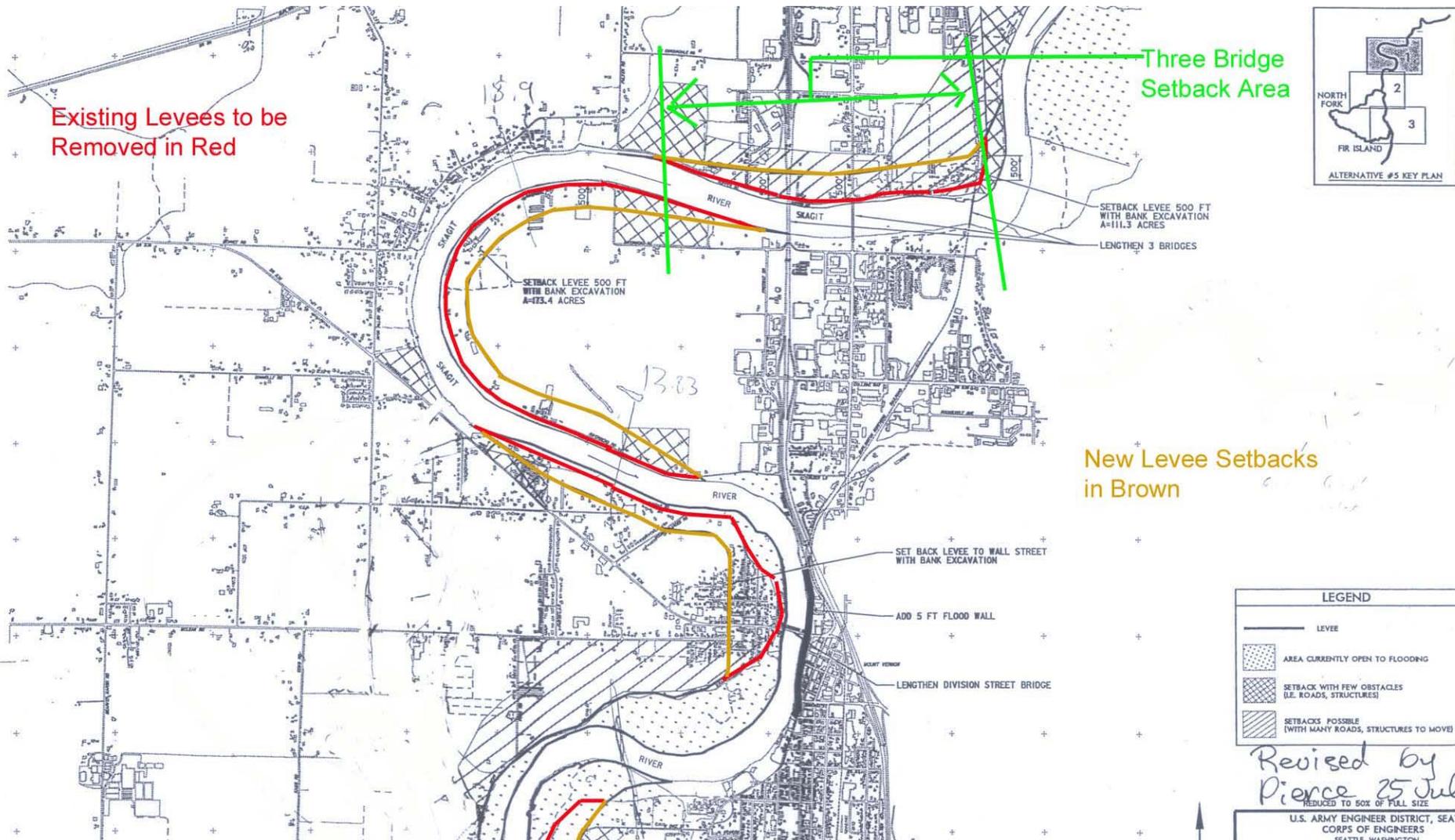


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# Measure 8

## Levee Setback

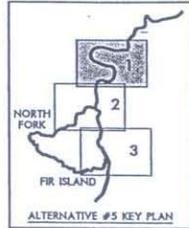
### 3-Bridge Corridor Only



Existing Levees to be  
Removed in Red

Three Bridge  
Setback Area

New Levee Setbacks  
in Brown



LEGEND	
	LEVEE
	AREA CURRENTLY OPEN TO FLOODING
	SETBACK WITH FEW OBSTACLES (I.E. ROADS, STRUCTURES)
	SETBACKS POSSIBLE (WITH MANY ROADS, STRUCTURES TO MOVE)

*Revised by  
Pierce 25 Jul*  
REDUCED TO SIZE OF FULL SIZE

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# Measure 8

## Levee Setback

### 3-Bridge Corridor Only

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- Description:
  - 500-foot setback levees on the mainstem from BNSF railroad bridge to downstream of I-5 bridge.
  - Would require modifications to the BNSF, I-5 and Highway 99 bridges to be fully functional.
- Preliminary Construction Costs: TBD
  - Have requested cost estimate from Washington Department of Transportation to replace I-5 bridge.
  - Some modifications to approaches to Highway 99 bridge needed.
  - Railroad bridge costs (2003) - \$32 million.
  - Require 500-foot setback of levees.



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# Measure 8

## Levee Setback

### 3-Bridge Corridor Only



#### Potential Advantages

- May reduce flooding upstream of the 3-Bridge Corridor.
- Setting back levees generally minimizes environmental impact and provides opportunity for riparian improvements.
- Bridge modifications could reduce debris management issues and impacts.

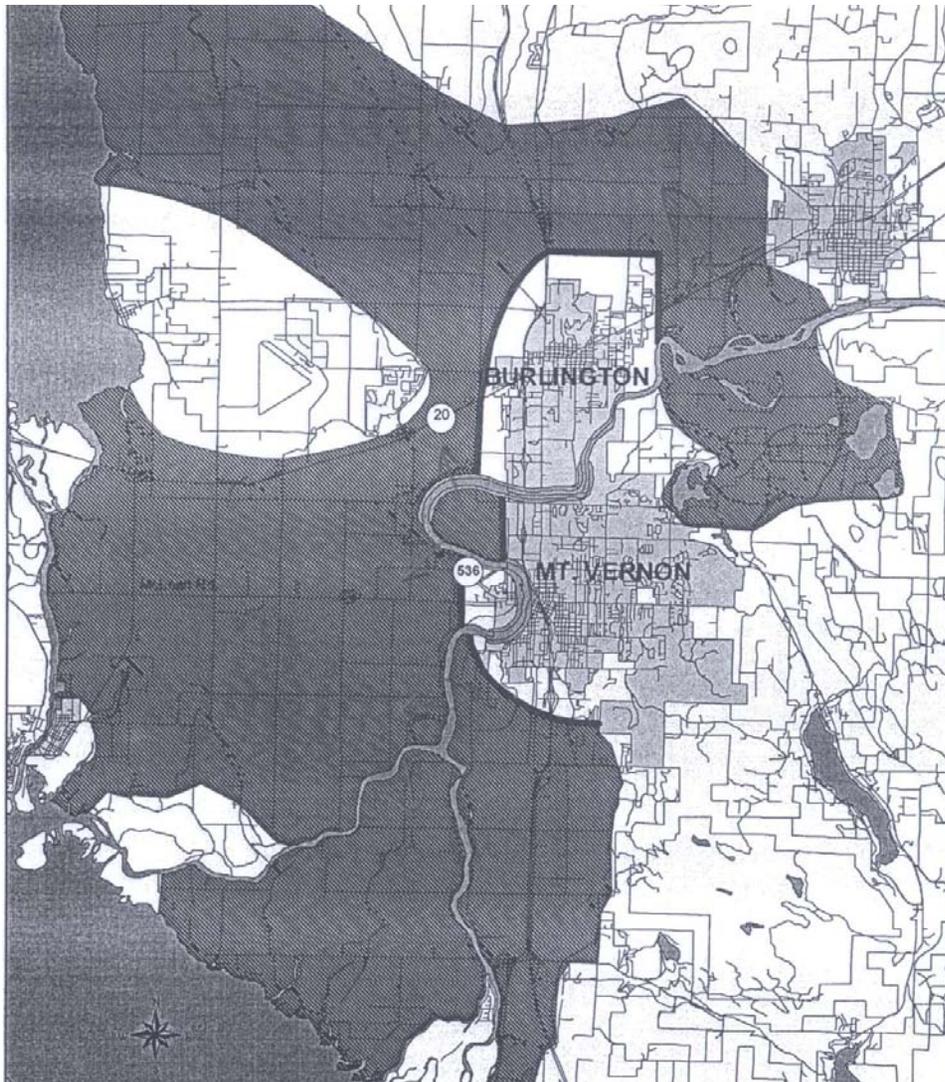
#### Potential Disadvantages

- Would require significant modifications to the three bridges to be fully effective.
- Bridge modifications responsibility of WDOT and BNRR.
- Hwy 99 bridge – new abutments.
- Requires purchase of real estate for setback, possible relocations, road and infrastructure modifications.
- Likely worsens downstream flooding.
- Corps project must “stand on its own.” Cannot assume bridges will be modified in time for completion of Corps project.



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# Measure 9 Overtopping Levees



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# Measure 9

## Overtopping Levees



- Description:
  - Purpose is to selectively allow flow to overflow the levees by creating low spots where water can start leaving the system.
  - Five locations would allow selective overtopping:
    1. Sterling – RM 21.9 – 1,000 feet – Right Bank
    2. Avon – RM 15.9 – 3,000 feet – Right Bank
    3. Forks – RM 10.5 – 2,000 feet – Right Bank
    4. Forks – RM 10.5 – 1,000 feet – Left Bank
    5. Dry Slough – North Fork RM 8.85 – 1,000 feet - Left Bank
- Preliminary Construction Costs: ~\$101 million
  - Includes real estate costs for new levees only.
  - Does not include mitigation or O&M costs.



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# Measure 9

## Overtopping Levees



### Potential Advantages

- Attempt to ensure areas share flood waters equally.
- Reduces flows in high flow events.

### Potential Disadvantages

- Flowage easements would be required.
- Measure requires additional levees and/or improvements to existing levees.
- Overtopping elevations would be set at a 5 to 10-year event.
- Overtopping areas will flood more frequently.
- Significant environmental impacts, including the stranding of fish when levees overtop.

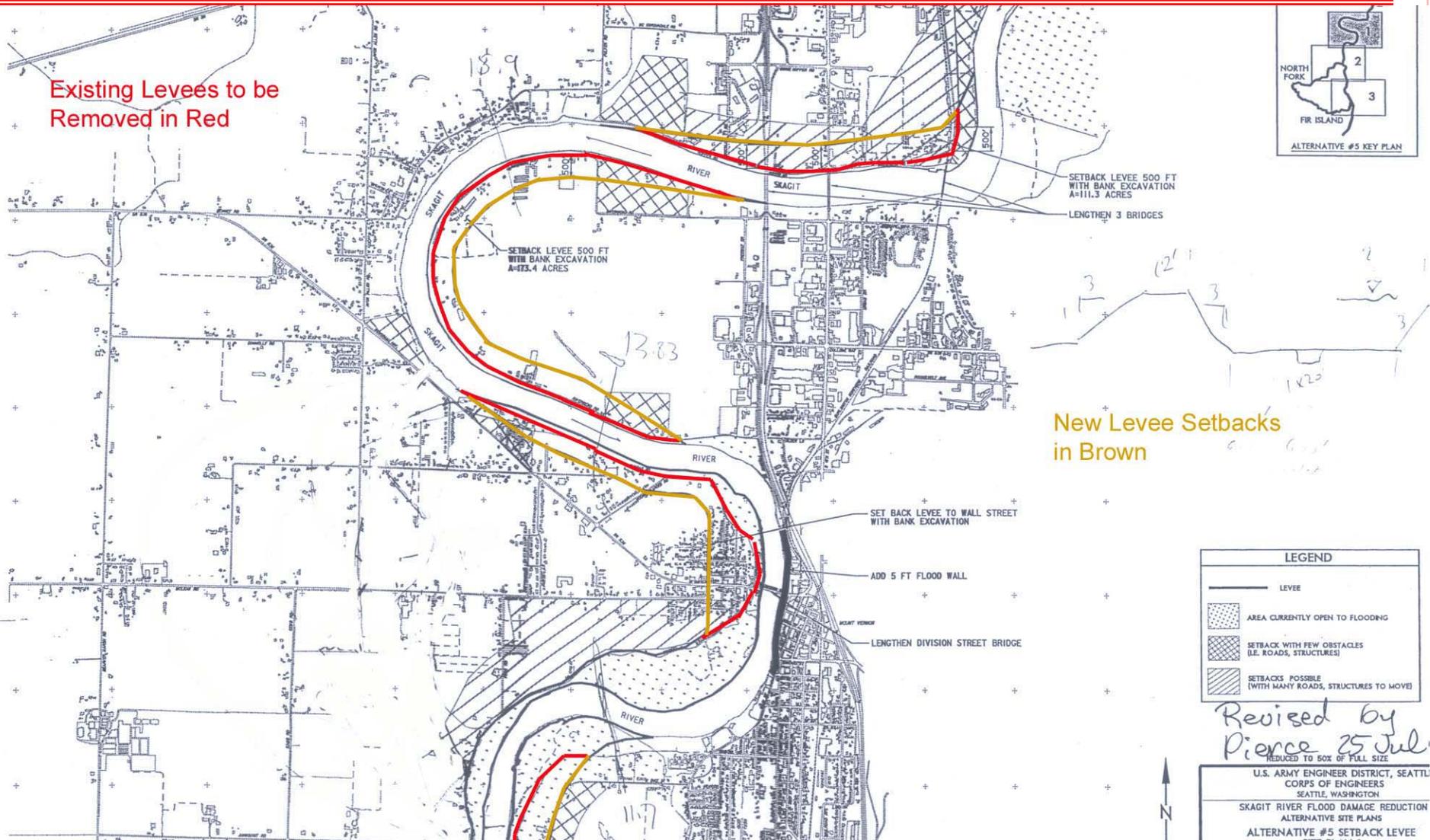
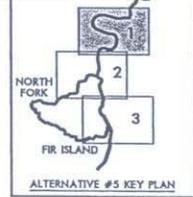


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# Measure 10

## Levee Setback

### Mainstem and North Fork Only





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# Measure 10

## Levee Setback

### Mainstem and North Fork Only



- Description:
  - 500-foot setback on the mainstem from below 3-Bridge Corridor to the Forks and the North Fork from the mainstem to its mouth.
  - Further evaluation would determine the optimum levee elevations (benefits/costs).
- Preliminary Construction Costs: ~\$395 million
  - Includes real estate costs.
  - Does not include mitigation or O&M costs.



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# Measure 10

## Levee Setback

### Mainstem and North Fork Only



#### Potential Advantages

- Potential to set levees back to sufficiently reduce induced flooding.
- Setting back levees generally minimizes environmental impact and provides opportunity for riparian improvements.

#### Potential Disadvantages

- Corps policy does not support projects that encourage development in rural areas.
- Would require setback of five bridges.
- Difficult to raise a levee on one side and not on the other.
- Increased sediment transport and localized erosion.
- Measure will necessitate purchasing a great deal of improved property and replacing a large portion of existing infrastructure.
- Would require relocations of structures riverward of levee.



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# Measure 11

## Improve Existing Levees



- Description:
  - Measure raises entire existing levee system and adds a levee on the right bank from Highway 9 to the start of the existing levee system.
- Preliminary Construction Costs: ~\$97 million
  - Derived from PIE report (2006). Includes real estate costs.
  - Does not include infrastructure modifications, mitigation, O&M or contingency costs.
  - Final measure will consider optimum level of protection.



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# Measure 11



## Improve Existing Levees

### Potential Advantages

- Minimal change in levee footprint versus levee setbacks.
- Potential to combine with other measures (i.e. bypass) to improve efficiency.

### Potential Disadvantages

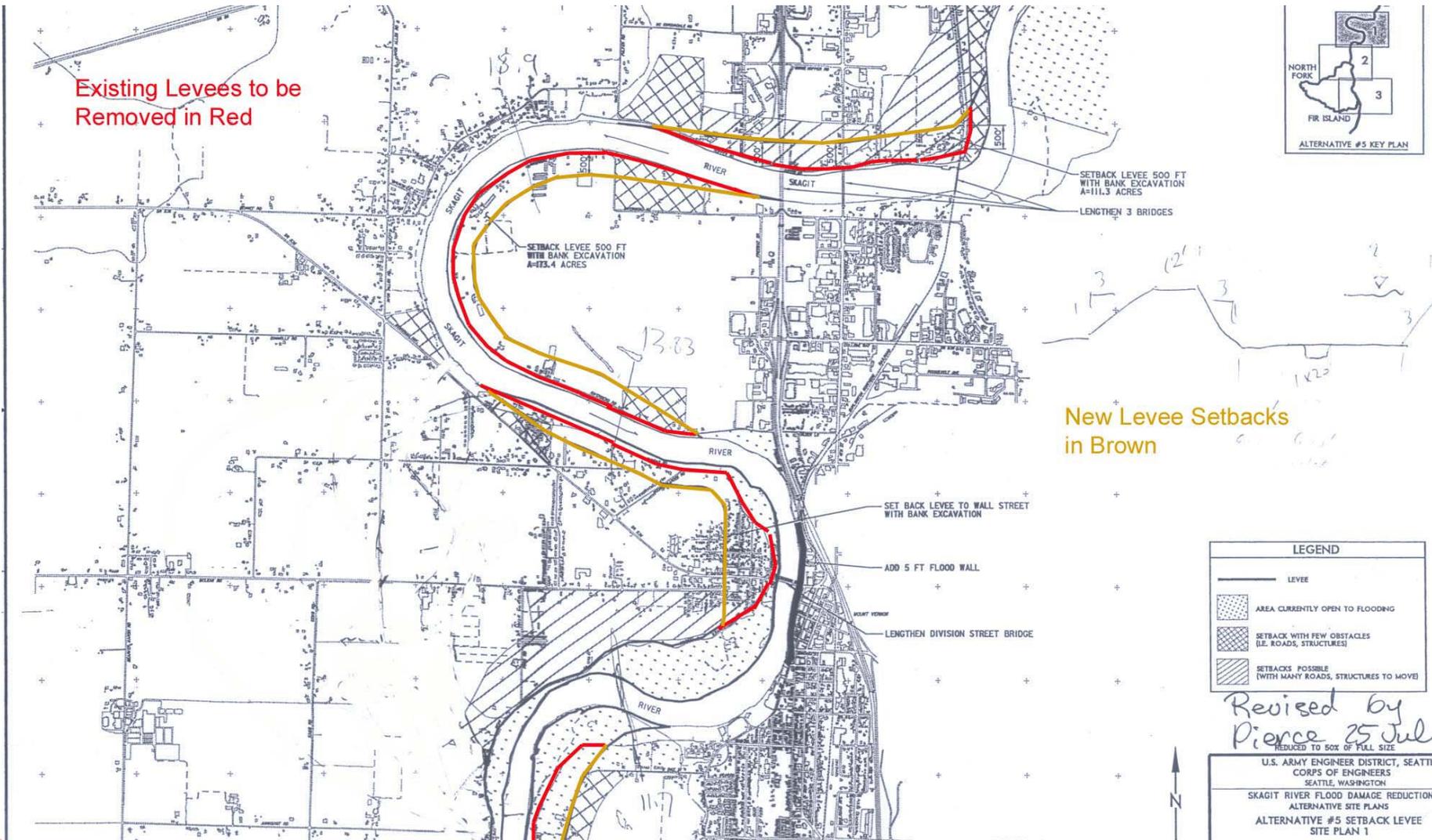
- Corps policy does not support projects that encourage development in rural areas.
- Would require improvement of all levees to avoid induced flooding (height).
- Significant mitigation for environmental impacts.
- Increase in sedimentation and localized erosion
- Levees must function as one project. Districts could not independently further raise their levees.
- Costs assume addition to existing levees.



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# Measure 12

## Setback Levees with Excavation





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# Measure 12

## Setback Levees with Excavation



- Description:
  - 500-foot setback with excavation in the overbank of the mainstem from RM 17.56 to the Forks, the North Fork from the mainstem to its mouth, and the South Fork from the mainstem to its mouth of 20 feet.
- Preliminary Construction Costs: Costs not developed, as measure is not feasible.



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# Measure 12

## Setback Levees with Excavation



### Potential Advantages

- Considered in 2001 to maximize channel capacity and minimize environmental impact.

### Potential Disadvantages

- High construction costs, due to massive removal of material.
- Measure does not have flood protection advantages beyond setback with no excavation, and costs are higher.
- Destabilizes channel, increasing sedimentation and erosion.
- High maintenance costs – would need constant dredging of eroded sediments. (100% Local Sponsor cost)
- Would require setback of five bridges.
- Measure will necessitate purchasing a great deal of improved property and replacing a large portion of existing infrastructure.
- Would require relocations of structures riverward of levee.
- Potential for environmental impacts through disturbance of riverbank and dredging.





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# Measure 13

## Setback Levees – Entire System



- Description:
  - 500-foot setback starting at the beginning of the 3-bridge corridor at the MNSF Bridge (RM 17.56) to where the mainstem splits into the North and South Forks and then extends out both the North and South Fork.
  - Further evaluation would determine the optimum levee elevations and locations.
- Preliminary Construction Costs: ~\$406 million
  - Includes real estate costs
  - Does not include mitigation, O&M, infrastructure modifications or relocations.



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# Measure 13

## Setback Levees – Entire System



### Potential Advantages

- Potential to set levees back to sufficiently reduce induced flooding.
- Setting back levees generally minimizes environmental impact and provides opportunity for riparian improvements.

### Potential Disadvantages

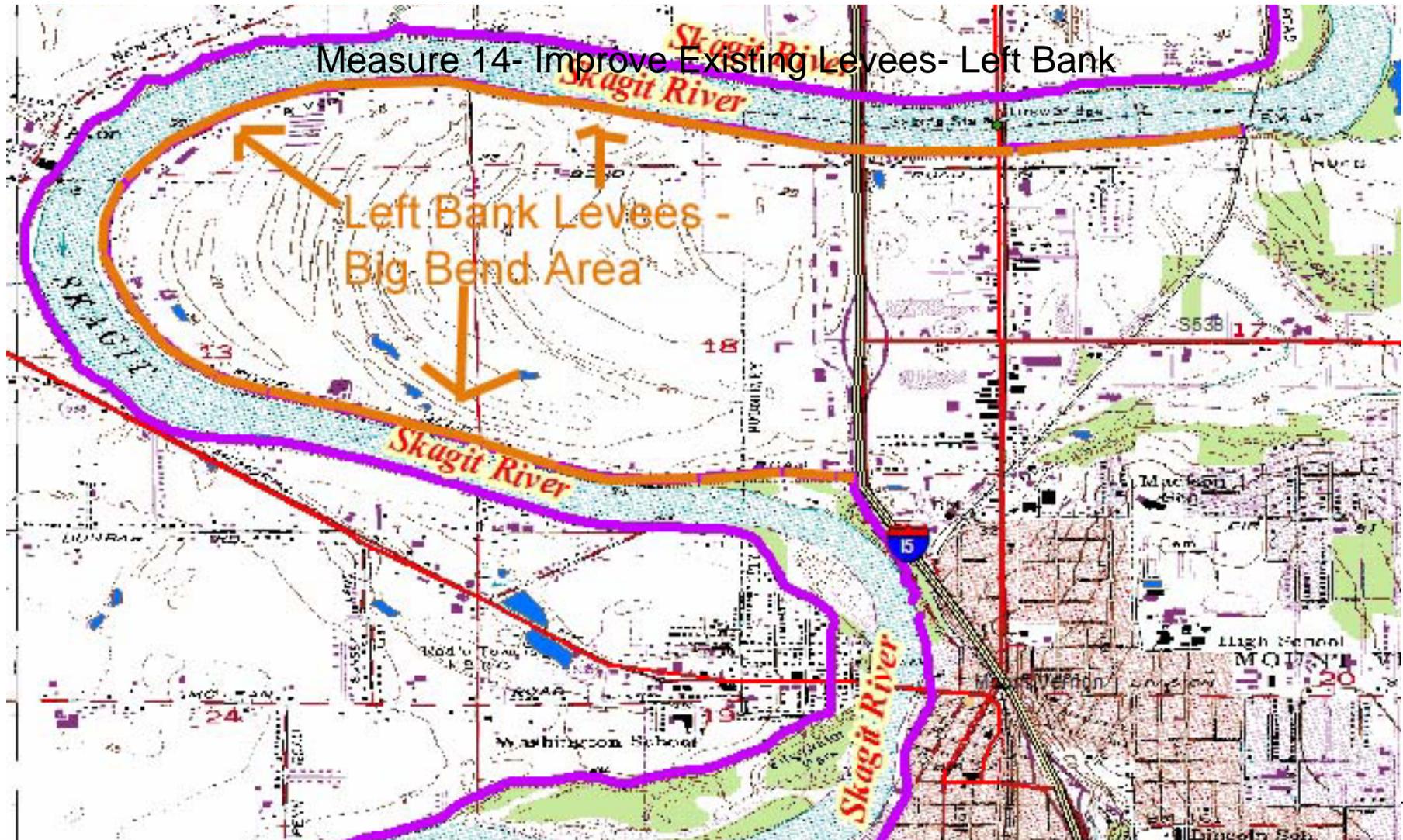
- Corps policy does not support projects that encourage development in rural areas.
- Would require setback of five bridges.
- Difficult to raise a levee on one side and not on the other.
- Increased sediment transport and localized erosion.
- Measure will necessitate purchasing property for a wider levee footprint and replacing a large portion of existing infrastructure.



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# Measure 14

## Improve Existing Levees – Left Bank





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# Measure 14

## Improve Existing Levees – Left Bank



- Description:
  - Raises the left bank of the existing levee system from Mount Vernon to the mouth of the South Fork.
- Preliminary Construction Costs: ~\$23 million
  - Derived from PIE report (2006). Includes real estate costs.
  - Does not include infrastructure modifications, mitigation, O&M or contingency costs.



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# Measure 14

## Improve Existing Levees – Left Bank



### Potential Advantages

- Minimal change in levee footprint versus levee setbacks.

### Potential Disadvantages

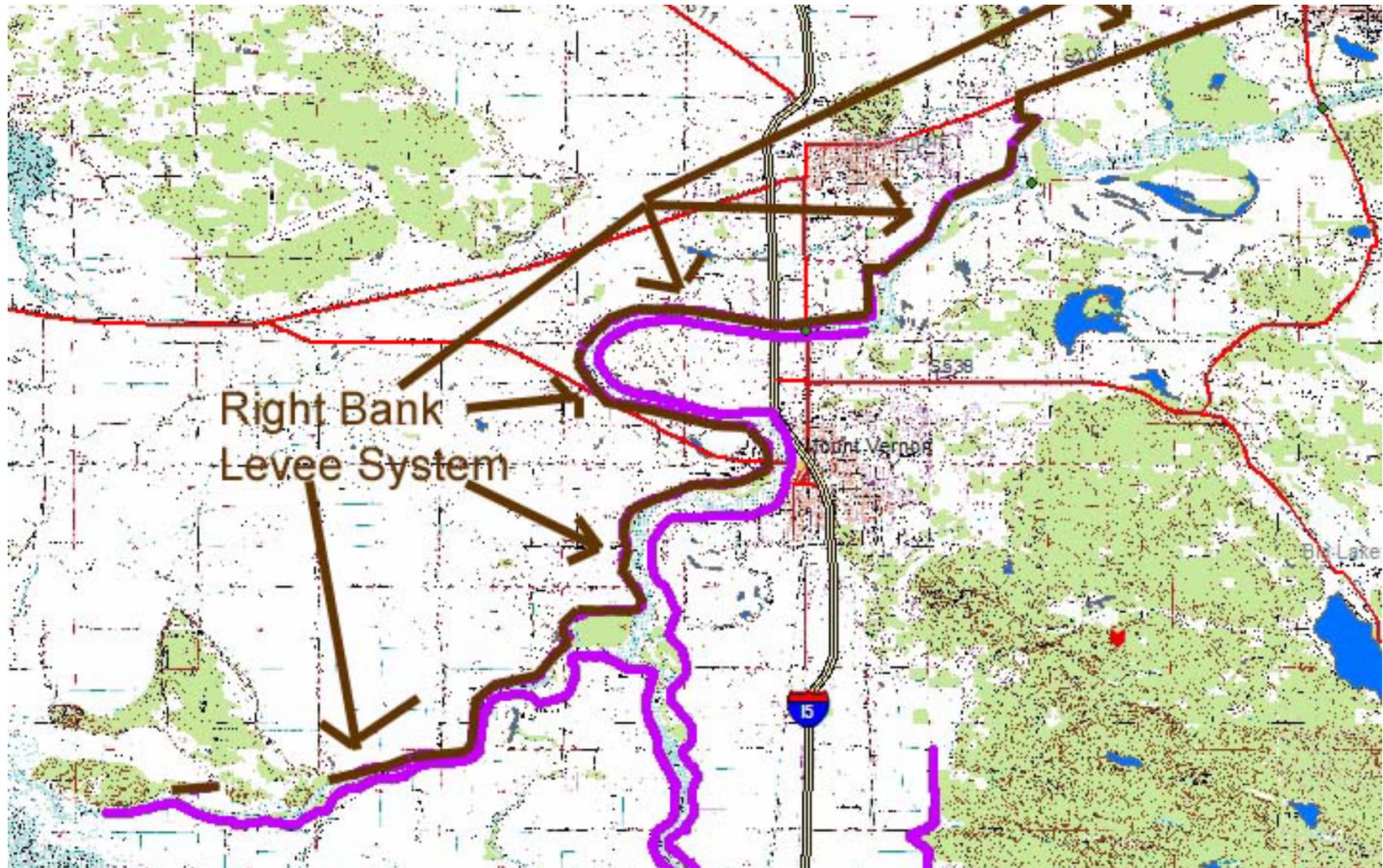
- Violates Corps policy and Executive Order 11988.
- Would require improvements to the entire existing system.
- Significant mitigation for environmental impacts.
- Increase in sedimentation and localized erosion.
- Difficult to raise a levee on one side and not on the other (impacts to right bank areas).



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# Measure 15

## Improve Existing Levees – Right Bank





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# Measure 15

## Improve Existing Levees – Right Bank



- Description:
  - Raises the right bank of the existing levee system and extends levee up to Highway 9 (RM 22.7) and down to the mouth of the North Fork.
- Preliminary Construction Costs: ~\$95 million
  - Derived from PIE report (2006). Includes real estate costs.
  - Does not include infrastructure modifications, mitigation, O&M or contingency costs.



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# Measure 15

## Improve Existing Levees – Right Bank



### Potential Advantages

- Will be considered in conjunction with a larger levee system during alternatives analysis.
- Minimal change in levee footprint versus levee setbacks.

### Potential Disadvantages

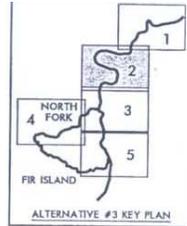
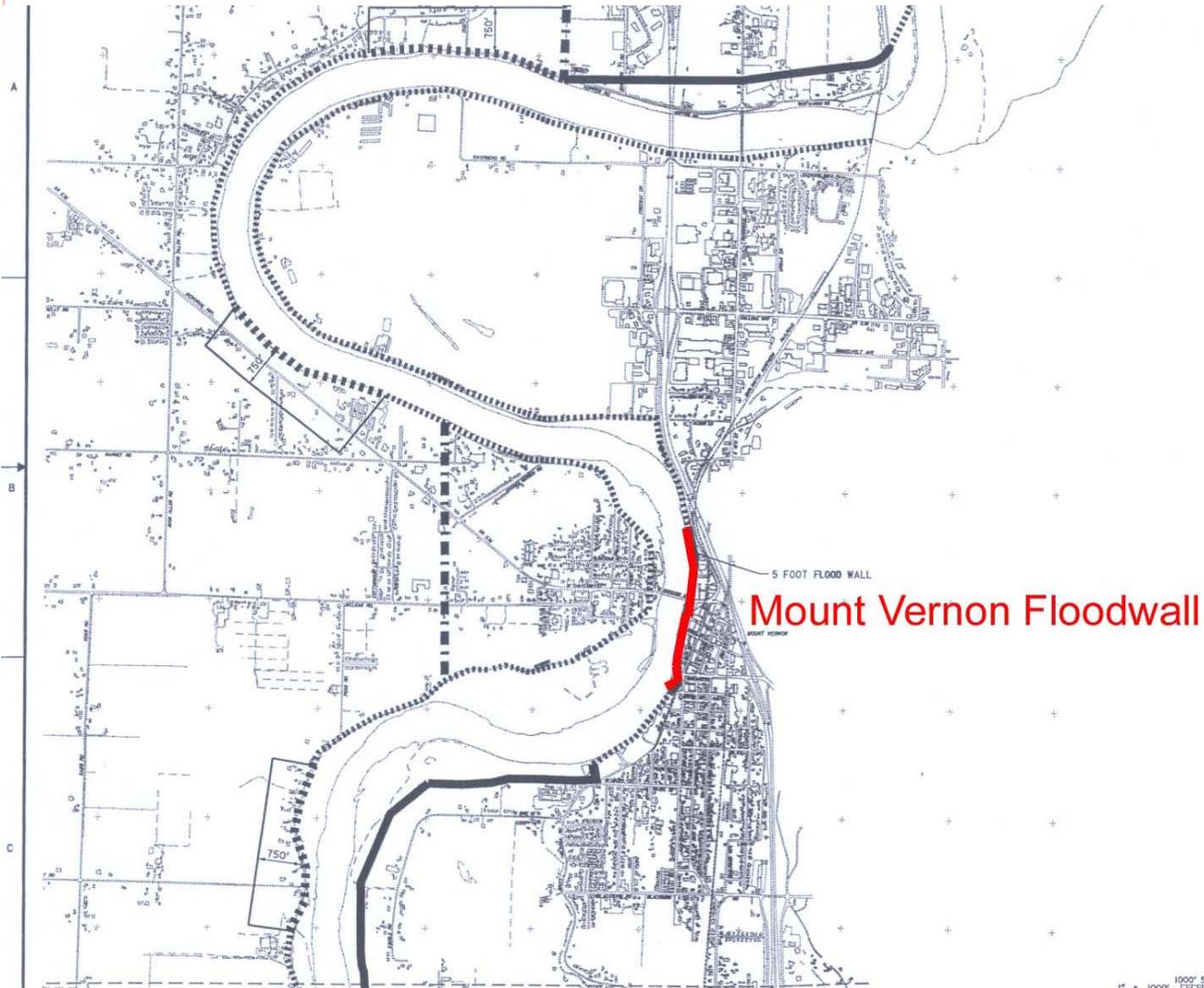
- Corps policy does not support projects that encourage development in rural areas.
- Would require improvements to the entire existing system.
- Would require significant maintenance.
- Significant mitigation for environmental impacts.
- Increase in sedimentation and localized erosion.
- Difficult to raise a levee on one side and not on the other, impacts to left bank.
- Induced flooding.



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# Measure 16

## Mount Vernon Floodwall



5 FOOT FLOOD WALL  
**Mount Vernon Floodwall**

LEGEND	
<b>NEW OFF RIVER LEVEE</b>	
	CONSTRUCT NEW LEVEE
	RAISE LEVEE 2 FT., UNLESS NOTED OTHERWISE
<b>NEW CONTROL STRUCTURE</b>	
	CONSTRUCT NEW CONTROL STRUCTURE
<b>EXISTING BANKSIDE LEVEE</b>	
	UPGRADE EXISTING BANKSIDE LEVEE



REDUCED TO 50% OF FULL SIZE  
U.S. ARMY ENGINEER DISTRICT, SEATTLE  
CORPS OF ENGINEERS  
SEATTLE, WASHINGTON  
SKAGIT RIVER FLOOD DAMAGE REDUCTION  
ALTERNATIVE SITE PLANS  
ALTERNATIVE #3  
RING DIKE W/SELECTIVE OVERTOPPING  
SITE PLAN 2  
CONCEPT FEASIBILITY STUDY



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# Measure 16

## Mount Vernon Floodwall



- Description:
  - A floodwall to raise the low spot that is currently sandbagged during floods on the left bank at East Mount Vernon (RM 12.96) to RM 12.4 to match elevations upstream and downstream.
  - This is not a stand-alone measure. It will be evaluated as part of a regional system during alternatives analysis.
- Preliminary Construction Costs: Will be developed during alternative analysis.



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# Measure 16

## Mount Vernon Floodwall



### Potential Advantages

- Permanent feature to reduce damages to downtown East Mount Vernon — replacing need for annual flood fighting.
- Compared to a levee, minimizes impacts to structures adjacent to the river.

### Potential Disadvantages

- Does not provide significant flood protection as a stand-alone project.
- Impacts to commercial structures (i.e. parking).
- Restricts public access to the river.
- Need to determine if impacts to historic buildings.



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# Measures



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## Bypass Systems

*Bypasses to remove  
floodwaters from mainstem*

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# Measure 17

## Swinomish Bypass



- Description:
  - A 6.7 mile-long bypass which would divert water out of the Swinomish Channel to Padilla Bay. The weir would allow overflow at a specific elevation and location. Then overflow would be confined by levees down to the Swinomish Channel.
  - Design requires setback of levees and bridge replacement in 3-bridge corridor.
  - Outlet set at 20-year flood event.
- Preliminary Construction Costs: ~\$328 million
  - Includes real estate.
  - Does not include infrastructure modifications, mitigation, O&M costs or costs for bridge modifications.



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# Measure 17

## Swinomish Bypass



### Potential Advantages

- Bypass has advantage of not failing catastrophically when exceeded.
- Potential for added recreation and/or environmental features.

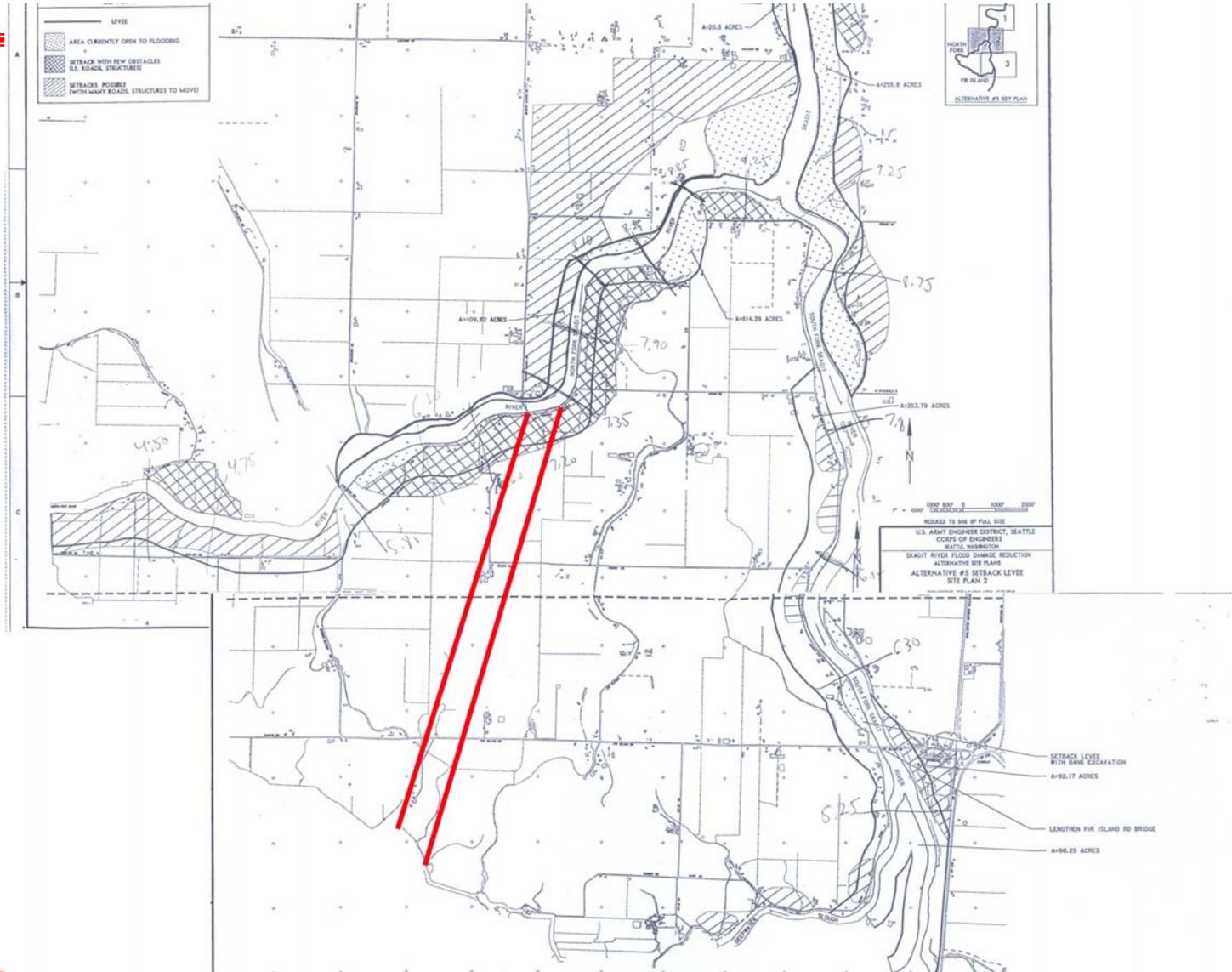
### Potential Disadvantages

- Could cause sediment deposition in Padilla Bay, a marine sanctuary.
- Localized erosion.
- Impacts to Swinomish Slough are unknown.
- Impacts to agricultural land.
- Will need to evaluate setting weir elevation to a 5-10-year flood event.
- Benefits not fully realized until 3 bridges replaced.



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# Measure 18 Fir Island Bypass





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# Measure 18

## Fir Island Bypass



- Description:
  - A 2.7 mile-long bypass which would divert water from the North Fork out to Skagit Bay via an excavated channel.
  - Based on width of 500 feet.
  - Will be considered in combination with other measures during alternative analysis (Mount Vernon bypass).
- Preliminary Construction Costs: ~\$77 million
  - Costs include real estate and construction of two county bridges.
  - Does not include any additional infrastructure modifications, mitigation or O&M costs.



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# Measure 18

## Fir Island Bypass



### Potential Advantages

- Bypass has advantage of not failing catastrophically when exceeded.
- Potential for added recreation and/or environmental features.
- Would create environmental complexity for Skagit River delta.
- Measure does not induce flooding elsewhere.
- Reduces flooding in Mount Vernon.
- Will consider wider channel with levees.

### Potential Disadvantages

- Sediment may be diverted to the central portion of the Skagit Bay shoreline.
- Impacts to agricultural land
- Would require infrastructure improvements
- Not economically justified as stand alone project.
- May require relocations.
- Could impact eelgrass beds.





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# Measure 19

## Samish Bypass



- Description:
  - An 11-mile long bypass which would divert water at the northernmost point of Hart's Slough at RM 22.0 into a 1500 foot wide corridor with levees on both sides out to Samish Bay
  - Assumes no excavation
  - Nine bridges would need to be replaced
- Preliminary Construction Costs: ~\$363 mil
  - Includes real estate
  - Does not include mitigation, O&M, infrastructure modifications and additions, levees, excavation.



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# Measure 19

## Samish Bypass



### Potential Advantages

- Bypass has advantage of not failing catastrophically when exceeded.
- Potential for added recreation and/or environmental features.
- Removes water upstream of the 3-bridge corridor.

### Potential Disadvantages

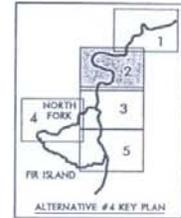
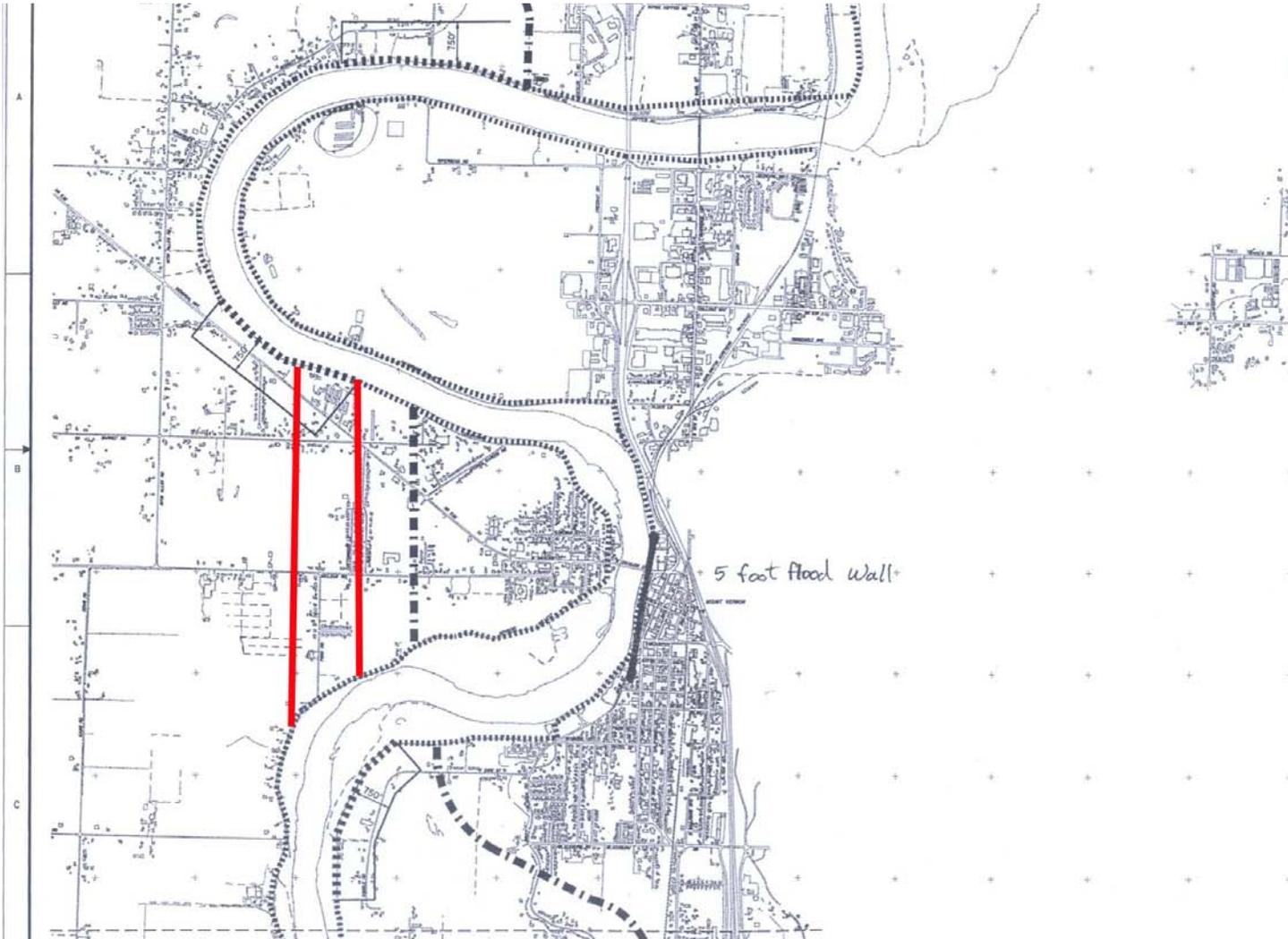
- Would require construction of nine bridges, additional levees and channel excavation.
- Will need to evaluate setting weir elevation to a 5-10-year flood event.
- Flooding impacts have not been evaluated to Samish basin.
- Environmental impacts have not been evaluated.
- Potential impacts to fish from cross basin mixing of the Skagit and Samish Rivers.
- Impacts to agricultural land.
- Fine sediment may be diverted to Samish Bay during flood events.



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# Measure 20

## Mount Vernon Bypass



LEGEND	
	NEW OFF RIVER LEVEE
	CONSTRUCT NEW LEVEE
	NEW CONTROL STRUCTURE
	CONSTRUCT NEW CONTROL STRUCTURE
	EXISTING BANKSIDE LEVEE
	UPGRADE EXISTING BANKSIDE LEVEE

REDUCED TO SIZE OF FULL SIZE  
 U.S. ARMY ENGINEER DISTRICT, SEATTLE  
 CORPS OF ENGINEERS  
 SEATTLE, WASHINGTON  
 SKAGIT RIVER FLOOD DAMAGE REDUCTION  
 ALTERNATIVE SITE PLANS  
 ALTERNATIVE #4 RING DIKE W/OVERTOPPING  
 SITE PLAN 2  
 CONCEPT FEASIBILITY STUDY WASHINGTON  
 SKAGIT COUNTY



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# Measure 20

## Mount Vernon Bypass



- Description:
  - A 1 mile-long bypass channel from upstream of West Mount Vernon at RM 14.0 to downstream at RM 11.2, designed to overcome the constriction of the Skagit River at the Division Street Bridge.
  - Would require two bridges at Highway 536 (Memorial Hwy) and McLean Road.
  - Based on width of 500 feet.
- Preliminary Construction Costs: (20A) ~\$73 million
  - Costs include real estate and construction of two county bridges.
  - Do not include any additional infrastructure modifications, mitigation, O&M costs or relocations.



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# Measure 20

## Mount Vernon Bypass



### Potential Advantages

- Reduces flood elevations near Mount Vernon.
- Bypass has advantage of not failing catastrophically when exceeded.
- Potential for added recreation and/or environmental features.
- Bypass minimizes environmental impact and provides opportunity for riparian improvements.

### Potential Disadvantages

- Would require infrastructure modifications, potential relocations of structures and loss of urban land.
- May need to be combined with another measure to reduce impacts to Fir Island.
- Potential sedimentation impacts include deposition downstream and erosion.
- May require levee improvements downstream of outlet.
- May require relocations.



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# Measures

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## Ring Dikes

*Levees surrounding urban areas*



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# Construction Costs



- Common cost items would include real estate, infrastructure modifications (bridges, roads, utilities), pumping plants for internal drainage, mitigation (flood and environmental), building relocations and O&M requirements.
- Costs have not been developed, and will be prepared in next phase.



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# City Ring Dikes

## Potential Advantages

- Urban areas would be protected from flood damages.

## Potential Disadvantages

- Life safety may be threatened when levees are exceeded, high risk to population.
- Would require an ensured escape route during flood events, effective flood warning and evacuation systems.
- Require an extensive pumping system.
- May potentially worsen flooding in rural areas.
- Issue for Corps support (bathtub effect).
- Corps cannot encourage development in floodplain.



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# Measure 28

## Sedro-Woolley Ring Dike

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- Description:
  - A levee would be constructed to protect Sedro-Woolley from flooding.
  - Need further study to determine flooding risk.



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# Measure 29

## Sedro-Woolley Sewage Treatment Plant Ring Dike



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# Measure 29

## Sedro-Woolley Sewage Treatment Plant Ring Dike



- Description:
  - The existing levee around the Sedro-Woolley Sewage Treatment Plant would be improved.
  - Require further information on flooding-riverine or internal seepage.



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# Measure 29

## Sedro-Woolley Sewage Treatment Plant Ring Dike



### Potential Advantages

- Increases protection of sewage treatment plant.
- Reduces potential for contamination in surrounding areas.

### Potential Disadvantages

- Unclear as to whether flooding is significant enough to justify improvement to the ring dike.
- Would require extensive pumping system.



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# Measure 30

## Sedro-Woolley Hospital Ring Dike



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# Measure 30

## Sedro-Woolley Hospital Ring Dike

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- Description:
  - A levee would be constructed to protect the Sedro-Woolley Hospital from flooding.



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# Measure 30

## Sedro-Woolley Hospital Ring Dike

### Potential Advantages

- Would protect hospital building.
- Improved life safety of patients.

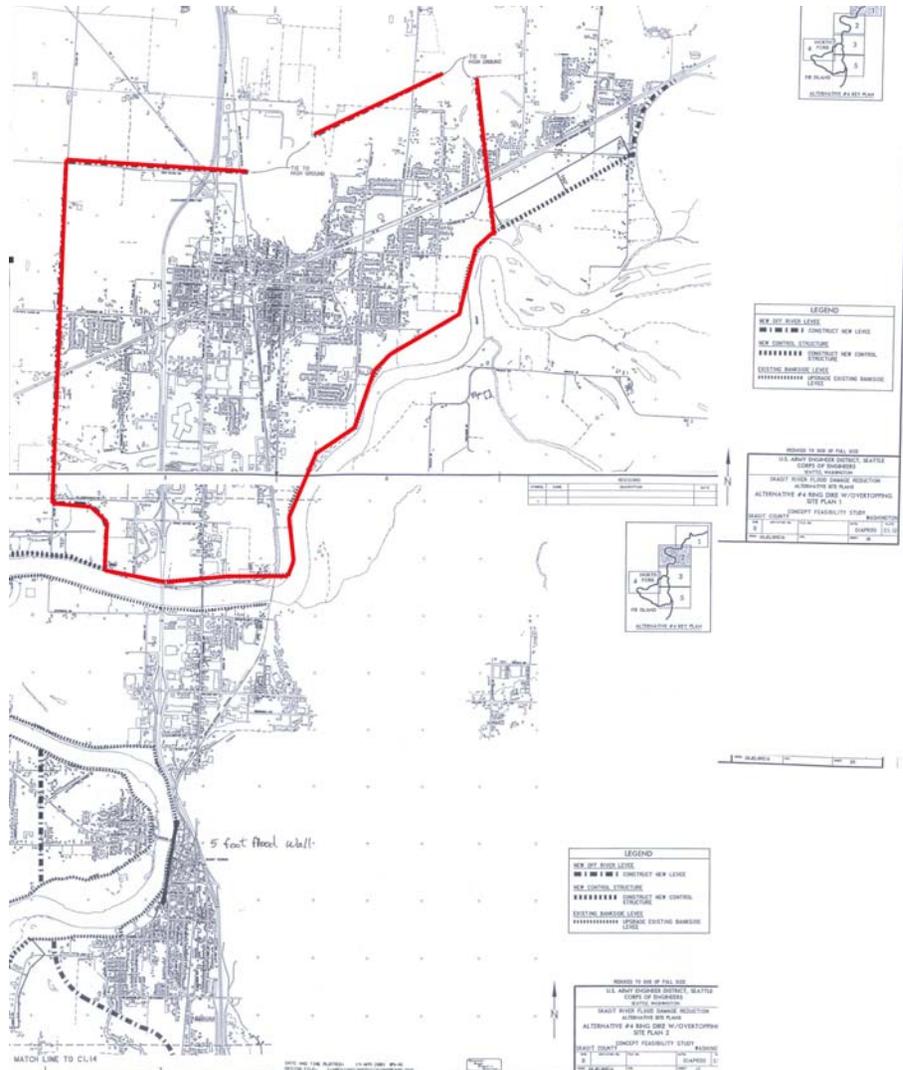
### Potential Disadvantages

- Egress and ingress routes to hospital would require barricades at entrances/exits (i.e. sandbags or floodgates).
- Dangers associated with isolation of people both inside and outside of hospital (i.e. no access).
- Would require extensive pumping system.



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# Measure 31 Burlington Ring Dike



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# Measure 31

## Burlington Ring Dike

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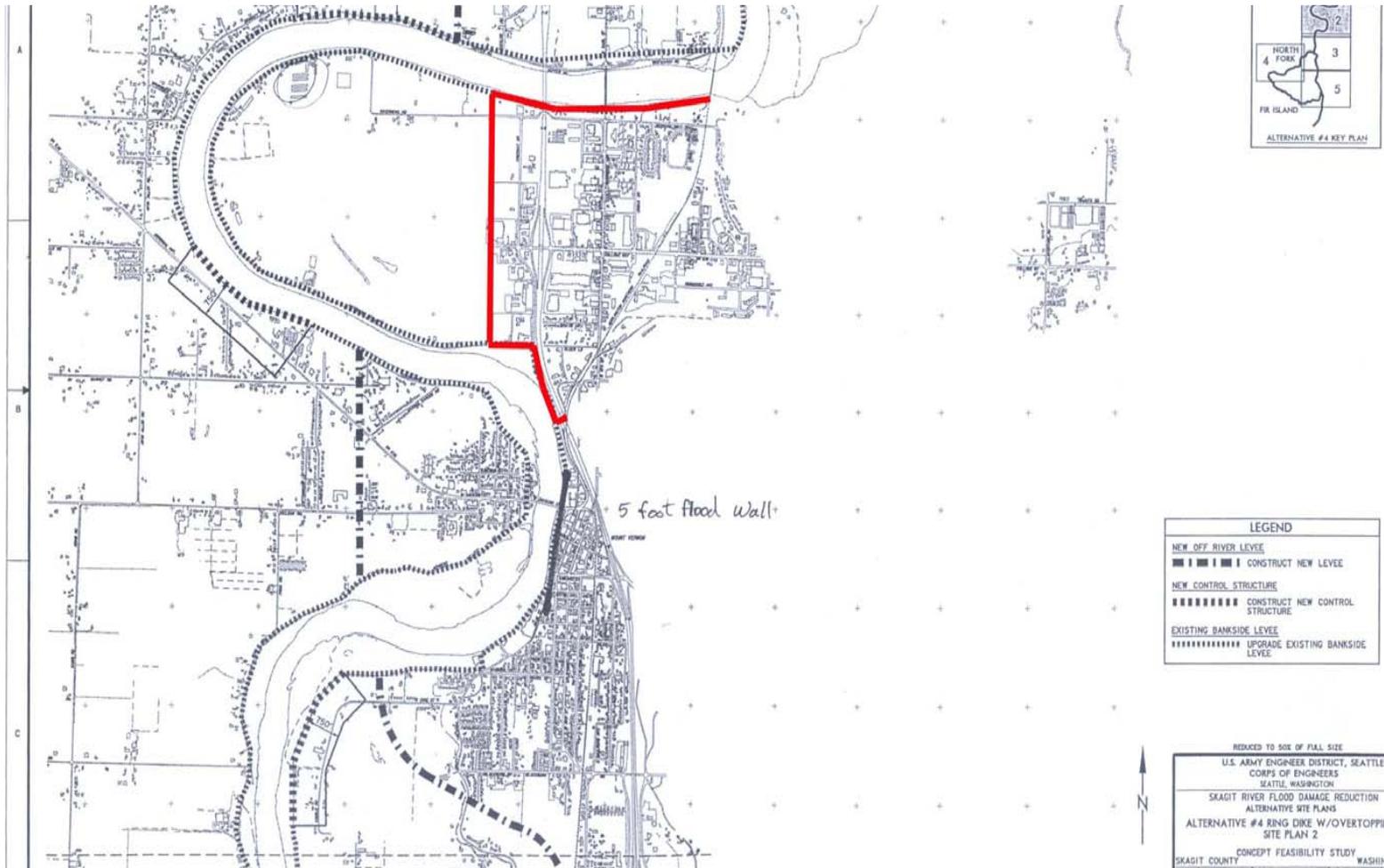
- Description:
  - A levee would be constructed to protect Burlington from flooding.



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# Measure 32

## North Mount Vernon Ring Dike



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# Measure 32

## North Mount Vernon Ring Dike



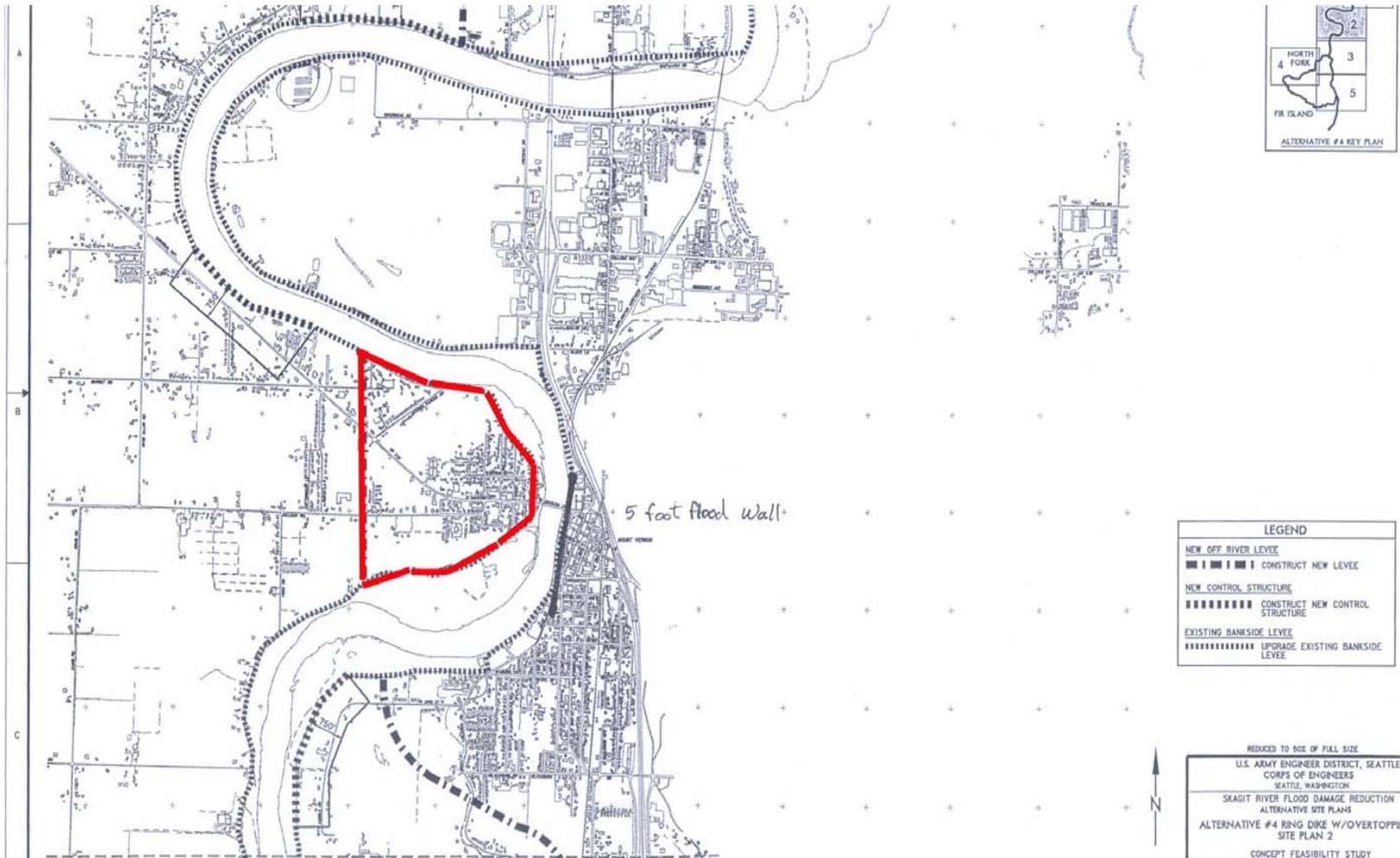
- Description:
  - A levee would be constructed to protect North Mount Vernon from flooding.
  - Executive Order 11988 states that the federal government is to avoid direct or indirect support of flood plain development; therefore, would need cross levee in Big Bend.



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# Measure 33

## West Mount Vernon Ring Dike



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# Measure 33

## West Mount Vernon Ring Dike

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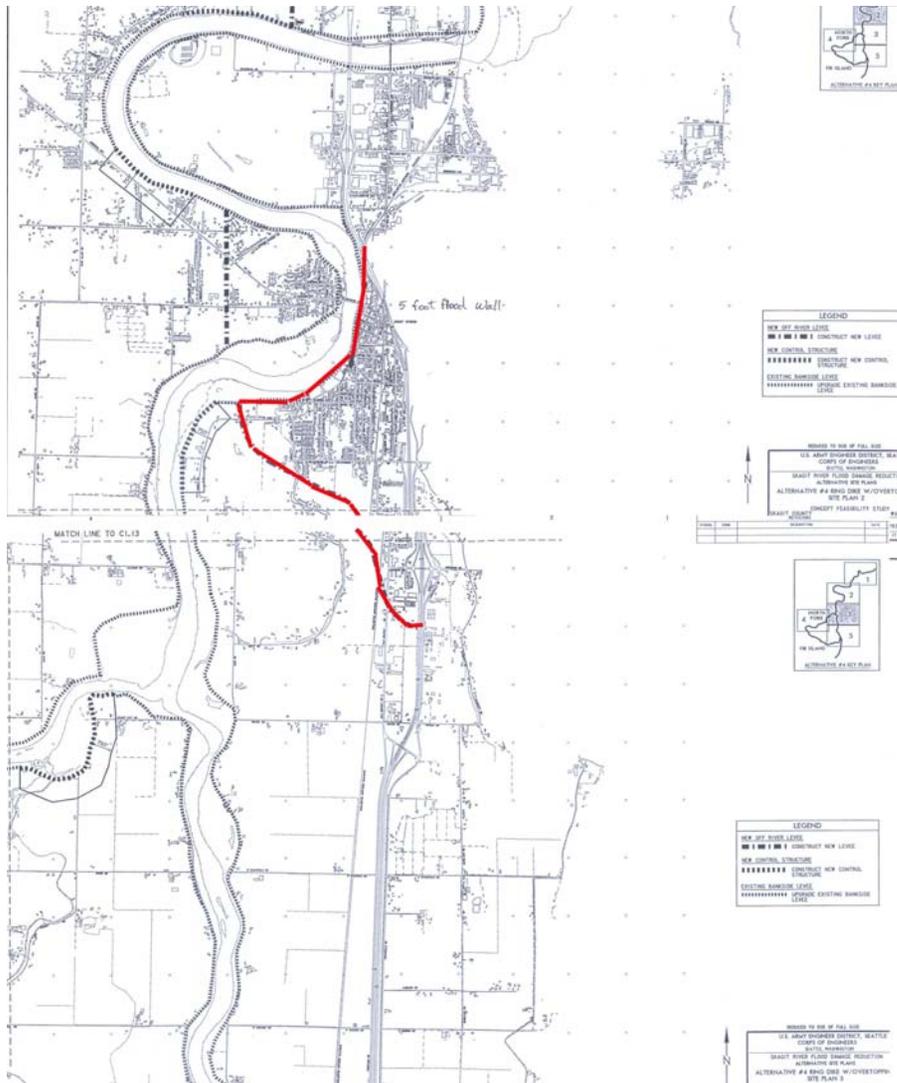
- Description:
  - A levee would be constructed to protect West Mount Vernon from flooding.



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# Measure 34

## East Mount Vernon Ring Dike



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# Measure 34

## East Mount Vernon Ring Dike

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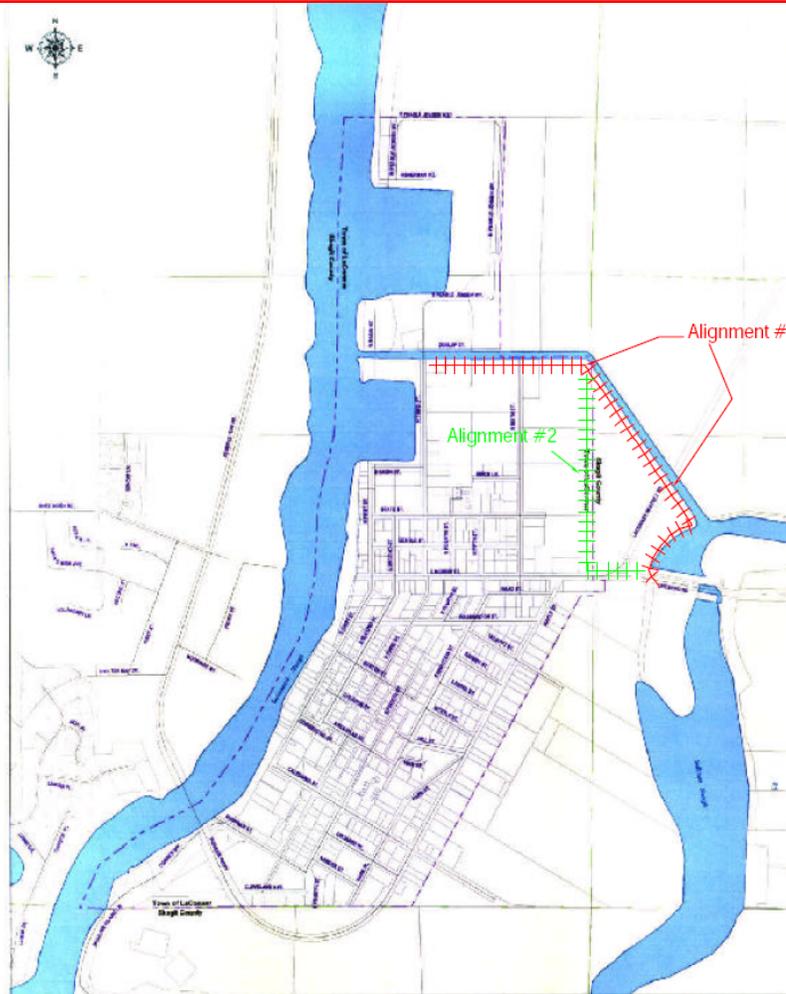
- Description:
  - A levee would be constructed to protect East Mount Vernon from flooding.



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# Measure 35

## La Conner Ring Dike



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# Measure 35

## La Conner Ring Dike

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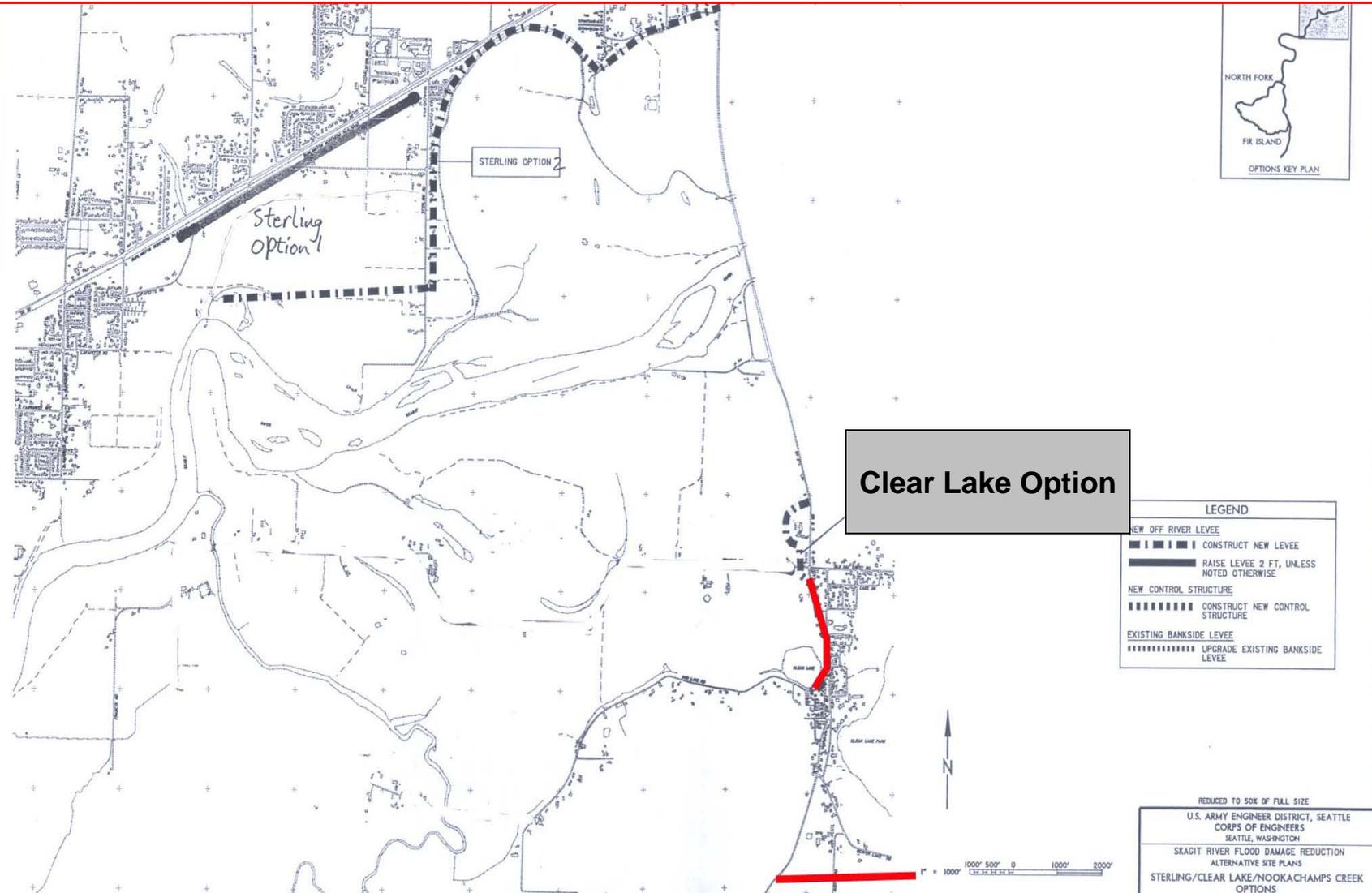
- Description:
  - A levee would be constructed to protect La Conner from flooding.



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# Measure 36

## Clear Lake Ring Dike





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# Measure 36

## Clear Lake Ring Dike



- Description:
  - A levee would be constructed to protect Clear Lake from flooding.



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# Measure 37



## Anacortes Water Treatment Plant Ring Dike





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# Measure 37

## Anacortes Water Treatment Plant Ring Dike



- Description:
  - A levee would be constructed to protect the Anacortes Water Treatment Plant from flooding.



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# Measure 37



## Anacortes Water Treatment Plant Ring Dike

### Potential Advantages

- Increases protection of water treatment plant.
- Protects water quality.

### Potential Disadvantages

- Would require an extensive pumping system.



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# Measures



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## Nonstructural and Restoration Measures

*Relocations, natural valley  
storage, levee setbacks/removals,  
floodproofing, habitat restoration*

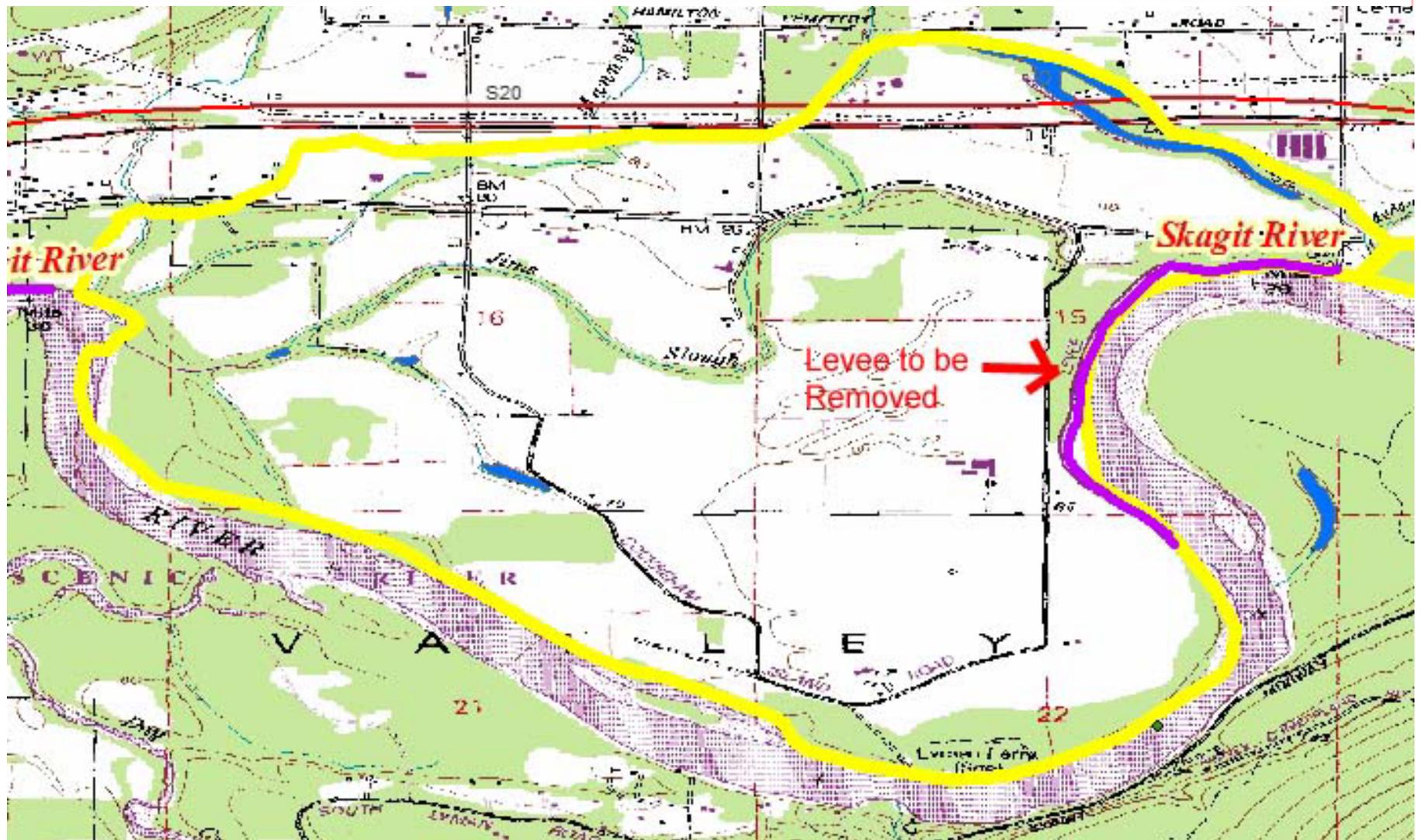
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# Measure 22 Cockreham Island





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# Measure 22

# Cockreham Island



- Description:
  - Includes removal of levee on right bank downstream of Hamilton.
- Preliminary construction costs will be developed when restoration projects are evaluated.



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# Measure 22

## Cockreham Island



### Potential Advantages

- Restores habitat.
- Provides natural valley storage.

### Potential Disadvantages

- Impacts to agriculture and local residents will need to be evaluated.
- Would require structure relocations.
- Very limited storage capacity.



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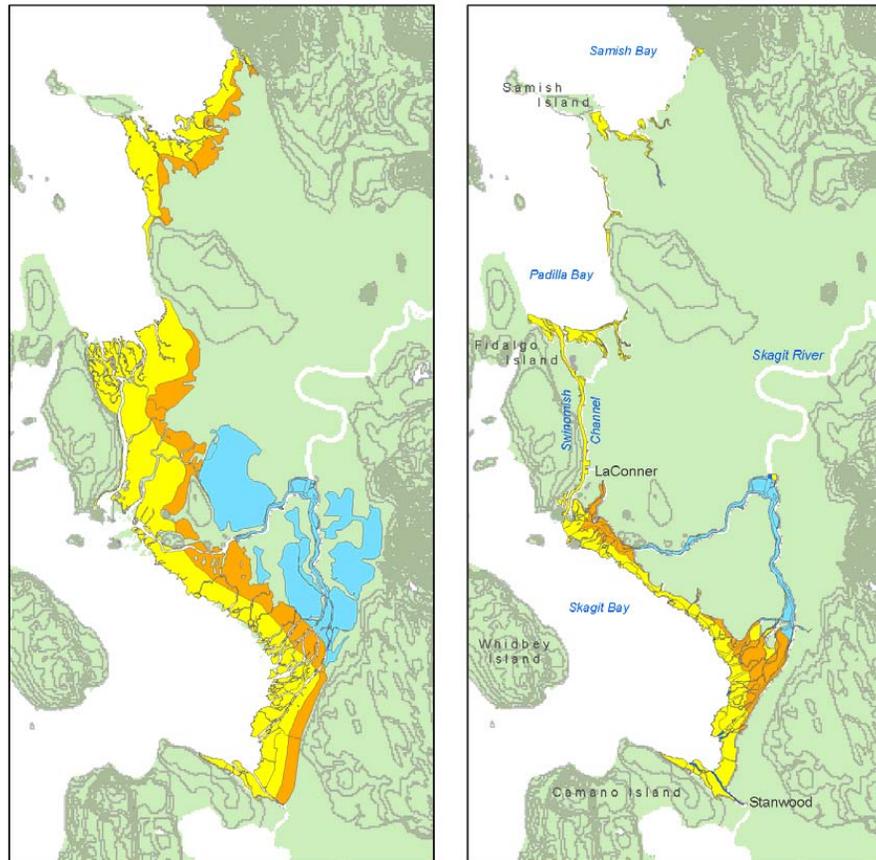
# Measure 23

# Estuarine Restoration

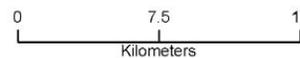


1860s

1991



- estuarine emergent marsh zone
- estuarine scrub shrub zone
- riverine tidal zone



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# Measure 23

## Estuarine Restoration



- Description:
  - Includes the Skagit Chinook Recovery Plan's measures for Theins Farm, Sullivans Hacienda, Wiley Slough, Milltown Island, Deepwater Slough, and Fisher Slough to expand conveyance areas near Skagit Bay.
- Preliminary construction costs will be developed when restoration projects are evaluated.



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# Measure 23

## Estuarine Restoration



### Potential Advantages

- Restores estuarine habitat.

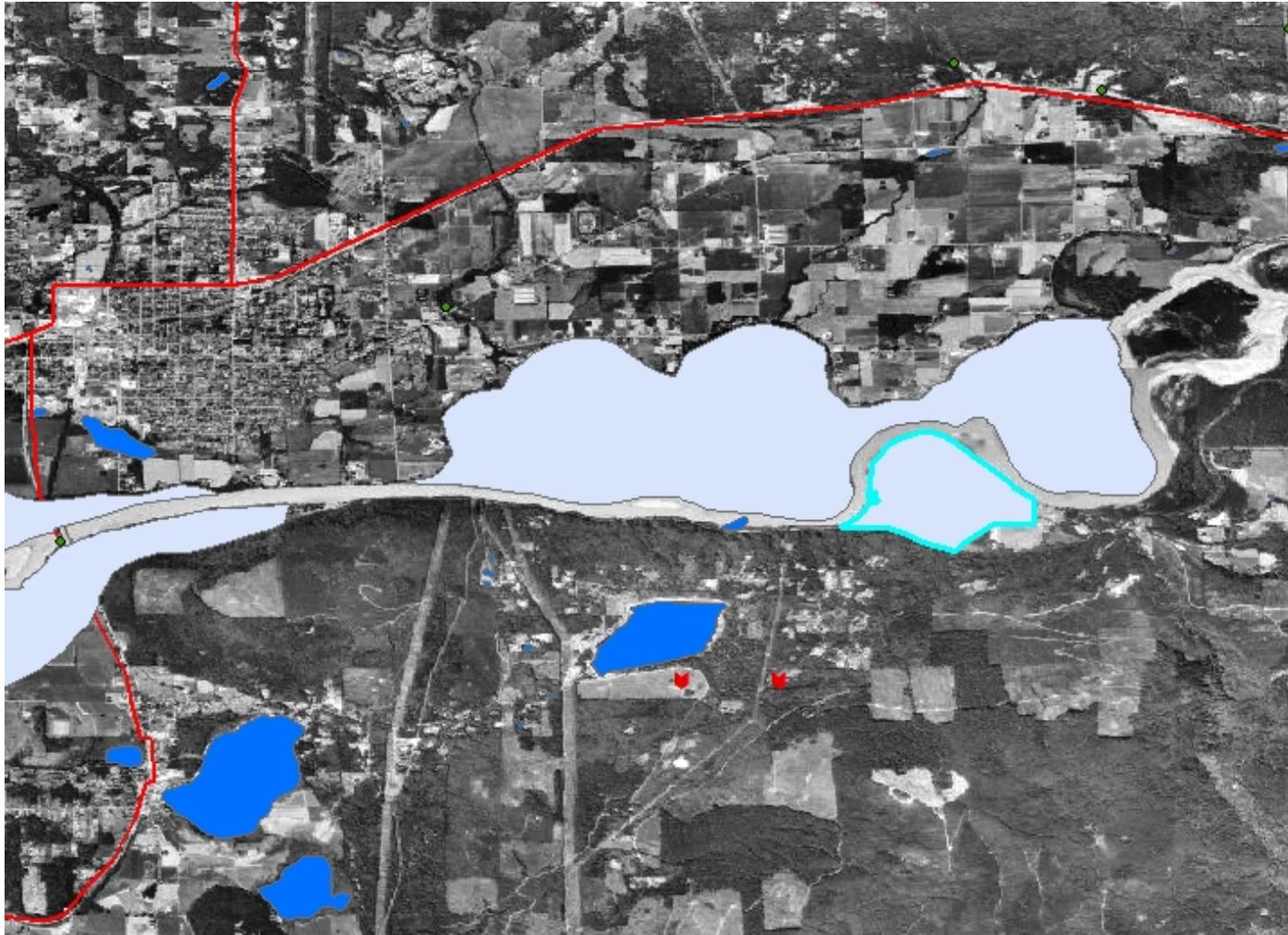
### Potential Disadvantages

- Impacts to agriculture and local residents will need to be evaluated.
- Flood reduction benefits may be minimal.



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# Measure 24 Riparian Restoration



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# Measure 24

## Riparian Restoration

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- Description:
  - Includes the following riparian restoration projects: Gilligan Floodplain, River Bend, Britt Slough Restoration and Cottonwood Island.
  - All projects are either levee removals or levee setbacks.
- Preliminary construction costs will be developed when restoration projects are evaluated.



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# Measure 24

## Riparian Restoration



### Potential Advantages

- Restores riparian habitat.

### Potential Disadvantages

- Flood reduction benefits may be minimal.
- Impacts to agriculture, local residents and infrastructure will need to be evaluated.
- Potentially some increase in floodplain deposition.



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# Measure 25

## Nonstructural Measures

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- Description:
  - Includes flood proofing, improved flood warning and evacuation systems.
  - Will be further developed during alternatives analysis.
- Preliminary construction costs have not been developed.



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# Measure 25



## Nonstructural Measures

### Potential Advantages

- Minimal environmental impact.
- Increased public safety and awareness.

### Potential Disadvantages

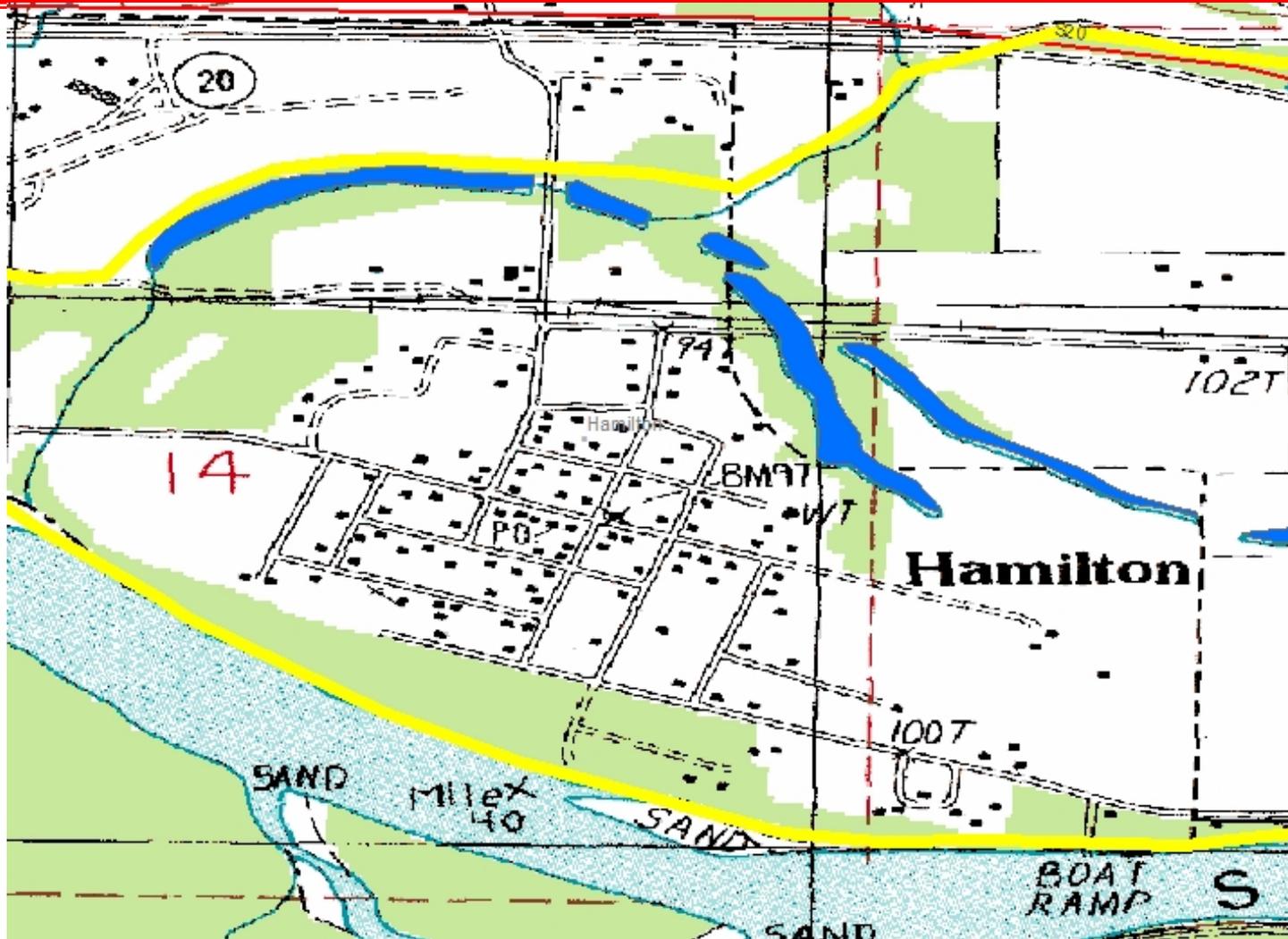
- Allows residual damages.



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# Measure 26 Hamilton Relocation



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# Measure 26

## Hamilton Relocation

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- Description:
  - Relocates the entire town of Hamilton.
- Preliminary Construction Costs: Project found infeasible based on a 1980's Section 205 study.



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# Measure 26

## Hamilton Relocation



### Potential Advantages

- May be justified based on environmental benefits.
- Removes structures and infrastructure from floodway.
- Increases public safety.
- Will work with state, local and private entities.

### Potential Disadvantages

- Environmental benefits may be not be sufficient to justify economic costs.
- Relocation costs are significant.



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# Measure 27 Debris Management





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# Measure 27

## Debris Management

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- Description:
  - Debris collection and removal.
  - Will be further evaluated during alternatives analysis in combination with other measures.
- Preliminary construction costs have not been developed.



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# Measure 27

## Debris Management



### Potential Advantages

- Reduced constriction of flows at bridges (i.e. blockage at the BNSF Bridge could be prevented).
- Reduced pressure on bridges.
- Reduces risks associated with debris removal during flood events, including life safety.

### Potential Disadvantages

- Large woody debris is valuable for fish habitat.
- Current environmental regulations do not allow for permanent removal of debris.



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# Comments

- 
- Need your comments on impacts of measures to: neighborhoods and businesses, environment, agriculture, cultural sites, etc.
  - Provide input on design issues or implementation issues.
  - Provide written comments to Skagit County Public Works.
  - Email address for submittal of comments to Skagit County.
  - Please provide comments no later than September 30.



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# What's Next?

- 
- Corps and County will compile comments.
  - Provide summary of responses and post them on County's webpage.
  - Present summary of comments and Corps' responses at follow up Flood Control Zone District meetings.
  - Continue to develop costs and refine measures.
  - Environmental scoping.
  - Corps Headquarters approval of the measures.

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