



KING COUNTY  
FLOOD CONTROL  
DISTRICT



King County

Basin Technical Committee (BTC)  
Snoqualmie/SF Skykomish  
Update

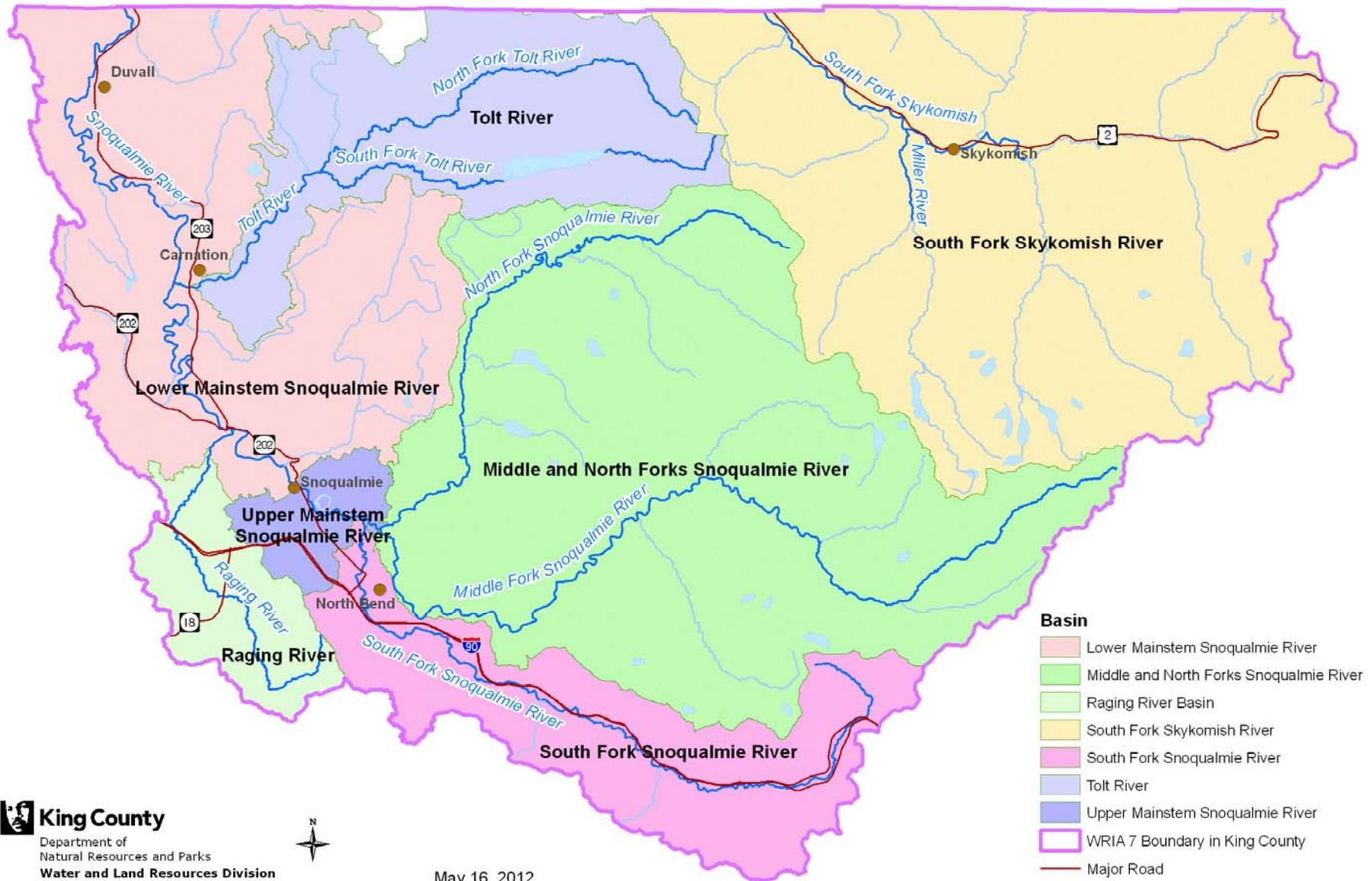
May 8, 2014



# Today's Presentation

- Brief overview of basin accomplishments 2008-2013
- Updates on major CIP projects
- Updates and status of Snoqualmie corridor planning efforts (some highlights and examples)
- Questions/discussion

# Snoqualmie/ SF Skykomish Watershed



- Basin**
- Lower Mainstem Snoqualmie River
  - Middle and North Forks Snoqualmie River
  - Raging River Basin
  - South Fork Skykomish River
  - South Fork Snoqualmie River
  - Tolt River
  - Upper Mainstem Snoqualmie River
  - WRIA 7 Boundary in King County
  - Major Road
  - Major Rivers
  - Other Rivers and Tribs.
  - Incorporated Area

**King County**  
 Department of  
 Natural Resources and Parks  
**Water and Land Resources Division**



May 16, 2012



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# Basin Characteristics

- No large dams
- Limited flood containment levees
- 250 flood protection facilities
- Over 80 river miles with floodplain management needs
- Many subbasins, each with different challenges, different management strategies



# Basin Flood Risks



**Flood inundation**



**Channel migration**



**Bank erosion**



**Alluvial fan hazards**

# Overall Approach

Corridor studies to determine best approaches

- Middle Fork
- South Fork
- Tolt
- Snoqualmie at Fall City

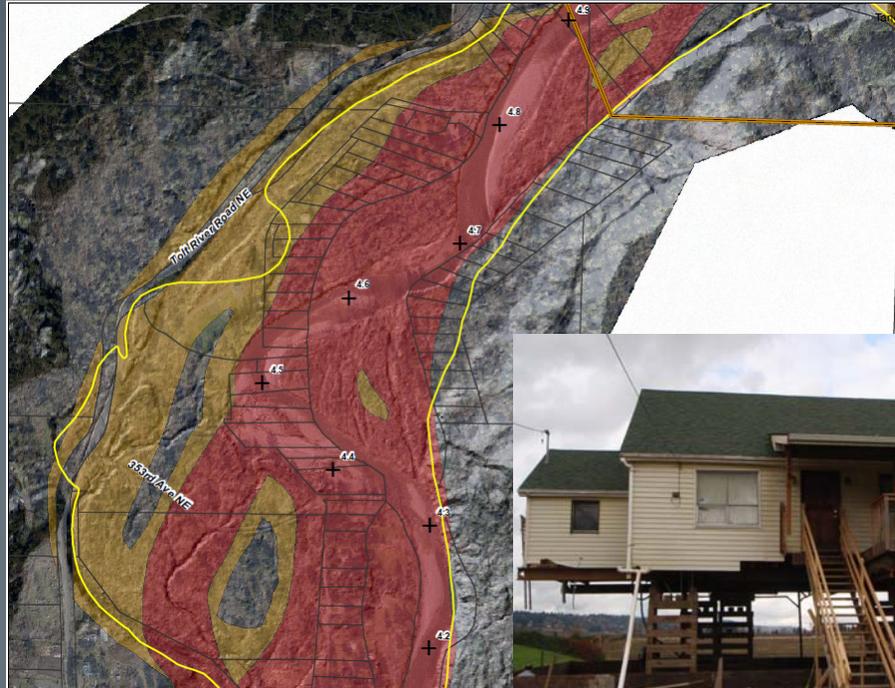
Focus on “non-structural” measures where feasible

- Buyouts
- Home elevations
- Farm pads

Protect critical infrastructure

- Levee retrofits and relocations
- Repairs when needed

Set back levees to allow room for floodwater and gravel storage, increase conveyance



# Basin Accomplishments 2008 - 2013

## Non-Structural

- 65 homes bought out and removed from floodplain (225 acres)
- 54 home elevations
- 26 farm pads and 3 barn elevations



*Fall City  
Area homes  
purchased after  
extensive flood  
damages*



*Large barn pilot  
elevation near  
Carnation*

# Basin Accomplishments

## Levee and Revetment Repairs

- Large flood events 2006, 2008, 2009, 2011
- Phase 2+ flooding over 25 times
- 33 flood damage repair construction projects



*Mason Thorson  
Extension*

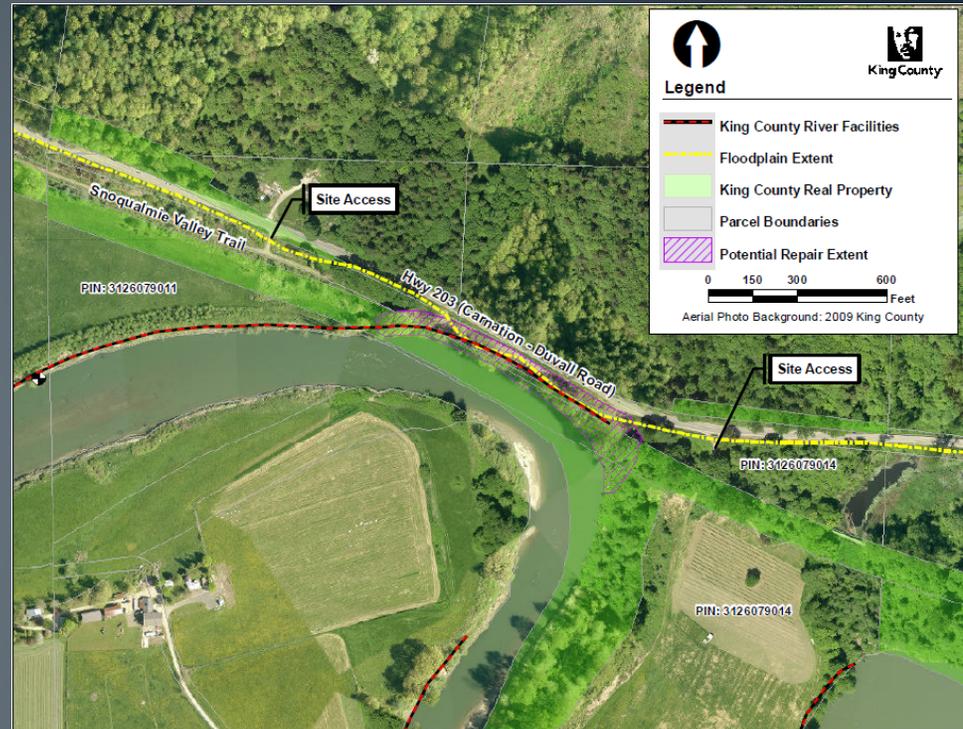


*Tolt 1.1 Emergency  
Repair*

# Large Capital Projects in Design

## Sinemamma Quaale Upper

- Rapidly eroding bank
- Protects SR 203, Snoqualmie Valley Trail
- \$3.7 million
- 2015 or 2016 construction
- Currently in preliminary design



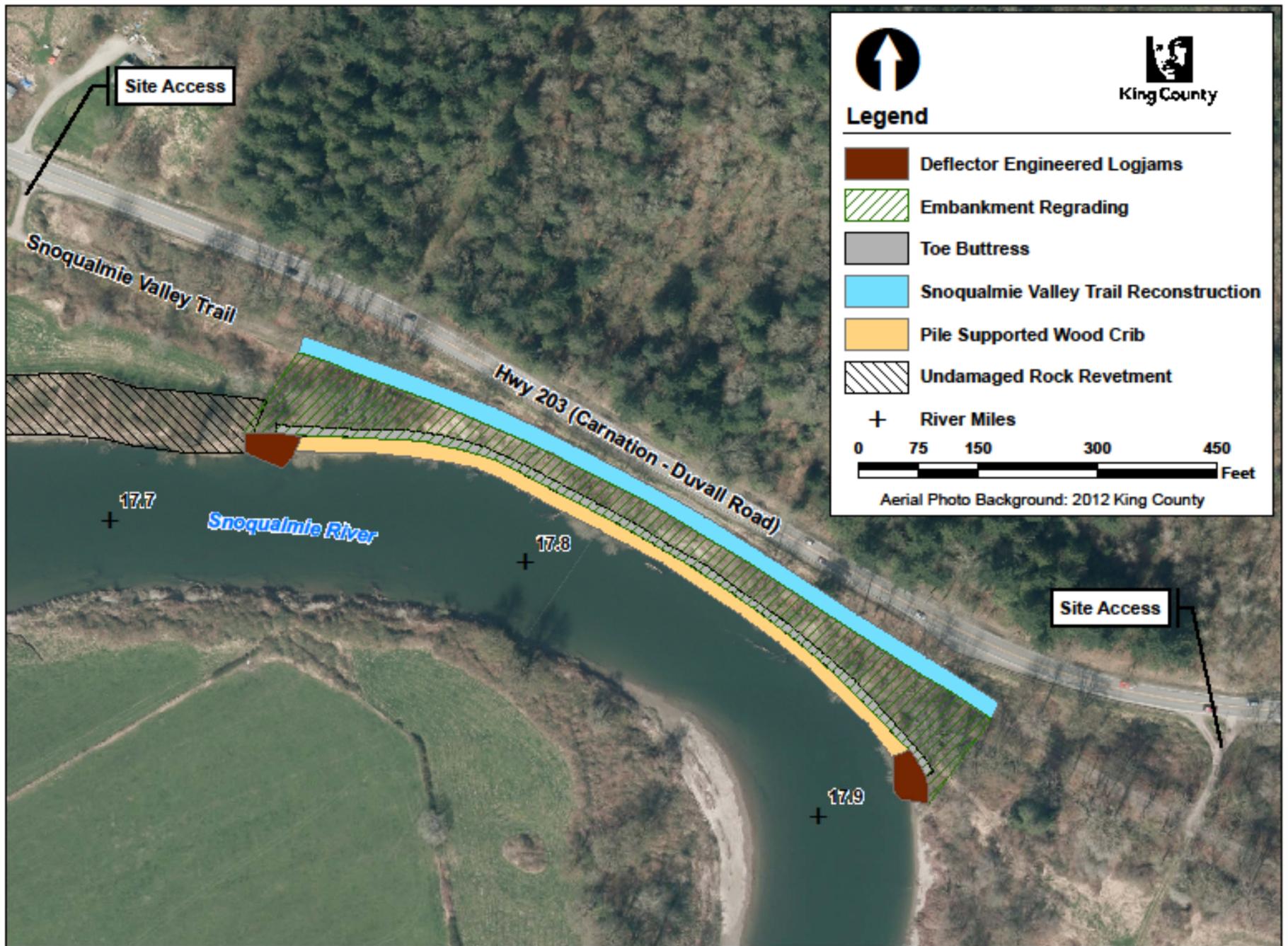


Figure X: Sinnema Quale Upper Revetment Reconstruction Selected Alternative Project Features

# Capital Projects in Design

## Winkelman

### (Tolt Pipeline Protection)

- Rapidly eroding bank
- Protects SPU Tolt water supply pipeline
- \$3.7M
- 2015 or 2016 construction
- Currently in alternatives phase



# Corridor Plans

- South Fork Snoqualmie
- Middle Fork Snoqualmie
- Tolt River
- Snoqualmie at Fall City
- Likely will initiate more in future years
  - Lower mainstem
  - Raging River

# General Approach to Corridor Plans

- Multi-objective: Scope and goals based on Flood Plan and County policies
  - Flood inundation, erosion, channel migration where applicable
  - Ecological resources, including salmon habitat where present
  - Economy, agriculture, recreation, other community goals
- Characterize existing and potential future conditions
- Develop and evaluate alternatives
  - Long-term: What will it take to “be done?”
  - Near-term: Priority actions for 6-10 year CIP
- Recommend long-term strategy and near-term actions

***Key is to customize to the needs  
of the river basin and segment!***

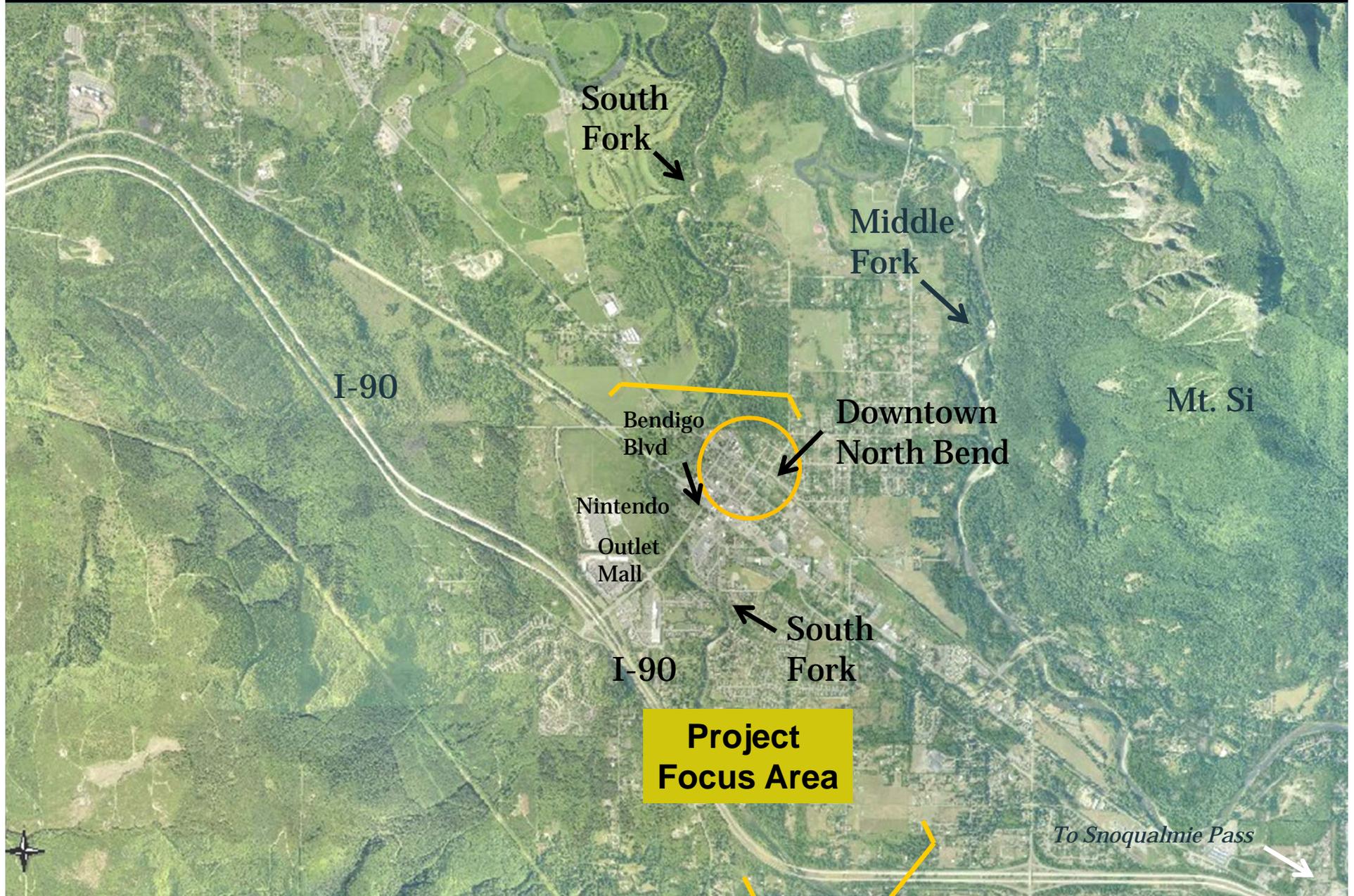
# South Fork Overview

- Corridor plan for river segment through North Bend (RM 2.0 – 5.5)
- Levees constructed mid-1960s
- Different flood protection on left and right banks
- Slope stability, seepage, scour, levee overtopping problems
- Gravel aggradation between levees



*Levee overtopping, January 2009*

# Upper Snoqualmie Valley



# Flooding, Damages, Repairs



Levee overtopping January 2009



Bendigo Bridge November 2006



North Bend retail November 2006



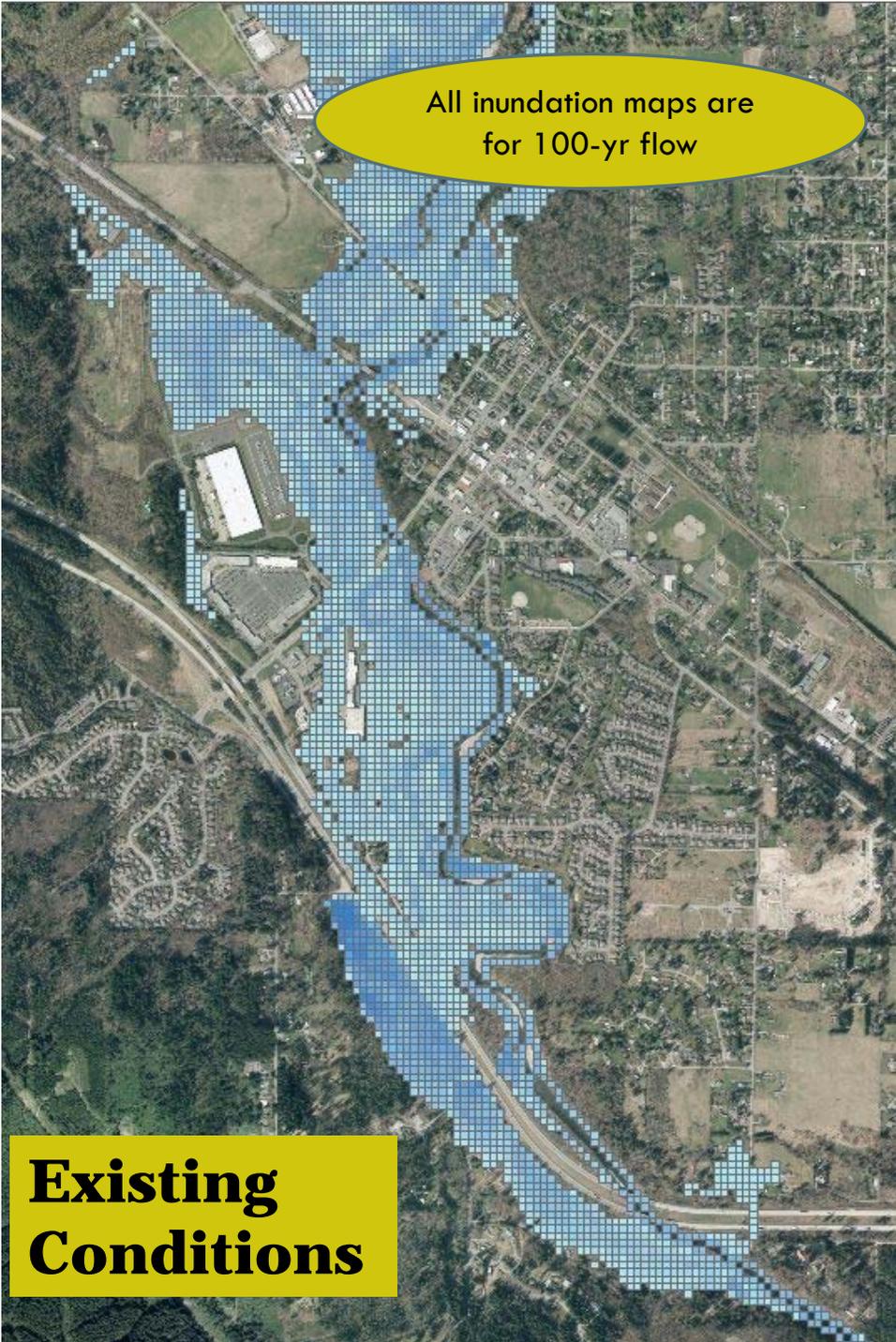
Seven bank repairs plus numerous sinkhole repairs between 2006 and 2012

# Project Status

- Characterization of conditions nearly complete
- Alternatives evaluation in progress
- Initial briefings of FCD board members
- Preliminary meetings with key stakeholders



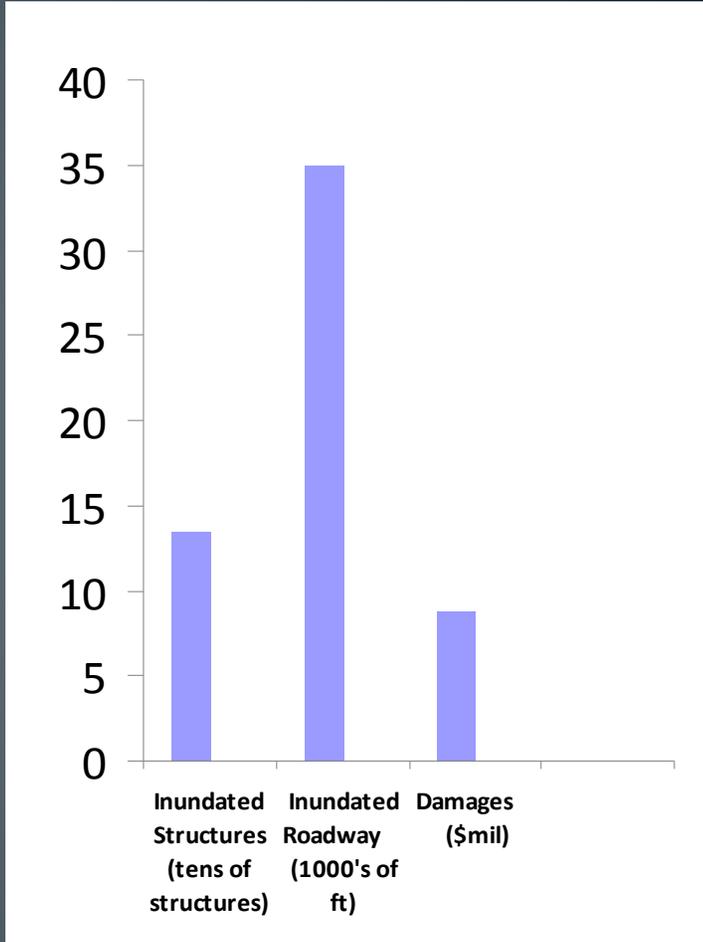
*Setting up for a boring to evaluate levee stability*



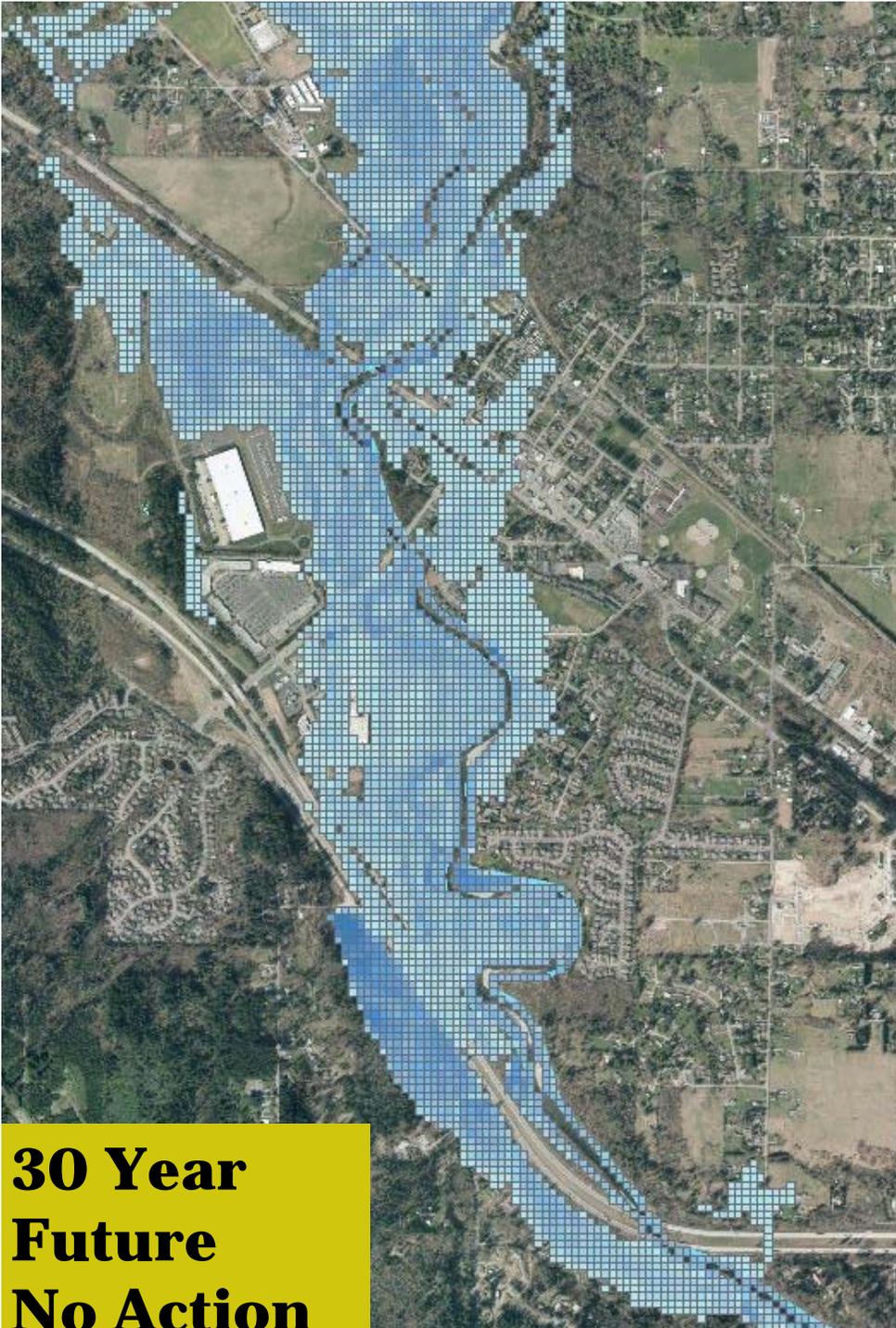
All inundation maps are for 100-yr flow

**Existing Conditions**

# Flooding Impacts

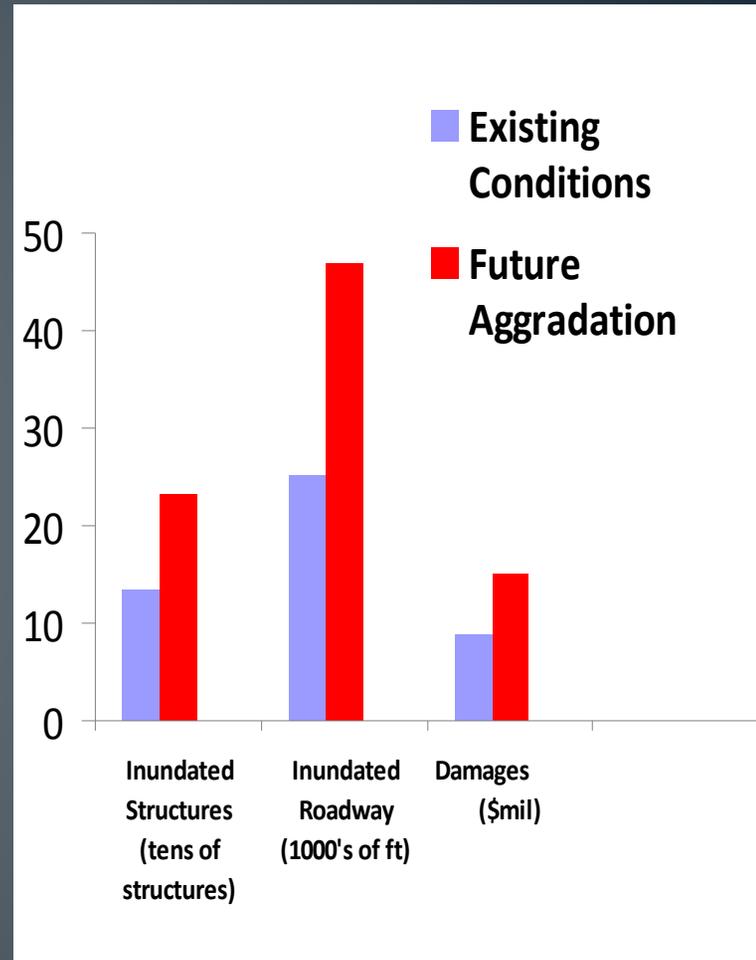


Preliminary results for 100-year event



**30 Year  
Future  
No Action**

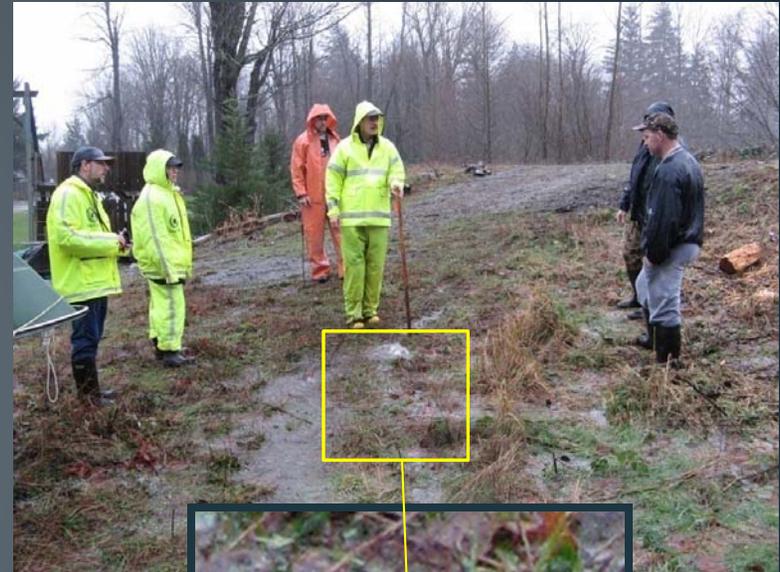
## Change in Impacts



Preliminary results for 100-year event

# Key Findings of Characterization

- Levees are more stable than expected, but some problem areas
- Significant hydraulic deficiencies
  - Levee overtopping
  - Seepage and tributary flows
- Bendigo Blvd Bridge important, but less than earlier thought
- I-90 flooding likely around 50-year flood event
- Sediment accumulation will worsen conditions



*Levee seepage,  
January 2009*

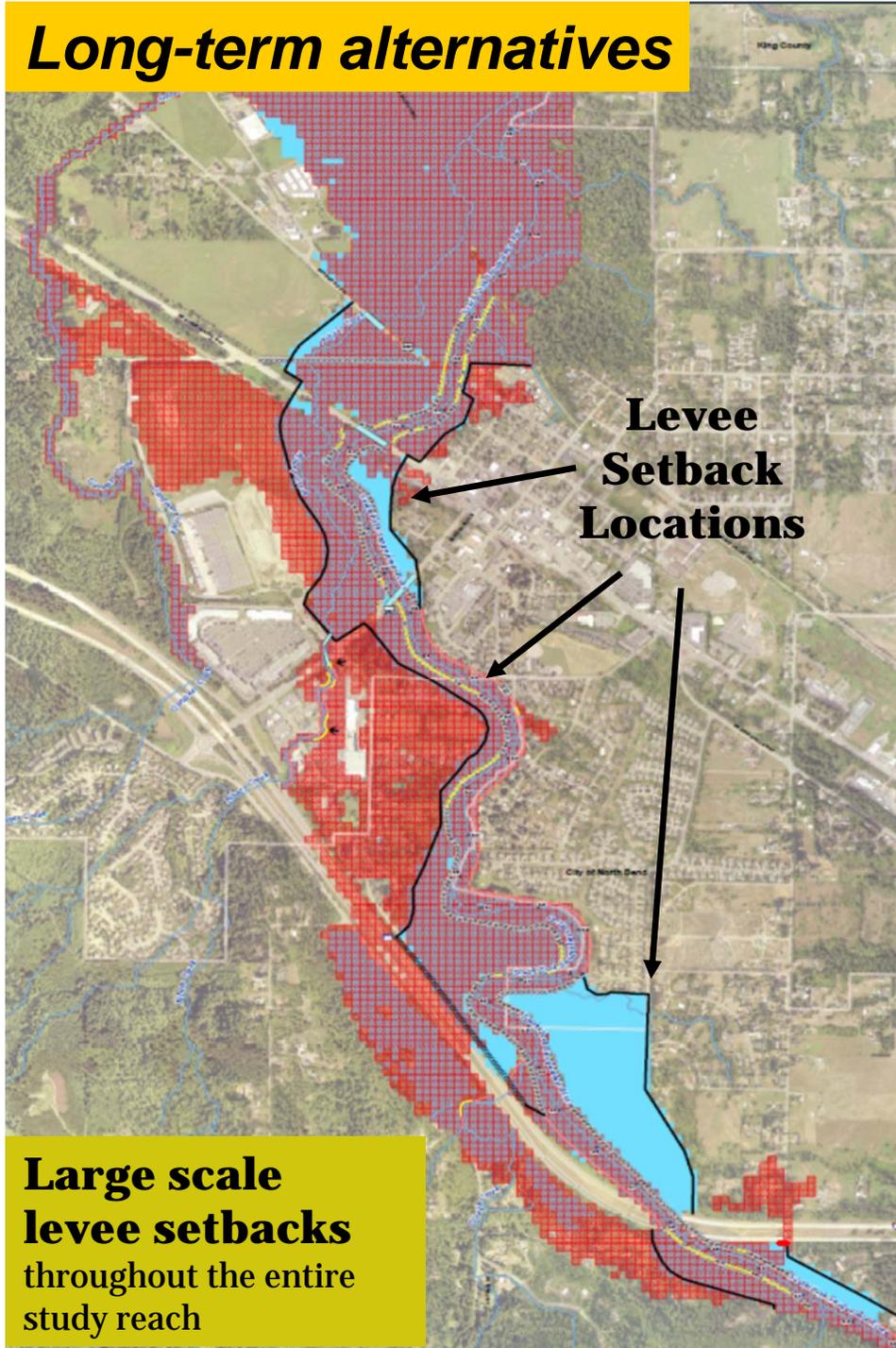
# Alternatives Being Evaluated

- Long-term, corridor scale
  - Major levee setback approach
  - Containment, raise in place approach
- Targeted projects for near-term capital program
  - I-90
  - Bendigo Blvd.
  - Nintendo levee setback
  - Gravel management
  - One or more near-term levee reconstruction sites

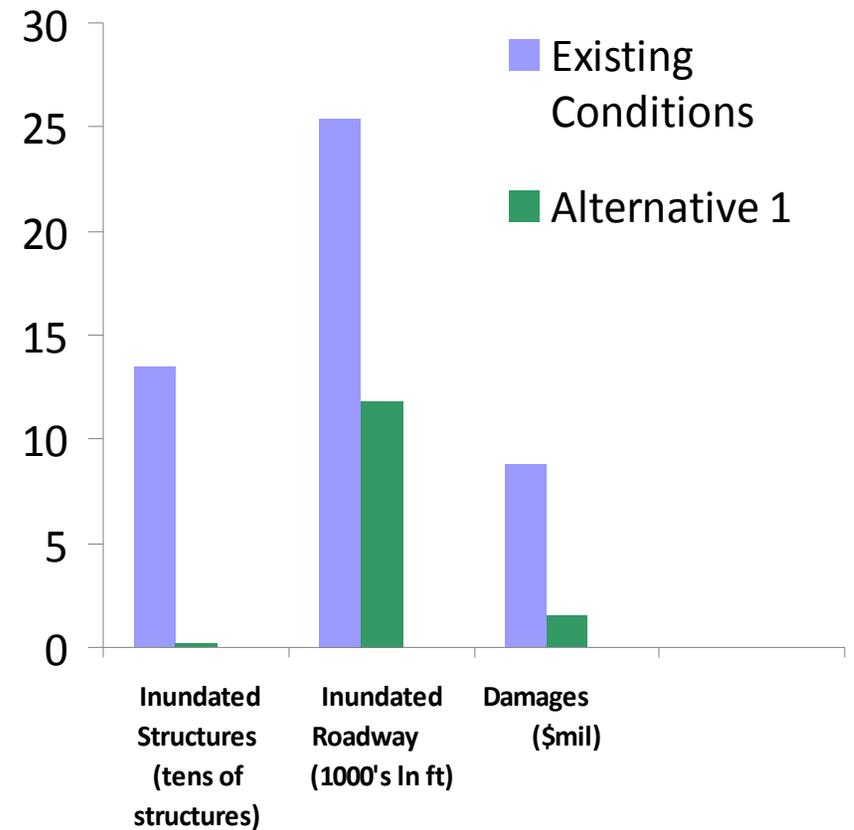


*Recent flood damage repair  
in project area*

## Long-term alternatives

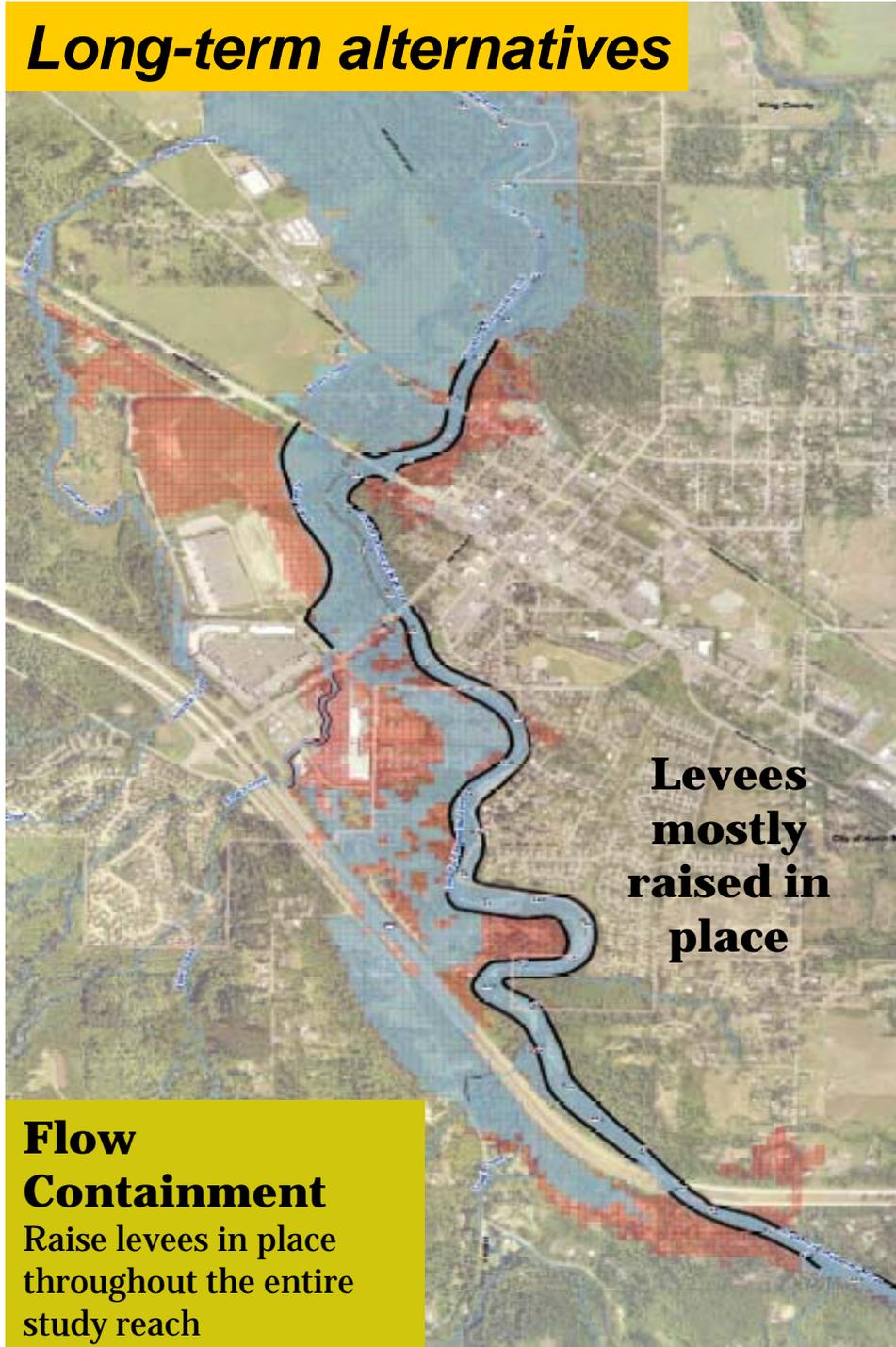


## Change in Impacts



Preliminary results for 100-year event

## ***Long-term alternatives***



### **Flow**

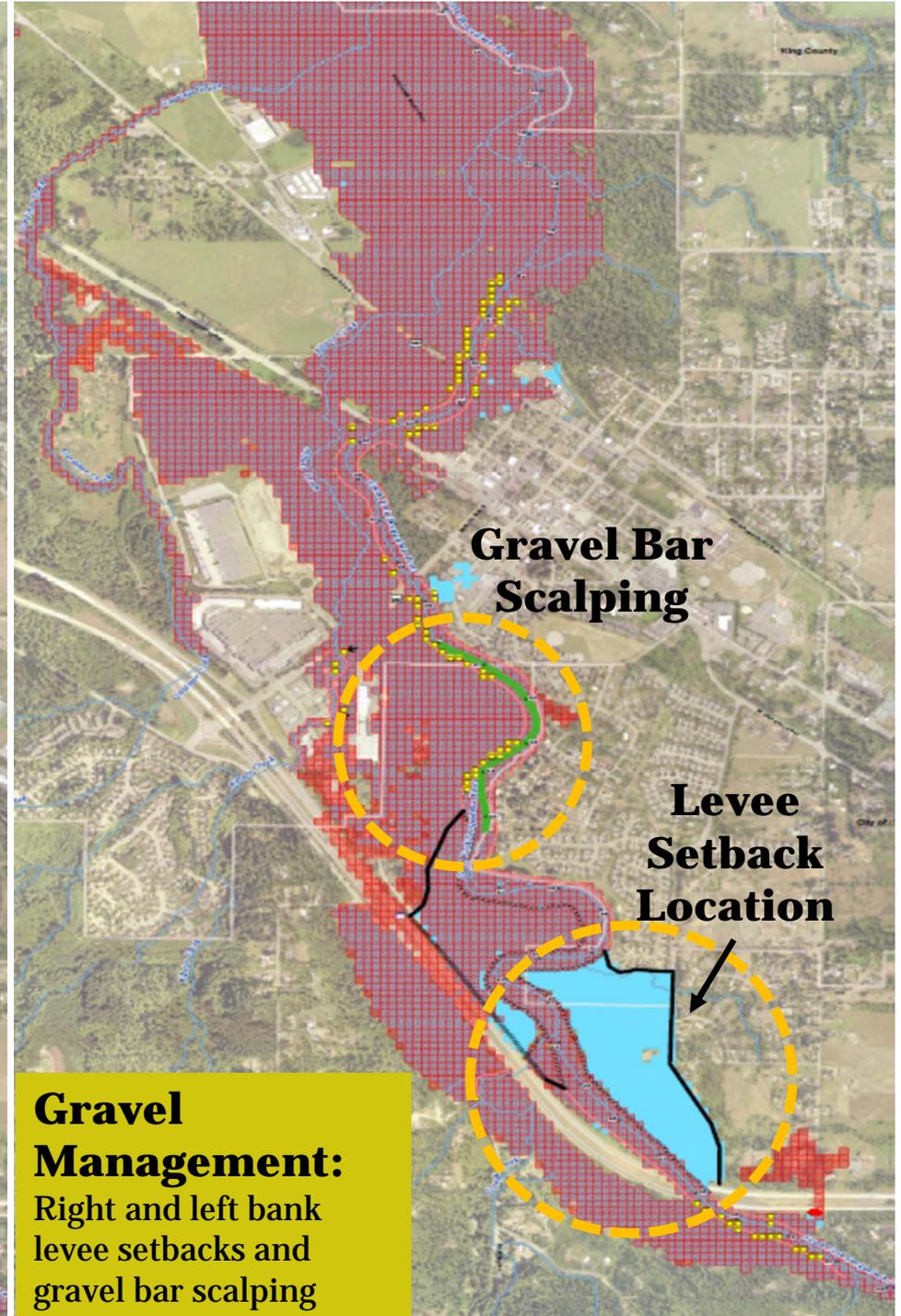
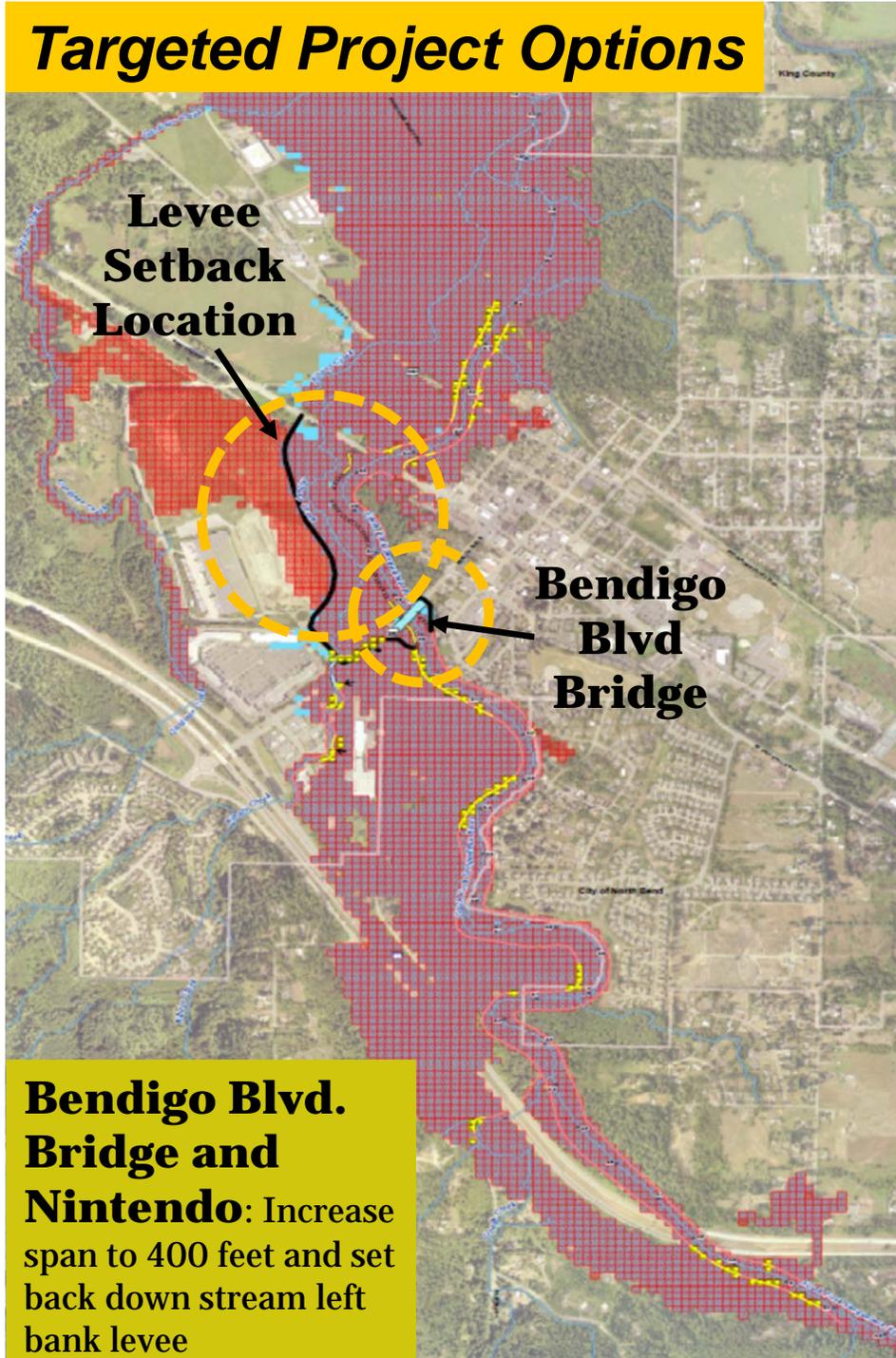
### **Containment**

Raise levees in place  
throughout the entire  
study reach

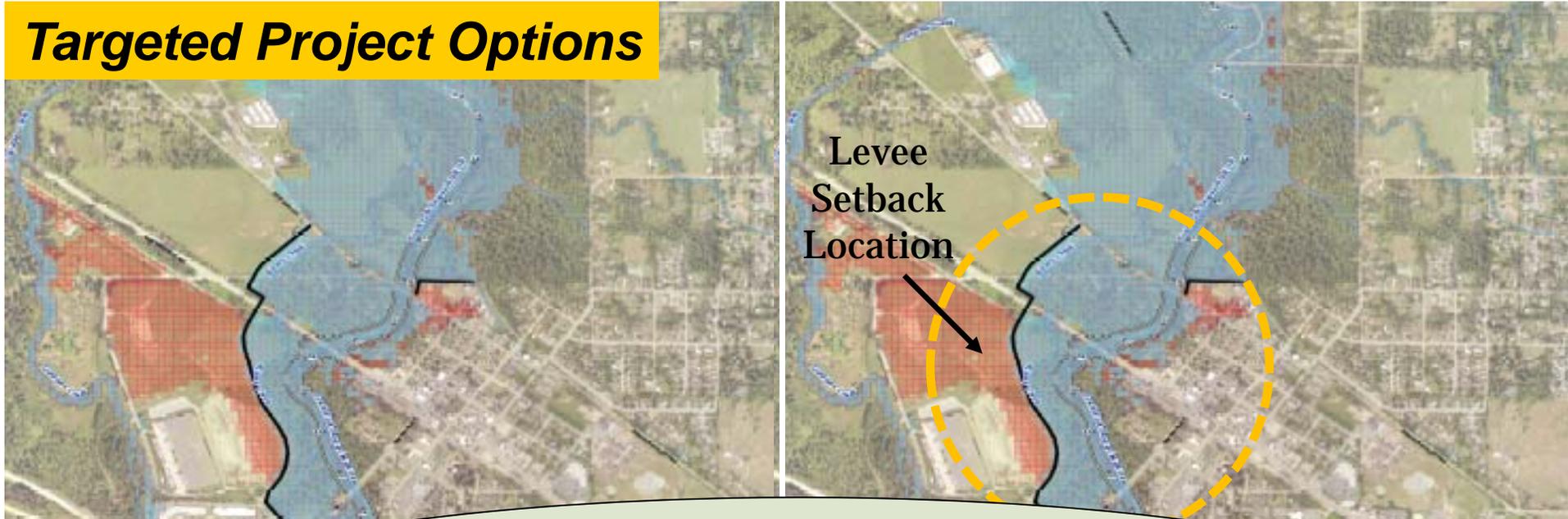
## **Change in Impacts**

*Under development*

# Targeted Project Options



# Targeted Project Options



*I-90 project budgeted as priority early action. Initial modeled looked at modifying one levee, but now appears solution may require changes to up to four levee segments.*



**I-90 Flood Reduction:**  
Levee setback upstream of I-90



**Nintendo Levee Setback:**  
Targeted opportunity project on Nintendo property and just downstream

# Next Steps

## April/May 2014

- Complete alternatives evaluation technical work and consultant reports

## May–Sept 2014

- Meet with stakeholders to discuss alternatives
- Flood District input on preferred alternatives and near-term capital project priorities

## 4<sup>th</sup> Quarter 2014

- Finalize recommendations

## 2015

- FCD Board final decisions
- Begin implementation

# Tolt River Corridor Plan

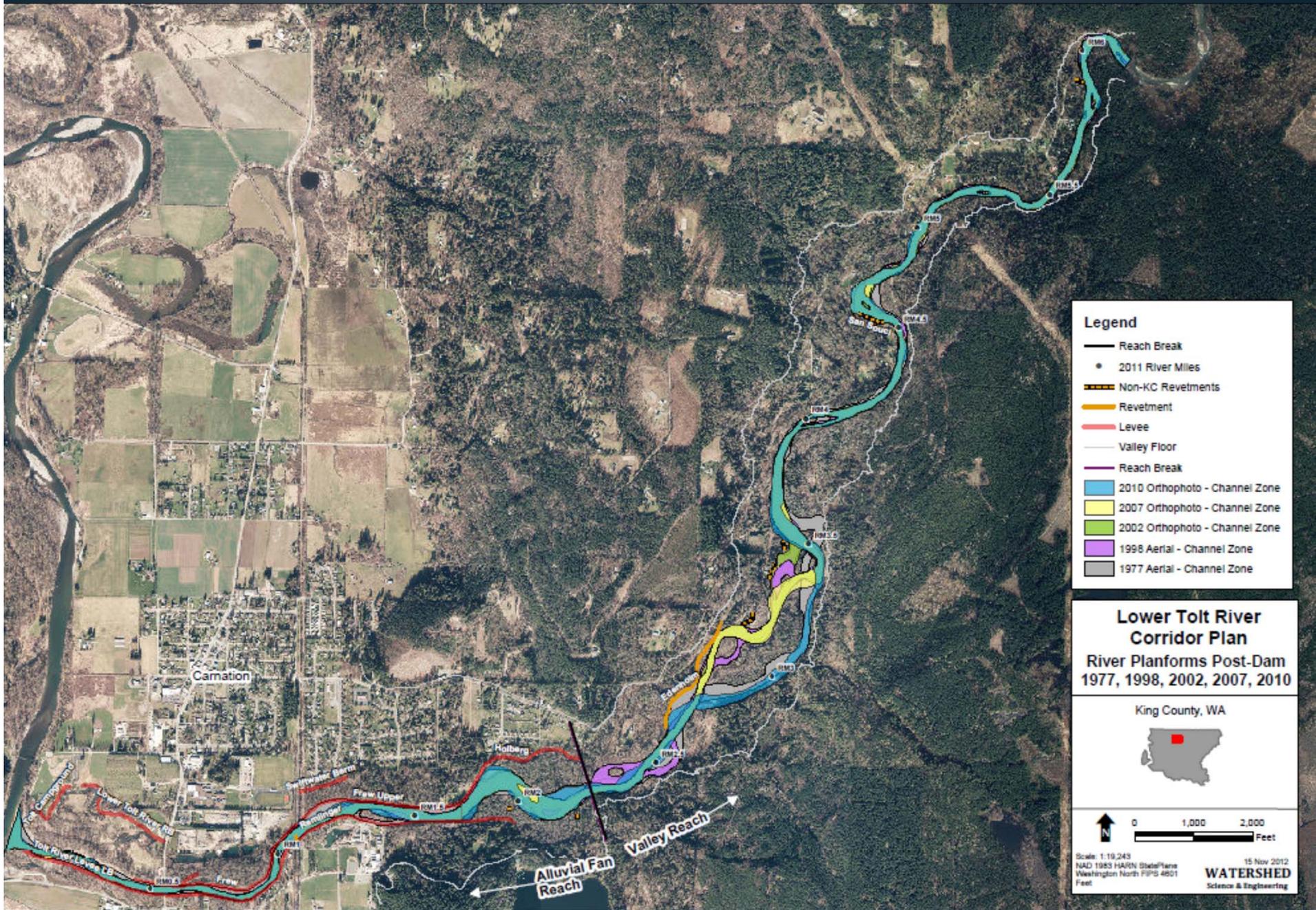
- Steep, dynamic river
- High sediment load, high channel migration risk
- Levees along lower 2 miles near Carnation
- Few levees for upper 4 miles
- Plan will establish priorities, strategy
- Current schedule to wrap up technical and planning work late 2014
- FCD decision making 2015

*Jan. '09 levee breach  
required emergency  
repair*



# Tolt River Corridor Action Plan

- Similarities in approach
  - Multi-dimensional: flooding, erosion, habitat
- Some key differences from South Fork
  - High priority in WRIA 7; partnership with salmon recovery interests
  - 2/3 of river segment lacks levees
    - Much less focus on levee stability, geotech
    - Significant channel migration hazard issues
    - Erosion and high velocities in floodplain
- Synthesis of different disciplines more challenging



**Legend**

- Reach Break
- 2011 River Miles
- - - Non-KC Revetments
- Revetment
- Levee
- Valley Floor
- Reach Break
- 2010 Orthophoto - Channel Zone
- 2007 Orthophoto - Channel Zone
- 2002 Orthophoto - Channel Zone
- 1998 Aerial - Channel Zone
- 1977 Aerial - Channel Zone

**Lower Tolt River Corridor Plan**  
**River Planforms Post-Dam**  
**1977, 1998, 2002, 2007, 2010**

King County, WA

0 1,000 2,000 Feet

# Flooding at San Souci, January 2009



# Some highlights of technical approach

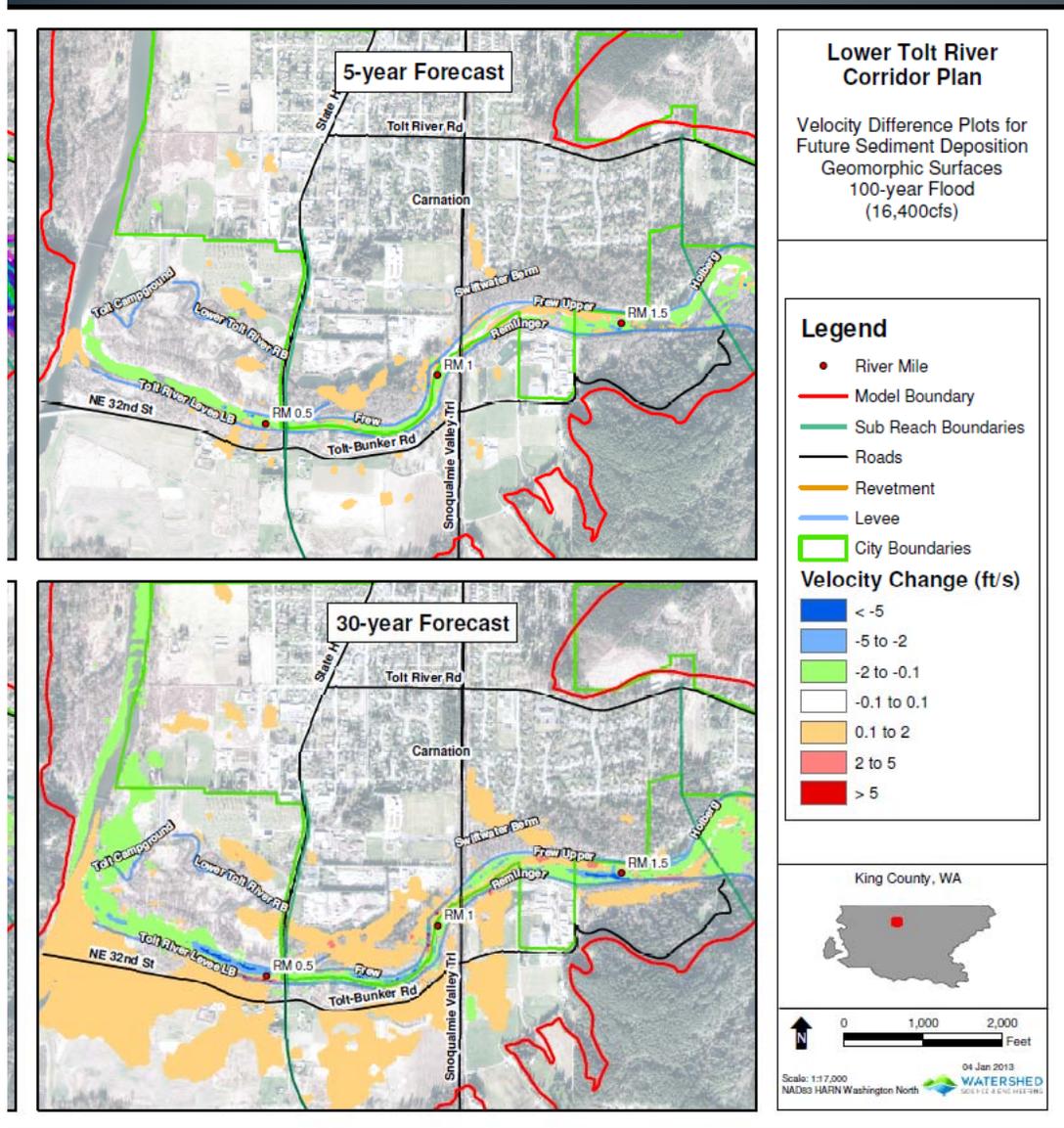


Figure 44

2-D model for inundation extents, depths, patterns, velocities

Channel migration and sediment trends over a range of time frames

Aquatic and riparian habitat

Overlaying and synthesizing data sets

Alternative suites of project actions

## Some Preliminary Findings

- Flood inundation at “end of road” more significant than anticipated – 20 homes for 100-year flood
- Much better understanding of road closure potential at more extreme events
- Sediment accumulation in lower two mile reach with levees can greatly change overtopping, floodplain inundation, velocities

# Status and timeline

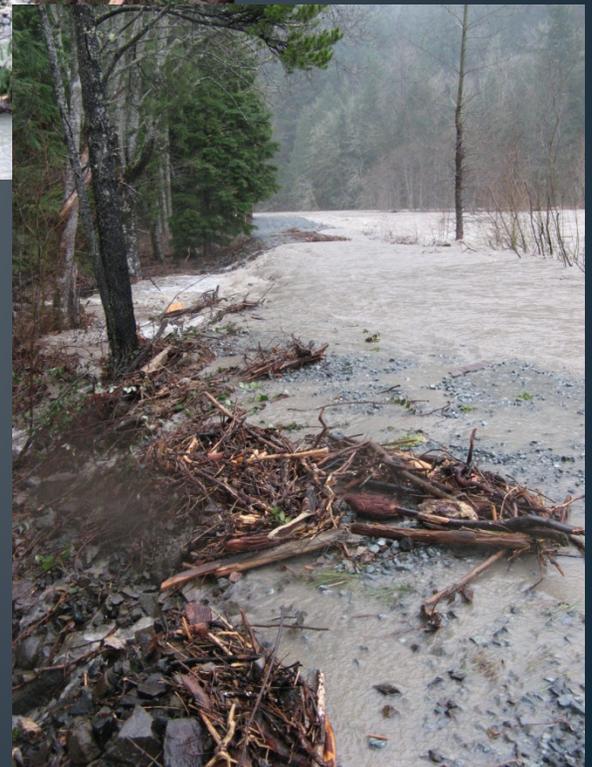
- Existing conditions analysis nearly complete
- Alternatives analysis to be completed by Dec. 2014.
  - Alternative Analysis Report
  - Concept-level project designs
- Design phase may be added by amendment:
  - Analysis, design and implementation of a select CIP project



*January 2009*

# Middle Fork Corridor Plan

- Dynamic alluvial fan
- High channel migration and erosion risks
- Facilities require frequent and costly repairs
- Plan completion delayed to 2015 to allow focus on other projects



Some similarities to Tolt  
in terms of range of  
issues

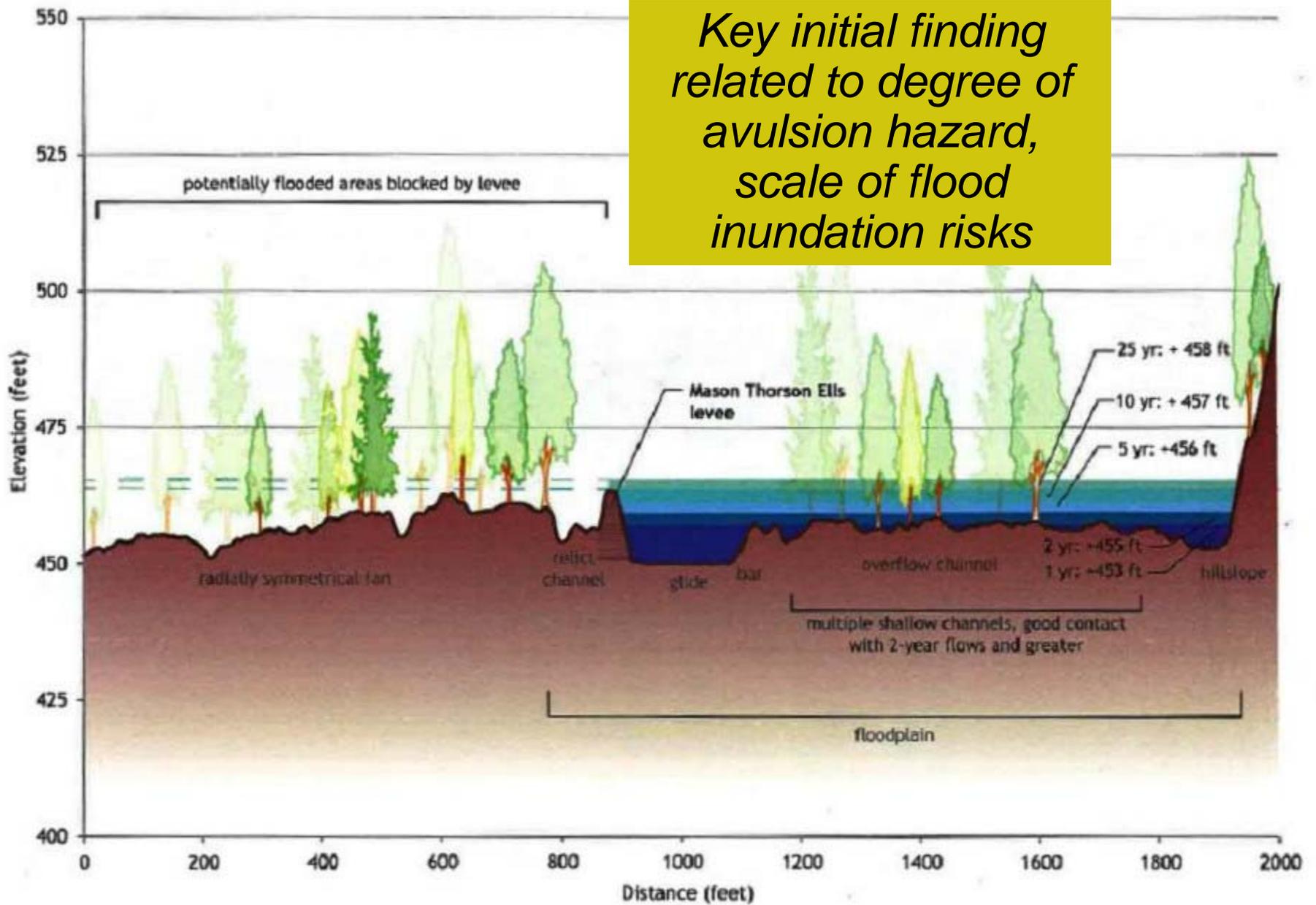
However...

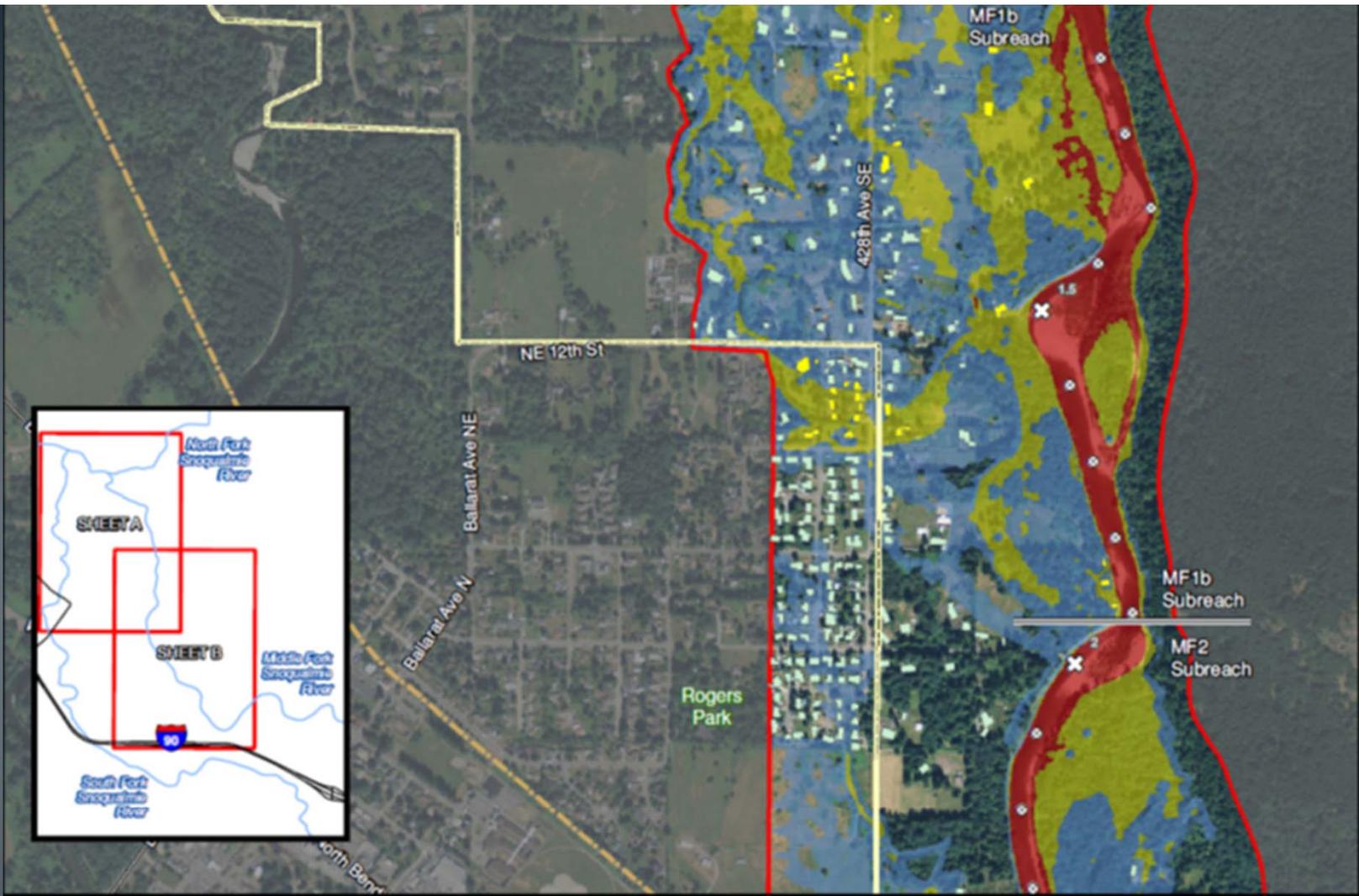
- No anadromous fish
- Alluvial fan setting perhaps even more complex (combined fan with South Fork)

## Channel changes 2005 to 2010



*Key initial finding related to degree of avulsion hazard, scale of flood inundation risks*





**Legend**

- River mile
- 1/10th river mile
- Subreach boundary
- Snoqualmie Valley Trail
- Highway
- Flow direction
- City of North Bend boundary
- Buildings in Hazard Areas
- Building Boundary
- Model Extents
- Exceeds King County Regulatory Depth-Velocity Standards (Deep and Fast)
- Depth-Velocity Hazards based on USBR approach (Deep and/or Fast)
- Inundated from 1 Percent Annual Chance Flood

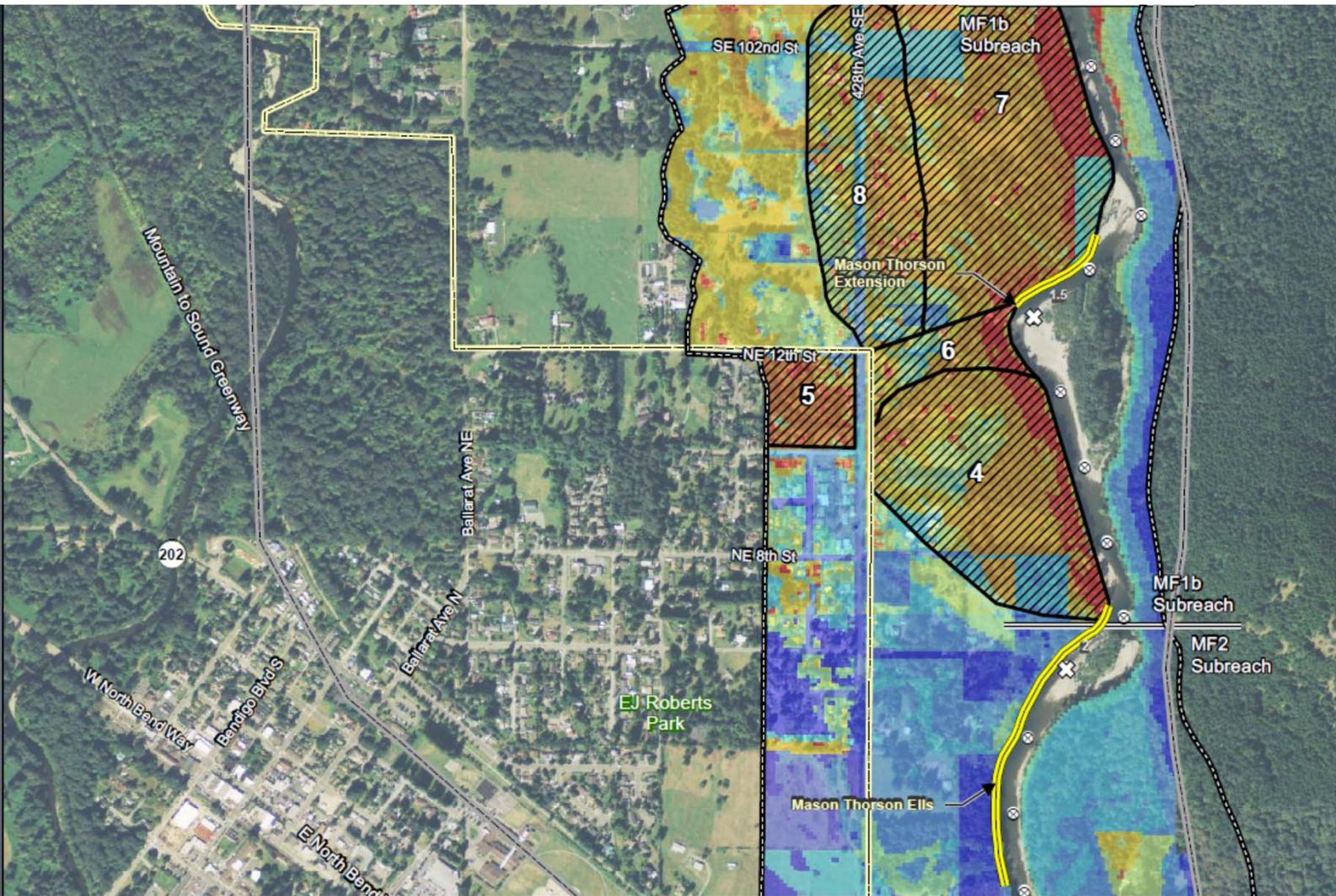
Note: For portions of the study area below the confluence with the North Fork, which serves as the origin for the King County Middle Fork Snoqualmie River channel coordinate system, river miles are based on the King County Snoqualmie River Mile system, which has its origin at the confluence with the Skykomish River.

**Plate 14a. Depth-Velocity Hazard Areas  
1 Percent Annual Chance Flood  
(100-year Event - 35,400 cfs)  
(Sheet 1 of 2)**



**King County**

Aerial: USDA (2011)  
Prepared for King County by WSE



**Legend**

Management zone

**Total risk score**

	0 to 1		4 to 6		12 to 14
	1 to 2		6 to 8		14 to 16
	2 to 4		8 to 10		16 to 18
			10 to 12		18 to 20
					> 20

City of North Bend boundary

Levee or revetment

Subreach boundary

River mile

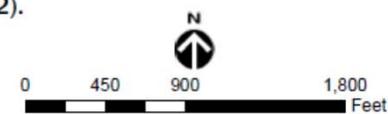
1/10 river mile

Project area

Model domain

Notes:  
 1. For portions of the study area below the confluence with the North Fork, which serves as the origin for the King County Middle Fork Snoqualmie River channel coordinate system, river miles are based on the King County Snoqualmie River Mile system, which has its origin at the confluence with the Skykomish River.  
 2. Upstream and downstream limits of levees and revetments as shown are approximate.

Figure 19. High Risk Zones for Which to Focus Future Flood and Erosion Hazard Management Planning (Sheet 1 of 2).



Aerial: USDA (2011)  
 Prepared for King County by Herrera

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## Snoqualmie at Fall City and Aldair Levee

- Cost-shared corridor plan with salmon recovery sponsors
- Four potential levee setbacks
- Aldair levee seepage and geotechnical problems, potential high risk
- Technical work for plan largely completed
- Highest risk acquisition completed
- Evaluating cost-share percentages for projects



*Flooding at  
Aldair Levee*

# Rounding out the CIP

Continued emphasis on non-structural projects

- Home buyouts
- Home elevations
- Farm pads
- Barn elevation pilot program

These remain large and essential parts of the Snoqualmie basin CIP program

# South Fork Skykomish and Miller Rivers

- Steep gradients, high velocities
- Channel migration hazards
- Focus on home buyouts and facility repairs as needed
- Develop/implement strategy for Miller River fan facilities
- Partner with Town of Skykomish, USFS and salmon recovery reps



May 8, 2014  
BTC  
Meeting

Snoqualmie/  
SF Skykomish  
Update



Questions? Comments?

Clint Loper

Supervising Engineer

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**Extra slides**

# Typical Steps and Phases

- **Historical Conditions Analysis**
  - Helps identify hazards
  - Defines limitations and potential of sites
- **Current Conditions Characterization**
  - Land use/Infrastructure
  - Hazards (Flooding, Geomorphic)
  - Conditions of existing system (Geotech)
  - Ecological – in-stream, floodplain, riparian, fish and wildlife
  - Other community factors (e.g., recreation)
  - Risks (Hazard x Consequence)

# Typical Steps and Phases cont.

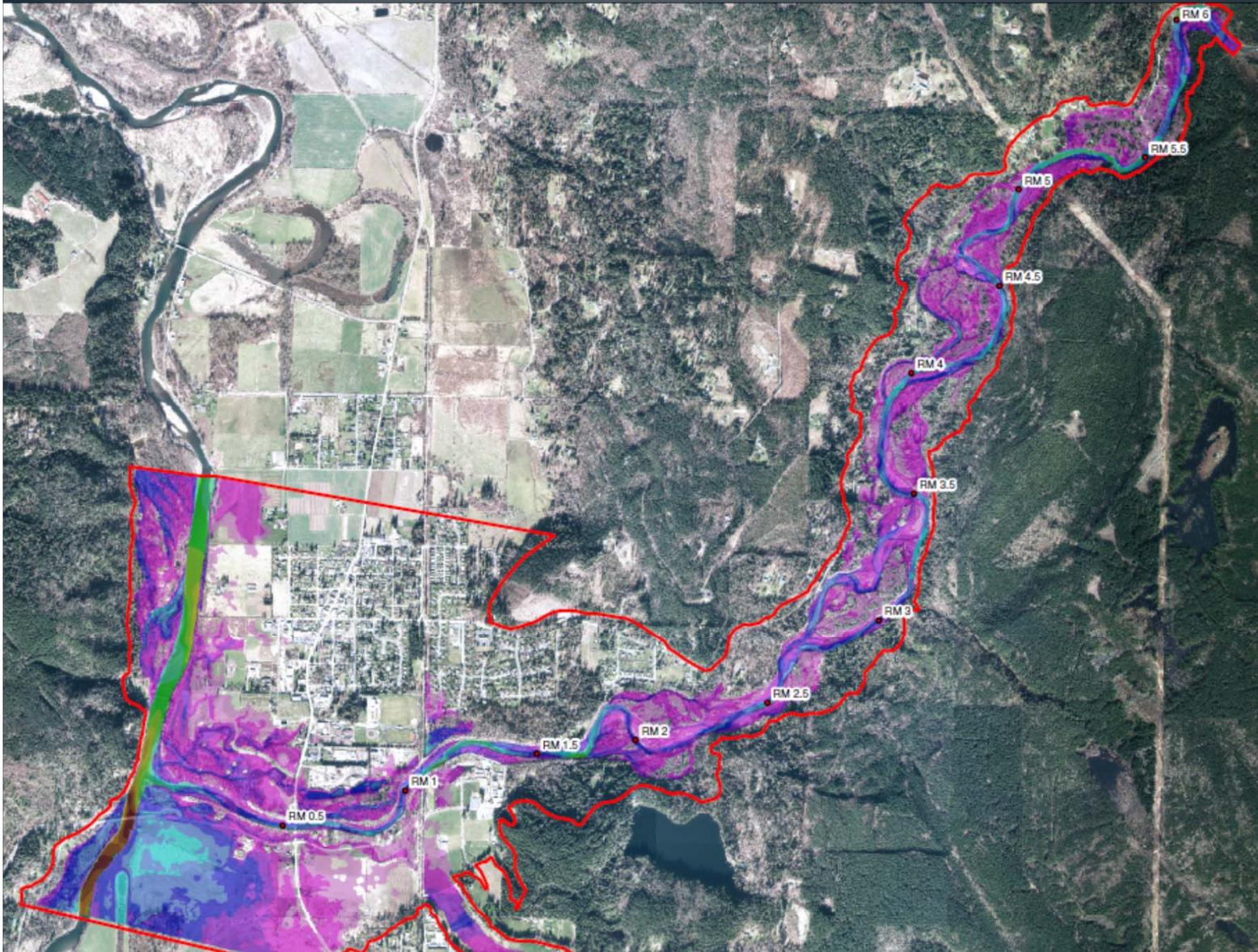
- **Future Conditions**
  - Project the result of the status quo alternative
  - Compare other sets of actions to status quo
- **Corridor Management Alternatives**
  - Identify project objectives and evaluation criteria
  - Identify, screen and group management actions
  - Conduct engineering evaluation and refine actions and scenarios
- **Develop Conceptual Designs**
- **Recommend a long-terms strategy and near-term actions**
- **Plan approval**

# Draft Criteria for Evaluating Alternatives

- **Flooding Impacts/ Benefits**
  - Public safety, critical facilities (wastewater plant)
  - Levee overtopping, freeboard
  - Numbers of structures inundated
  - Roadway inundation and closures
  - Economic costs of damages
- **Geotechnical Impacts/ Benefits**
  - Slope stability
  - Seepage
- **Capital cost of solutions**
- **Maintenance costs and longevity of solutions**
- **Environmental benefits/impacts**



*Bendigo Blvd. flooding*



### Lower Tolt River Corridor Plan

Existing Conditions Depth:  
100-year Flood  
(16,400cfs)

#### Legend

- River Mile
  - Model Boundary
- Depth (ft)**
- > 26
  - 24 - 26
  - 22 - 24
  - 20 - 22
  - 18 - 20
  - 16 - 18
  - 14 - 16
  - 12 - 14
  - 10 - 12
  - 8 - 10
  - 6 - 8
  - 4 - 6
  - 2 - 4
  - 0 - 2

King County, WA



Scale: 1:21,000  
 NAD 1983 HARN StatePlane  
 Washington North FIPS 4601 Feet

21 Nov 2012  
**WATERSHED**  
SCIENCE & TECHNOLOGY



**Table 8. Scoring System Used for Synthesis of Flooding, Erosion, and Geomorphic Process Hazards.**

Criterion	Score	Multiplier
<b>Flooding</b>		
Inundation in simulated 10 percent annual chance flood	4	–
Inundation in simulated 4 percent annual chance flood	3	–
Inundation in simulated 1 percent annual chance flood	2	–
Inundation in simulated 0.2 percent chance annual flood	1	–
Not flooded in any simulated event	0	–
Located in “3/3” (deep and fast) flow area in any simulated event	–	1.5
<b>Lateral Erosion</b>		
Extremely Erosion Prone <sup>1</sup>	4	–
Very Erosion Prone <sup>1</sup>	3	–
Erosion Prone <sup>1</sup>	2	–
Located in Perkins’ (1996) CMZ “potential hazard” zone	1	–
Vulnerability of existing levee or revetment to bank erosion (higher value equates to greater vulnerability; see Figure 3)	–	–
Duprels Revetment		1.0
Mason Thorson Extension Levee		0.8
Moskvin Revetment		0.8
Mt Si Road Protection		0.8
Mason Thorson Ells Levee		0.5
Tanner Revetment		0.35
All other (nine) facilities		0.25
<b>Avulsion or Other Geomorphic Process Area</b>		
General risk of floodplain change given location parallel to subreach MF1a	1.5	–
General risk of floodplain change given location parallel to Confluence subreach	1.5	–
General risk of floodplain change given location parallel to subreach MF1b	1	–
General risk of floodplain change given location parallel to subreach MF2	0	

**Table 10. Scoring System Used to Define the Relative Levels of Concern for Population, Development, and Critical Facilities due to Flooding and Erosion Hazards.**

	Points
<b>Population Density</b>	
Pixel Located Where 2010 Census Population Density per Developed Parcel > 5 people/acre	4
Pixel Located Where 2010 Census Population Density (Block Level) > 2 and < 5 people/acre	3
Pixel Located Where 2010 Census Population Density (Block Level) > 0 and < 2 people/acre	2
<b>Habitable Structure</b>	
Pixel partially or completely contains a habitable structure(s)	2
Pixel does not contain any part of a habitable structure(s)	0
<b>Critical Facilities</b>	
Critical facility(ies) partially or completely present in pixel (except roads and bridges ignored)	8
No critical facility(ies) partially or completely in pixel	0
<b>Land Use Type</b>	
<b>Built</b>	4
Agricultural (actively farmed areas)	1
Developed Recreational (of regional importance)	2
Developed Recreational	1.5
Passive Recreational	1
Other land use	1