Critical Area Monitoring and Adaptive Management

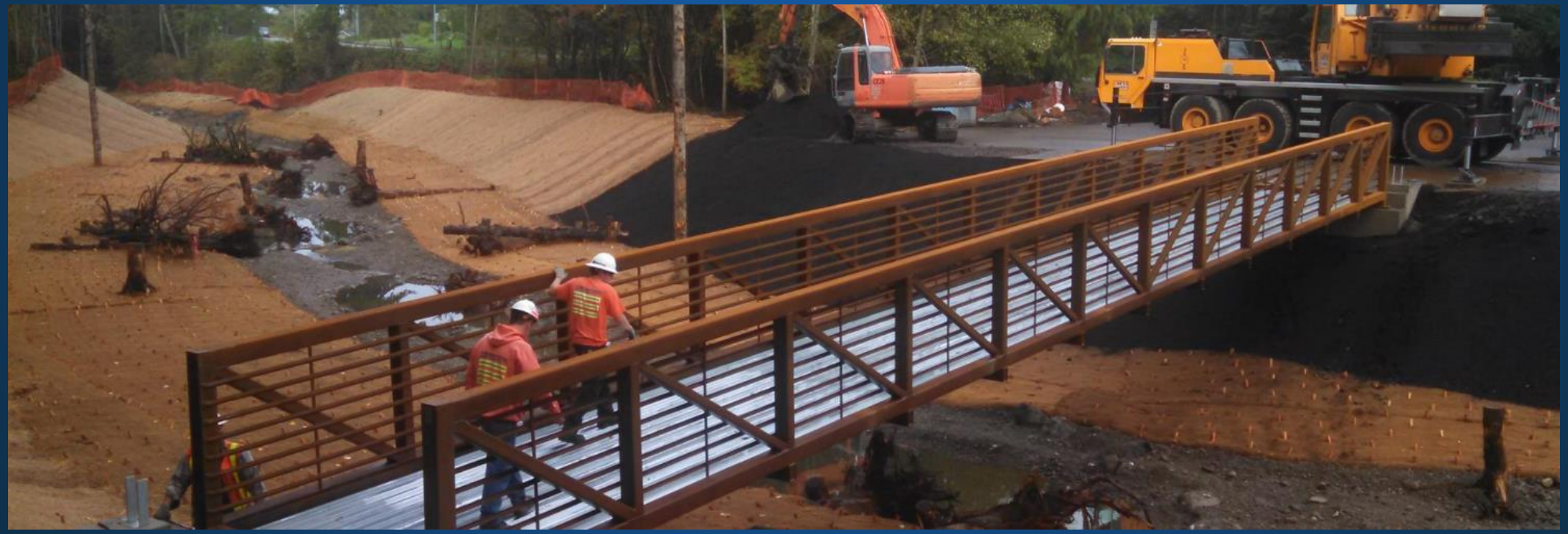
Kim Weil &
Chris Behee

City of Bellingham
Planning &
Community
Development

February 5, 2018

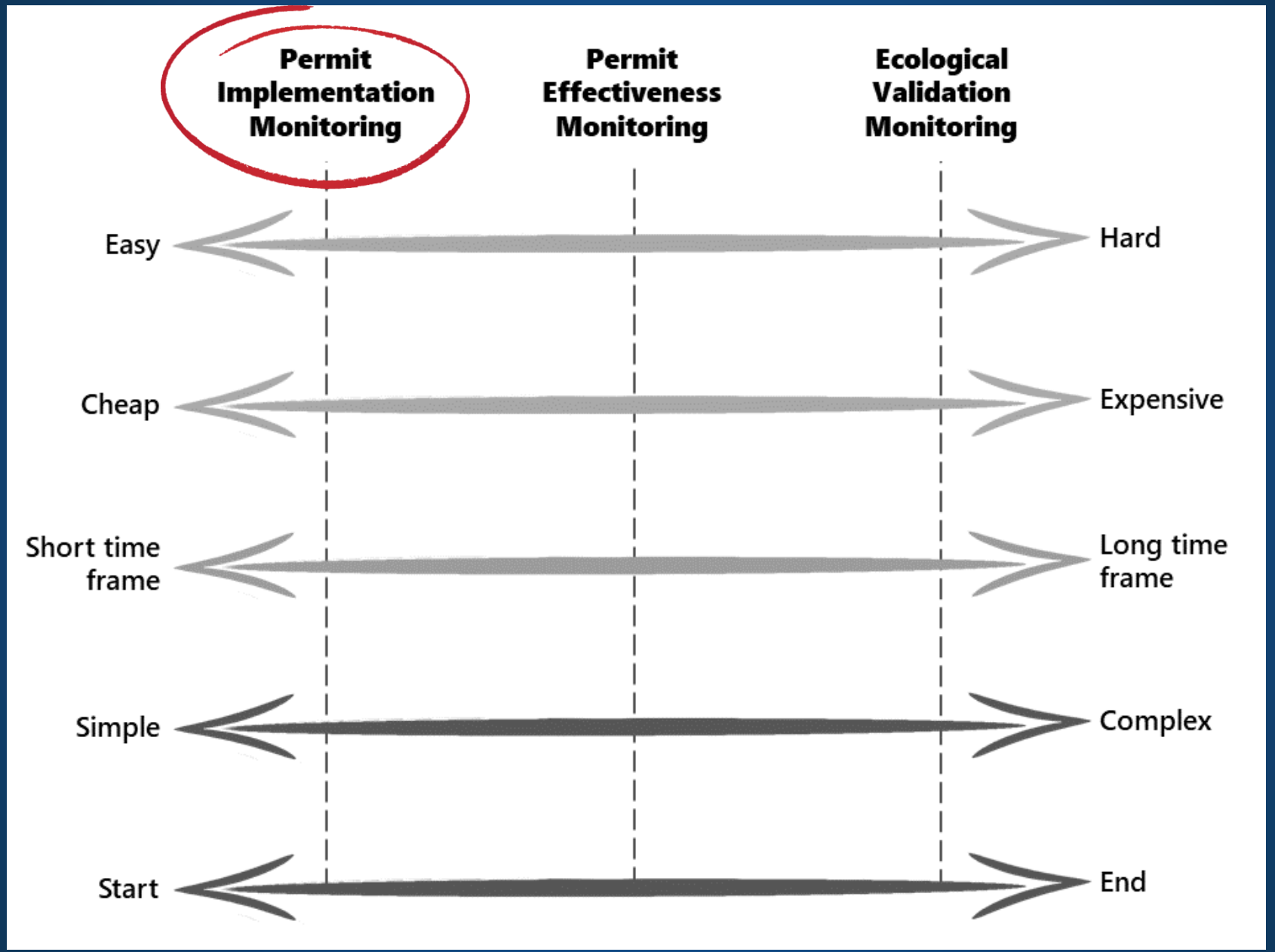
Outline

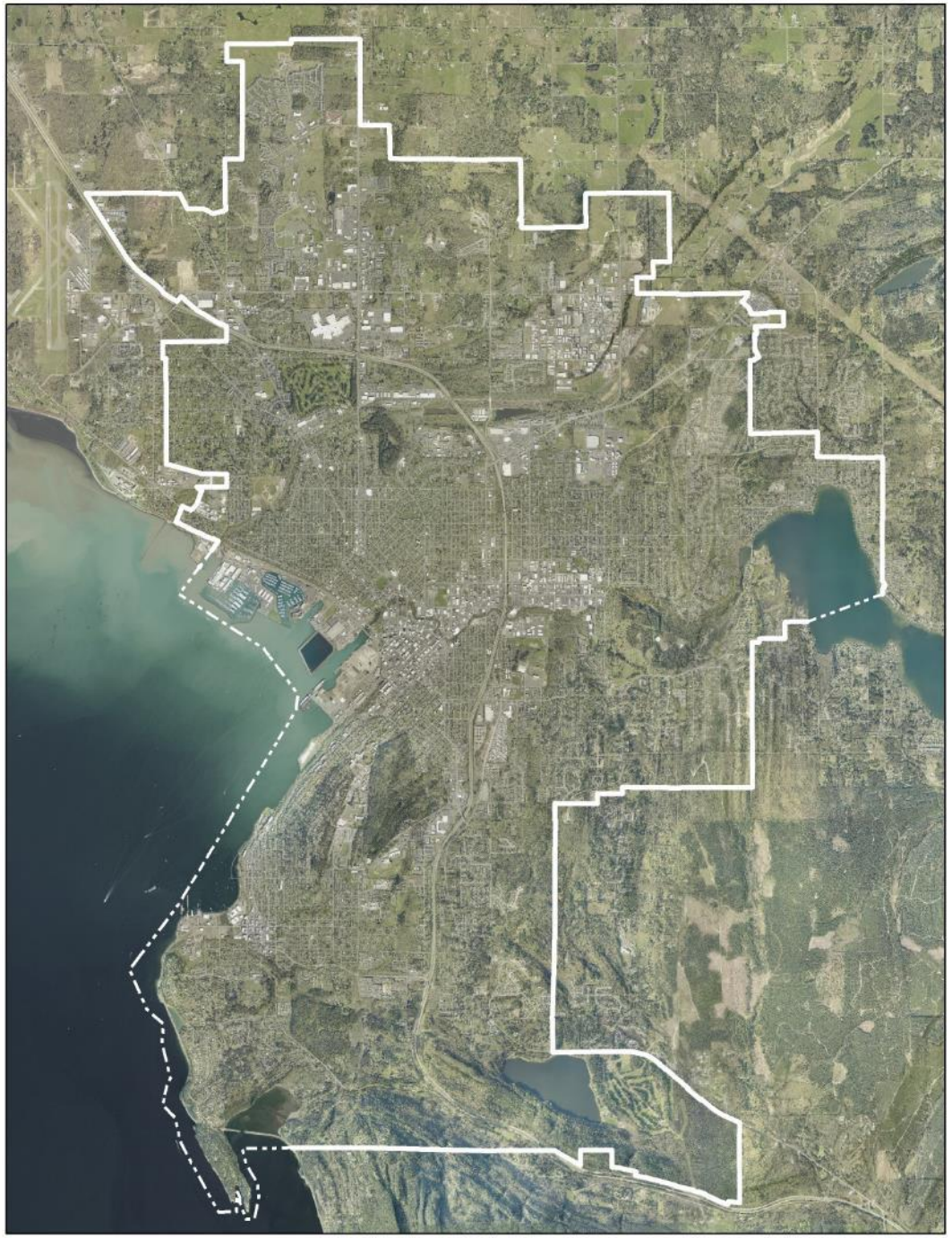
- COB Monitoring Program for private and public projects
- COB Vegetation Classification & Change Detection in Riparian Corridors



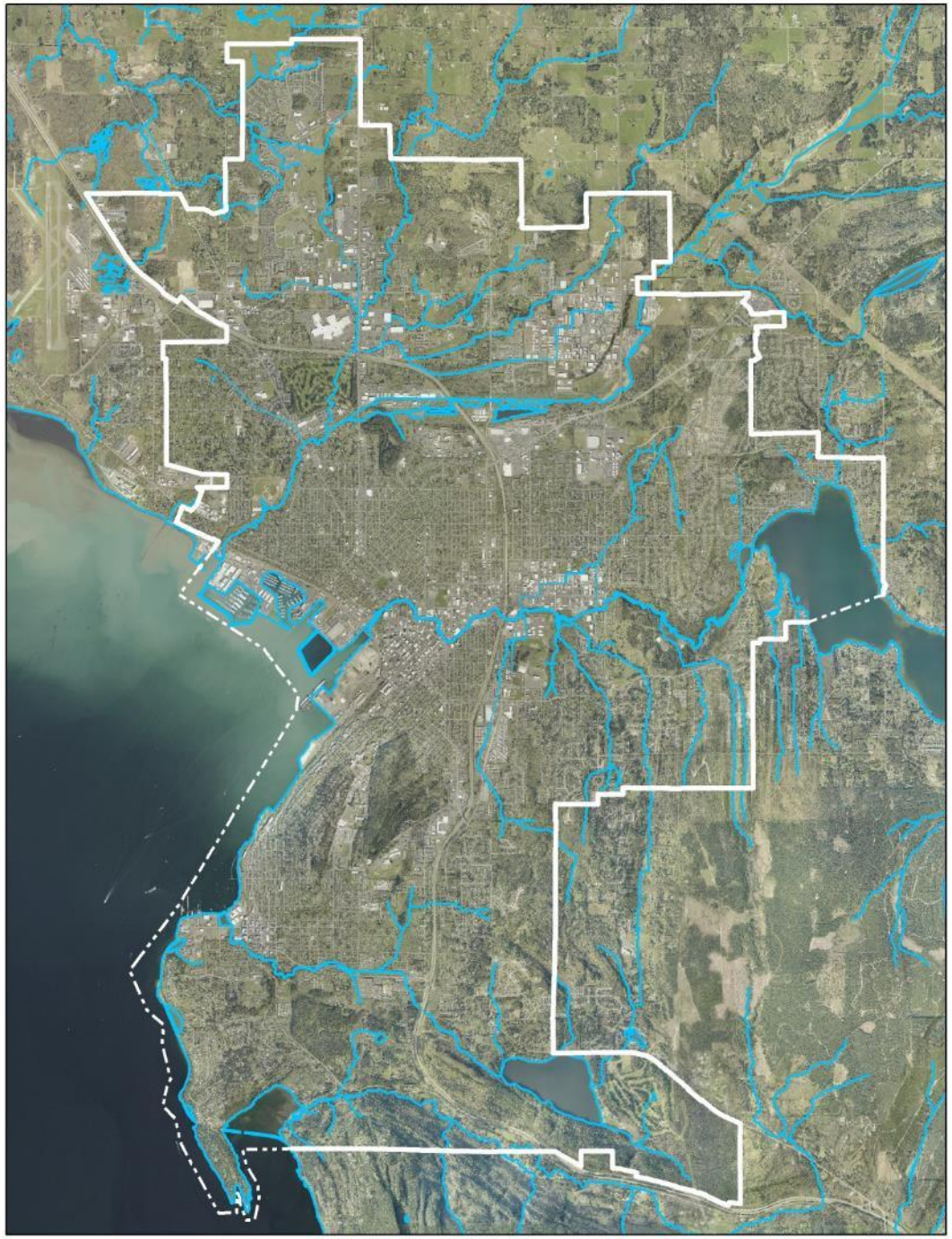
Why & How COB Monitors

- Place high value on environment → Environment Chapter
- Know where critical areas are →GIS mapping
- Know how they're functioning →HRTA
- Regulations that protect & restore →CAO & SMP
- Consistent permit writing/tracking → software
- Monitoring for effectiveness→ financial assurances
- Metrics → Ecological Validation Monitoring

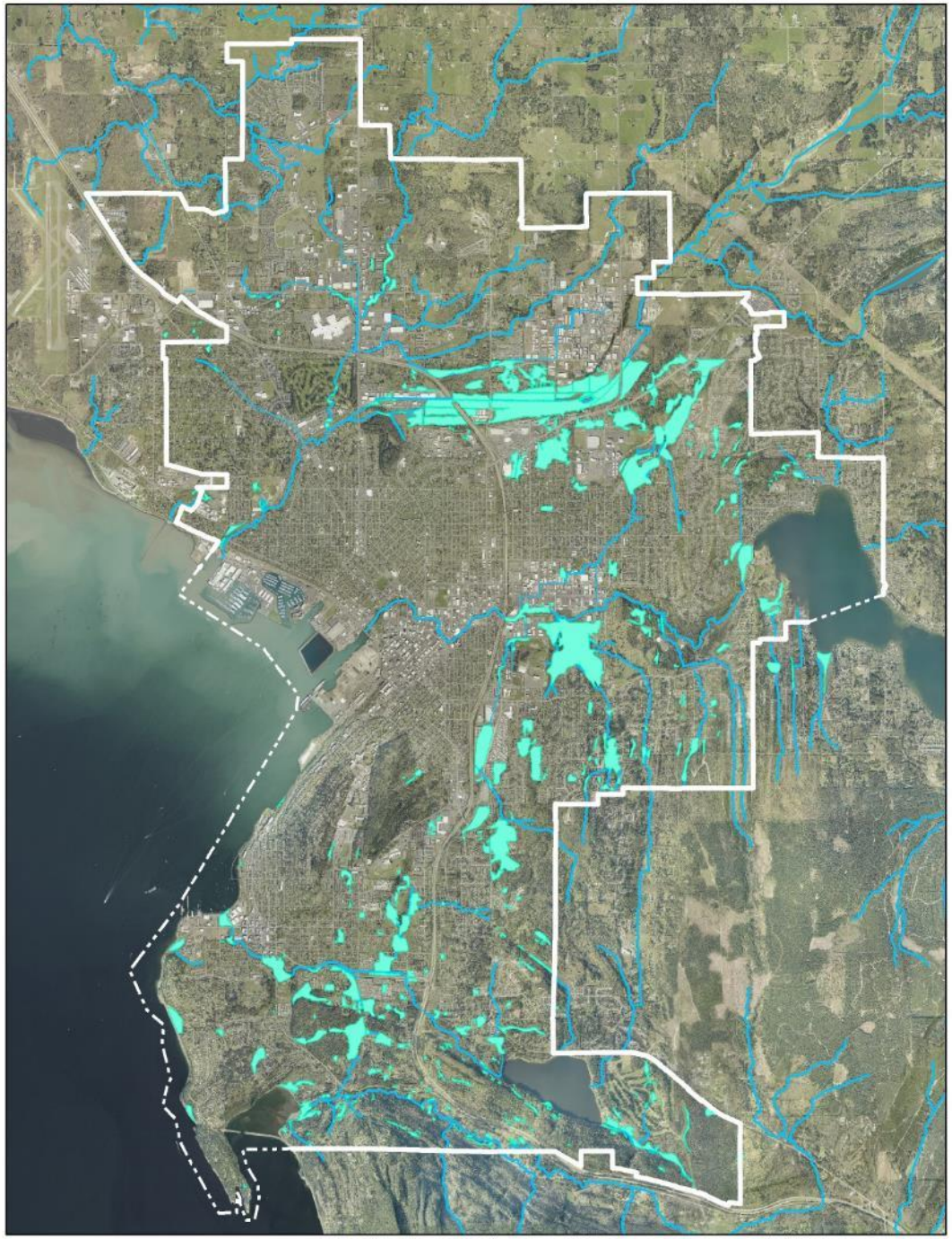

Permit Implementation Monitoring
Permit Effectiveness Monitoring
Ecological Validation Monitoring
Easy
Hard
Cheap
Expensive
Short time frame
Long time frame
Simple
Complex
Start
End



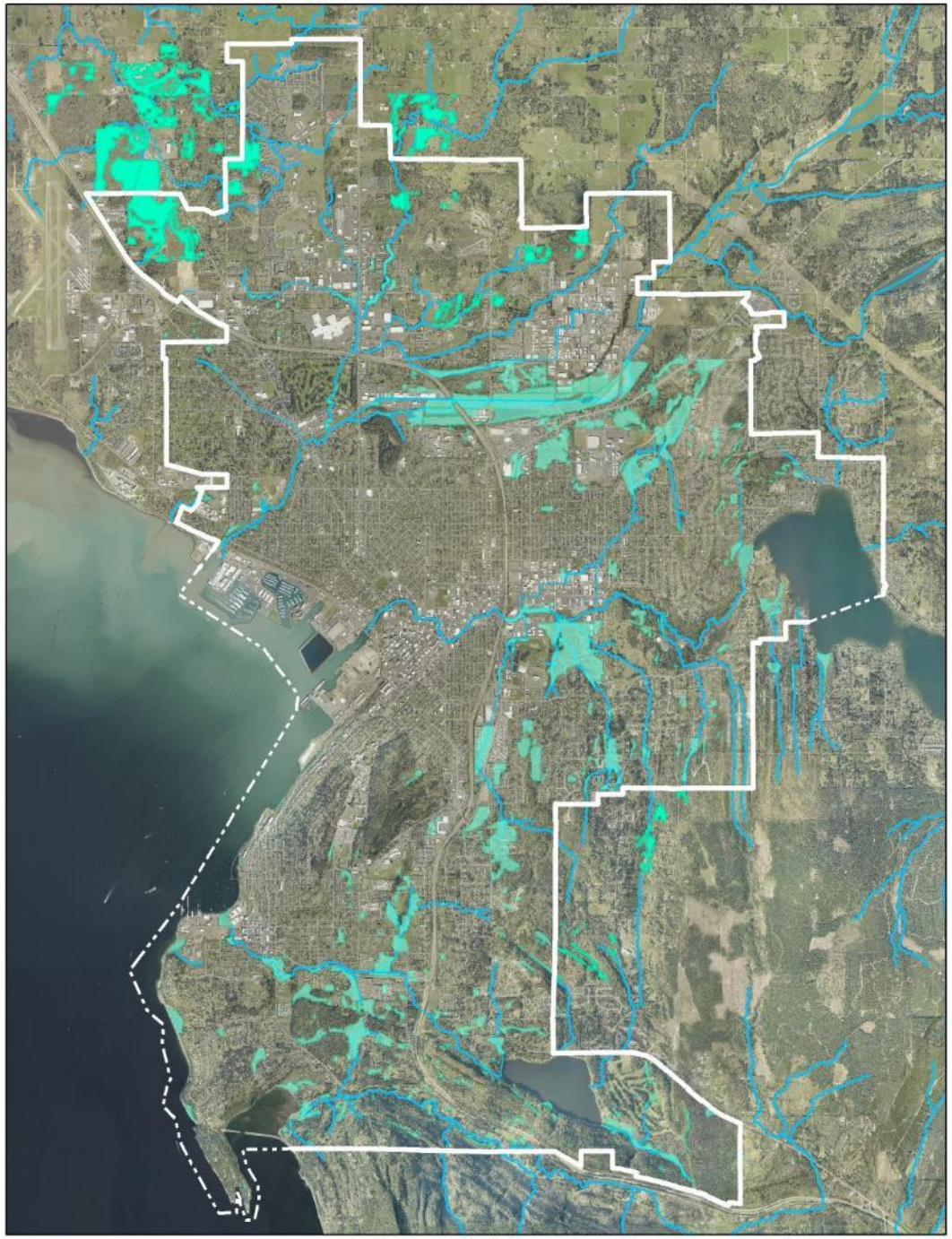

Strait of Georgia
Vancouver
Canada
USA
Bellingham
CASCADE RANGE
San Juan Islands
Victoria
Mt Vernon
Strait of Juan De Fuca
Everett
OLYMPIC RANGE
Puget Sound
Seattle
Tacoma
Olympia
Miles
0
10
20
Bellingham
NORTH AMERICA
Pacific Ocean



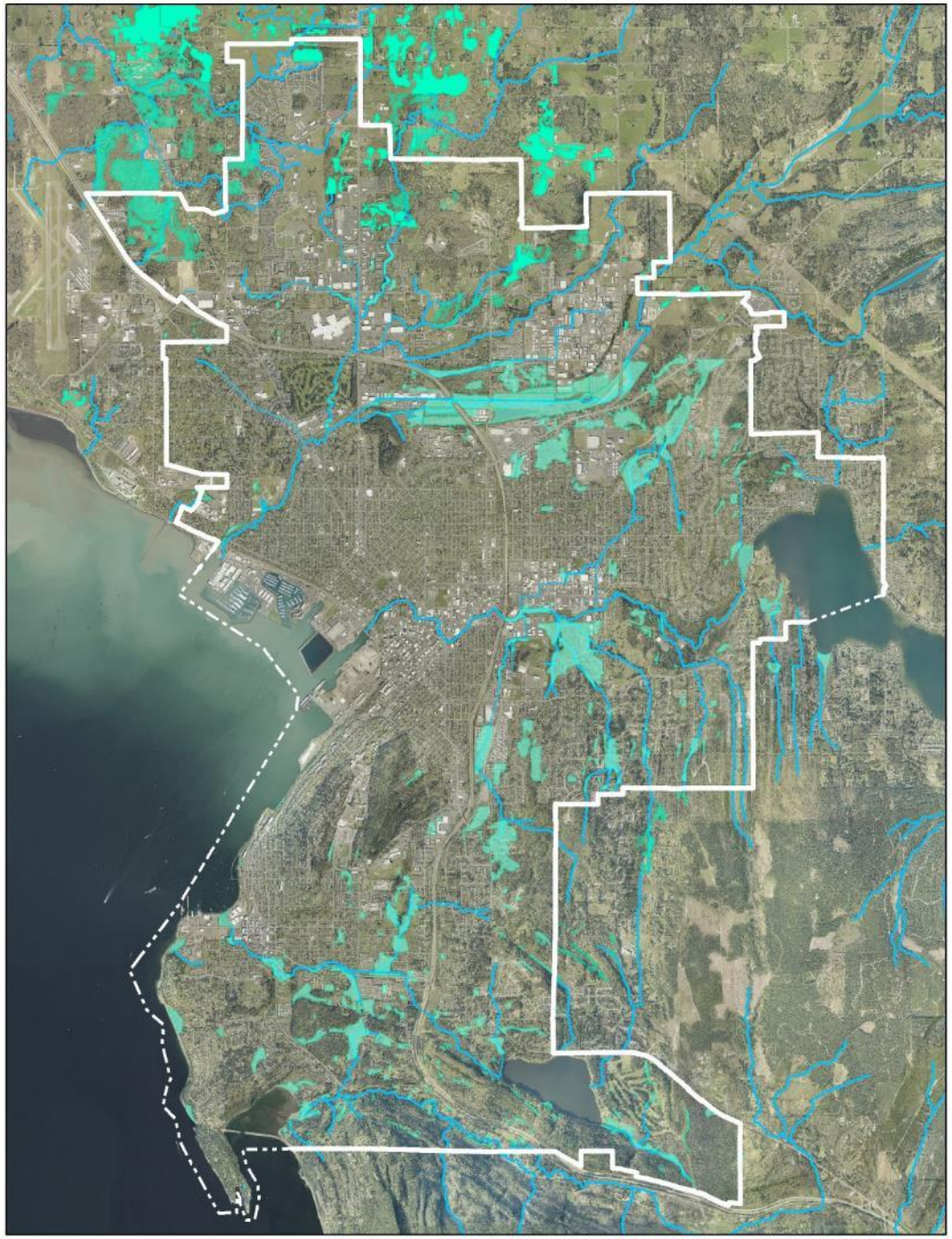
- Stream Corridors & Shorelines



- 1992 Wetland Inventory



- 1992 Wetland Inventory
- 2003 Wetland Inventory



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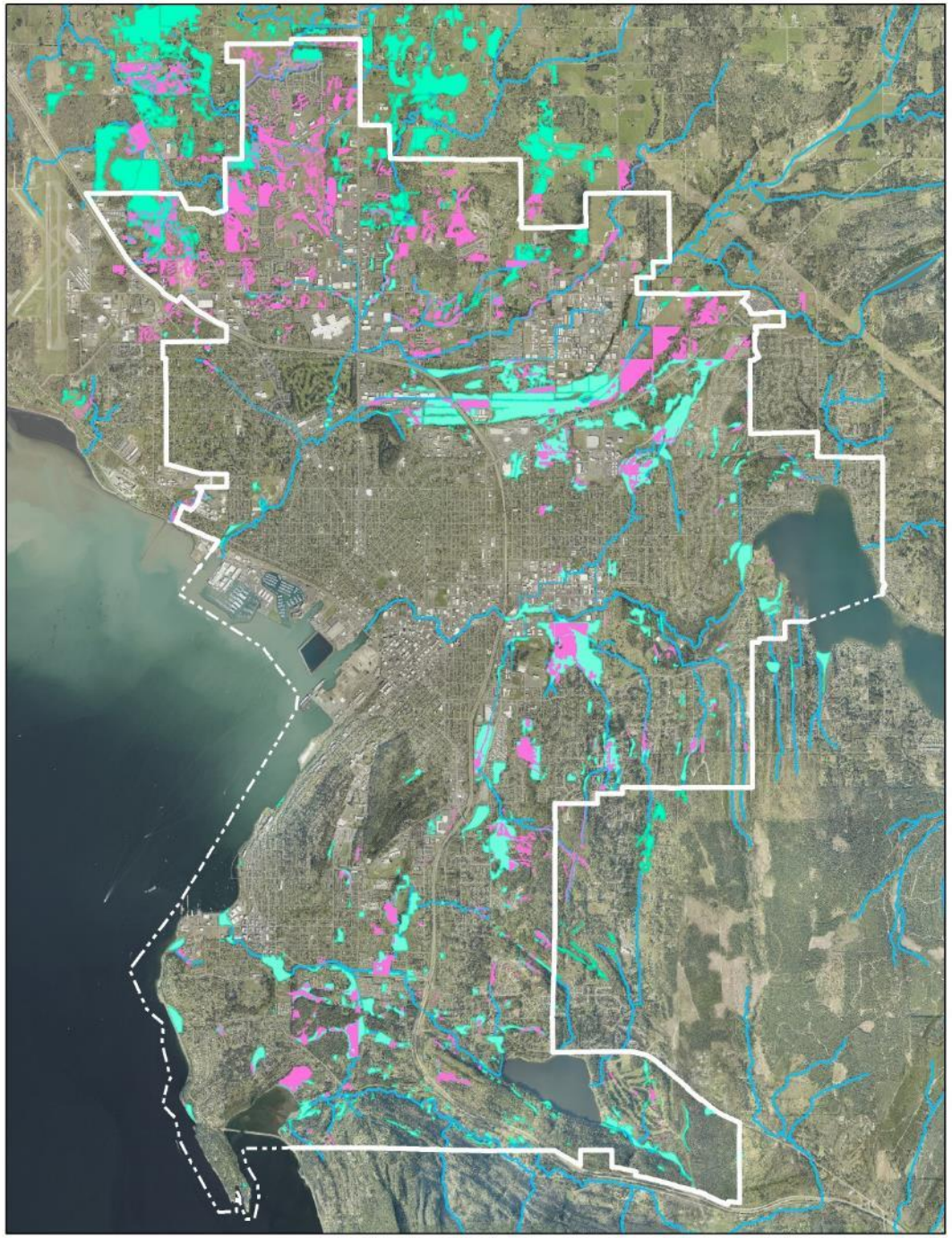
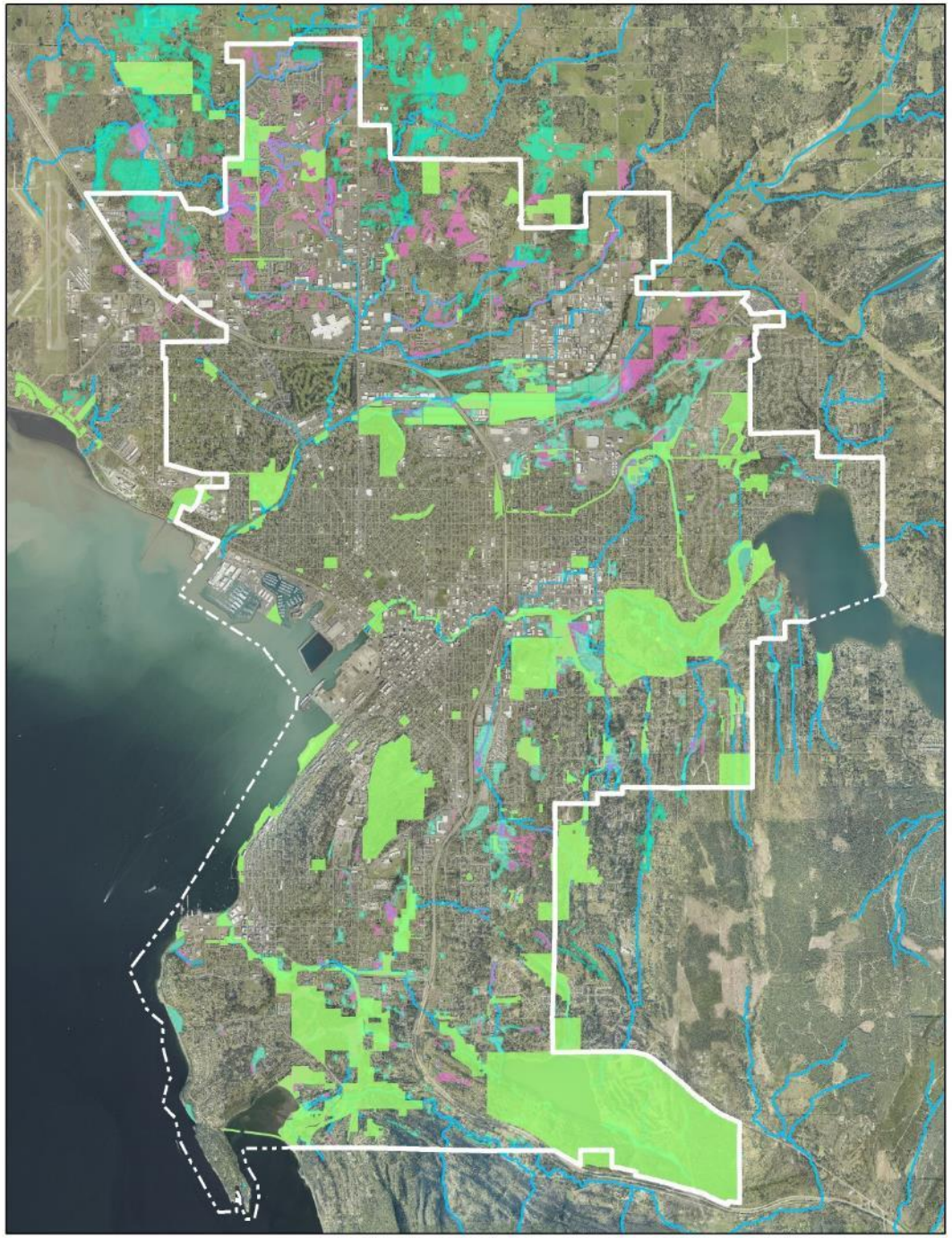


- 1992 Wetland Inventory
- 2003 Wetland Inventory
- 2015 Wetland Inventory
- Site Specific Wetland Delineations



- 1992 Wetland Inventory
- 2003 Wetland Inventory
- 2015 Wetland Inventory
- Site Specific Wetland Delineations
- Parks & Open Space

Monitoring Program

Legacies and Strategic Commitments

"We are working today so future generations will benefit from…"

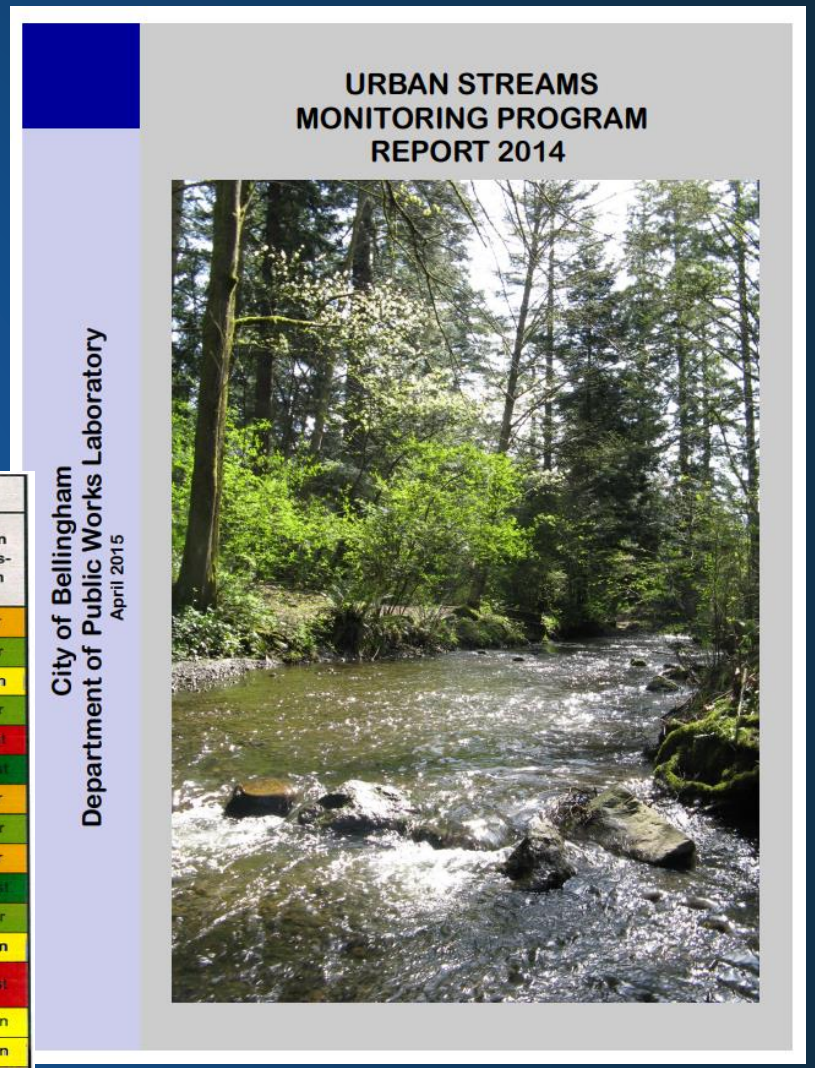
Healthy Environment

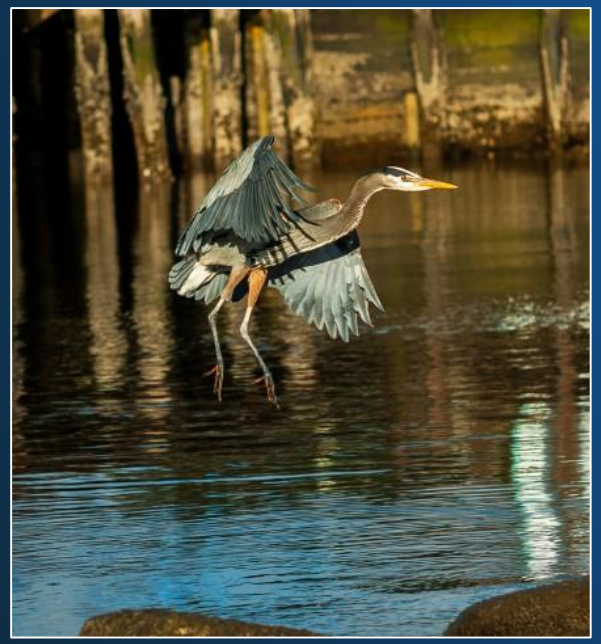
- Protect & improve the health of lakes, streams & bay
- Protect & restore ecological functions & habitat
- Reduce contributions to climate change
- Conserve natural & consumable resources

- Habitat Restoration Technical Assessment
- Shoreline Characterization
- Lake Whatcom Annual Water Quality Monitoring
- Heron Colony Annual Monitoring Report

Lake Whatcom—municipal water supply

Sub-watershed	WETLAND HABITAT GROUP FUNCTION						
	Surface Water Storage	Nitrogen Removal	Pathogen Removal	Organic Matter Export/ Contribution	Sediment/ Phosphorus Removal	Wildlife Habitat	Carbon Seques-tration
Alderwood Creek	Lowest	Lower	Lower	Lowest	Lower	Lower	Lower
Baker Creek Tributary	Higher	Highest	Highest	Median	Higher	Higher	Higher
Bear Creek	Higher	Highest	Higher	Higher	Highest	Highest	Median
Cemetery Creek	Highest	Higher	Median	Highest	Median	Higher	Higher
Central Bellingham	Lowest	Lowest	Highest	Lowest	Lowest	Lowest	Lowest
Chuckanut Creek	Highest	Higher	Highest	Higher	Higher	Highest	Highest
Connelly Creek	Median	Lower	Lower	Median	Lowest	Median	Lower
Fever Creek	Median	Lower	Lowest	Median	Median	Median	Higher
Fort Bellingham	Median	Higher	Higher	Lowest	Higher	Lower	Lower
Hannah Creek	Highest	Median	Median	Higher	Median	Median	Highest
Lake Padden	Higher	Higher	Median	Higher	Median	Higher	Higher
Lincoln Creek	Lower	Median	Lower	Lower	Lower	Lower	Median
Little Squalicum Creek	Lower	Lowest	Lowest	Lower	Lower	Lowest	Lowest
Lost Creek	Median	Highest	Higher	Median	Higher	Median	Median
Lower Baker Creek	Higher	Median	Higher	Higher	Highest	Higher	Median
Lower Padden Creek	Lower	Lower	Lower	Lower	Lowest	Median	Median
Lower Spring Creek	Lower	Median	Median	Lower	Higher	Median	Lower
Lower Squalicum Creek	Higher	Highest	Higher	Higher	Highest	Highest	Median
Lower Toad Creek	Lower	Lower	Higher	Median	Median	Lowest	Lower
Lower Whatcom Creek	Lowest	Lowest	Lowest	Lowest	Lowest	Lower	Lowest
North Lower Squalicum	Lower	Lowest	Lowest	Lower	Lower	Lowest	Highest





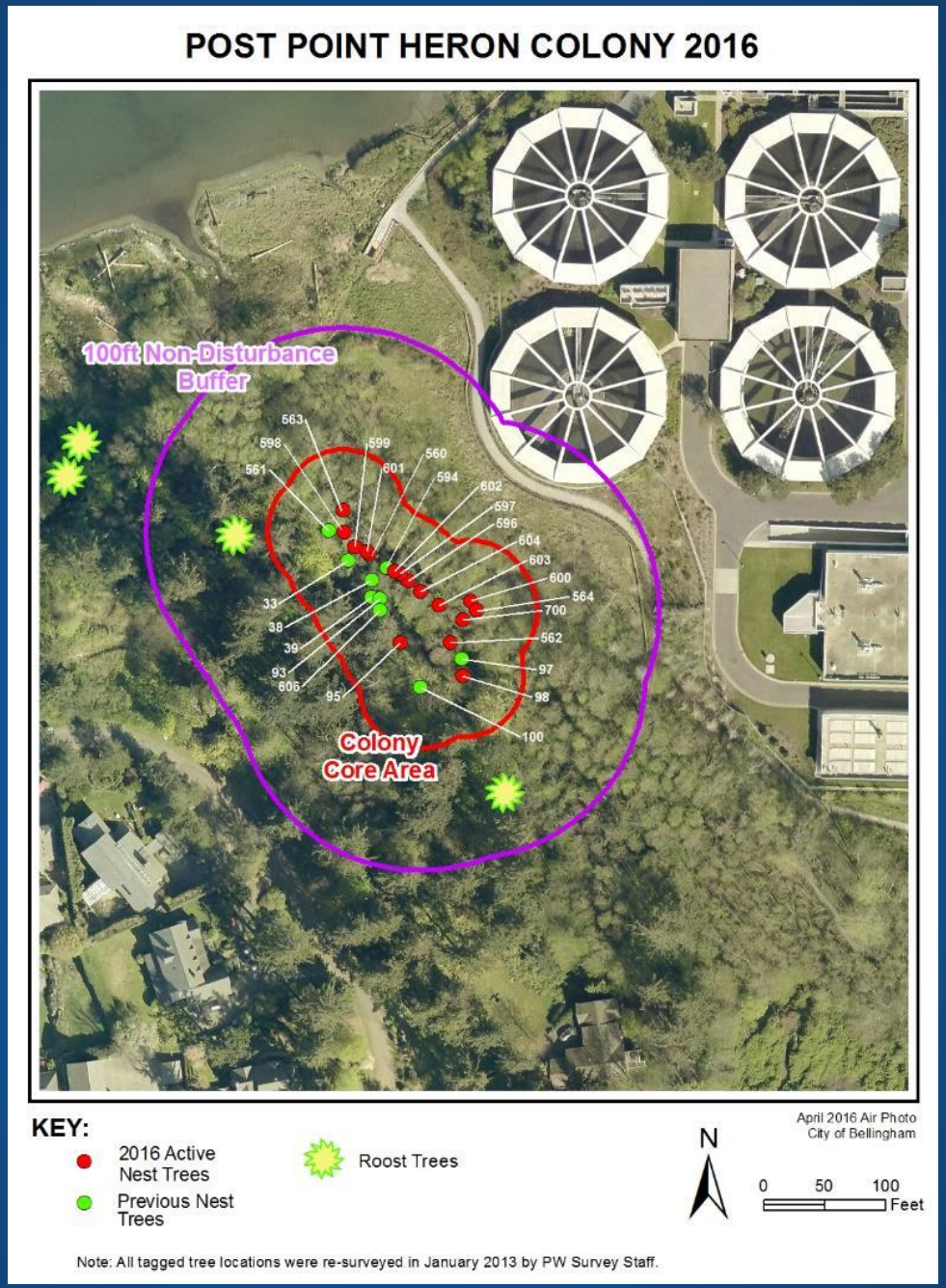


Photo by Alan Fritzberg

- Great blue heron colony
- Monitored since 2000

BMC 16.55.010D(4)

Purpose:

Prevent cumulative adverse environmental impacts to water quality, wetlands, and fish and wildlife habitat, and the overall net loss of wetlands, frequently flooded areas, and habitat conservation areas.

The Hannegan Permit

- 10.8-acre site
- 0.12-acre wetland fill
- Applied for permit in August 2005

- Issued permit May 2011
- Findings of Fact & Conclusions of Law—demonstrates consistency with CAO
- *Ex. The buffer standard for wetlands (BMC 16.55.340B) is not met.*

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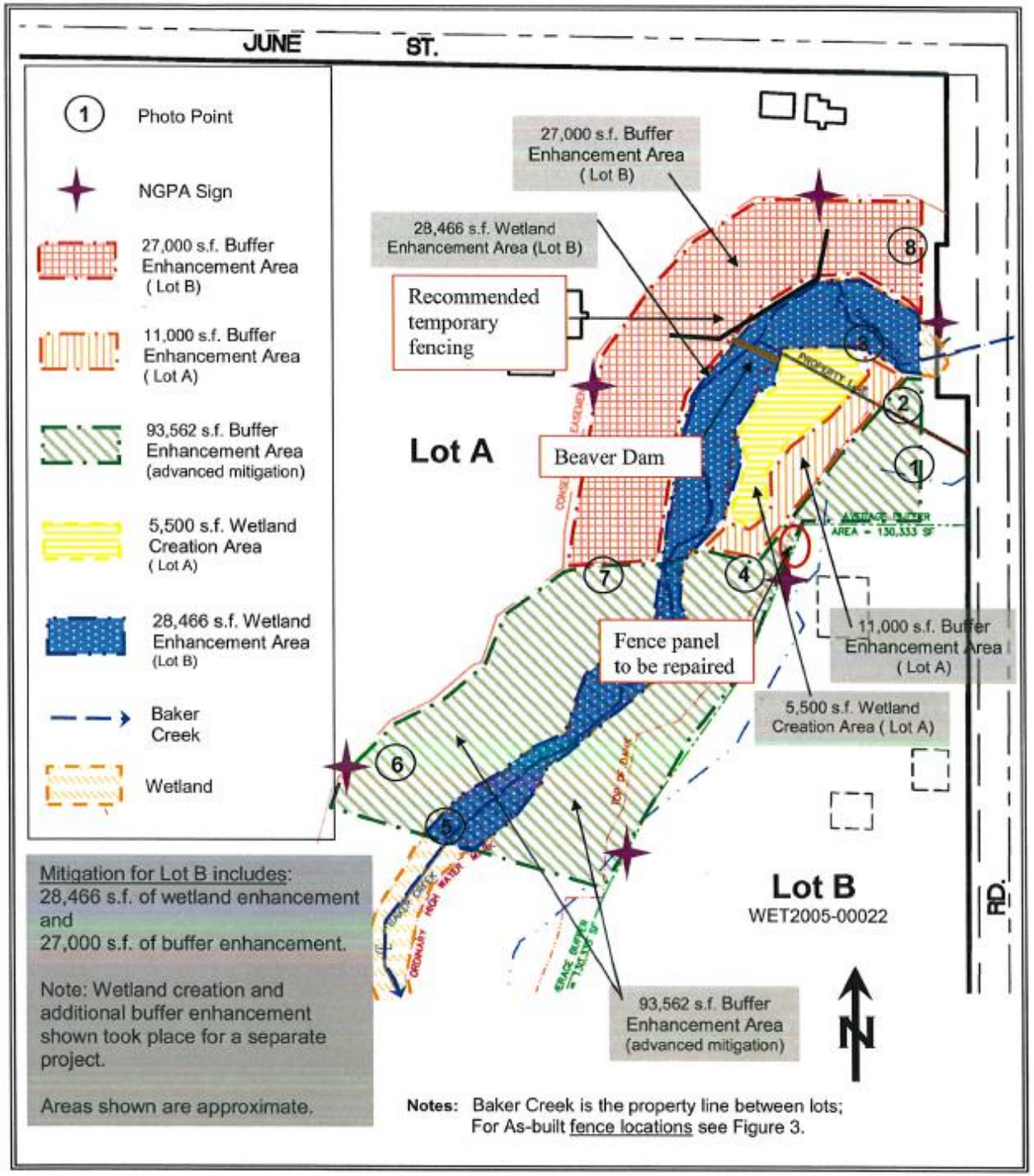
ADAPTIVE *MANAGEMENT*



- Conservation easement
- Recorded before site disturbance at the Whatcom County Auditor

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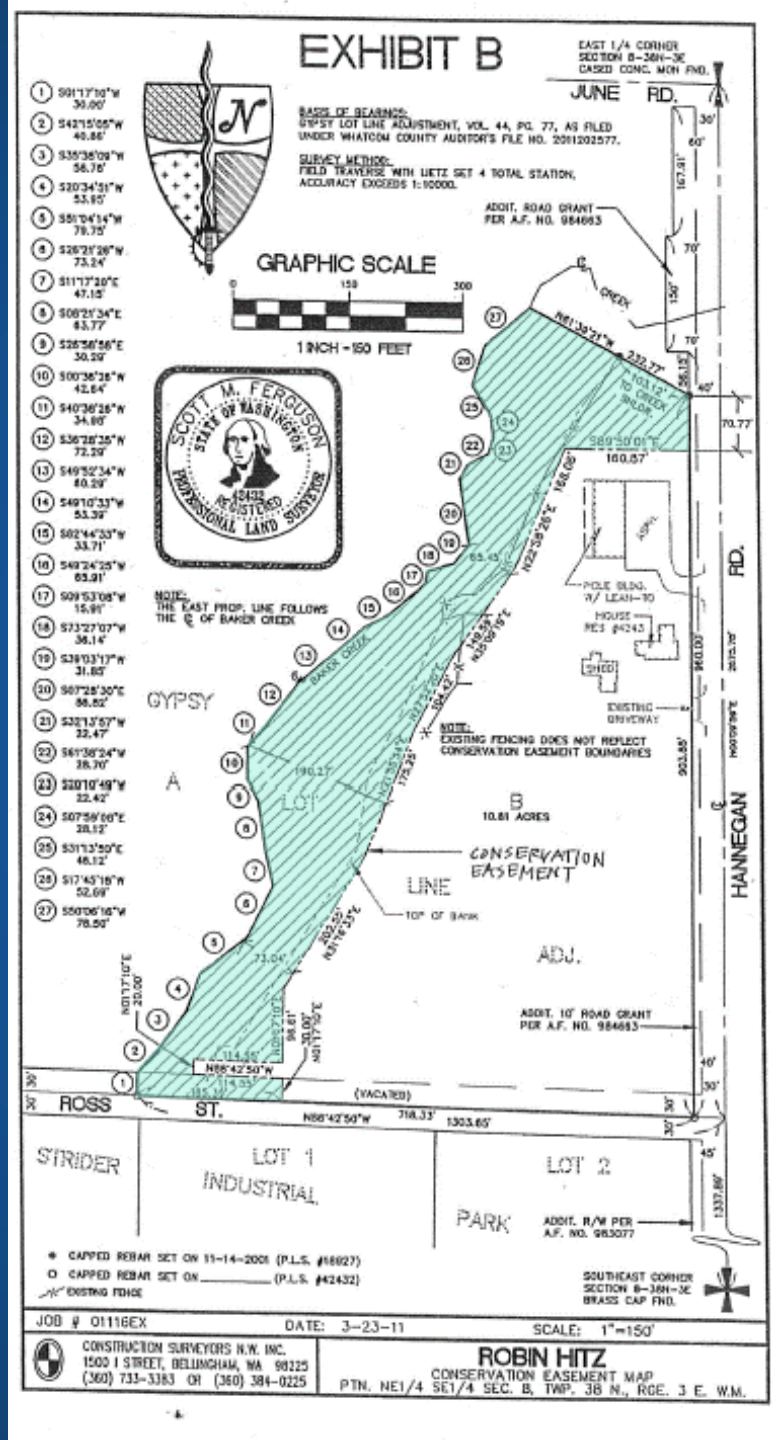

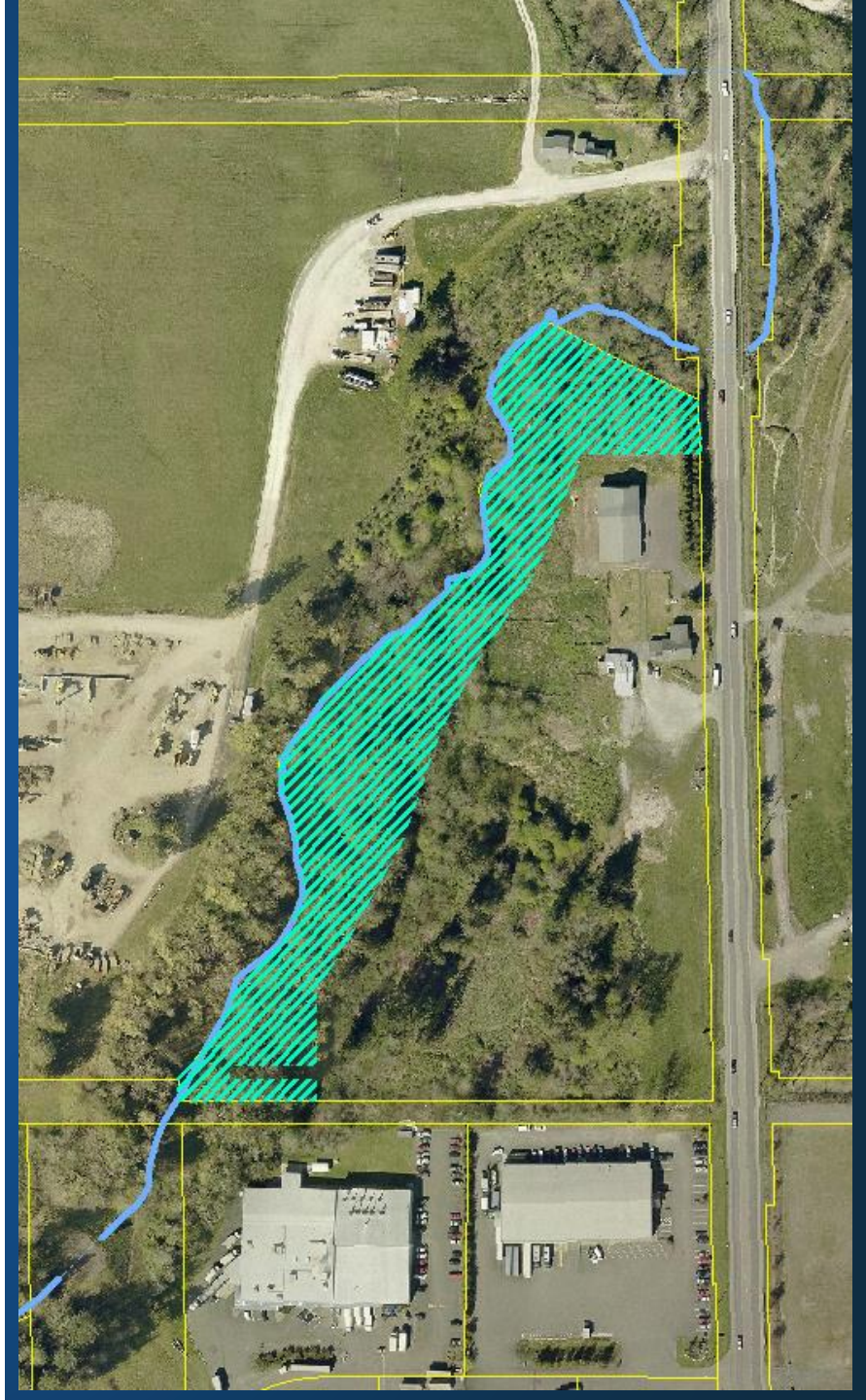

The following items are included in the bond amount for this project:

• Plants (shrubs): (50 plants x $5 /plant)	$ 250.00
• Mulch: (50 plants x $4 /plant)	$ 200.00
• Signage: (1 sign x $45/sign)	$45.00
• Fencing (20ft x $5/ft)	$100.00
• Biological Supervision	$250.00
• As-built Report	$ 625.00
• Monitoring (Year 1= $875, Years 2-5= $625)	$3,375.00
• Maintenance ($200/ year for 5 years)	$ 1,000.00
subtotal	$ 5,845.00
x (50%)	$ 2,922.50
Total Bond:	$ 8,767.50

- Financial surety requirement: assignment of funds or bond for 150% of costs

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Assessments
Monitoring & Performance Standards
CAO
Comp Plan & Legacies
Conditions
Permits


PROTECTED WETLAND
DO NOT DISTURB


NOTICE
TREE PROTECTION ZONE
DO NOT ENTER
KEEP ALL EQUIPMENT AND MATERIALS
OUTSIDE OF FENCED AREA

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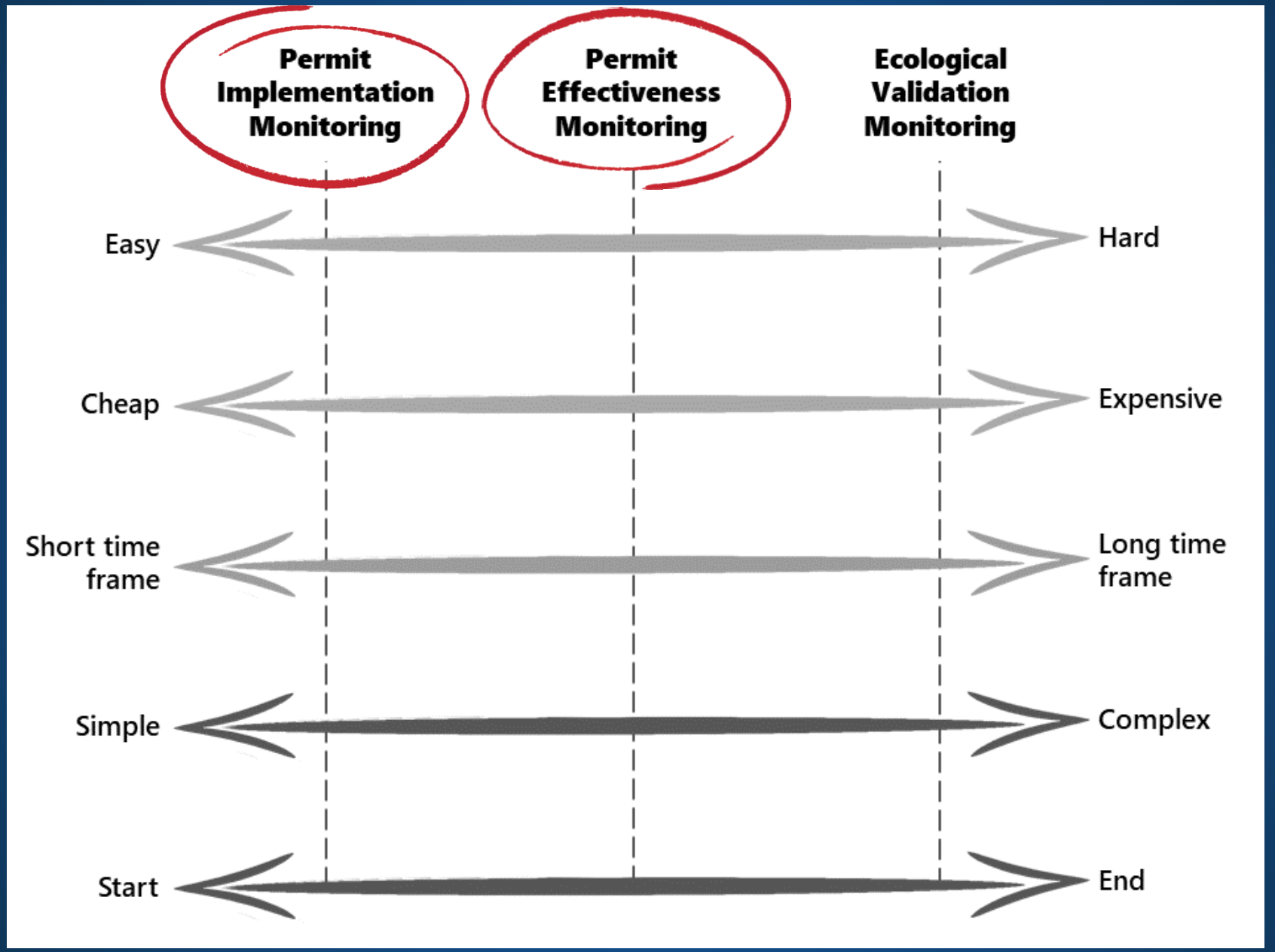
Fencing

Detail of wetland enhancement

- As-built mitigation report
- First surety release

Detail of wetland buffer enhancement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Long time frame
Simple
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Start
End

Goal: create 5,500 square feet of seasonally saturated palustrine scrub/shrub wetland.

Objective: The created wetland shall have seasonally saturated soils.

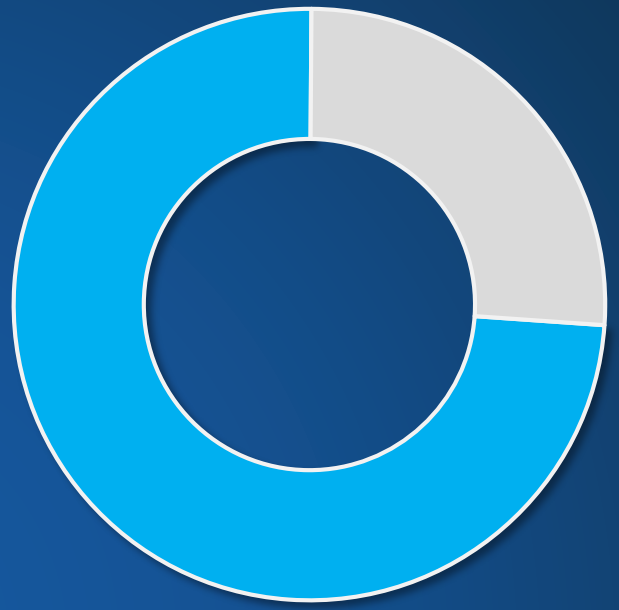
- Performance Standard: Soils will be inundated or saturated within 12 inches of the surface, for at least 10% of the growing season, defined as April through mid-October

Yes, this performance standard is being met

Compliance Status	Project #	Mitigation Installation Due / Completed	As-Built Due / Received	Year 1 Monitoring Due / Received	Year 2 Monitoring Due / Received	Year 3 Monitoring Due / Received	Year 4 Monitoring Due / Received	Year 5 Monitoring Due / Received	Surety Status	Performance Standards Met / Case Closed
	CAP2014-00032	Due before building permits		12/31/17 - Due 3/11/16 - Received					$10,254	
	CAP2014-00049		Partial as-built 12/09/14 - Received		12/31/16 - Due 11/10/16 - Received				$400	
	CAP2014-00052			6/28/16 - Received 10/21/16 - Received	12/31/17 - Due				$1,125	
	CAP2014-00072	3/15/15 - Due	4/29/15 - Received 4/14/15 - Received	12/31/15 - Received 5/16/17 - Received	12/31/17 - Due				$5,850	
	CAP2015-00001			10/10/17 - Received	12/31/18 - Due				$10,200	
	CAP2015-00007		4/13/16 - Received	10/10/17 - Received	12/31/18 - Due					
	CAP2015-00008		4/26/16 - Received	12/31/16 - Due					$3,000	
	CAP2015-00017		Due around Sep-2015	Due after planting for Phase II						
	CAP2015-00020		3/22/16 - Received	12/31/17 - Due 5/15/17 - Received						
	CAP2015-00049			10/19/16 - Received	12/31/17--Due				$1,800	
	CAP2015-5004		3/31/16 - Due							
			Onsite Mitigation	300 additonal plants to be installed by 2/28/18>release surety					$257,505	
	CAP2015-5007		12/16/16 - Received	11/28/17 - Received	12/31/2018					

- Year 7 monitoring report
- Final surety release
- Conservation easement provides legal protection in perpetuity

74%



Healthy Environment

- **Protect & improve the health of lakes, streams & bay**
- **Protect & restore ecological functions & habitat**
- **Reduce contributions to climate change**
- **Conserve natural & consumable resources**

Percent of residents surveyed rating the job the City is doing protecting the environment as “good” or “excellent”.

Chris Behee
GIS Analyst

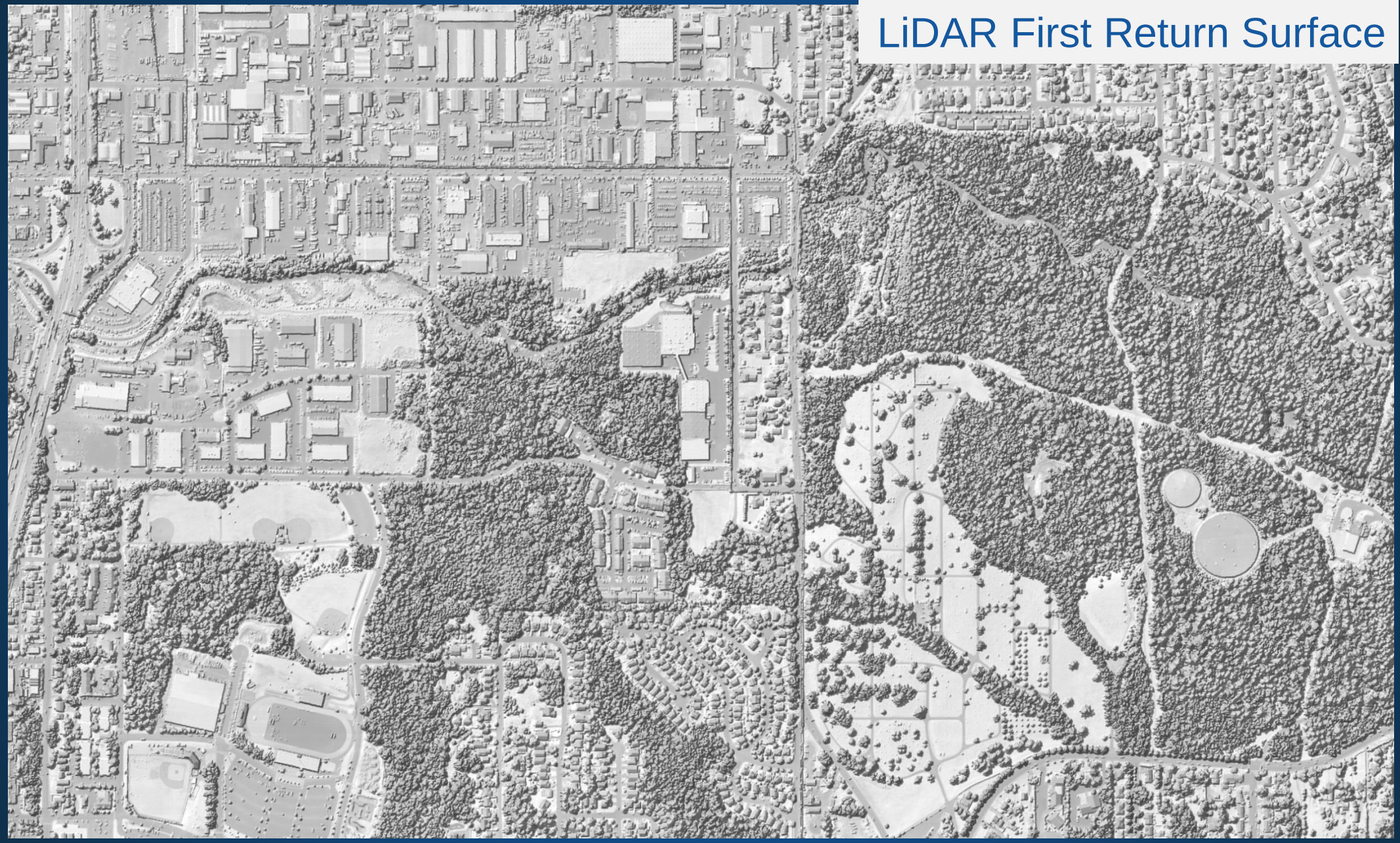
Outline

Vegetation Classification with Color-IR & LiDAR (2013 data)

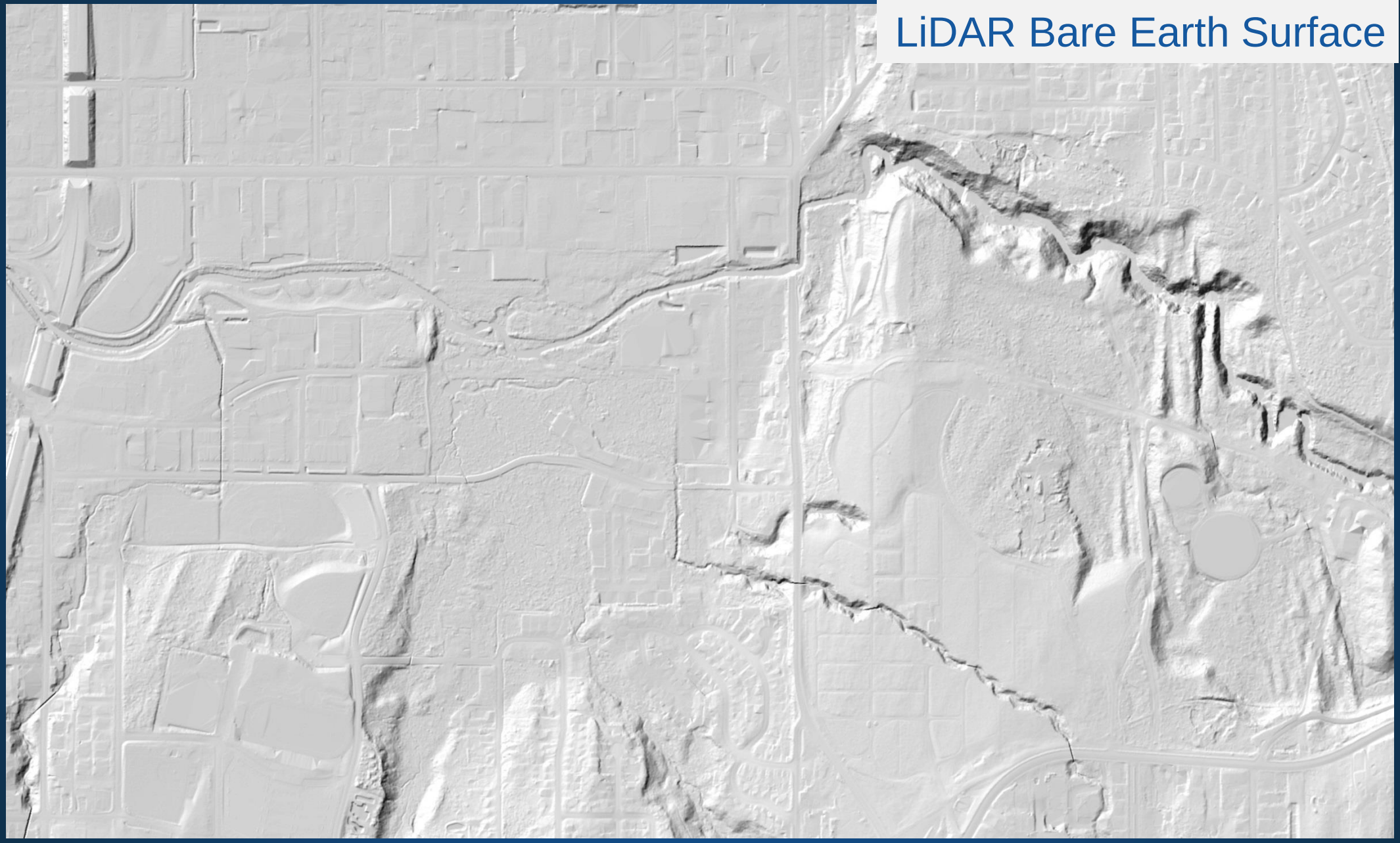
Change Detection with NAIP Imagery (2009 to 2015)

Vegetation Classification with Color-IR & LiDAR

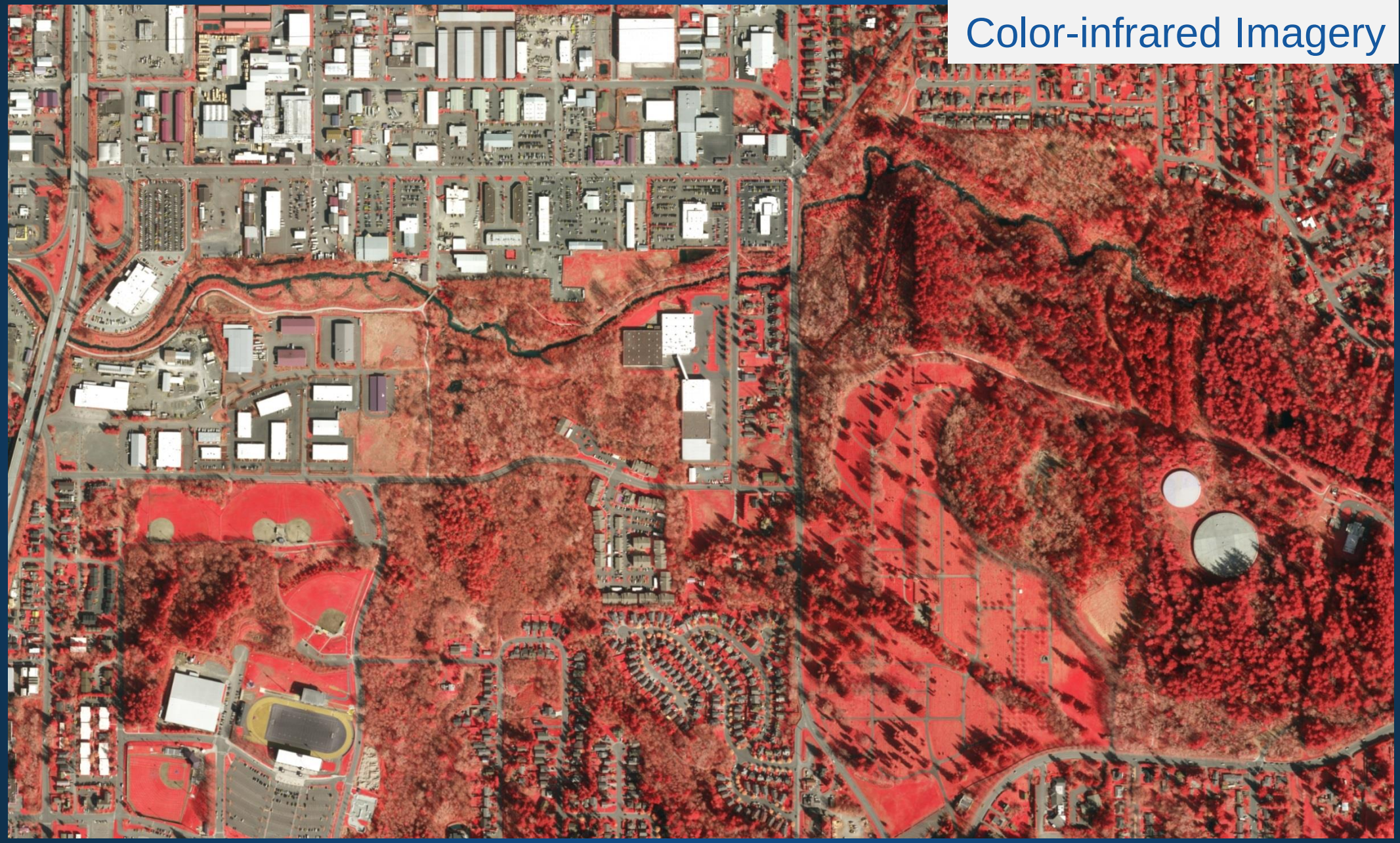
LiDAR First Return Surface



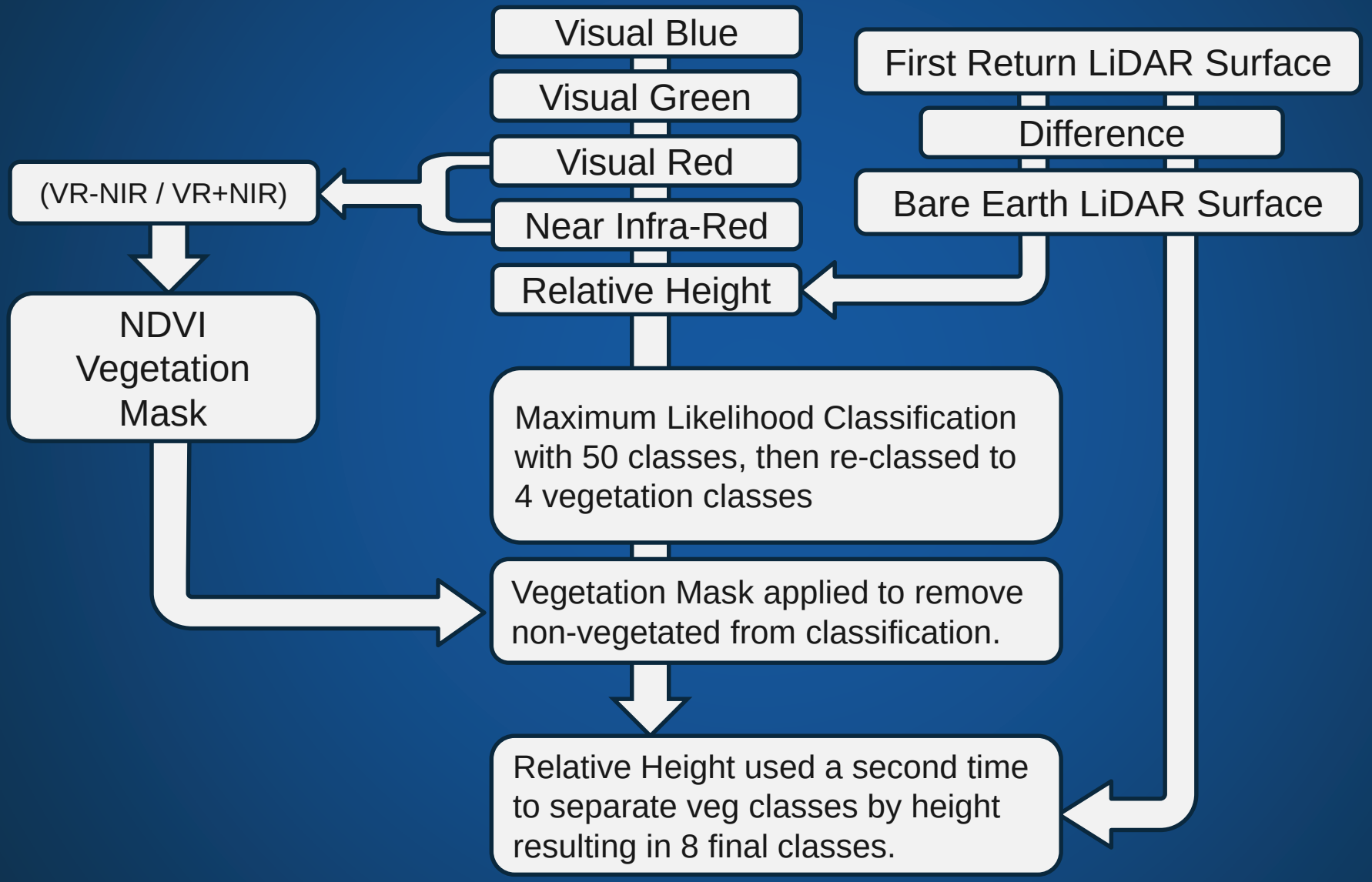
LiDAR Bare Earth Surface



Color-infrared Imagery



Vegetation Classification Model

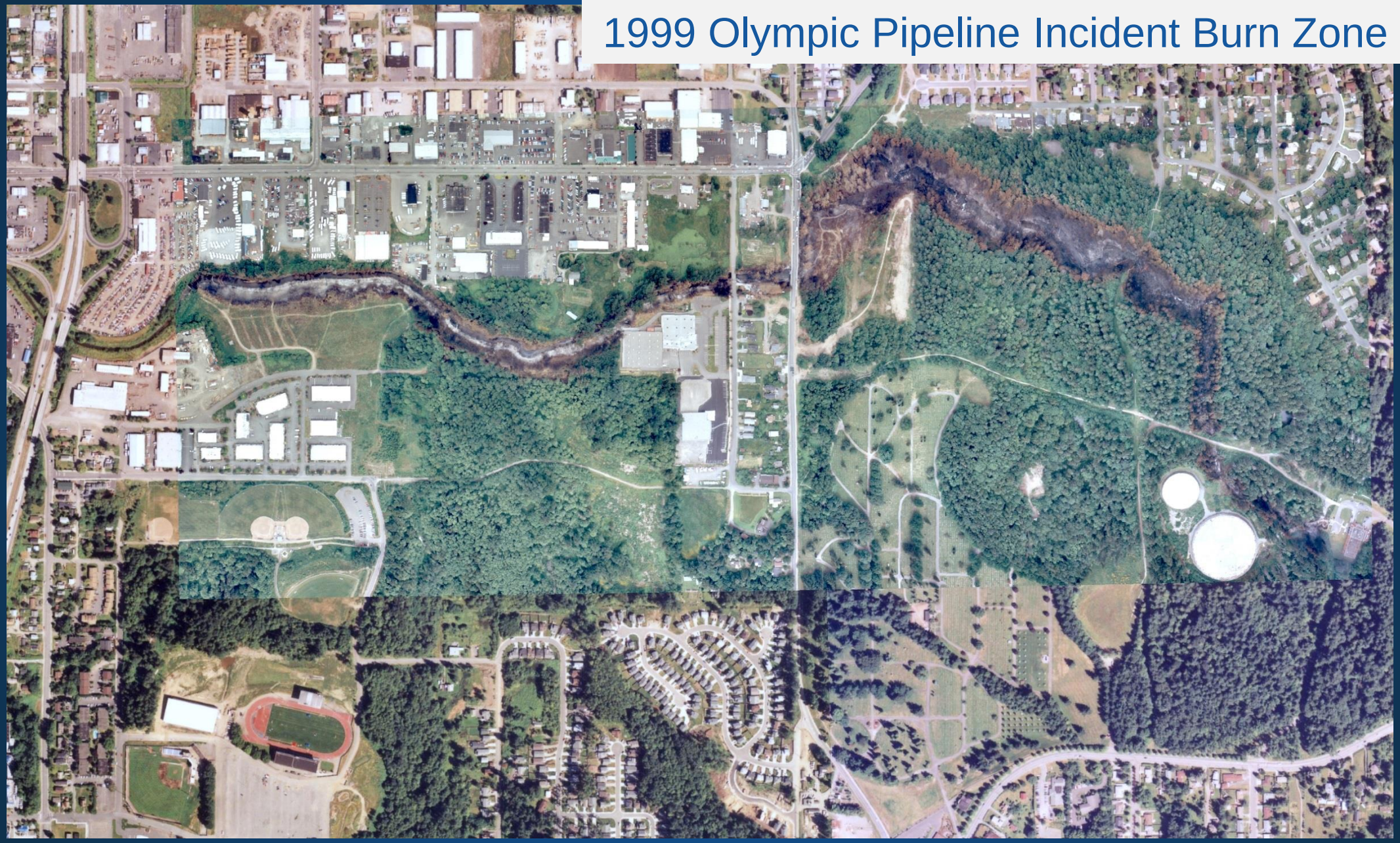


Final Classification

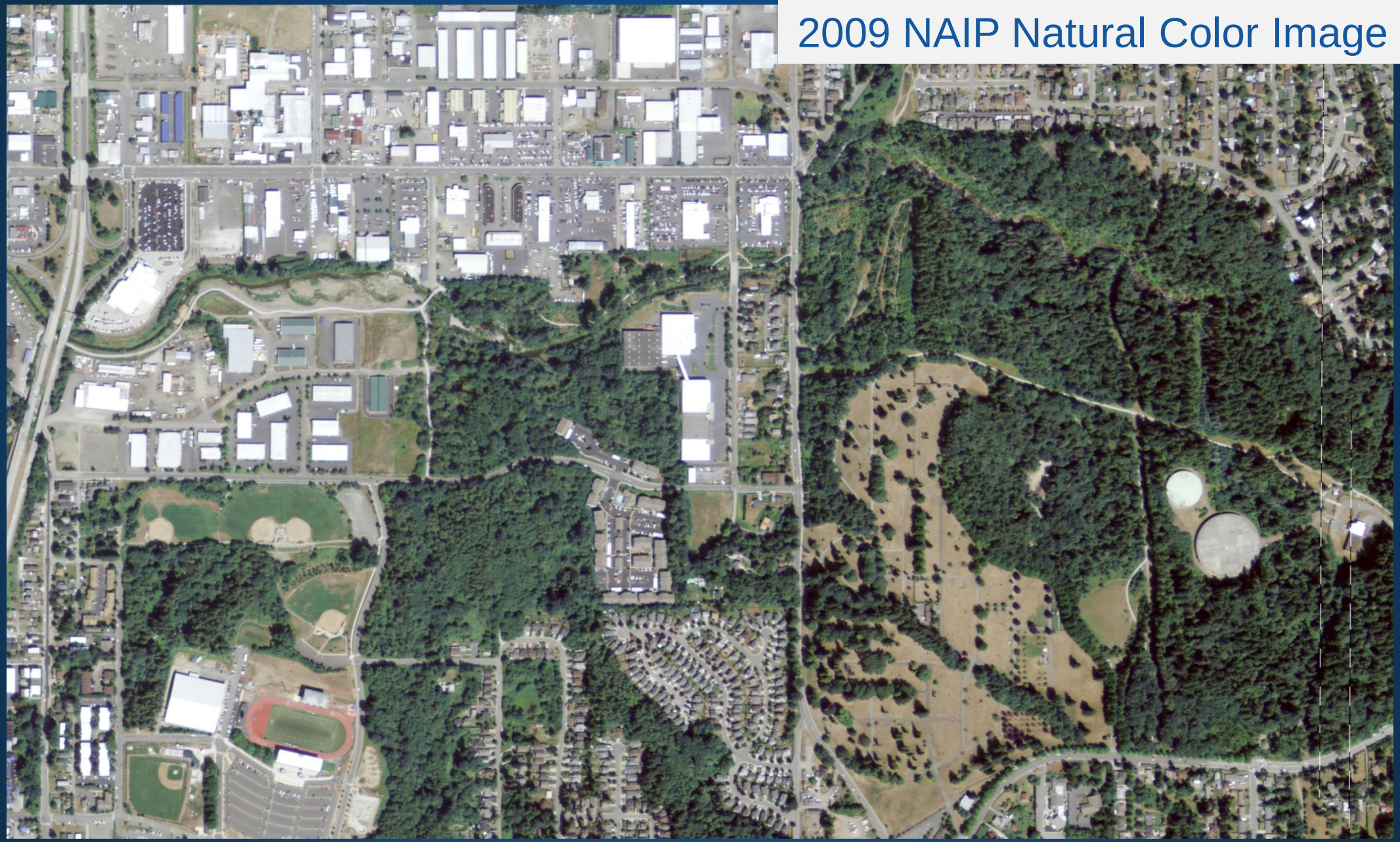
Change Detection with NAIP Imagery

1997 Whatcom Creek Corridor

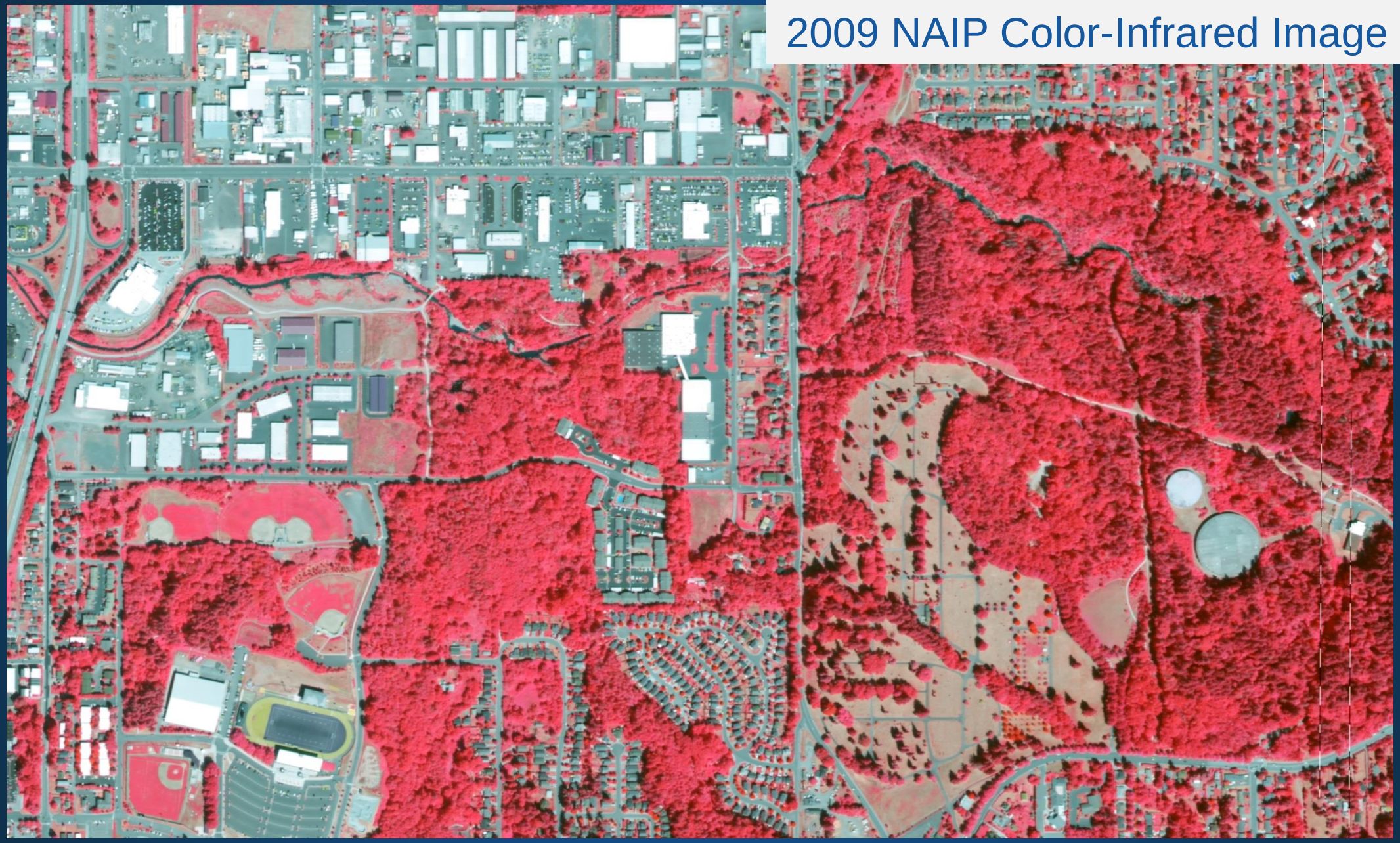
1999 Olympic Pipeline Incident Burn Zone



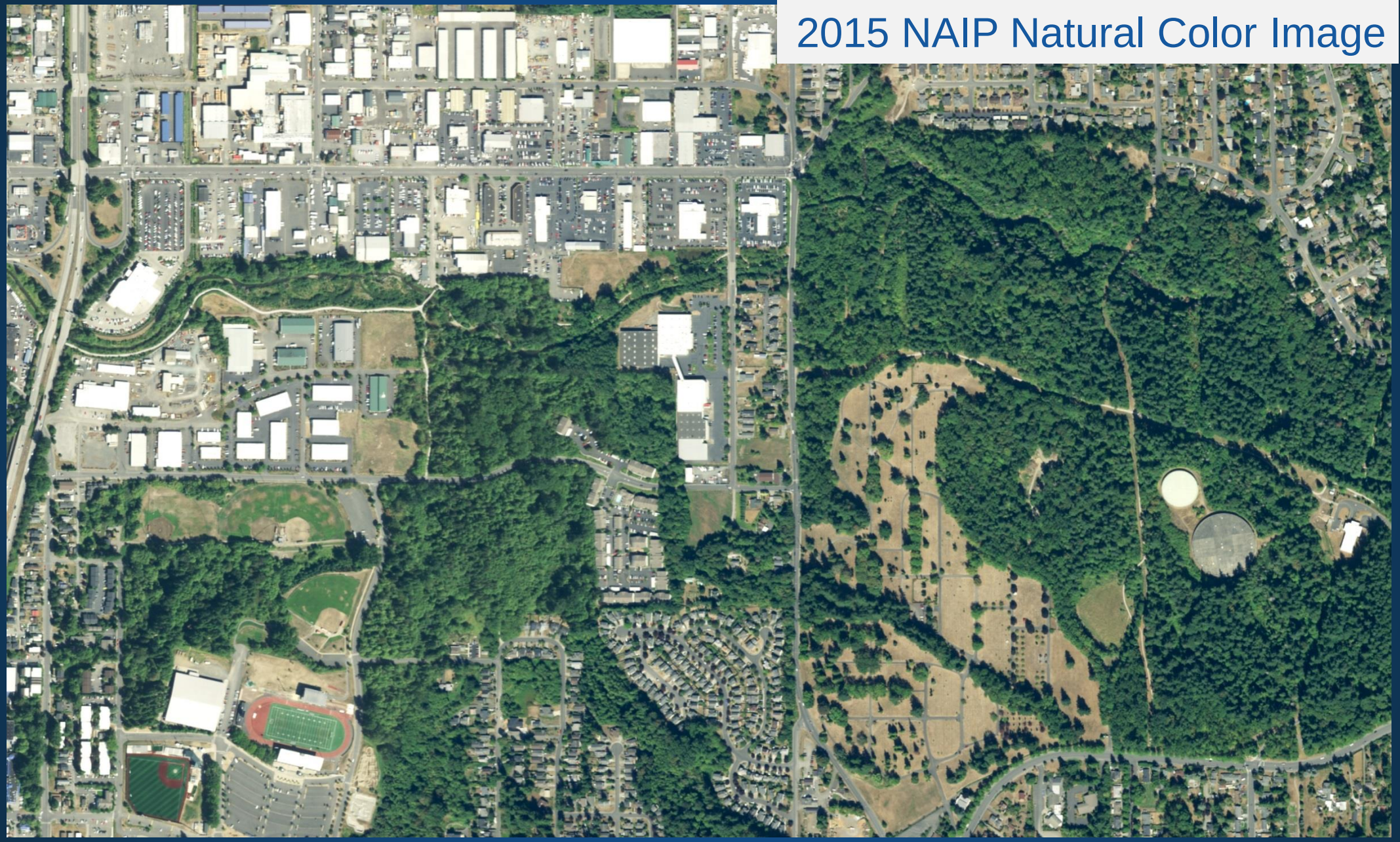
2009 NAIP Natural Color Image



2009 NAIP Color-Infrared Image



2015 NAIP Natural Color Image



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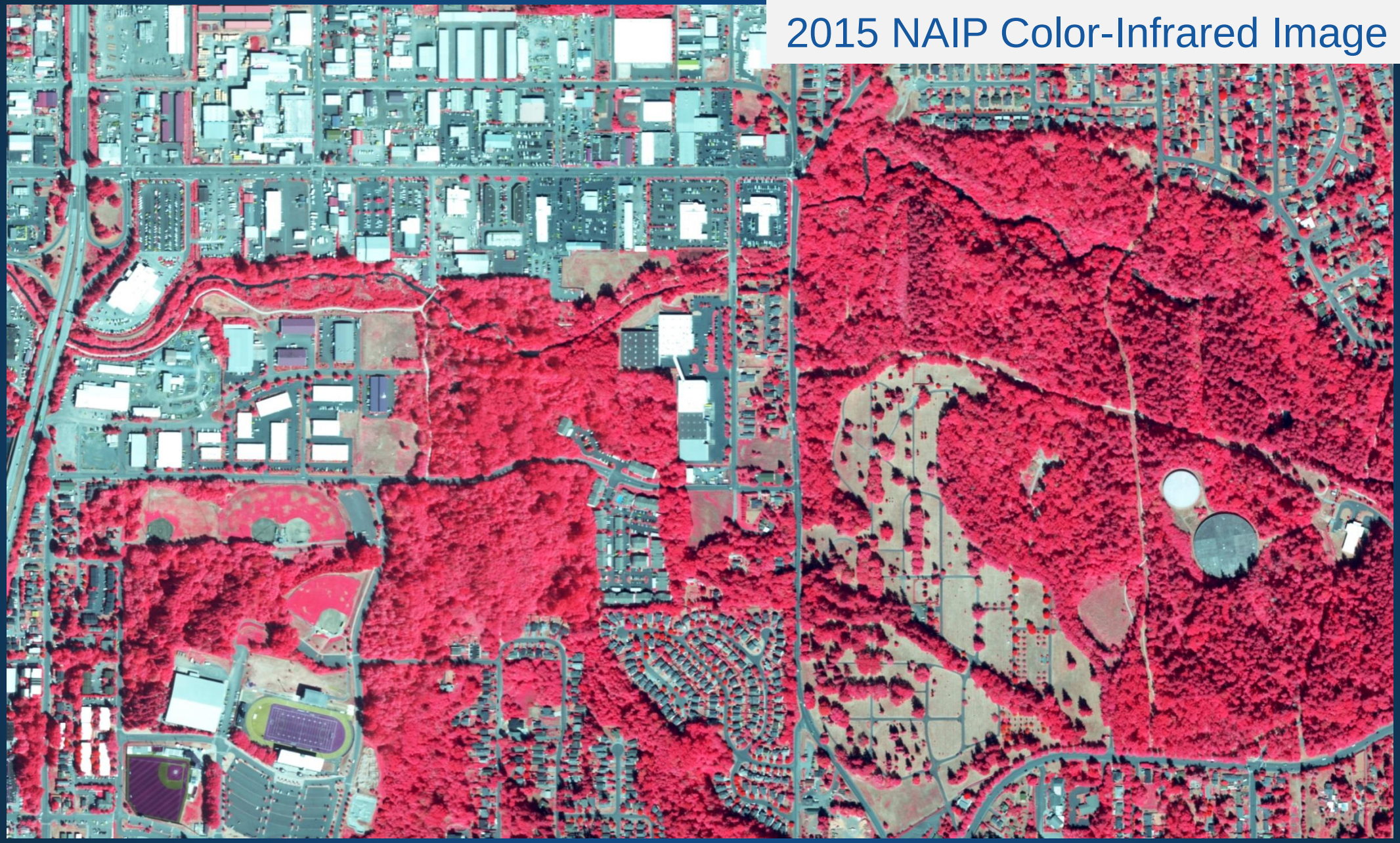

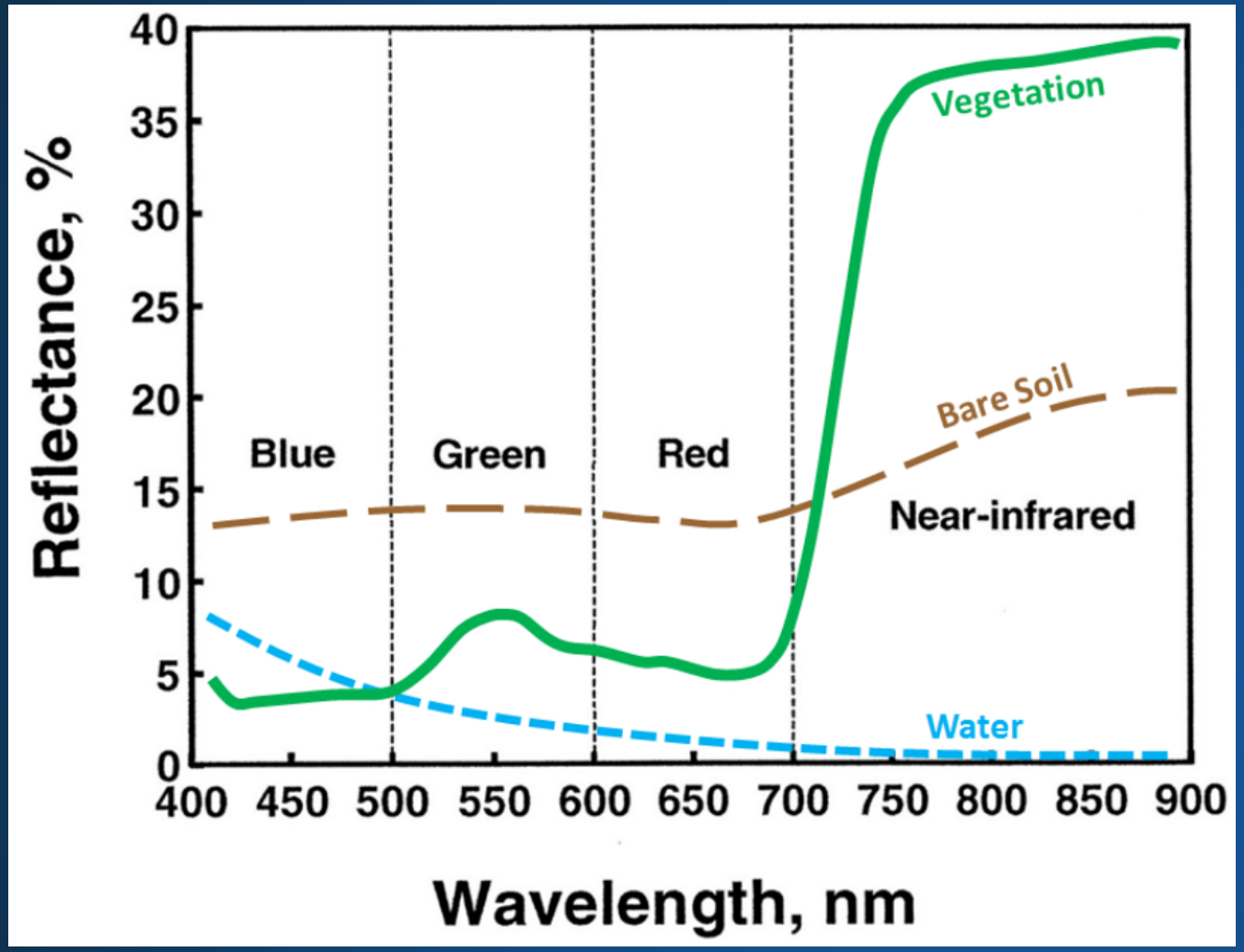
Reflectance, %
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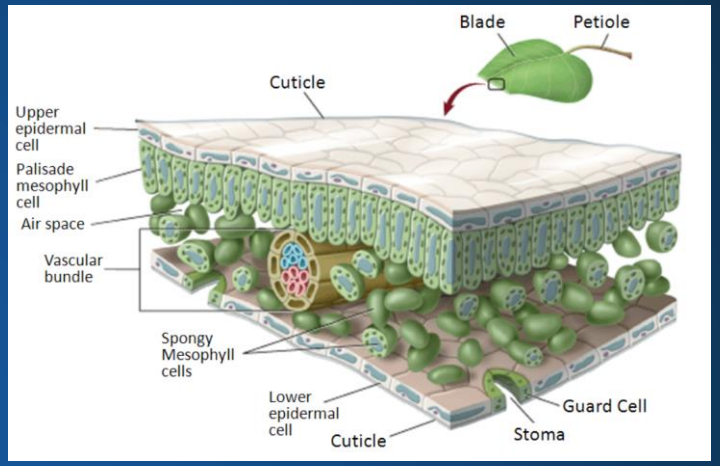
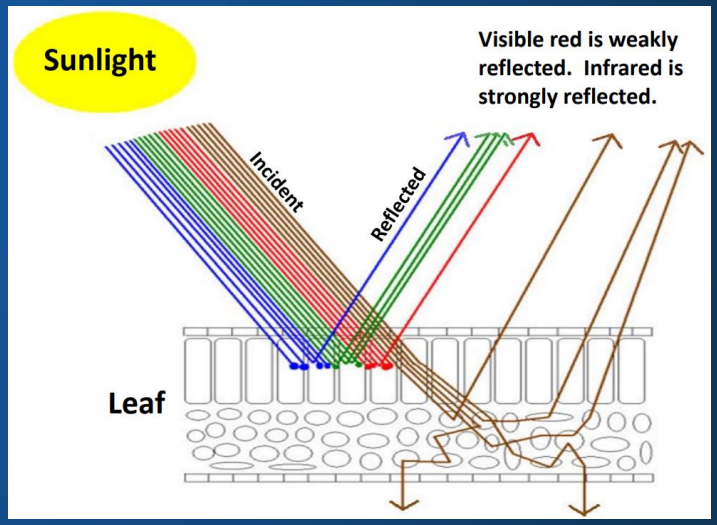
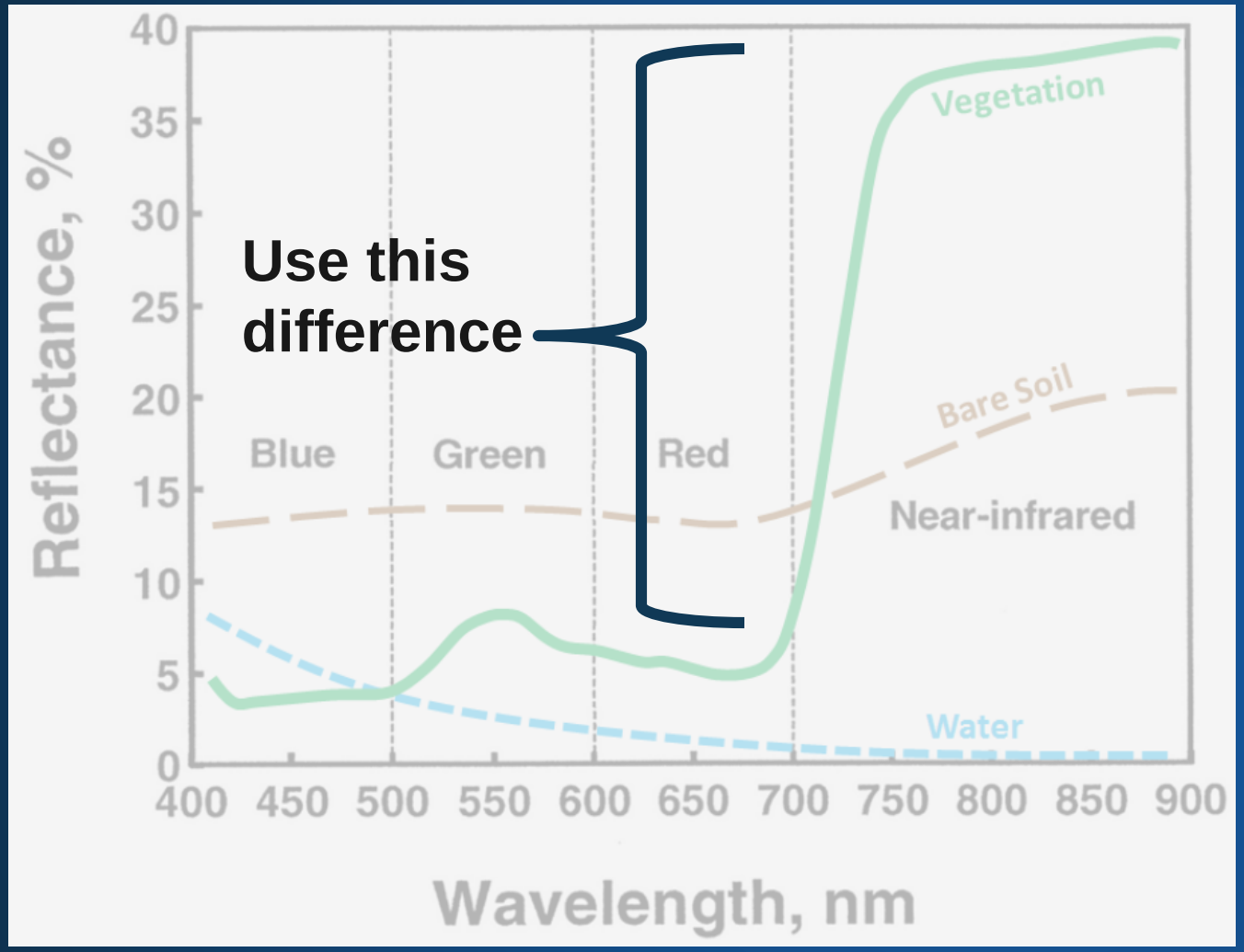
400 450 500 550 600 650 700 750 800 850 900
Wavelength, nm
Blue
Green
Red
Near-infrared
Vegetation
Bare Soil
Water


Blade
Petiole
Cuticle
Upper epidermal cell
Palisade mesophyll cell
Air space
Vascular bundle
Spongy Mesophyll cells
Lower epidermal cell
Cuticle
Guard Cell
Stoma


Sunlight
Visible red is weakly reflected. Infrared is strongly reflected.
Incident
Reflected
Leaf


Reflectance, %
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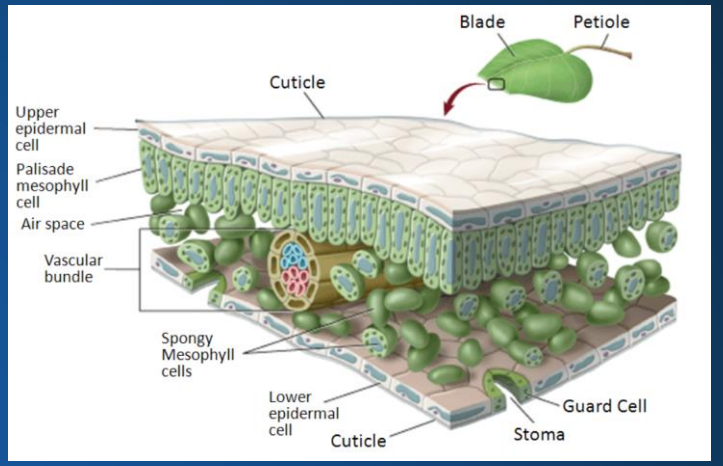
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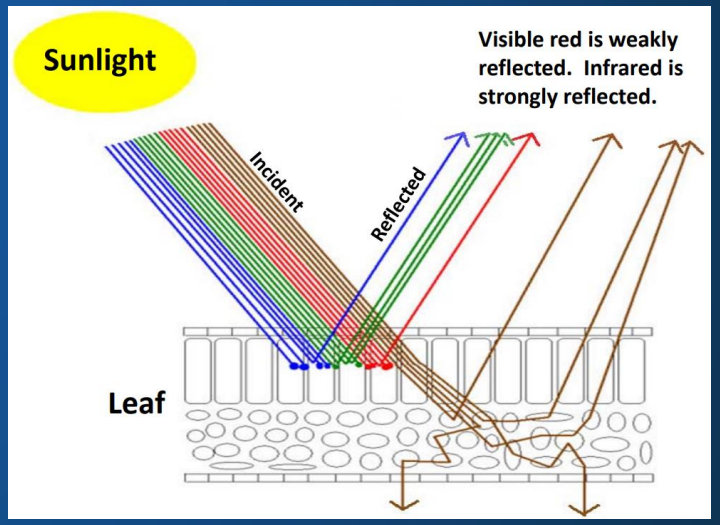
Sunlight
Visible red is weakly reflected. Infrared is strongly reflected.
Incident
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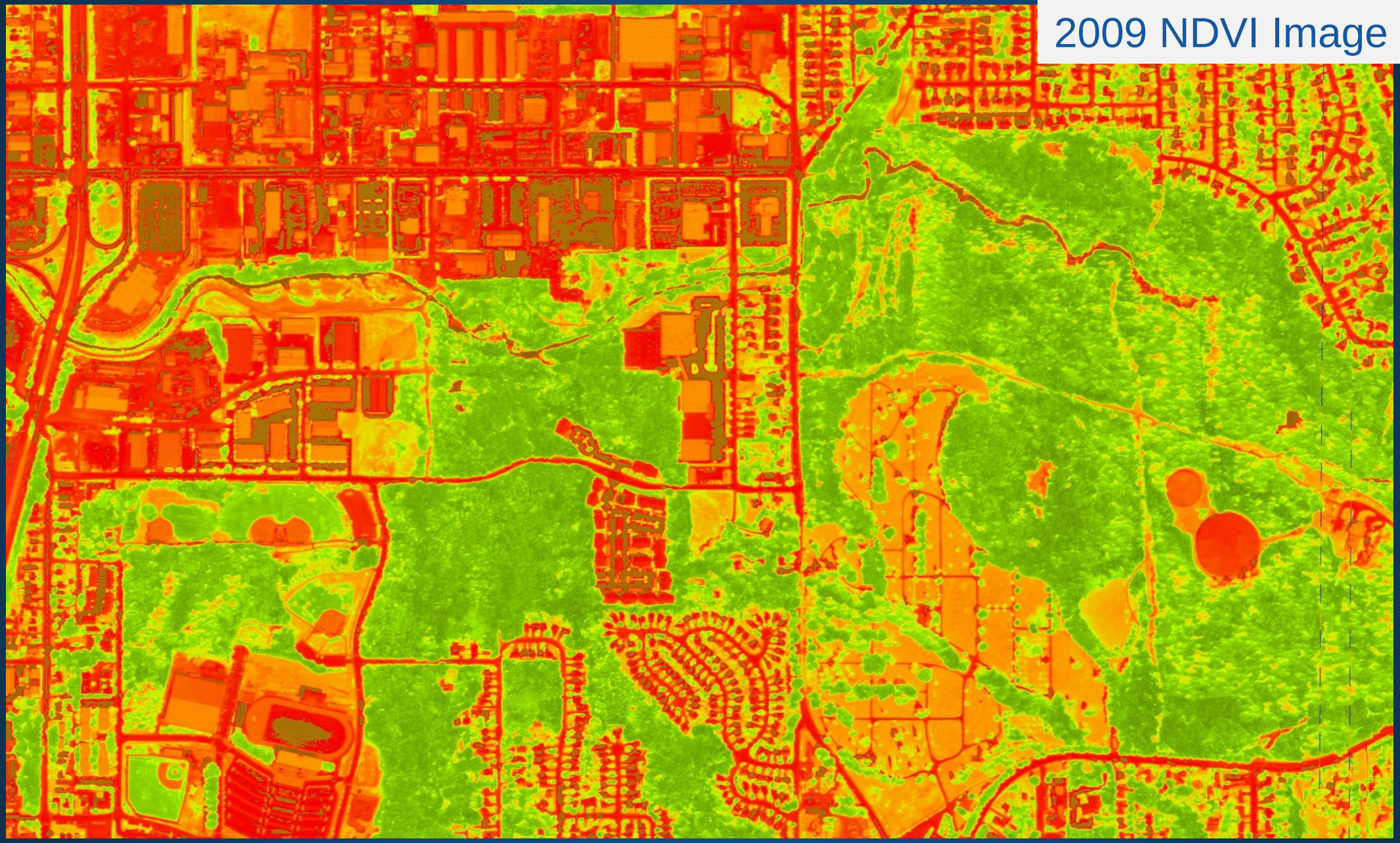
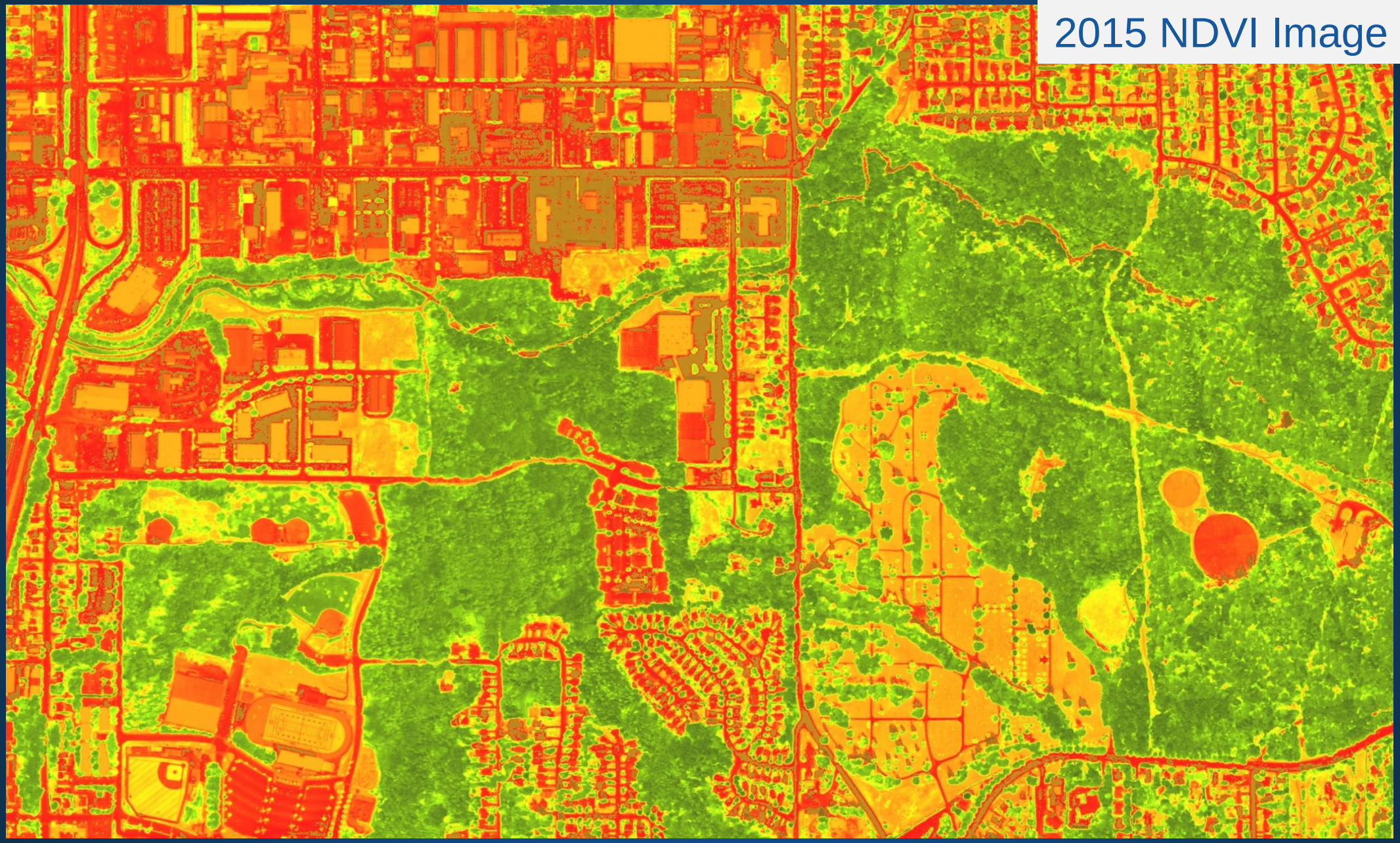
Leaf

$$NDVI = \frac{(Red - NIR)}{(Red + NIR)}$$

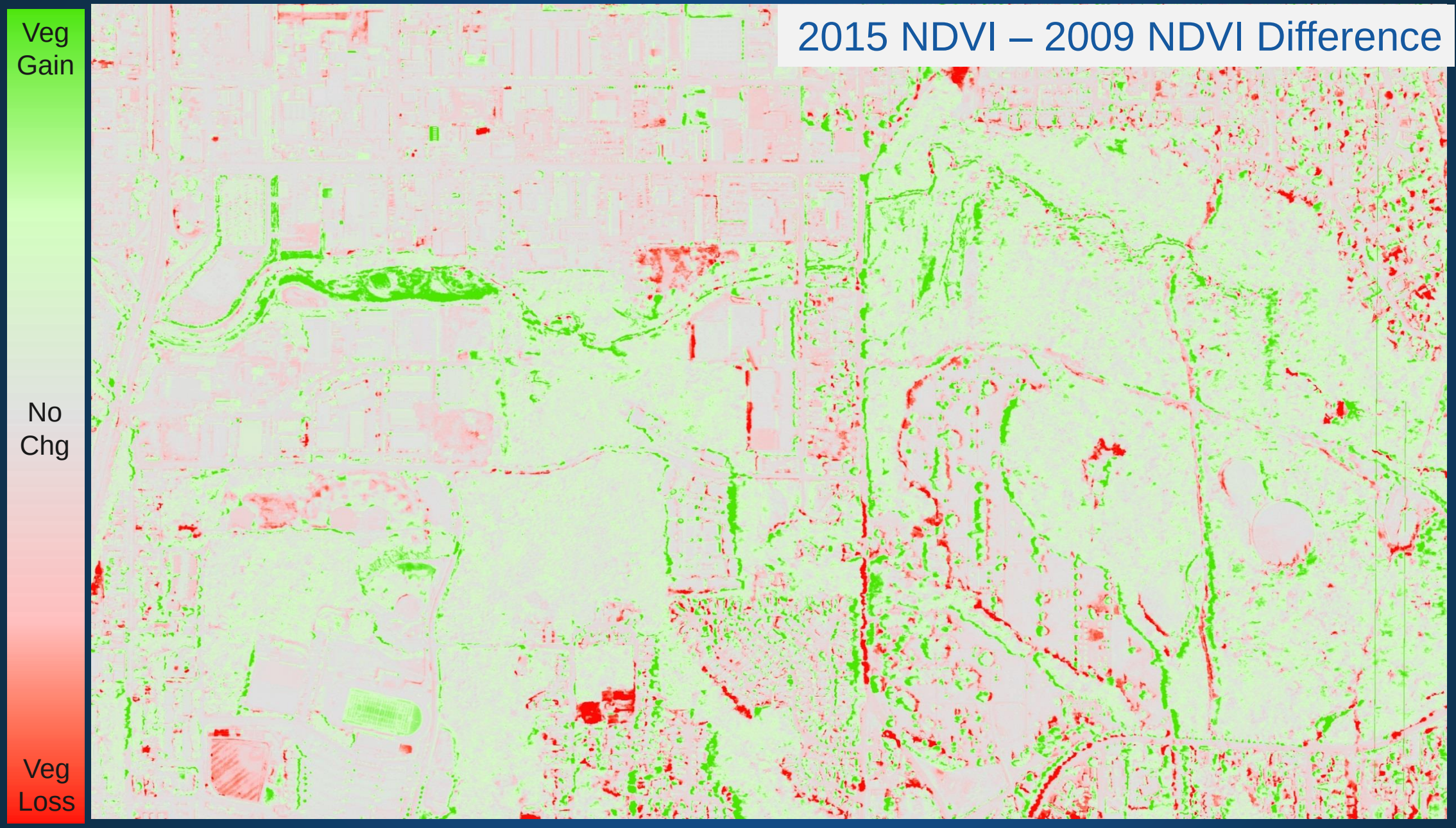
2009 NDVI Image



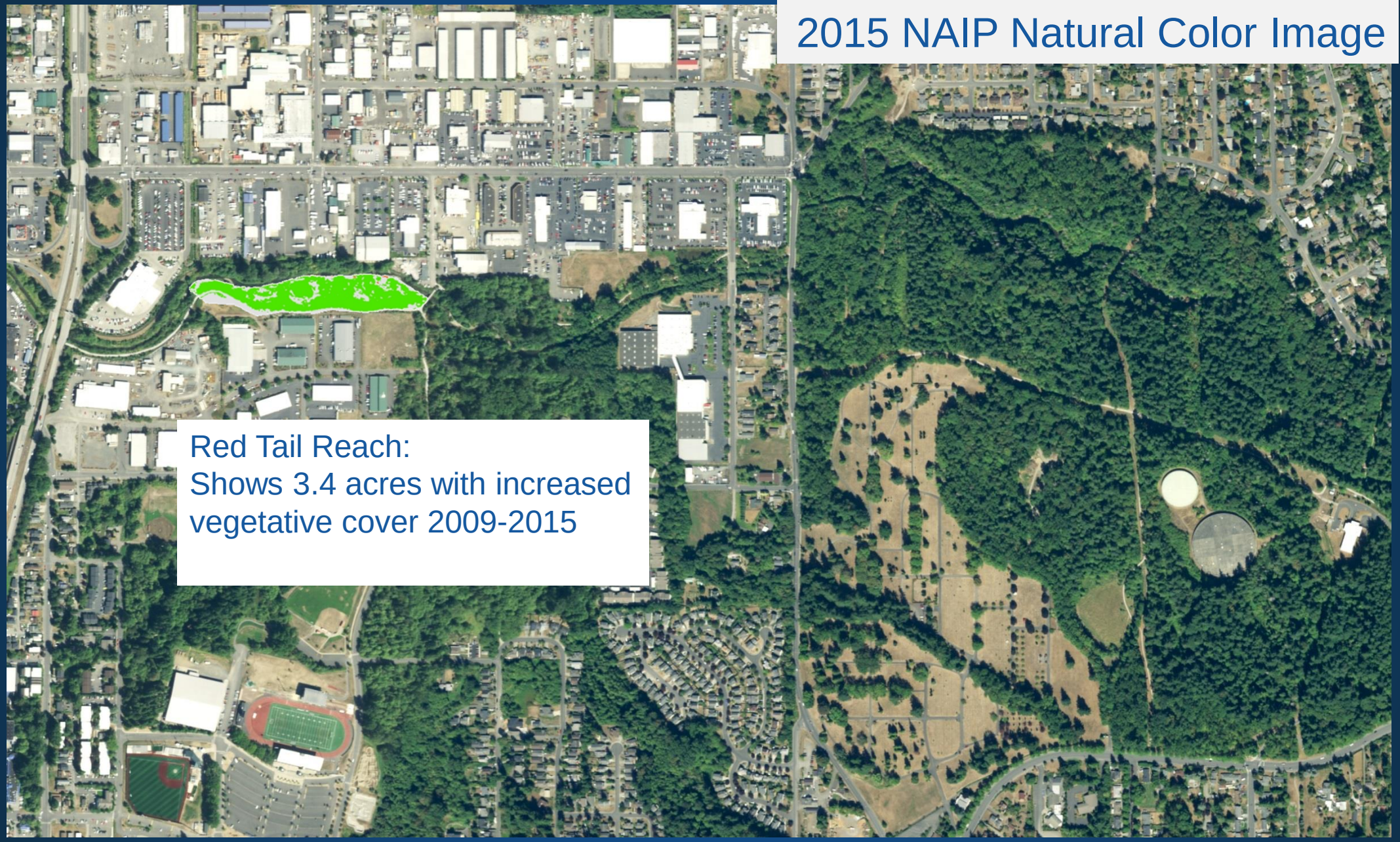
2015 NDVI Image



2015 NDVI – 2009 NDVI Difference



2015 NAIP Natural Color Image



Red Tail Reach:
Shows 3.4 acres with increased vegetative cover 2009-2015

Applications

- Assessing current vegetation on-site for Watershed Purchase Program, Greenways Program, etc.
- Monitoring change for restoration sites, and riparian corridors.

Next Steps

- Add additional (2017) NAIP imagery.
- Improve NAIP image spatial registration between years (offsets yield false positives & negatives).
- Drone footage to supplement LiDAR data.

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Chris Behee *cbehee@cob.org*