

Examining the Functions and Forms of Restored Channel Outlets in Floodplains of the Lower Columbia River Estuary

Curtis Loeb, PE

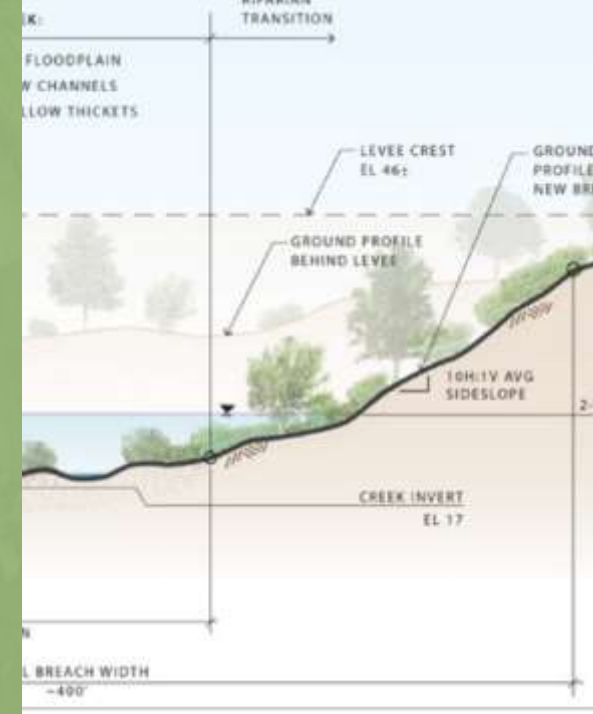
Jeremy Lowe

Wolf Water Resources, Inc. | Portland, Oregon

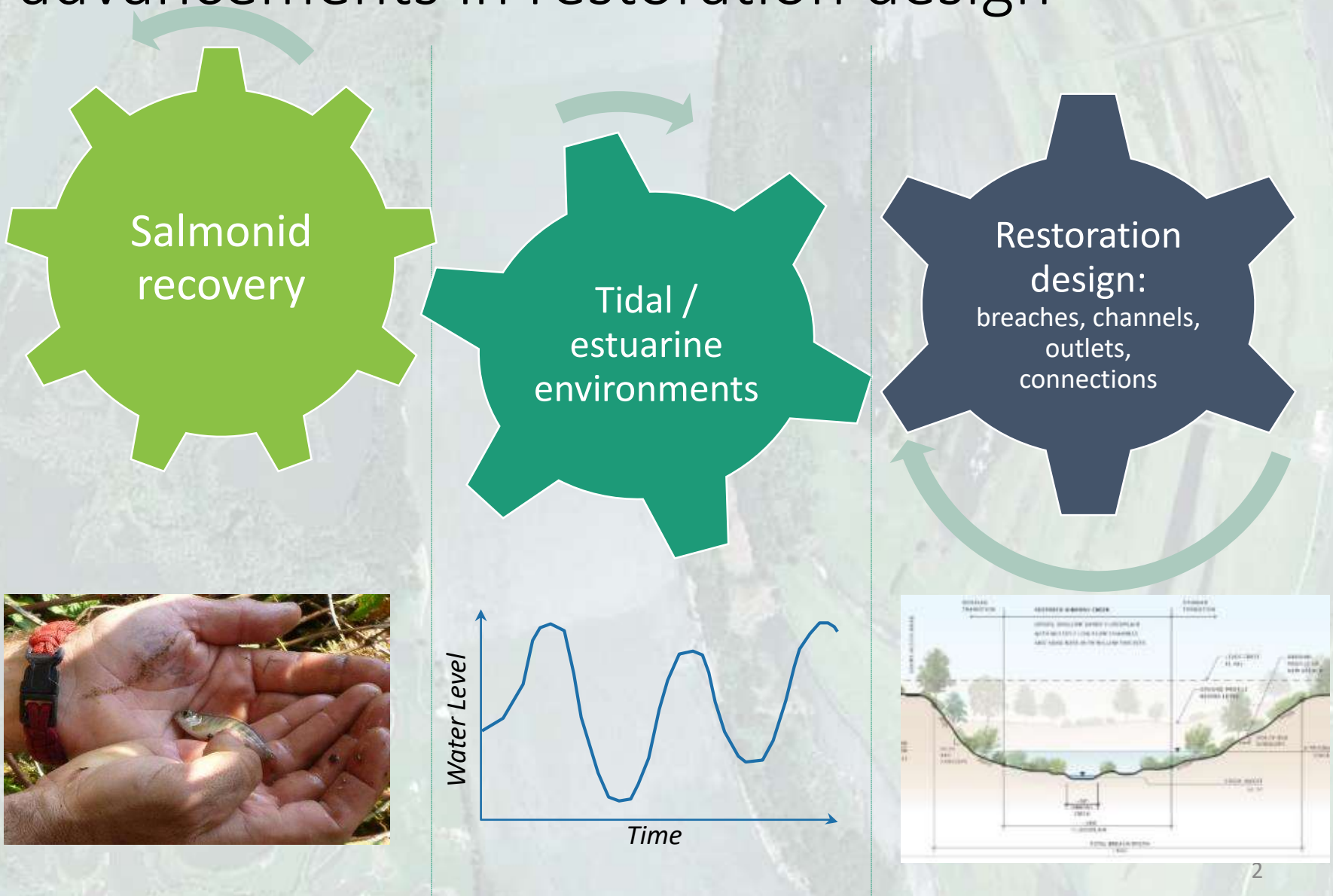
Columbia River Estuary Conference

Astoria, Oregon

April, 2018



Salmonid recovery driving the need for advancements in restoration design



Why focus on connections?

- Fish and aquatic species ingress / egress
- Affect marsh geomorphology and ecology
- Transport water, biota & nutrients, sediment



LCRE Connections

DOWNSTREAM

UPSTREAM

TIDAL WETLAND



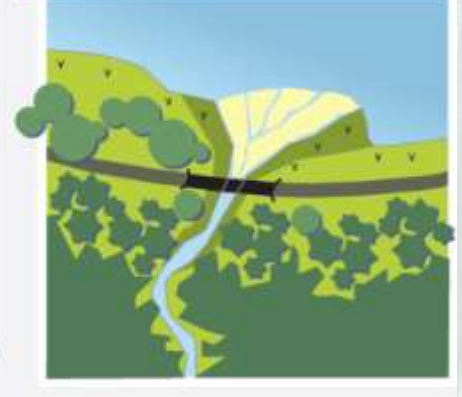
SURGE-PLAIN TIDAL ISLANDS



MIXED REGIME, MUTED TIDAL BACKSWAMP



CREEK CONFLUENCE

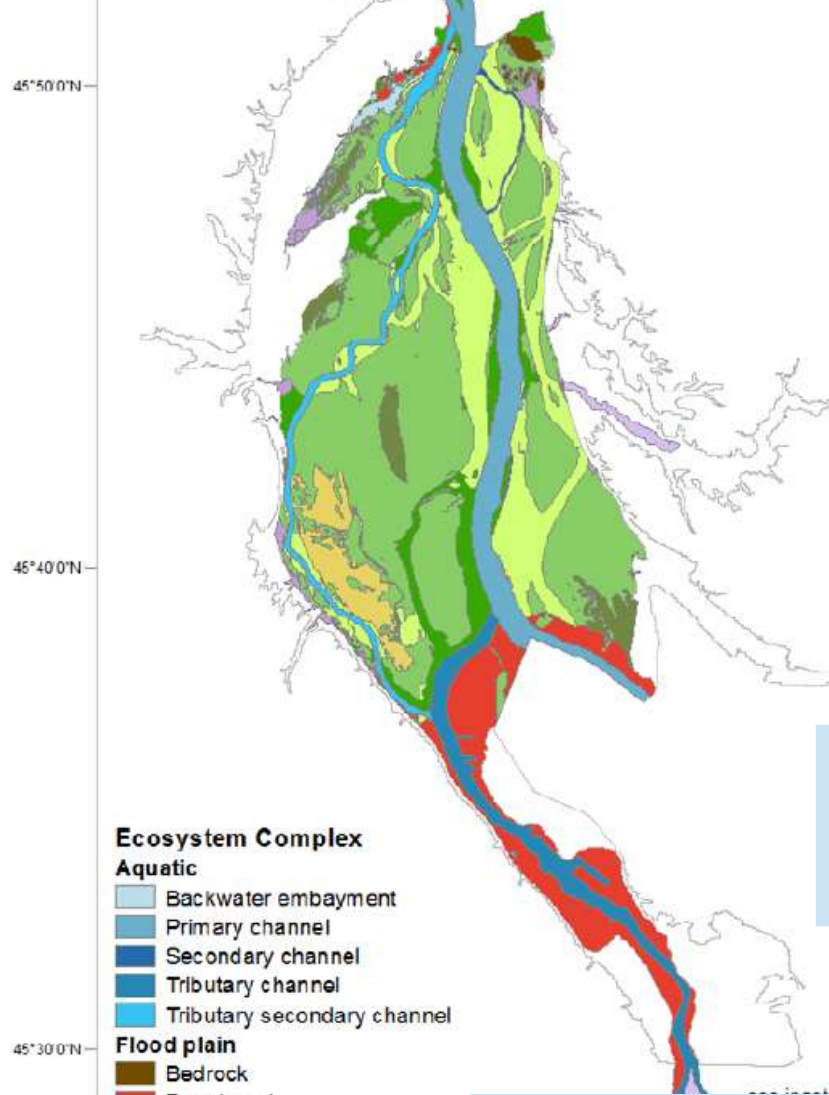


HYDROGEMORPHIC REACH

A



H



Ecosystem Complex

Aquatic

- Backwater embayment
- Primary channel
- Secondary channel
- Tributary channel
- Tributary secondary channel

Flood plain

- Bedrock
- Developed
- Dune deposit
- Flood plain
- Flood-plain backswamp
- Flood-plain bar and scroll
- Landslide
- Terrace
- Tributary fan
- Tributary flood plain
- Unknown
- Outside Holocene flood plain

Level 4
Ecosystem
Complexes



Geomorphic Catena

Aquatic

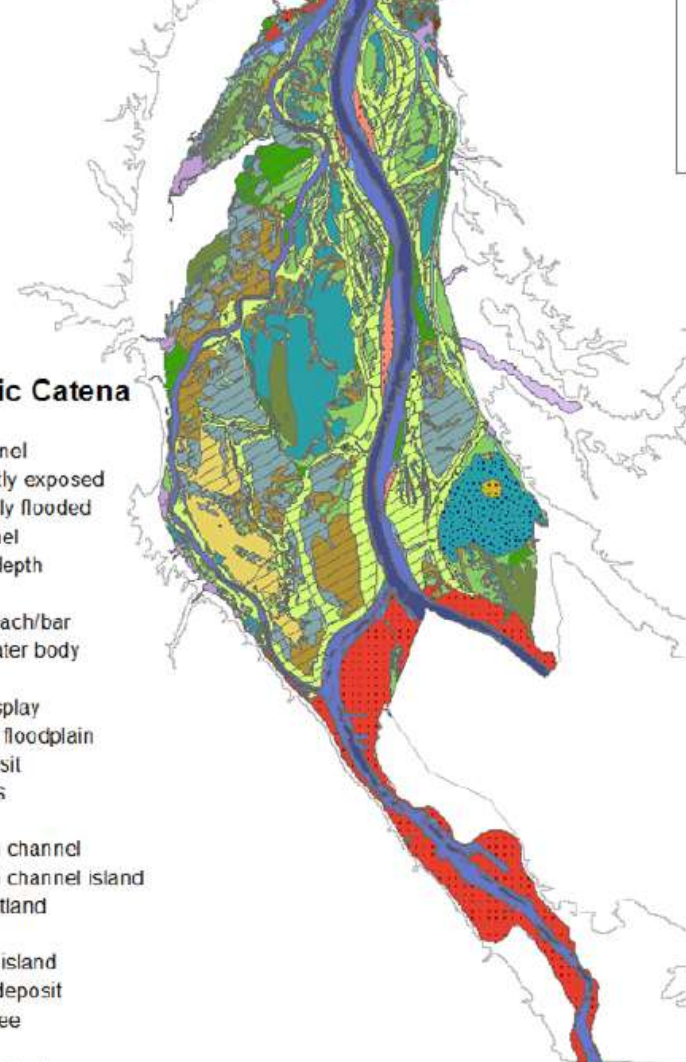
- Deep channel
- Intermittently exposed
- Permanently flooded
- Side channel
- Unknown depth

Flood plain

- Artificial beach/bar
- Artificial water body
- Bedrock
- Crevasse splay
- Developed floodplain
- Dune deposit
- Filled areas
- Flood plain
- Flood-plain channel
- Flood-plain channel island
- Lake or wetland
- Lake/pond
- Lake/pond island
- Landslide deposit
- Terrace
- Tributary (minor)
- Tributary fan
- Tributary valley (outside flood plain)
- Unknown
- Wetland
- Outside Holocene floodplain

Modifiers

- Artificial
- Altered
- Altered hydrology
- Diked
- Partially diked



Level 5
Geomorphic
Catena

How to restore connectivity?

Remove.
the.
impairments...



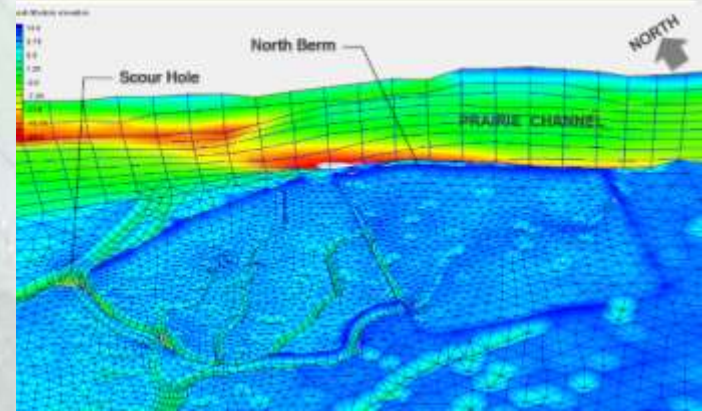
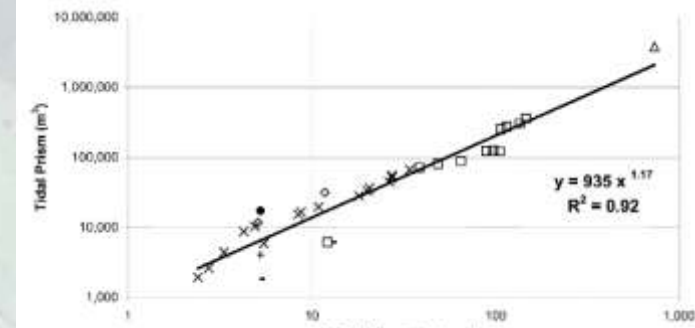
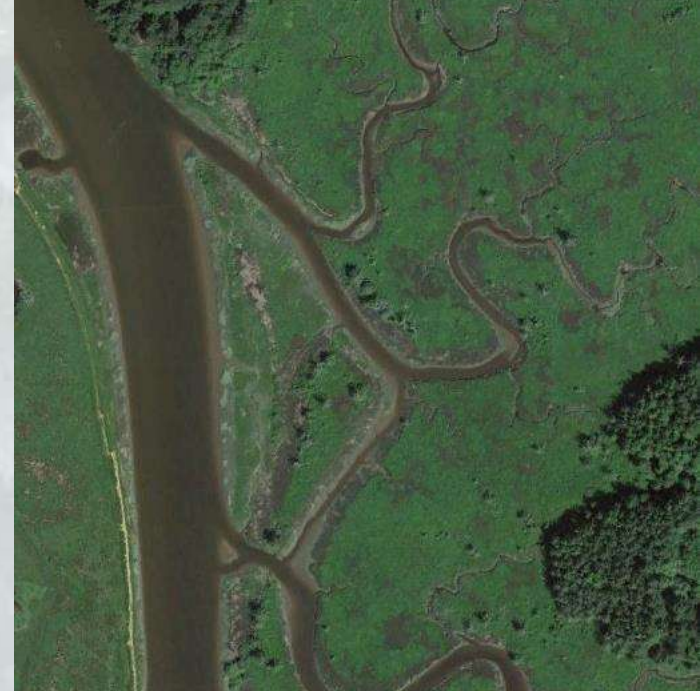
... RIP!



Evidence-based approach (multiple lines of evidence)

1. Least disturbed sites
 2. Tidal hydraulic geometry
 3. Hydrodynamic modeling
- Experience, constraints, costs

Sounds great.....!



Evidence-based approach – limitations?

- *Reference site?*
Extensively disturbed, man-made
- *Hydraulic geometry guide?*
Tidally challenged - above tidal range, combined fluvial/tidal (special cases, or “misfits”)
- *Modeling?*
Difficult to survey, large, expensive



Evidence limitations?

Location	Primary restored channel connection type
Sauvie Island - FE	Upper tidal, redundant connections
<i>Sauvie Island – NU (multiple)</i>	<i>Muted tidal channel</i>
Sauvie Island - Sturgeon	Upstream-island / redundant channel connection
Multnomah Channel - bottomlands	Creek tributary; muted tidal
Multnomah Channel - Scappoose	Creek tributary, high floodplain, above MHHW
Multnomah Channel – Mult. Co.	Creek tributary, high floodplain, above MHHW
Sandy R. Delta Natural Area	Creek tributary, high floodplain, above MHHW
Columbia floodplain – Washougal	Alluvial fan, high wetland channels, above MHHW
<i>Dibblee – Rainier</i>	<i>Muted tidal channel</i>
<i>Tongue Point</i>	<i>Tidal channel</i>
<i>Cathlamet Bay Island</i>	<i>Tidal & fluvial-surge channels</i>
<i>Youngs River</i>	<i>Tidal channel</i>
<i>Fort Clatsop</i>	<i>Tidal channel</i>
Columbia Passage Connection 1	River distributary / passive restoration
Baker Bay - WSI	Vegetation removal with high tidal zone connections
Columbia Passage Connection 2	Creek tributary / tidal inlet
Willamette River – Oaks	Bluff seeps, high floodplain
Miller Creek	Creek tributary, high floodplain

Gray – evidence non-limited (reference/design guidance applicable)

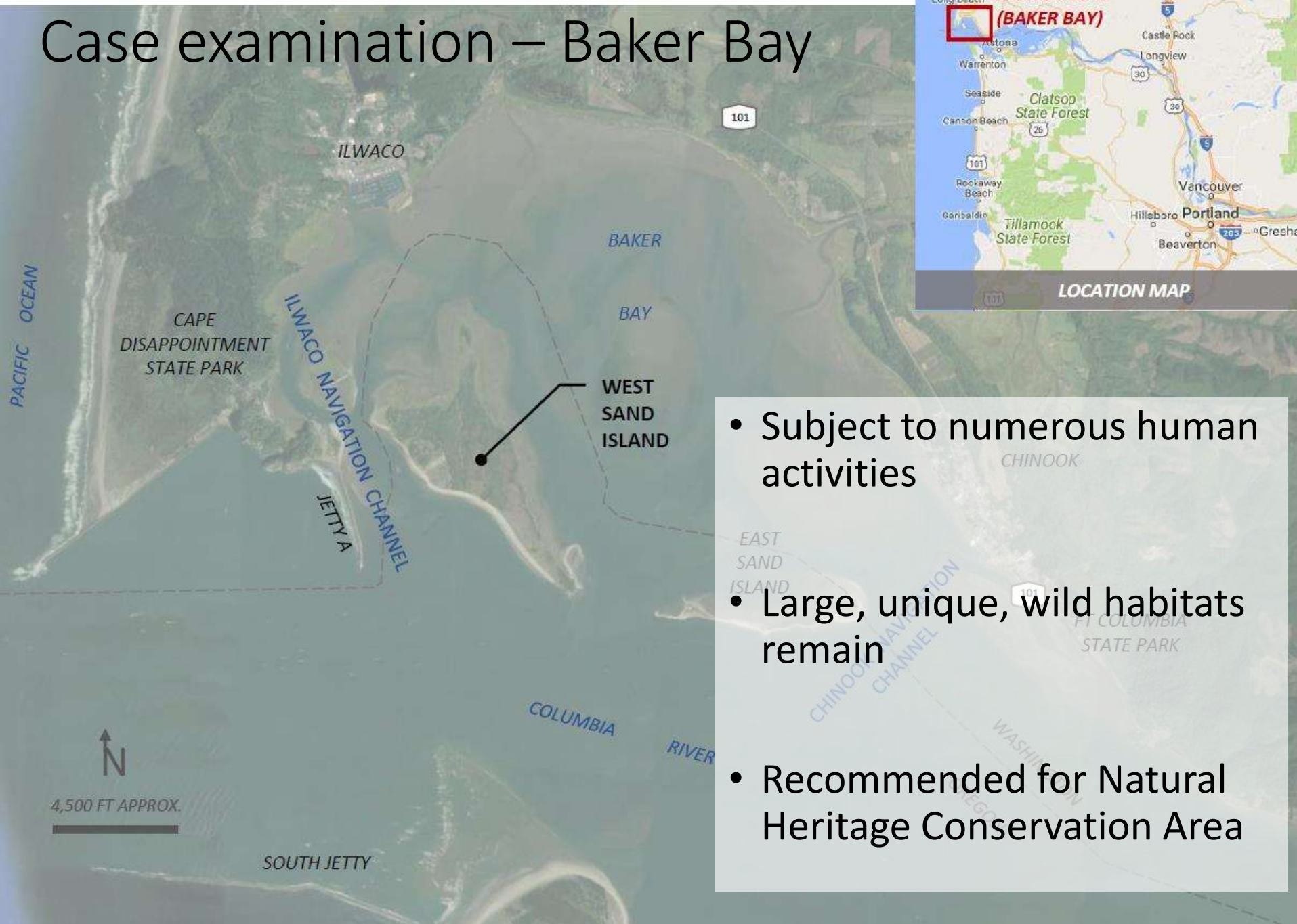
Black – special cases (misfit connections)



Case examination – Baker Bay

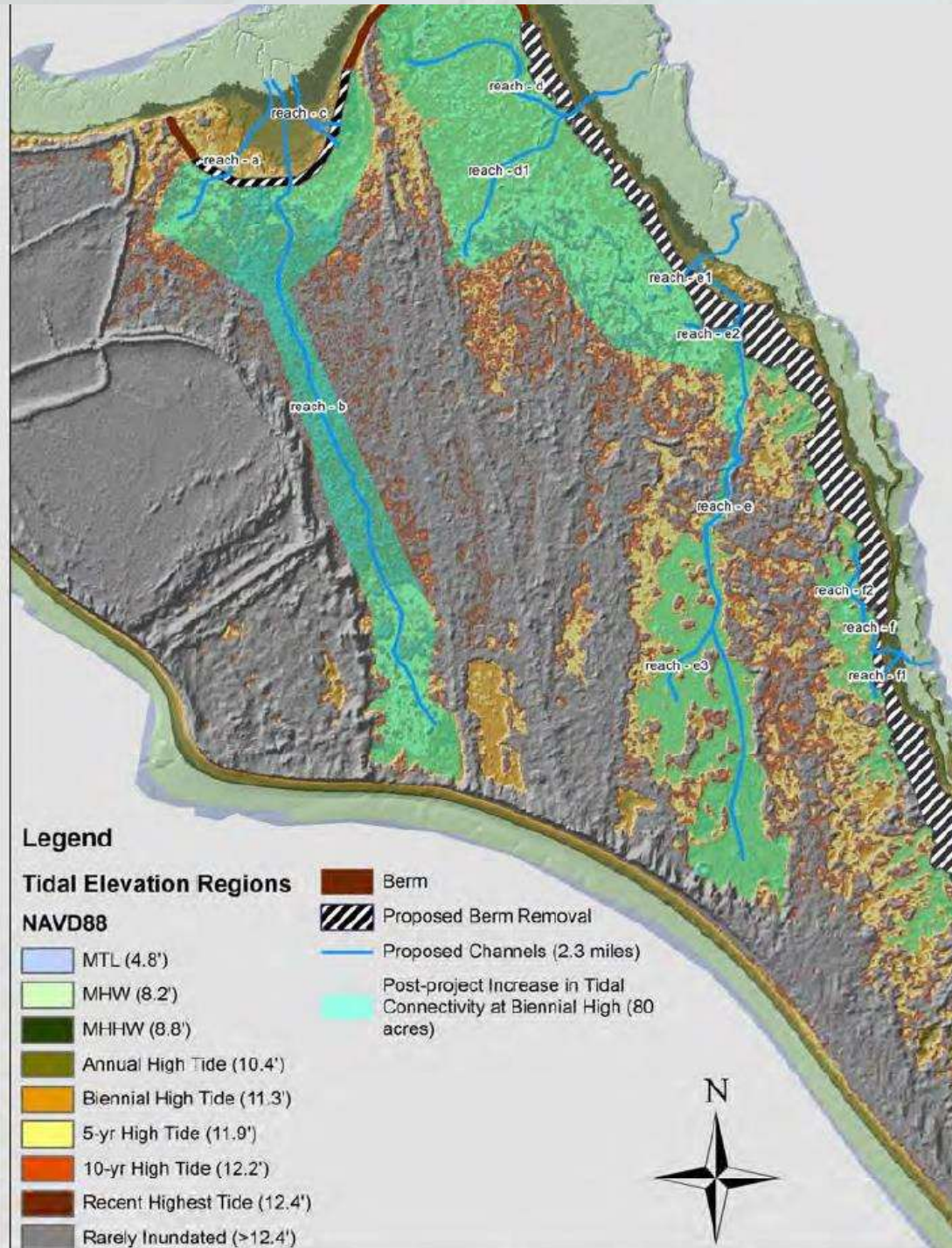


Case examination – Baker Bay



- Subject to numerous human activities
- Large, unique, wild habitats remain
- Recommended for Natural Heritage Conservation Area

Initial conceptual design



- Invasive veg. removal & revegetation
- Numerous connections & long channels
- Biennial high tide connectivity increase

• Preliminary reviews → **additional analysis warranted**

Field reconnaissance

EAST-SHORELINE-CHANNEL-D-REGION—EXTERIOR-AND-INTERIOR-WETLANDS



Not visible on aerials / LiDAR



Numerous small flow paths



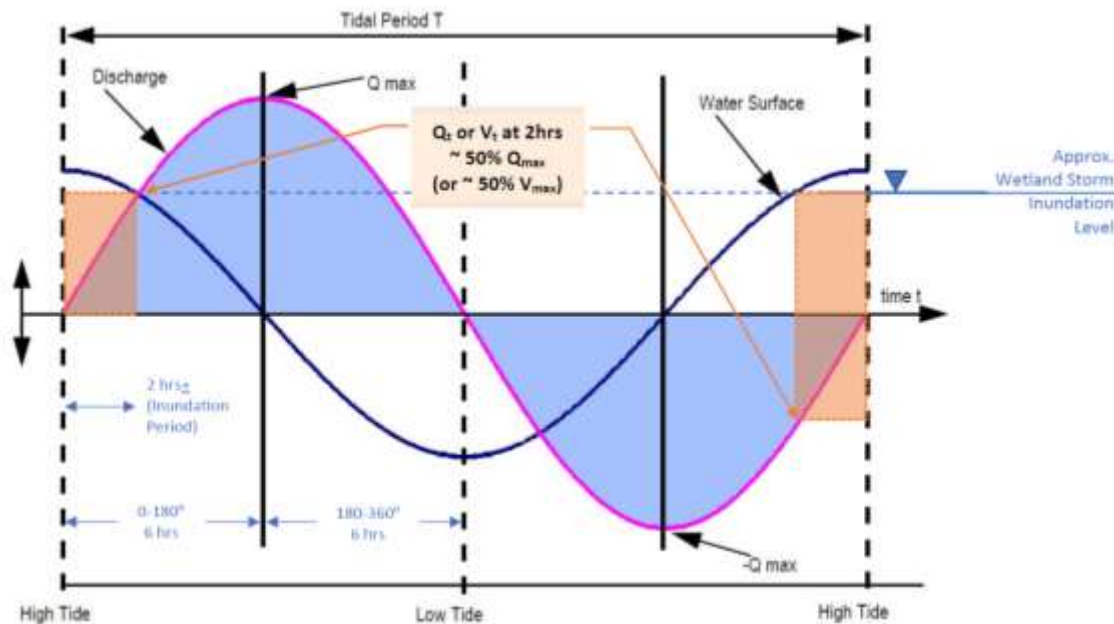
Hydraulic evaluation of erosion

- Tidal prism approach - max. theoretical flow (USFHA 2004, HEC-25)

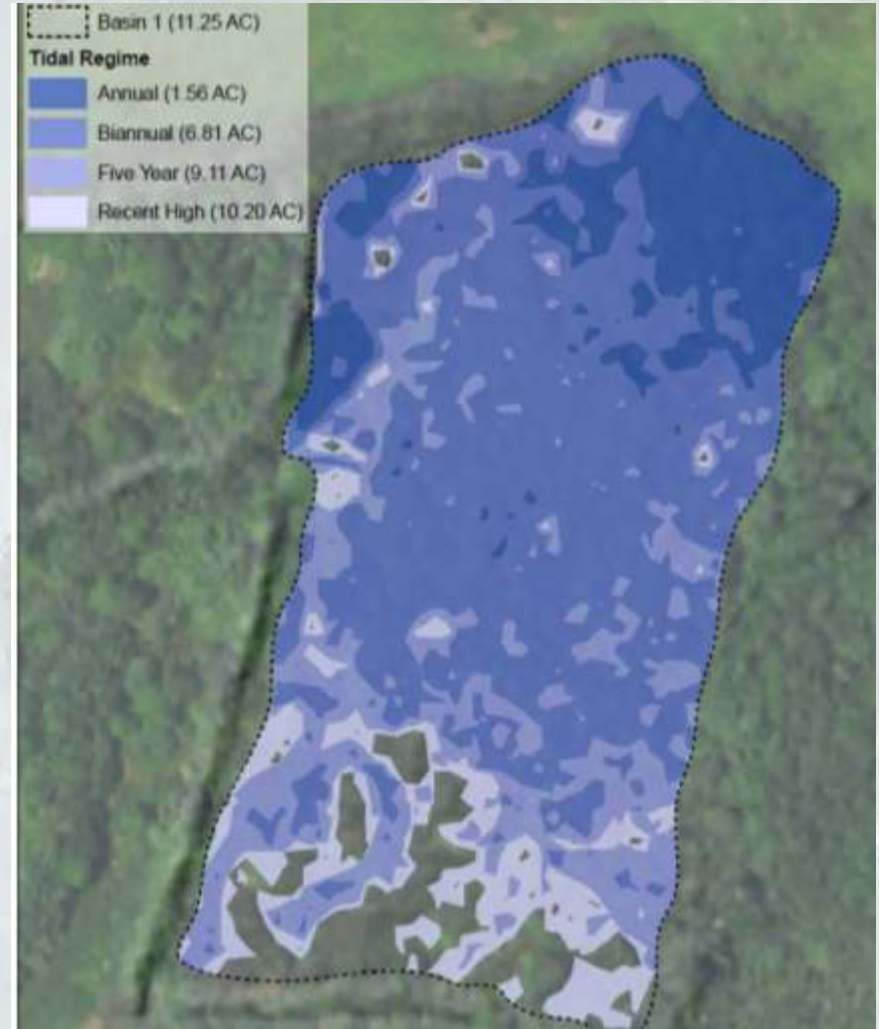
$$Q_{max} = \frac{\pi Vol}{t}$$

where:

Q_{max}	=	Maximum discharge during a tidal cycle (cfs)
π	=	Constant, 3.1416
Vol	=	Volume of tidal prism (inundated volume) (ft ³)
t	=	Time between successive high tides (sec.)



Basin delineation & hypsometry



Initial hydraulic results

Water Level / Datum	Elev. (Feet NAVD88)	Wetland Area (AC)	Wetland Vol. (AF)	Max Theor. Flow (CFS)	Max Theor. Vel. (FT/S)	Actual Vel. (FT/S)
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Basin 1

No. Channels to Basin: 2

Recent Highest Tide	12.4	10.2	14.0	22.2	11.1	5.6
5-yr Water Level	11.9	9.1	9.2	14.6	7.3	3.7
Biennial High Tide	11.3	6.8	4.2	6.7	3.3	1.7
Annual High Tide				4	0.7	0.4
MHHW				0	0.0	0.0

Basin 2

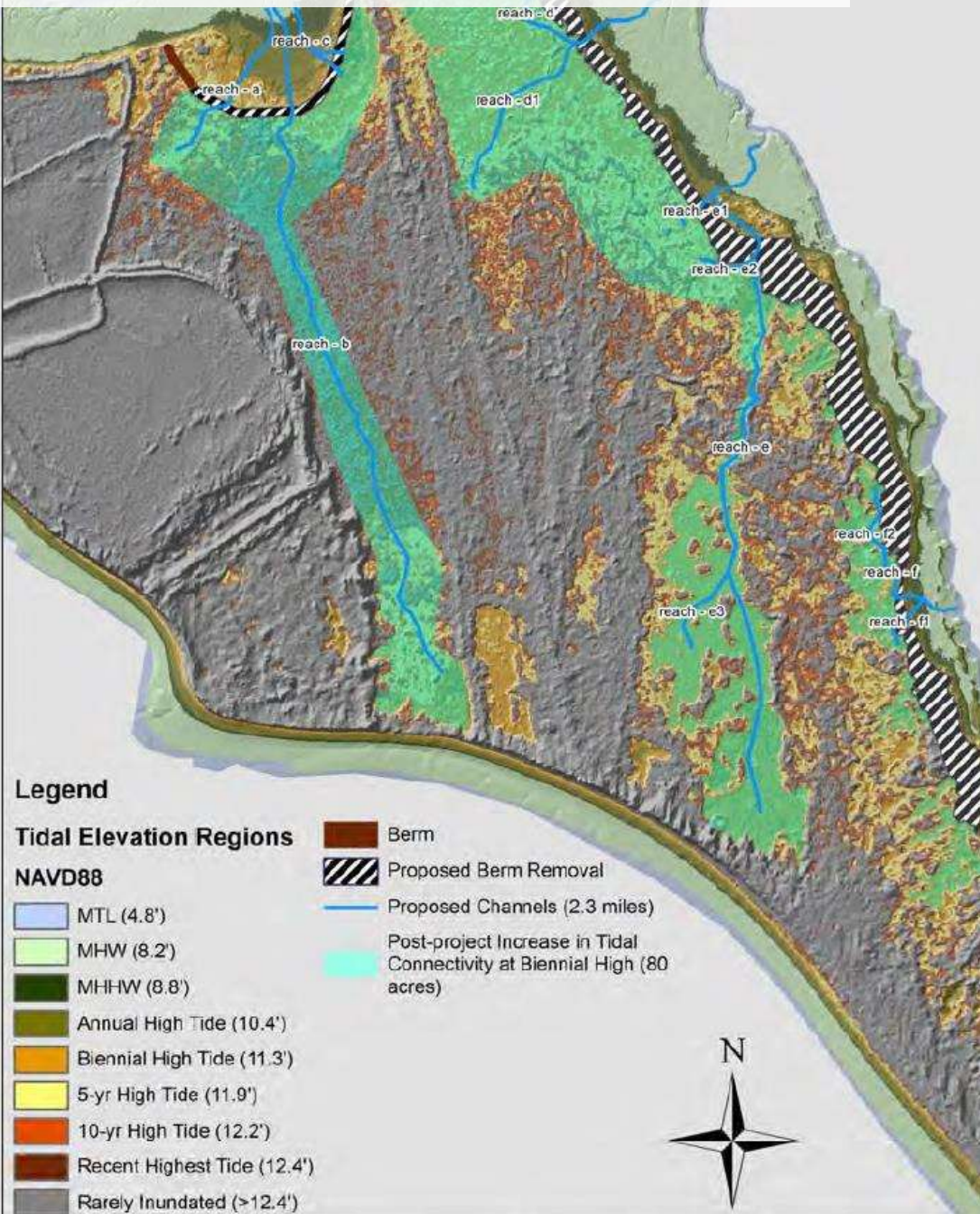
No. Channels to Basin:

Recent Highest Tide				5	26.2	13.1
5-yr Water Level				7	17.4	8.7
Biennial High Tide				5	8.7	4.4
Annual High Tide				5	2.2	1.1
MHHW	8.8	0.36	0.12	0.2	0.1	0.0

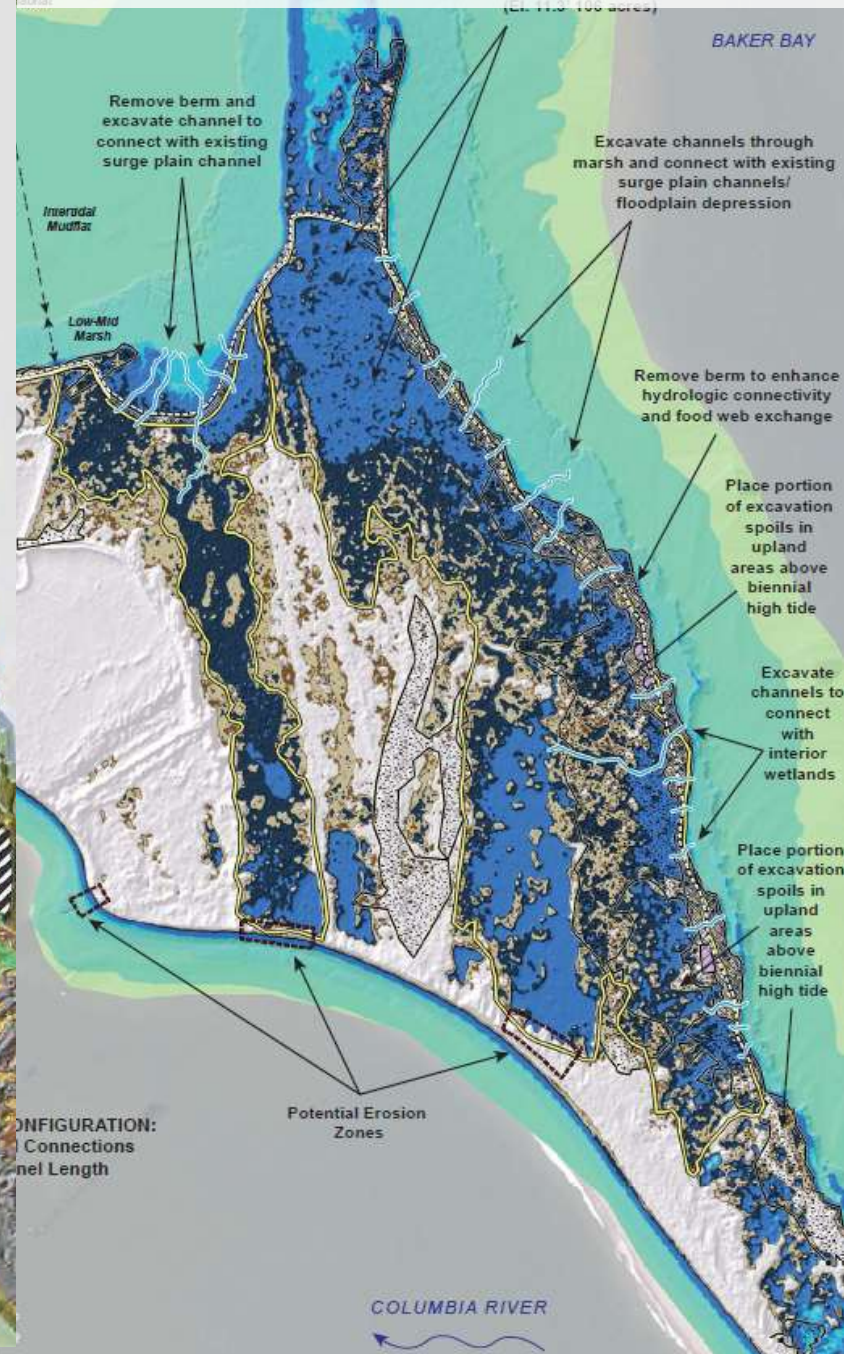
Apparent
inconsistency in
hydraulic regime –
maybe reviewers
were right



Initial conceptual design



Revised conceptual design



Revised hydraulic results

Water Level / Datum	Elev. (Feet NAVD88)	Wetland Area (AC)	Wetland Vol. (AF)	Max Theor. Flow (CFS)	Max Theor. Vel. (FT/S)	Actual Vel. (FT/S)
Basin 1						
<i>No. Channels to Basin:</i>	2					
Recent Highest Tide	12.4	10.2	14.0	22.2	3.7	1.9
5-yr Water Level	11.9	9.1	9.2	14.6	2.4	1.2
Biennial High Tide	11.3	6.8	4.2	6.7	1.1	0.6
Annual High Tide	10.4	1.6	0.9	1.4	0.2	0.1
MHHW					0.0	0.0
Basin 2						
<i>No. Channels to Basin:</i>						
Recent Highest Tide					5.8	2.9
5-yr Water Level	11.9	21.3	21.9	23.2	3.9	1.9
Biennial High Tide	11.3	13.6	11.0	11.6	1.9	1.0
Annual High Tide	10.4	4.0	2.8	3.0	0.5	0.2
MHHW	8.8	0.36	0.12	0.1	0.0	0.0

Hydraulics consistent w/
field observations



Findings and recommendations

- Common tools/approaches are usually necessary but not necessarily sufficient
- LiDAR and historical depictions may not tell the story well enough
- Technical staff lead ground survey & observations
- Incorporate remote sensing/survey technology

Findings and recommendations

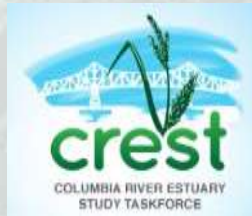
- Incorporate higher resolution data – UAV, ground survey



Findings and recommendations

- Moderate design modifications → significant habitat improvements
- Numerous small connections >> few large connections (don't just go big, go small too!)
- In LCRE, the habitat forming processes vary...
...the preceding may or may not apply to your site!

Thank you contributors & partners



Reference slides

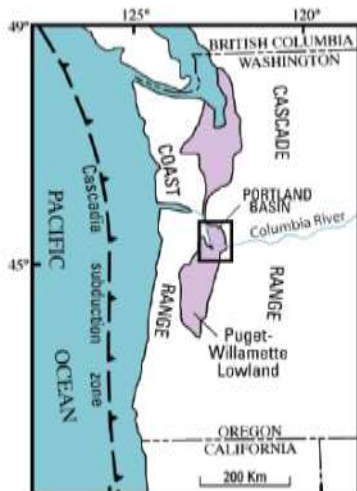


Challenges

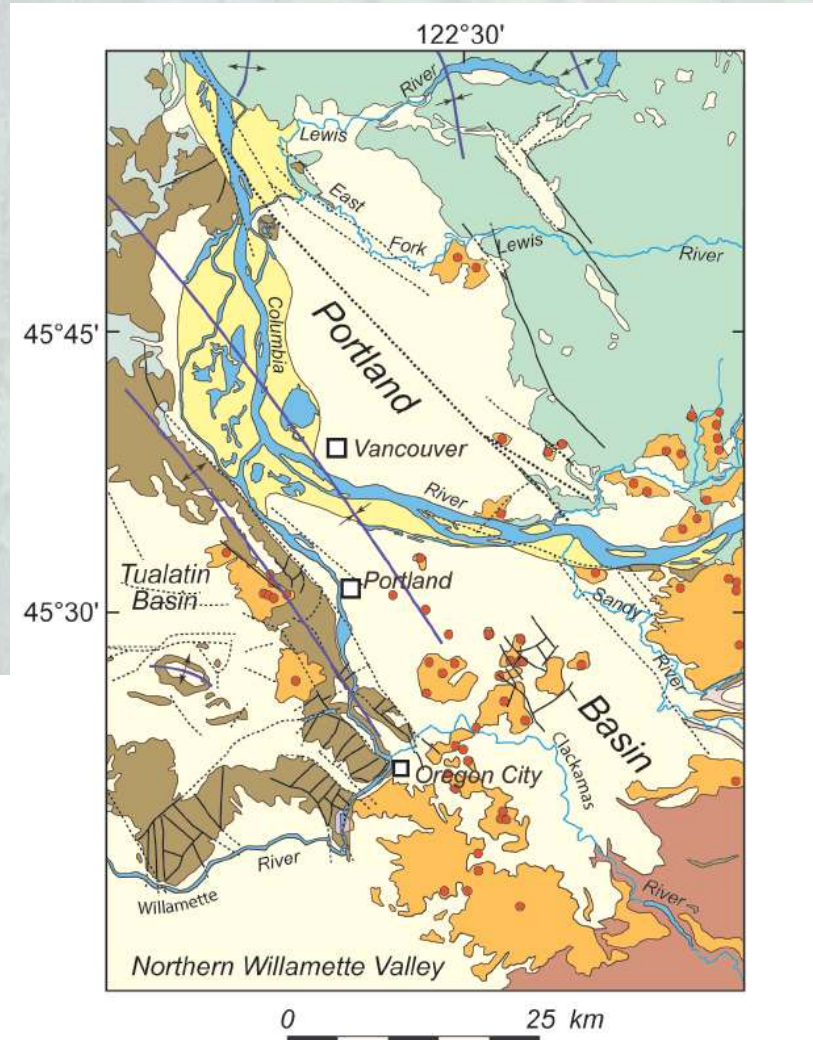
The LCRE middle reach...

...“occupies the globally exceptional situation of a forearc basin bisected by a large continental river – a unique juxtaposition of local and regional geologic processes.”

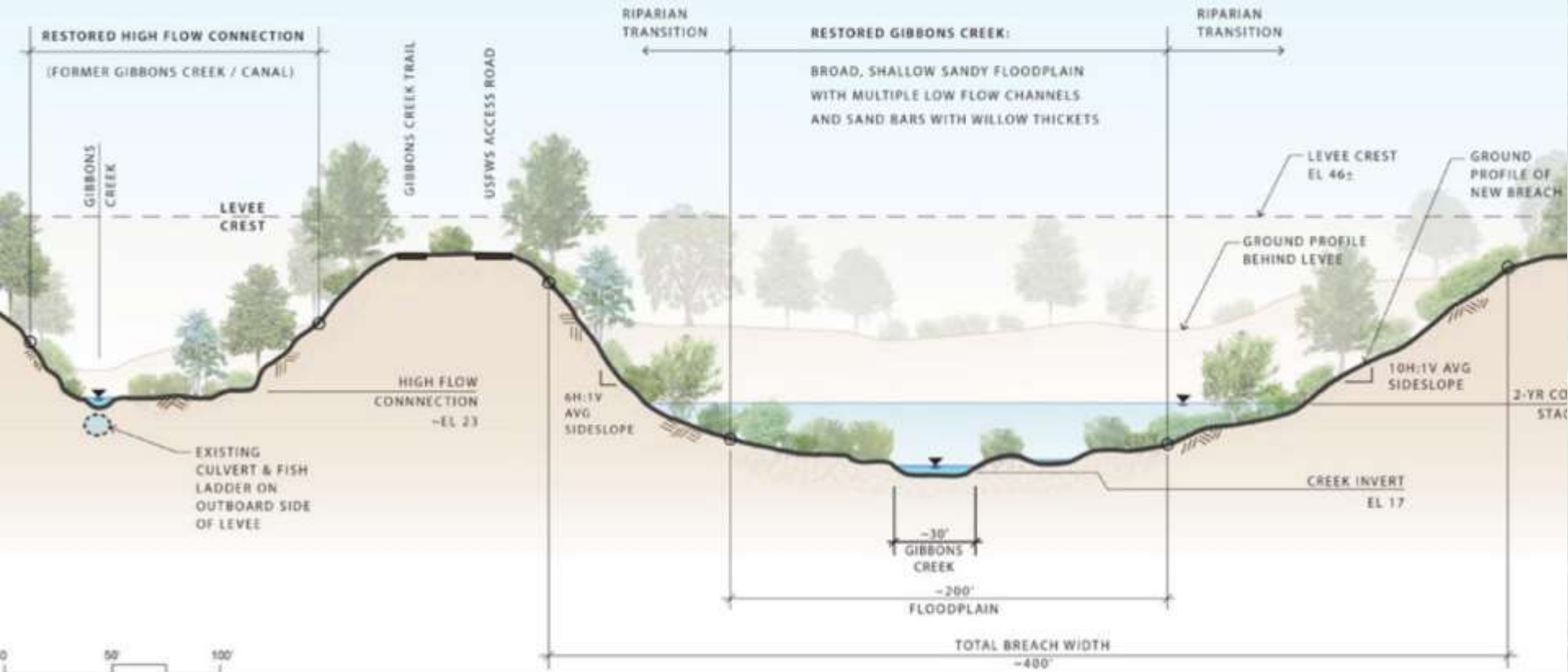
Evarts, O’Conner, Wells, Madin. 2009 GSA Today



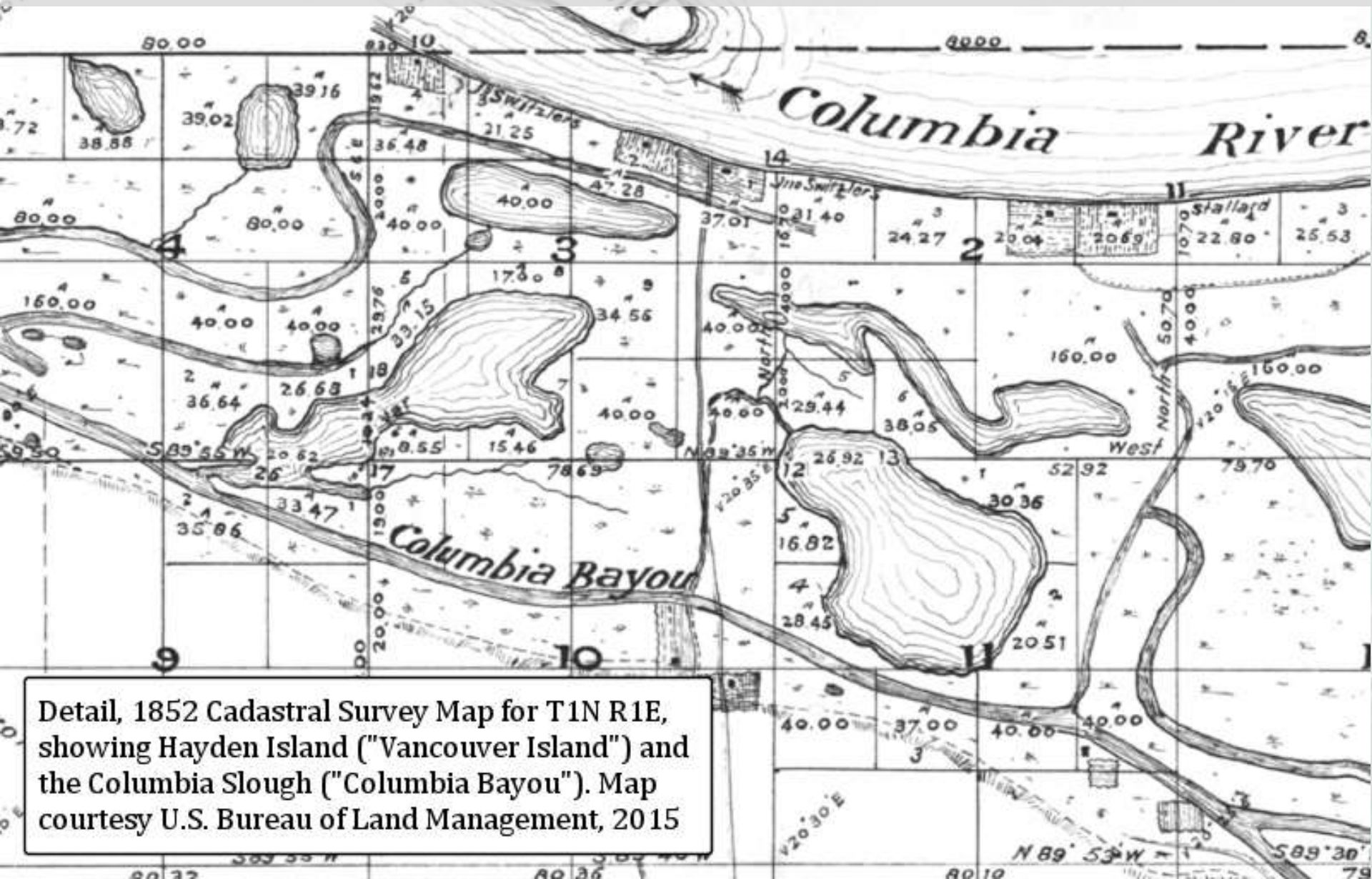
- Holocene sediments
- Miocene–Pleistocene sediments
- Plio-Pleistocene volcanic rocks
- Rhododendron Formation
- Columbia River Basalt Group
- Paleogene volcanic arc rocks
- Paleogene marine sedimentary rock:
- Fault, dotted where concealed
- Anticline
- Syncline
- Plio-Pleistocene volcanic vent



Types of Connections

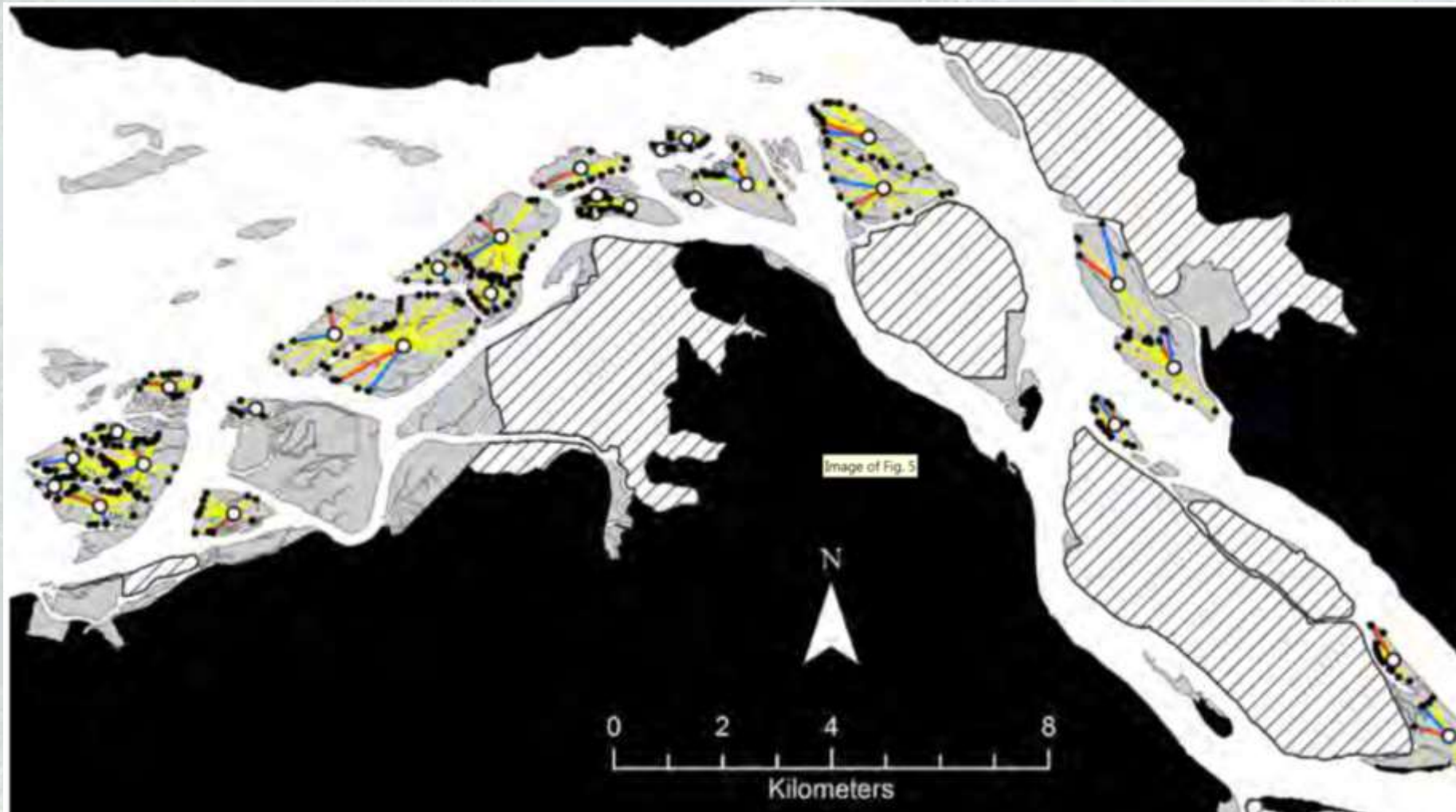


Types of Connections

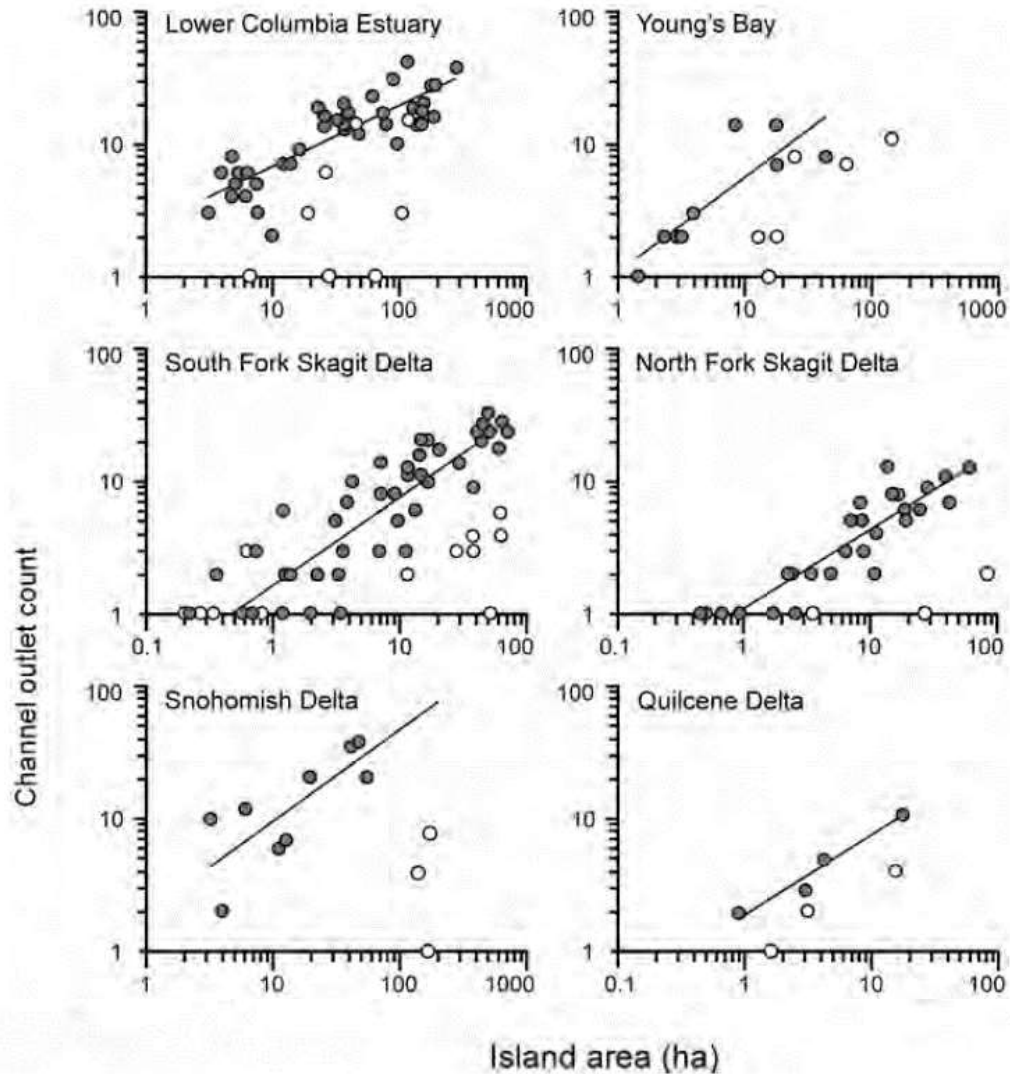


Detail, 1852 Cadastral Survey Map for T1N R1E, showing Hayden Island ("Vancouver Island") and the Columbia Slough ("Columbia Bayou"). Map courtesy U.S. Bureau of Land Management, 2015

Hood, 2015



How to restore?



Late 1800s Marsh Mapping



B
M
S

Re

SUPPORTED CHANNEL
PROPERTY BOUNDARY
ENCAVATION
DITCH
DITCH
DITCH

CHANNELS - SUMMARY TABLE

CHANNEL ID	BOTTOM ELEVATION (FT)	BOTTOM WIDTH (FT)	APPROX TOP WIDTH (FT)
1-1	14-15	6-10	10-24
2-1	14-15	2-8	3-10
3-1	14-15	2-8	3-10

W. QUINN

Geomorphic & feasibility assessment

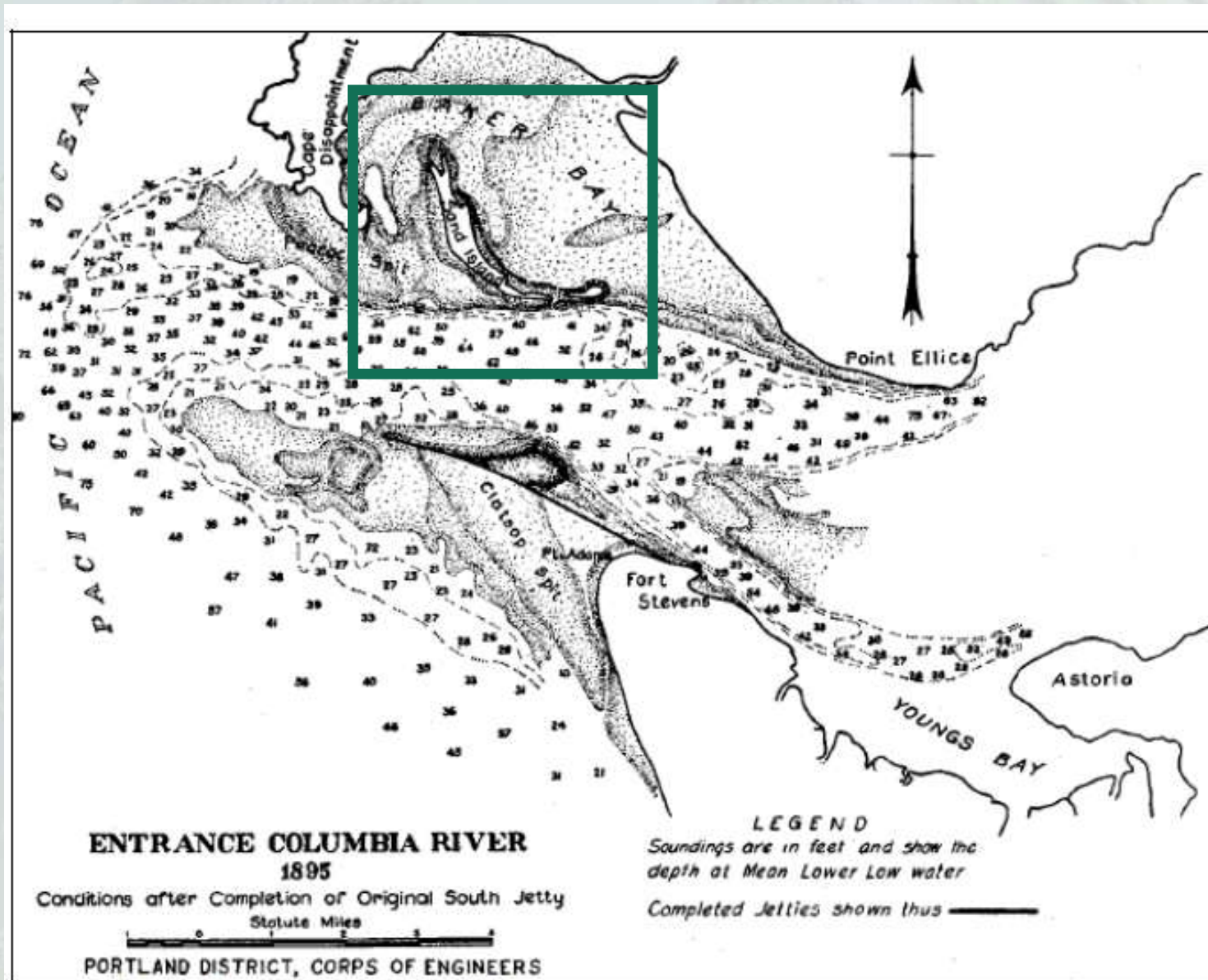
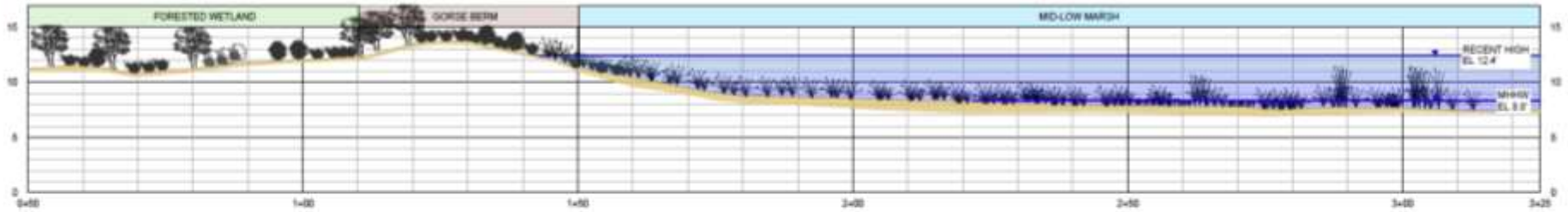
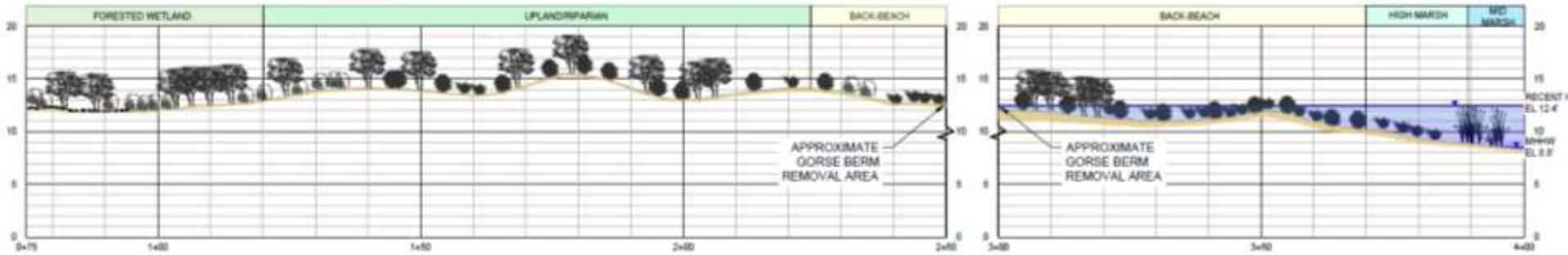


Figure 6. 1895 survey showing the south jetty and adjacent accretion.

Survey results



D SECTION - NORTH BERM



E SECTION - SOUTH BERM