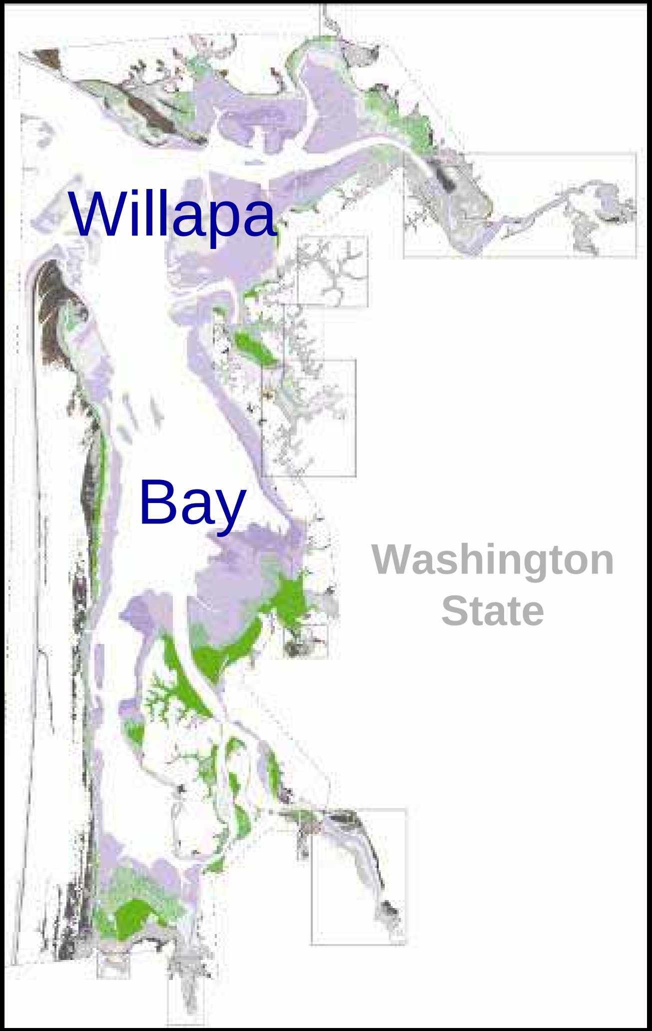
Mapping Predicted Tidal Exposure Durations Using a MLLW-Referenced LiDAR Terrain Model

for Management of *Spartina alterniflora* in Willapa Bay, Washington



Meeting the Challenge:
Invasive Plants in PNW Ecosystems
September 20, 2006

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University of Washington Olympic Natural Resources Center

Making this work possible:

US Fish and Wildlife Service – Willapa National Wildlife Refuge

Willapa Bay-Grays Harbor Oyster Growers Association

Coastal Resources Alliance

Pacific County

Washington State University

Pacific Coast Shellfish Growers Association

University of Washington

Pacific Conservation District

Washington State Department of Natural Resources

Washington State Department of Agriculture

Special Thanks to:

David Finlayson, Robert Norheim, Kim Patten, Charlie Stenvall,

David Gonzales, Jim Assenberg, Mark Scott, Kyle Murphy

Visit the Spartina website from: **www.onrc.washington.edu**

Nearly 1/3 of all viable fish and wildlife tide-flat habitat in Willapa Bay is infested with *Spartina alterniflora*.

The bay supports shellfish and fin fisheries as well as the Willapa National Wildlife Refuge.

At risk: biological diversity, the local economy…

Methods used to control the infestation

Chemical Mechanical Biological








We use GIS for:

Bay-wide planning

Site-specific planning

Communication among stakeholders
And the public

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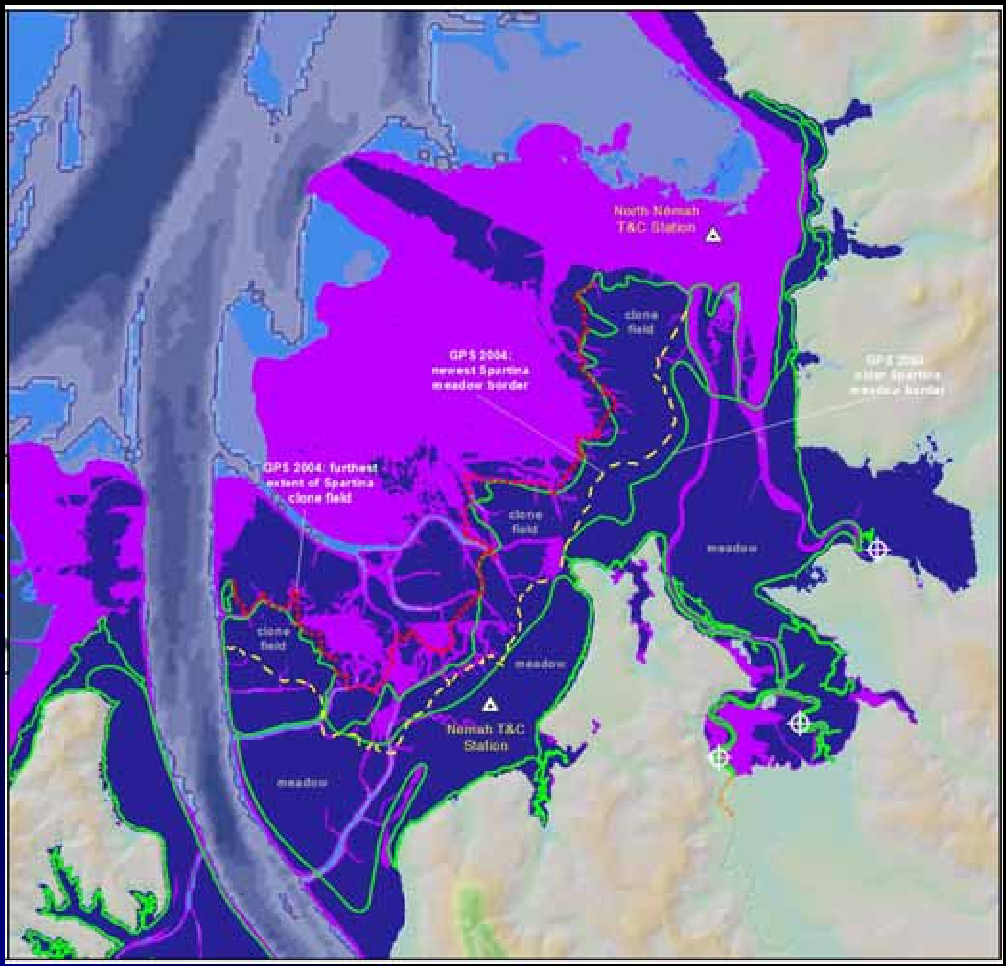
Providing spatially explicit tide prediction maps for chemical applications

Showing when, where and for how long plants will be exposed for treatments

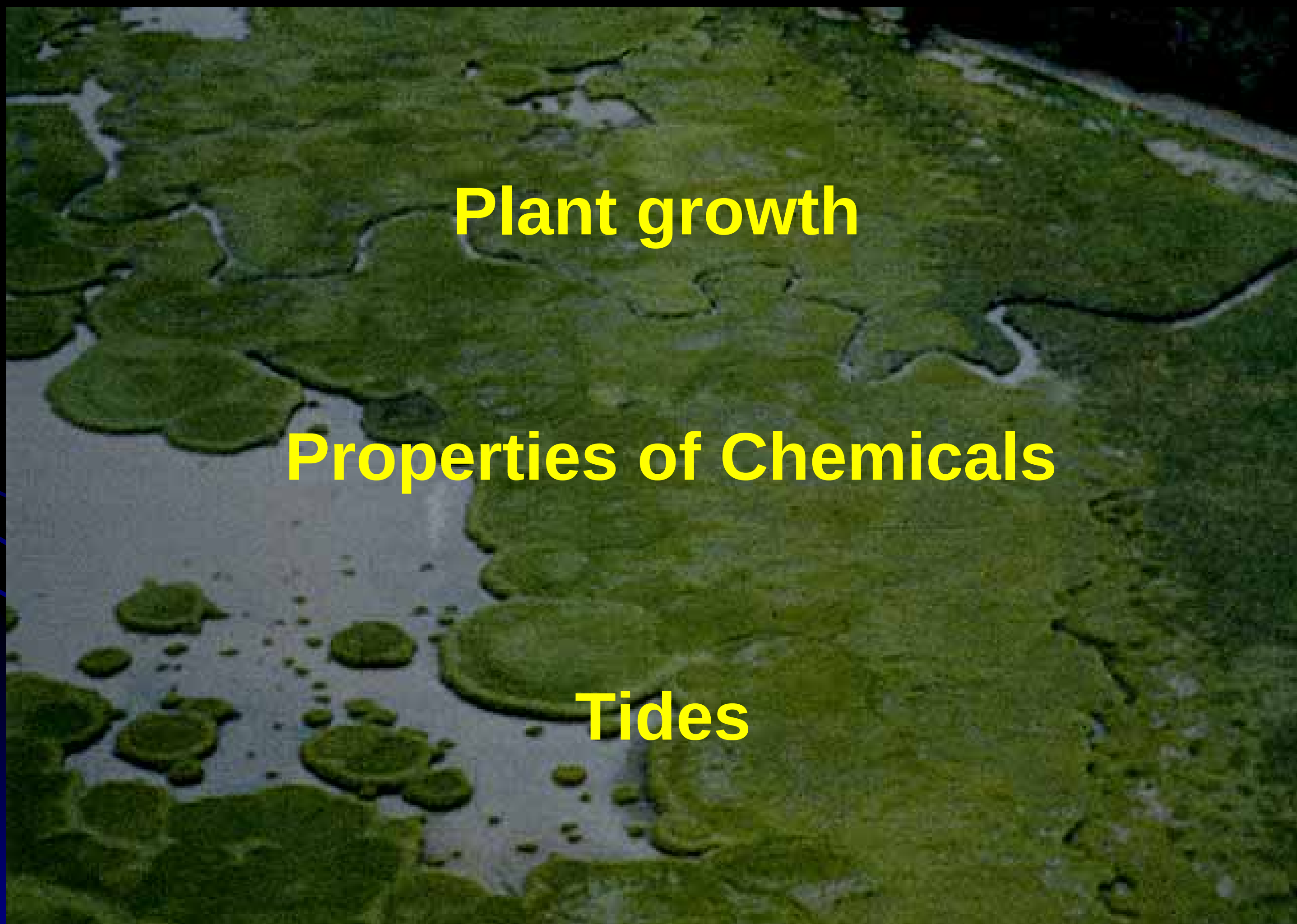


Minimize treatment impact

Optimize treatment efficacy

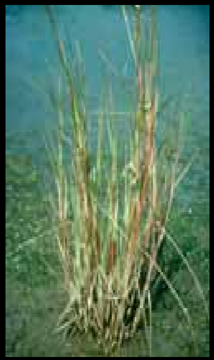
Determining appropriate areas and times for chemical applications

Environmental Factors:



Plant Growth and Chemical Properties

Plant Growth

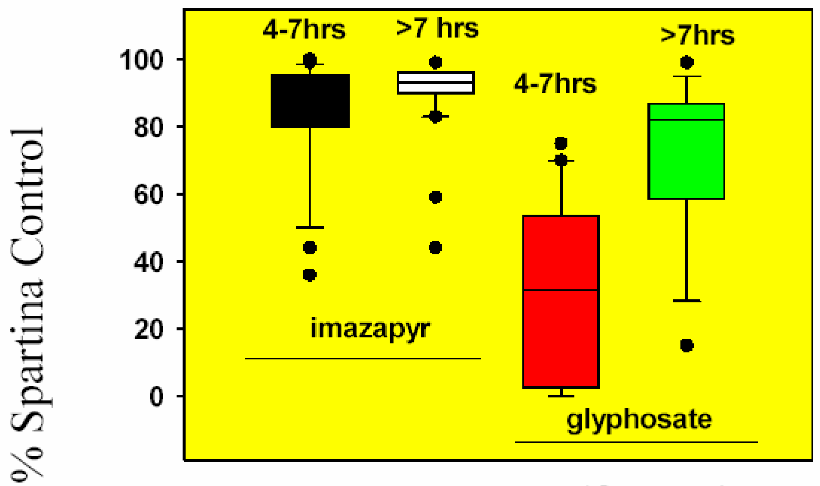


Early season

plants very short, treatment of plant low on tideflats more difficult

Late season

plants much taller, treatment of plants low on tideflats much easier



*Spray volume <200 l/ha

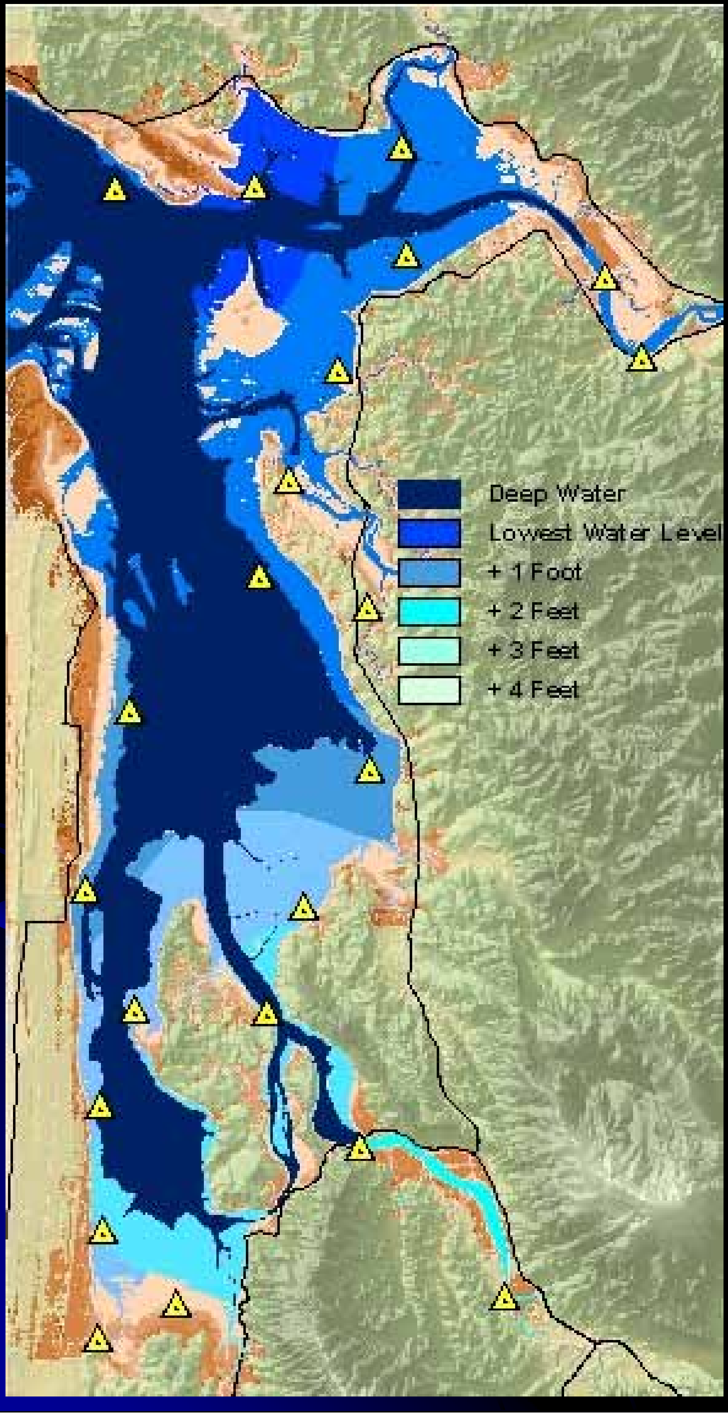
Efficacy comparison for 1.68 kg/ha imazapyr and 8.4 kg/ha glyphosate as a function of dry times*

Research by Dr. Kim Patten, WSU Long Beach

Chemical Properties

Different chemicals need different minimum exposure times

Leaves must be *dry* a certain amount of time to give the herbicide time to affect the plant



The Tides

No fixed patterns

- **Treatable areas change daily**

Tide timing varies across the bay

- **Timing varies by approximately 1 hour depending on distance from the mouth of the bay**

Water levels vary across the bay

- **Levels can vary by more than 3 feet at any given time**
- **Levels become more extreme in channel / sloughs as well as areas farther from the mouth**

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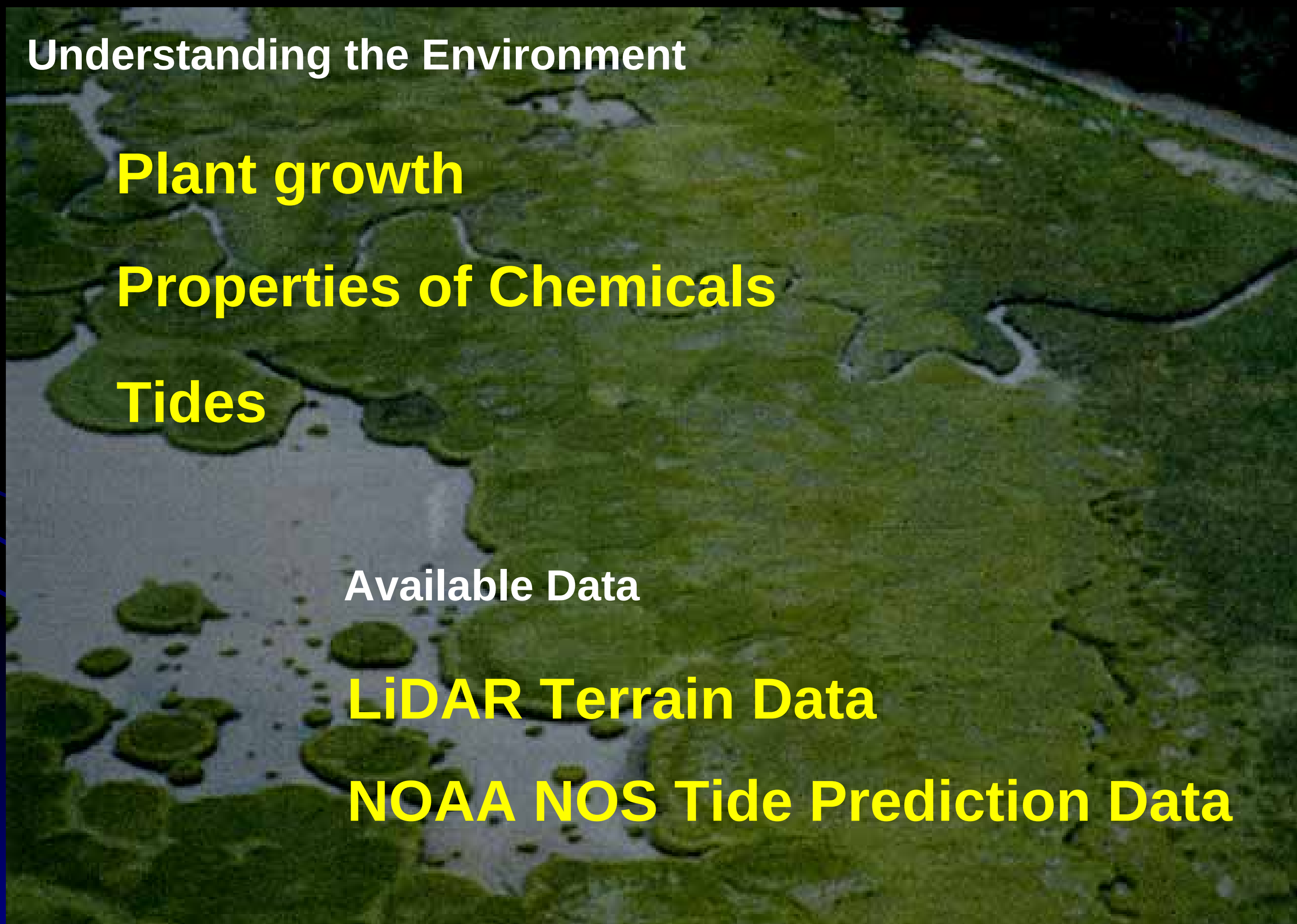
Preparation for Mapping



Understanding the Environment

Plant growth

Properties of Chemicals

Tides

Available Data

LiDAR Terrain Data

NOAA NOS Tide Prediction Data

Using a Common Elevation Reference

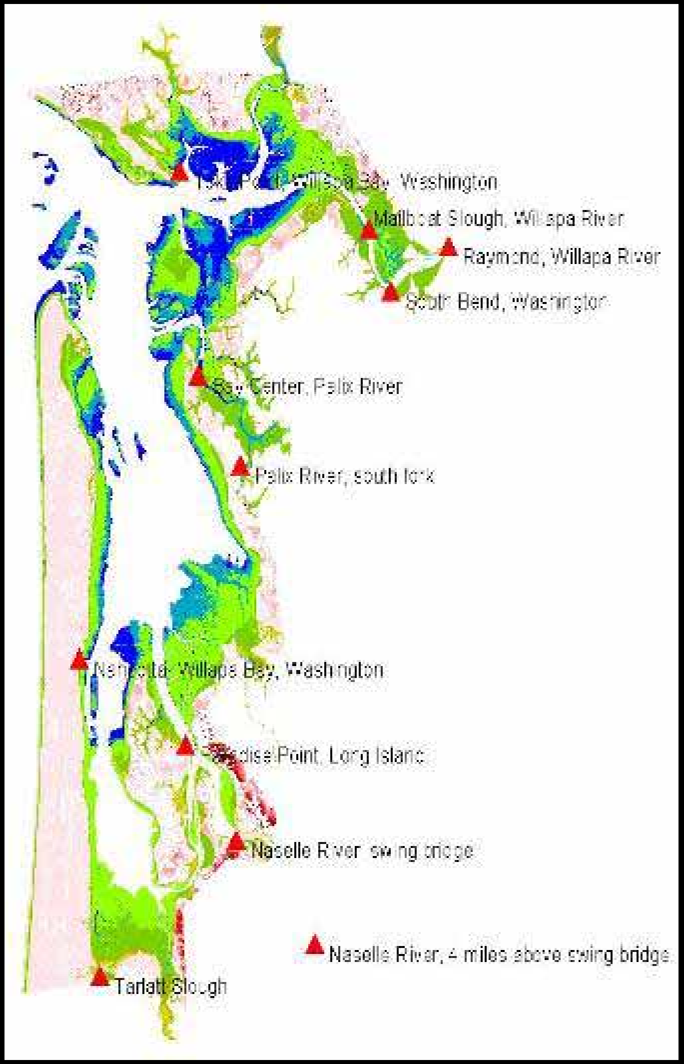
Different terrain data use different elevation datums

- **LiDAR derived terrain model elevation datum is NAVD88**
- **NOAA NOS Tide Prediction stations datum is MLLW (Mean Lower Lowest Water)**

The Solution

- **Adjust terrain model elevations to MLLW to match the tide prediction data**

We can then "flood" the terrain model using "water" whose surface is interpolated from NOAA NOS tide prediction stations.



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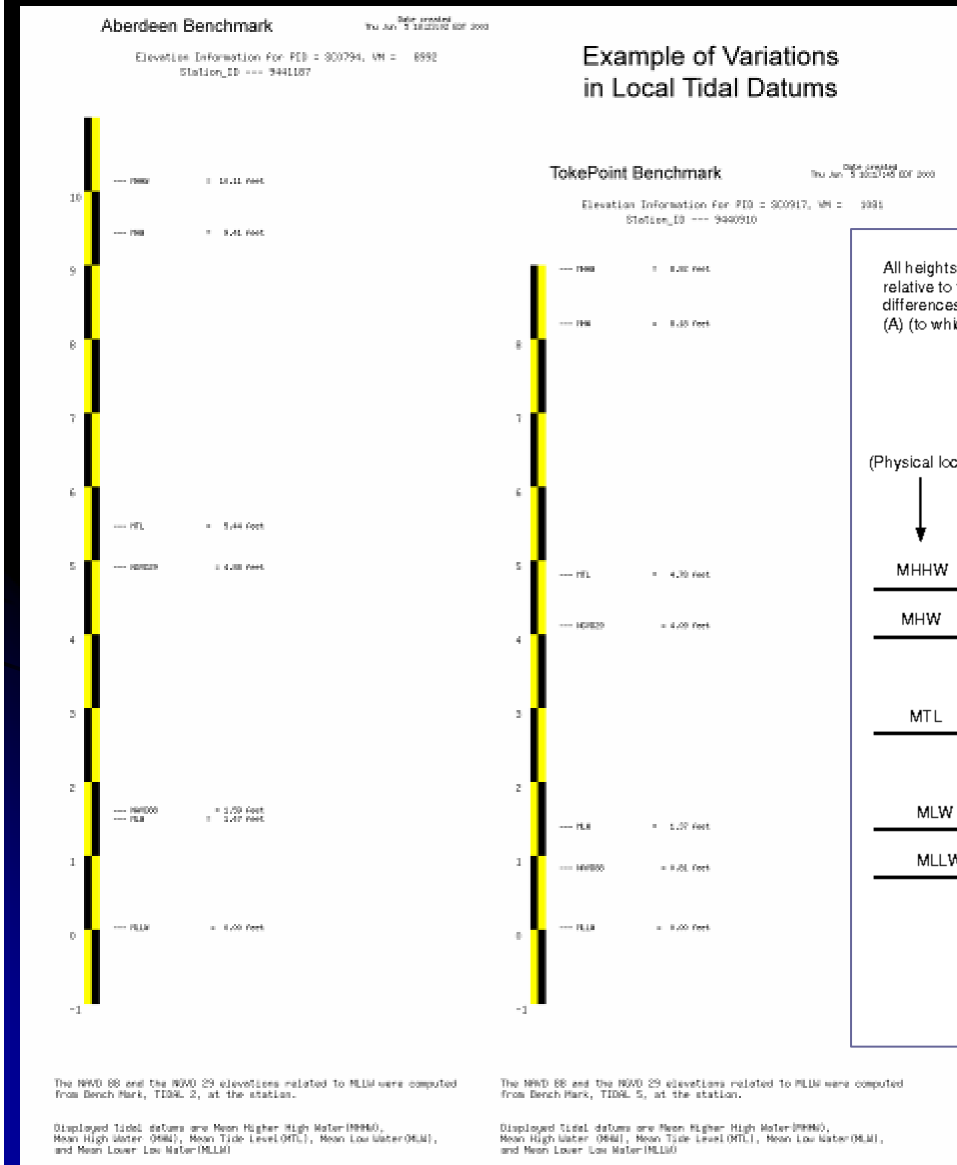
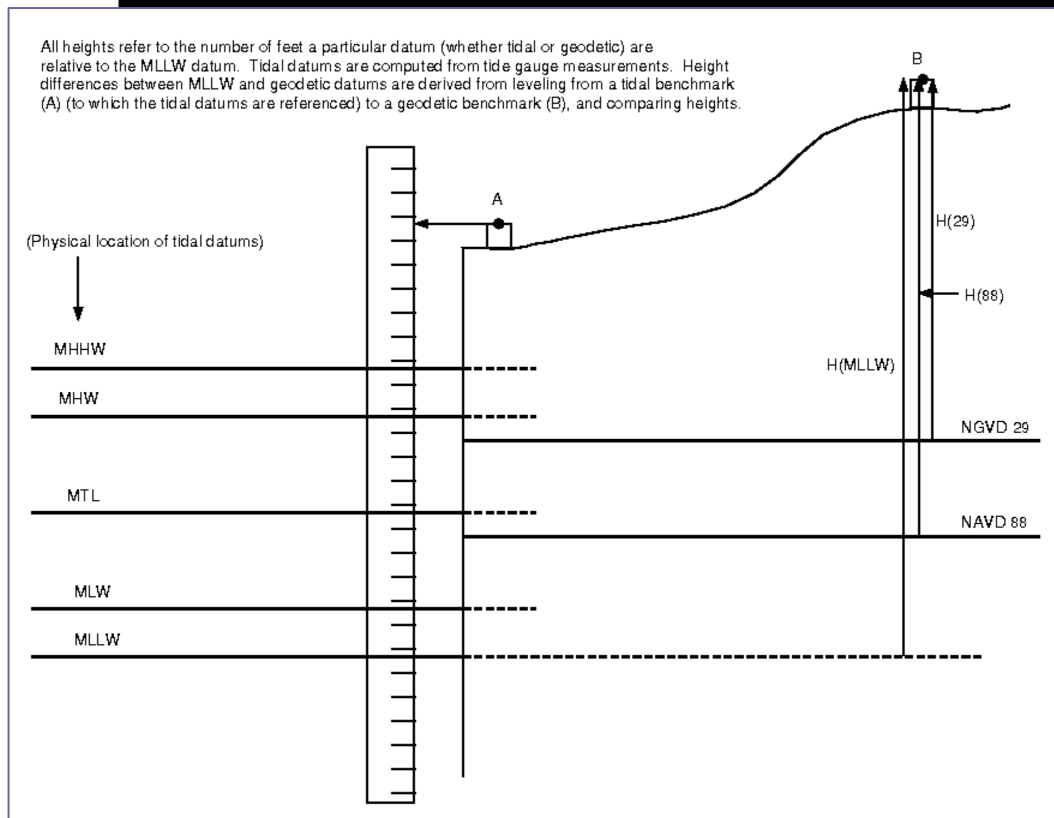
Referencing the Terrain Data

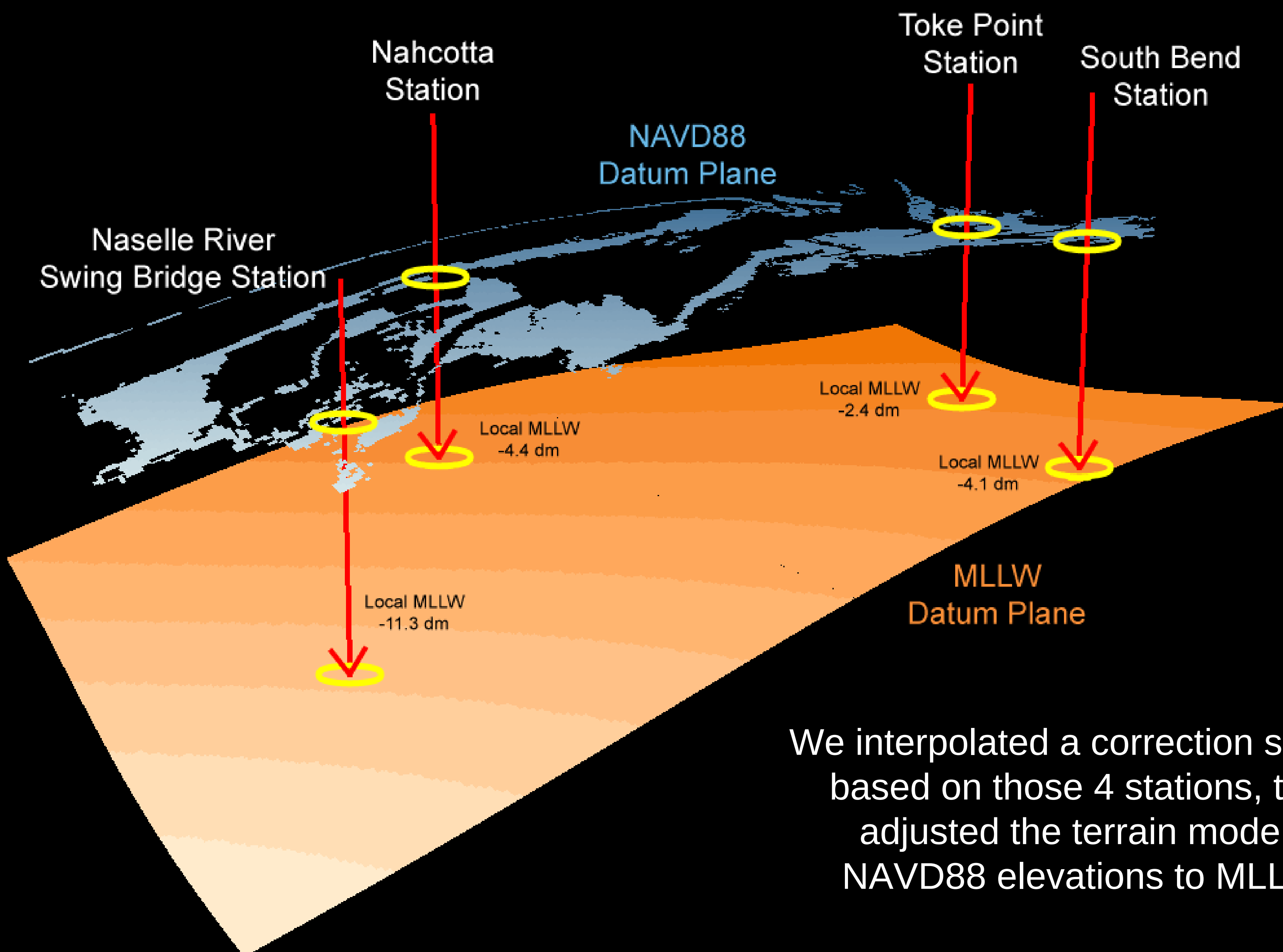
Tide Datums vary from location to location



Only 4 stations in Willapa Bay have NAVD88 elevations relative local MLLW datum (NOS/NGS Leveling Data Points)



Referencing the Base Terrain Data



We interpolated a correction surface based on those 4 stations, then adjusted the terrain model's NAVD88 elevations to MLLW.

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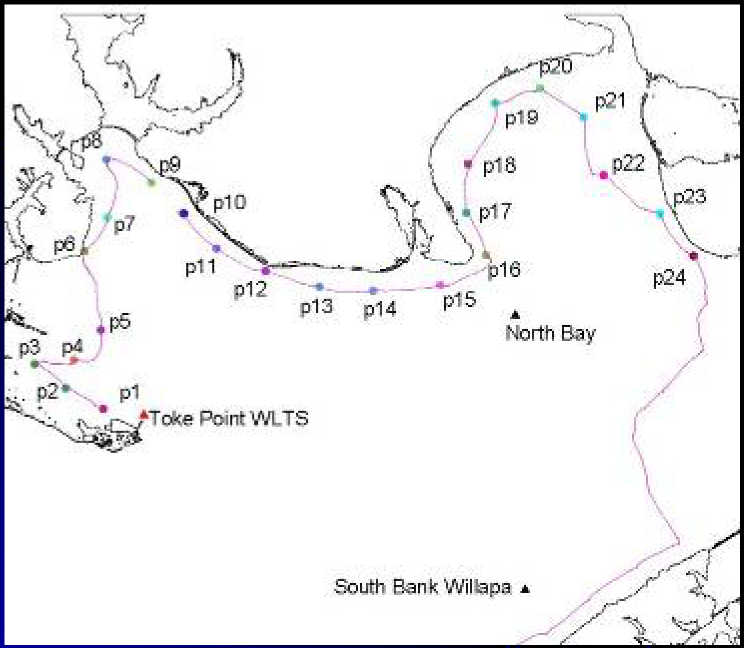
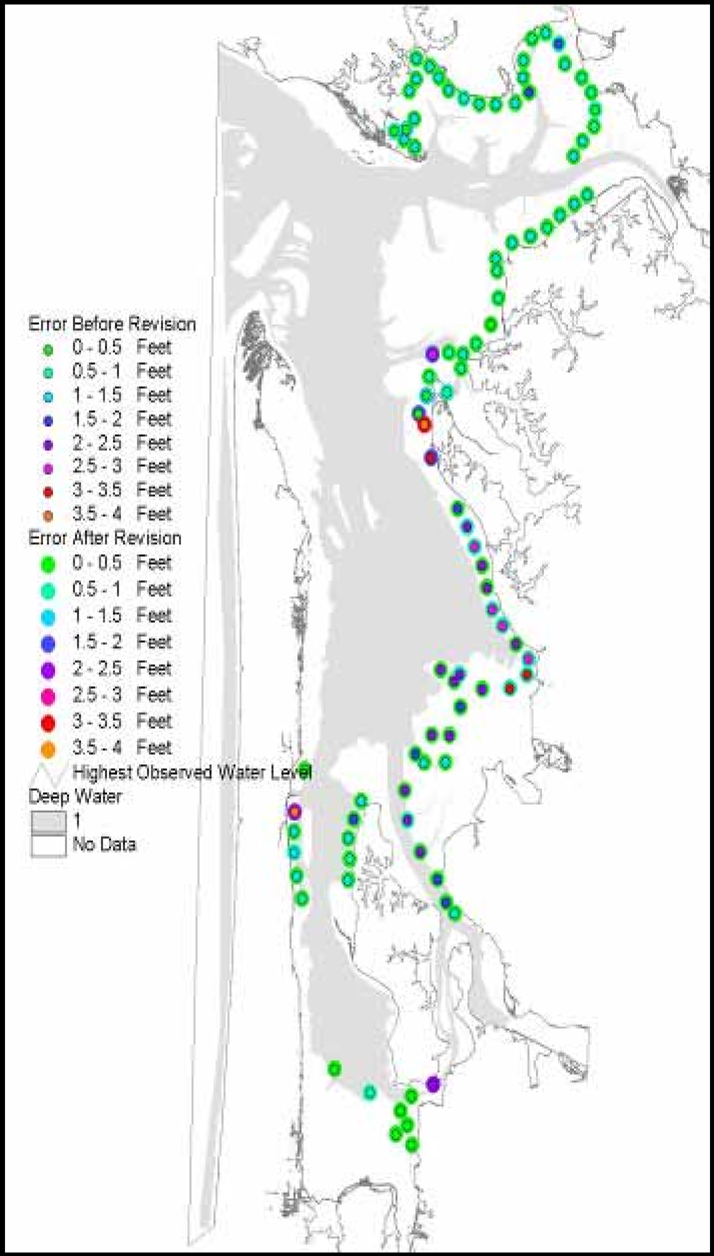
Validating the MLLW-Referenced Terrain Model

1. Capture a water line with a time and location at each point using GPS

Each point on the water line is a point where the water's surface intersects the terrain.





2. Compare the terrain model at each location with a surface representing the tide at each time. Any difference is an error.

3. We assign this error value to each GPS point, then interpolate an 'error surface' and adjust the terrain model.

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Validating the MLLW-Referenced Terrain Model

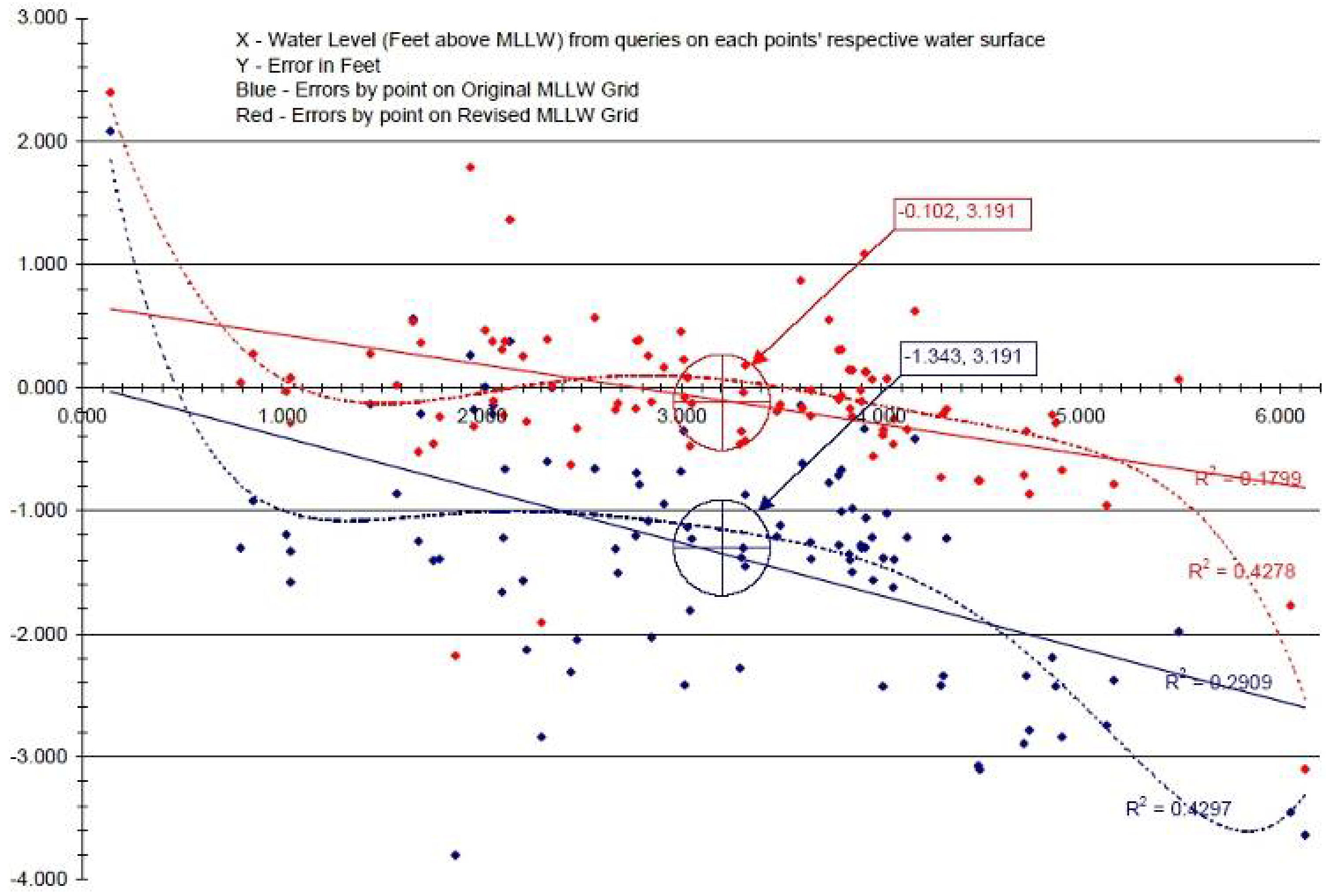


Figure 9. Error clouds before (blue) and after (red) corrections

The 6th order regression curves and linear regressions were done using Excel, the software used for creating these xy scatter plots. They x axis is the water level at each point, obtained by querying that point's water "snapshot" and remains the same for both error clouds. The y-axis is the difference between that water level and the respective terrain models.

Gathering Tide Prediction Data

* **Data on the Cheap**

We needed high temporal resolution prediction data for as many locations as we could get. We evaluated different free and for-purchase software packages. Of all the tide prediction programs offered, we found Nobeltec's Tides & Currents (T&C) software to be most consistent with NOAA's tide predictions.

* **Tide Station Updates**

Last year, NOAA updated to the 1983-2001 tidal Epoch from the 1960-1978 Epoch used in previous years. Not all stations were updated. In addition, they dropped 1 of 12 stations that provides hourly tide predictions. As of April 1, their new web page is http://www.tidesandcurrents.noaa.gov

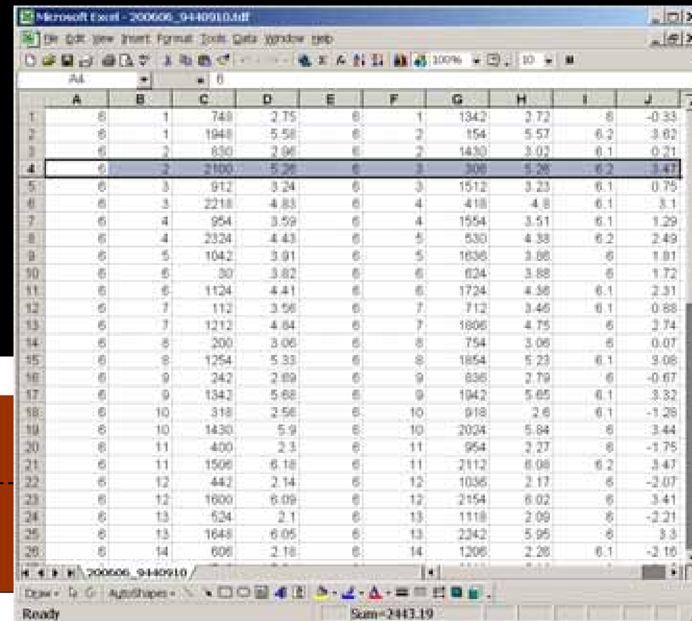
* **Whose Data Is Best?**

To save time and money, we adapted NOAA CO-OPS data as the "gold standard" for six-minute and hourly prediction data. Here is a short description of the data we work with:

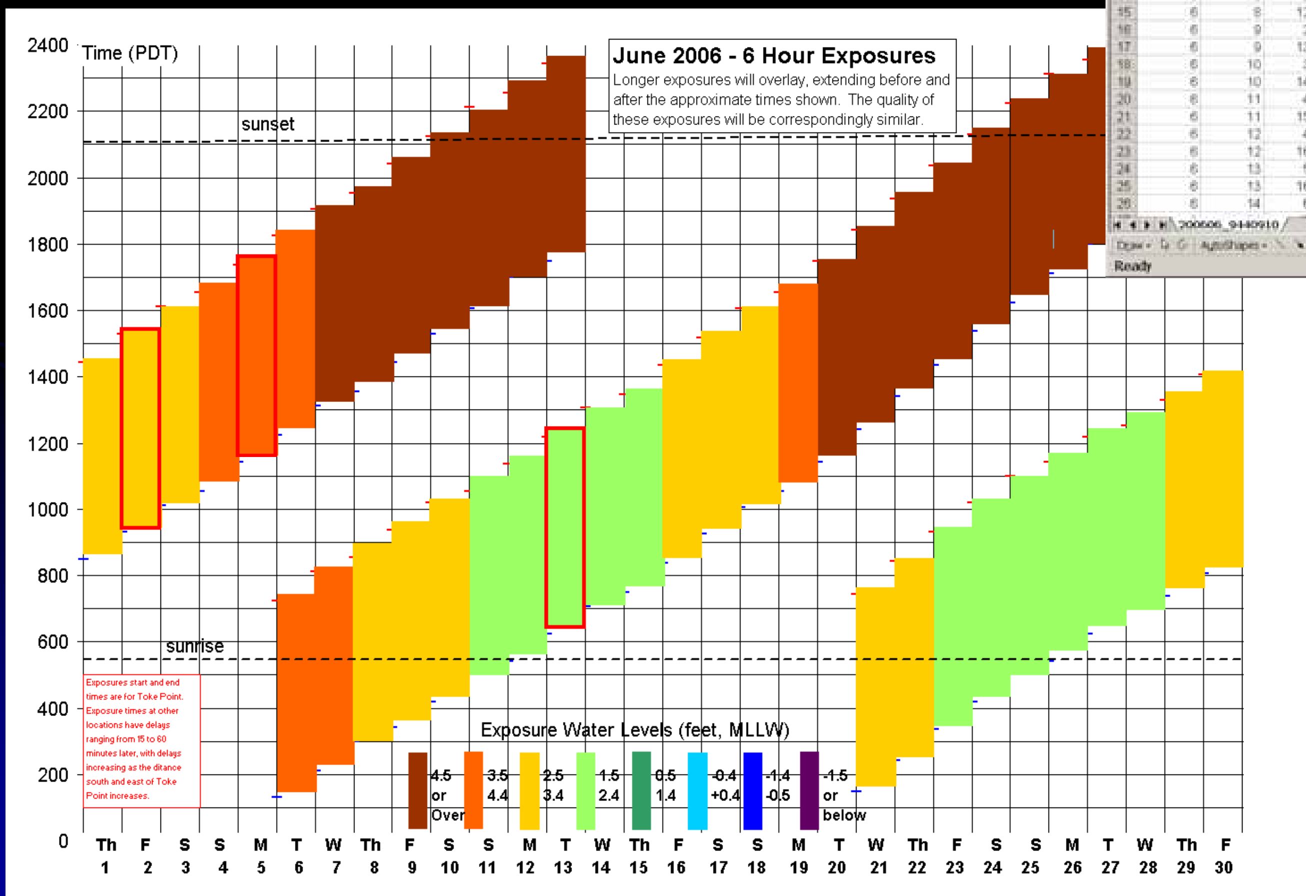
Type	Availability	Number of Stations
Six-minute	On-the-fly	3
Hourly	Published Tables	11
Parameters	Published Tables	11

Generating Monthly Overview Charts

Our program downloads, assembles, and generates tabular compilations used to generate monthly charts in Microsoft Excel

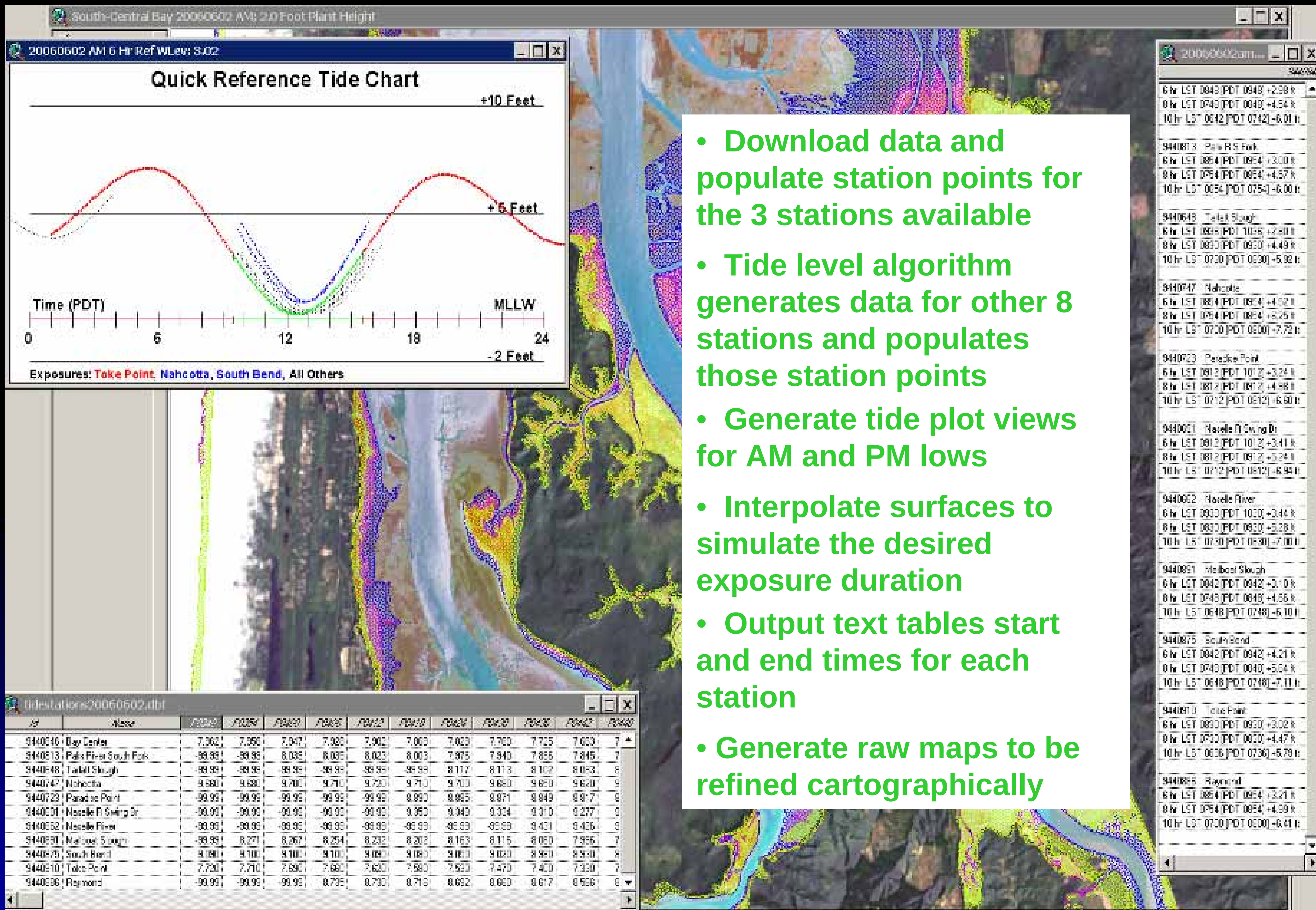


	A	B	C	D	E	F	G	H	I	J
1	6	1	748	2.75	6	1	1342	2.72	6	-0.33
2	6	1	1948	5.58	6	2	154	5.57	6.2	3.62
3	6	2	830	2.96	6	2	1430	3.02	6.1	0.21
4	6	2	2100	5.28	6	3	308	5.28	6.2	3.47
5	6	3	912	3.24	6	3	1512	3.23	6.1	0.75
6	6	3	2218	4.83	6	4	418	4.8	6.1	3.1
7	6	4	954	3.59	6	4	1554	3.51	6.1	1.29
8	6	4	2324	4.43	6	5	530	4.38	6.2	2.49
9	6	5	1042	3.91	6	5	1636	3.88	6	1.81
10	6	6	30	3.82	6	6	624	3.88	6	1.72
11	6	6	1124	4.41	6	6	1724	4.38	6.1	2.31
12	6	7	112	3.56	6	7	712	3.46	6.1	0.88
13	6	7	1212	4.84	6	7	1806	4.75	6	2.74
14	6	8	200	3.06	6	8	754	3.06	6	0.07
15	6	8	1254	5.33	6	8	1854	5.23	6.1	3.08
16	6	9	242	2.89	6	9	836	2.79	6	-0.67
17	6	9	1342	5.68	6	9	1942	5.65	6.1	3.32
18	6	10	318	2.56	6	10	918	2.6	6.1	-1.28
19	6	10	1430	5.9	6	10	2024	5.84	6	3.44
20	6	11	400	2.3	6	11	954	2.27	6	-1.75
21	6	11	1506	6.18	6	11	2112	6.08	6.2	3.47
22	6	12	442	2.14	6	12	1036	2.17	6	-2.07
23	6	12	1600	6.09	6	12	2154	6.02	6	3.41
24	6	13	524	2.1	6	13	1118	2.09	6	-2.21
25	6	13	1648	6.05	6	13	2242	5.95	6	3.3
26	6	14	606	2.18	6	14	1206	2.26	6.1	-2.16



Managers can use the charts to determine ideal windows of treatment and begin scheduling

Integrating and processing the data for the maps

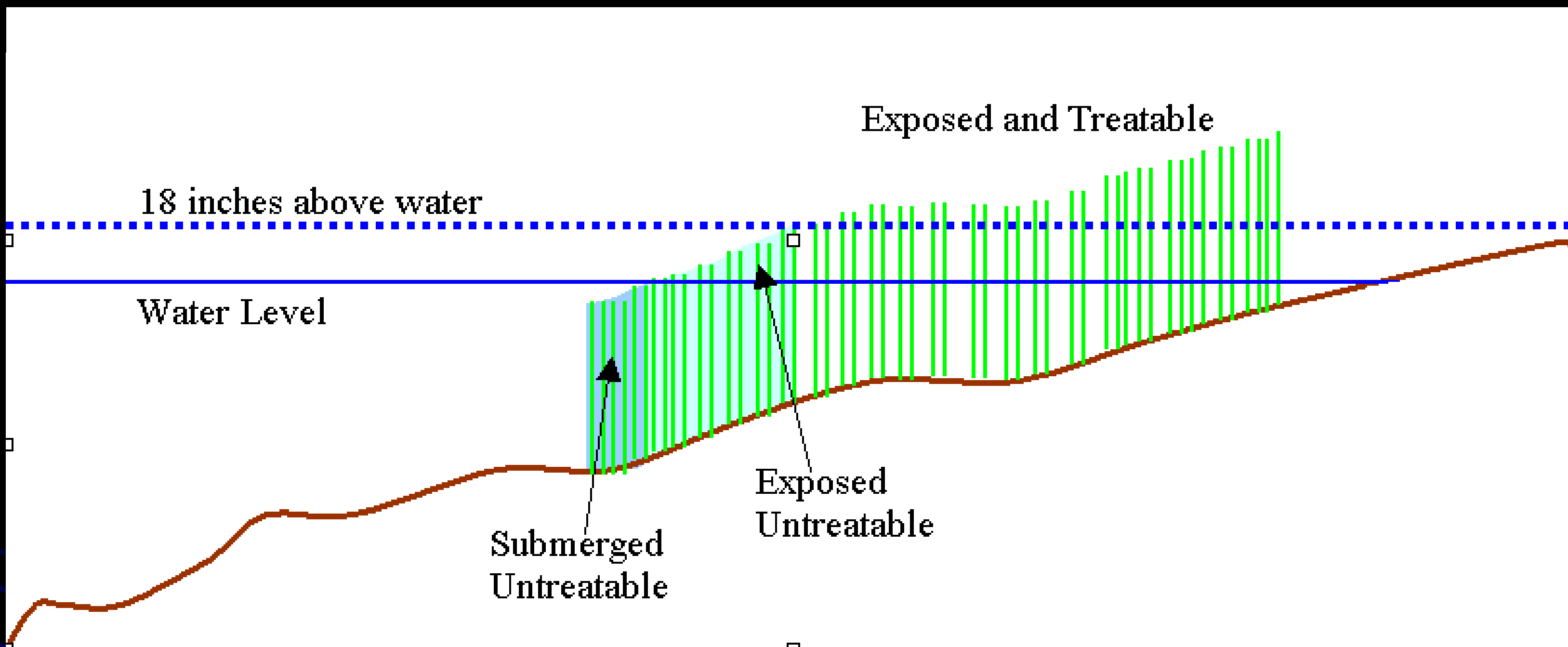


- Download data and populate station points for the 3 stations available
- Tide level algorithm generates data for other 8 stations and populates those station points
- Generate tide plot views for AM and PM lows
- Interpolate surfaces to simulate the desired exposure duration
- Output text tables start and end times for each station
- Generate raw maps to be refined cartographically

How it works!

1. Start with the MLLW referenced LiDAR terrain model

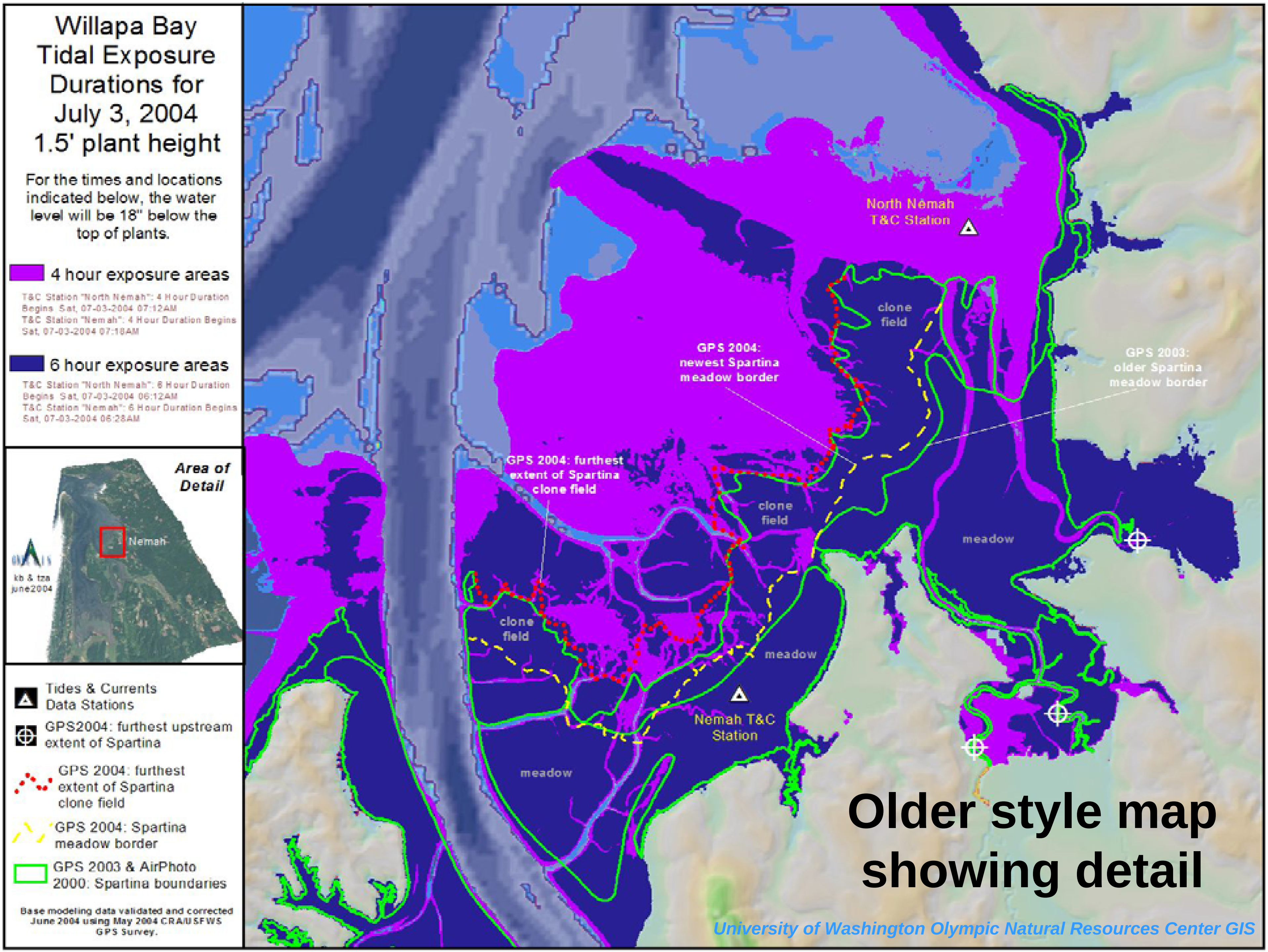
2. A Spartina stem height grid is overlaid onto the terrain model



3. "Flood" the terrain model with the interpolated water surface

Anything 18" above the water surface is exposed and treatable for the desired duration.

Tidal Exposure Duration Maps: The Final Product


Willapa Bay
Tidal Exposure
Durations for
July 3, 2004
1.5' plant height
For the times and locations indicated below, the water level will be 18" below the top of plants.
4 hour exposure areas
T&C Station "North Nemah": 4 Hour Duration Begins Sat, 07-03-2004 07:12AM
T&C Station "Nemah": 4 Hour Duration Begins Sat, 07-03-2004 07:18AM
6 hour exposure areas
T&C Station "North Nemah": 6 Hour Duration Begins Sat, 07-03-2004 06:12AM
T&C Station "Nemah": 6 Hour Duration Begins Sat, 07-03-2004 06:28AM
Area of Detail
Nemah
kb & tza
june2004
Tides & Currents Data Stations
GPS2004: furthest upstream extent of Spartina
GPS 2004: furthest extent of Spartina clone field
GPS 2004: Spartina meadow border
GPS 2003 & AirPhoto 2000: Spartina boundaries
Base modeling data validated and corrected June 2004 using May 2004 CRA/USFWS GPS Survey.
North Nemah
T&C Station
GPS 2004:
newest Spartina
meadow border
clone
field
GPS 2003:
older Spartina
meadow border
GPS 2004: furthest
extent of Spartina
clone field
clone
field
meadow
clone
field
meadow
Nemah T&C
Station
meadow
Older style map
showing detail
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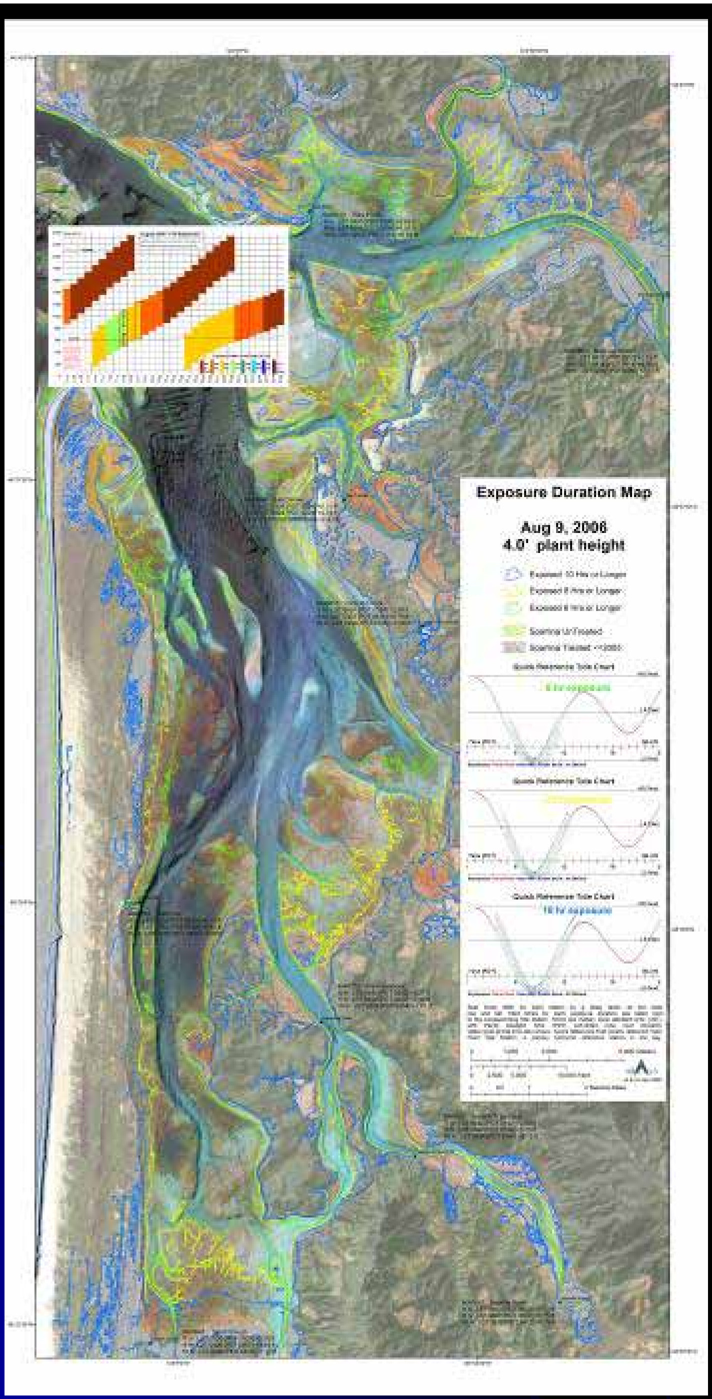

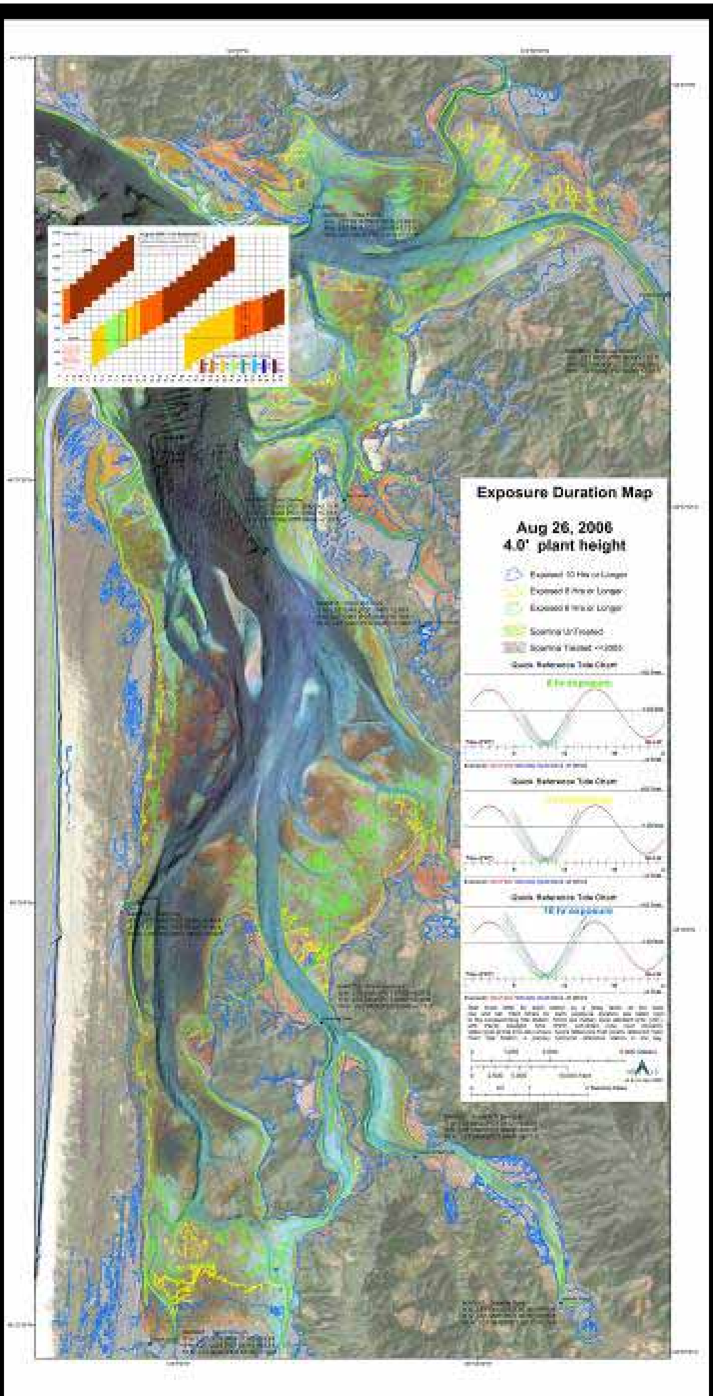

2006 maps

full bay view