

# **A Strawman Proposal to Address Hydrodynamic and Sediment Transport Issues Related to SFO Runway Expansion**

**Ralph T. Cheng**

**U. S. Geological Survey**

**Menlo Park, California**

**Tel: (650) 329-4500; e-mail: [rtcheng@usgs.gov](mailto:rtcheng@usgs.gov)**

**Water Resources Group**

**ASCE-SF**

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# Strawman's Proposal to Hydrodynamics and Sediment Transport Issues of SFO Runway Expansion

## **Introduction:**

### **SFO Runways Expansion:**

#### **Historical and Philosophical Perspectives**

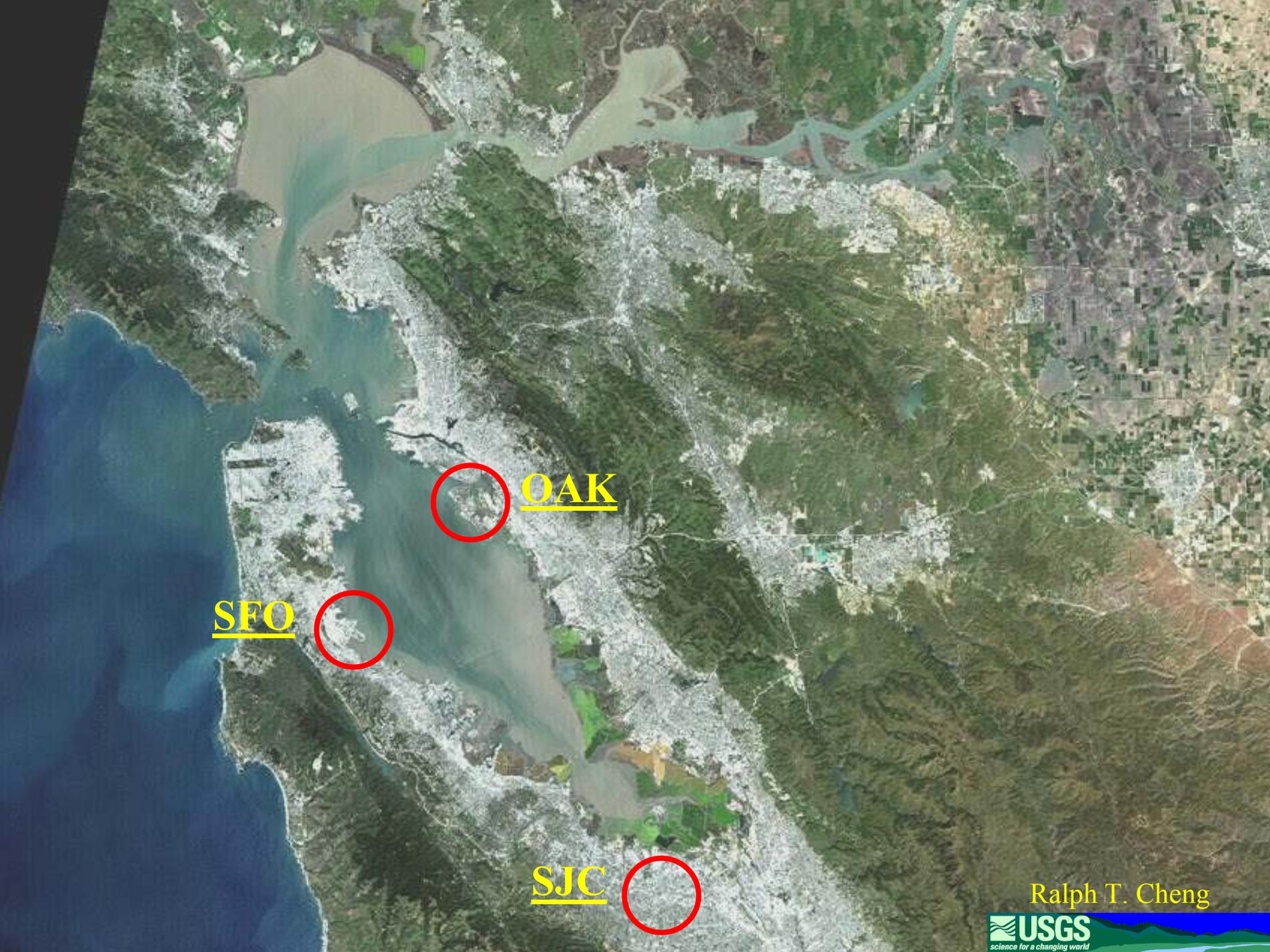
#### **Issues Related to SFO Runway Expansion**

#### **Hydrodynamics and Sediment Transport**

#### **An Assessment of Present Knowledge**

#### **A Proposed Solution**

#### **Conclusion**



SFO

OAK

SJC

Ralph T. Cheng

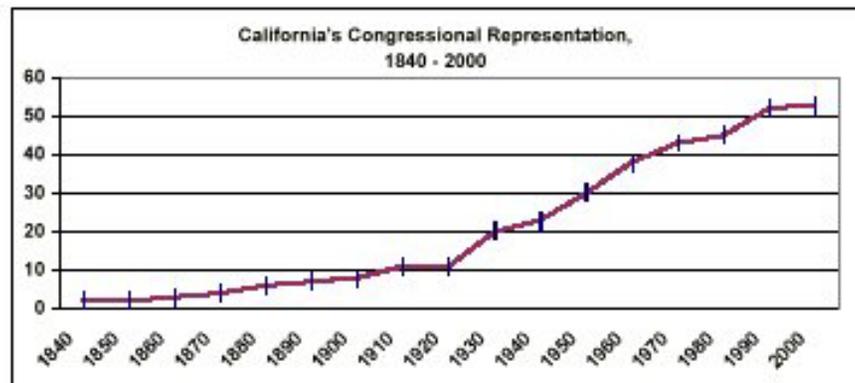
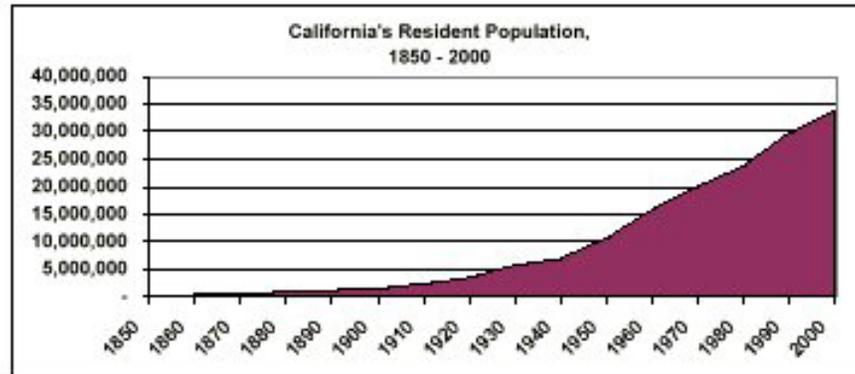


## Resident Population and Apportionment of the U.S. House of Representatives



### California

Year	Resident Population	Number of Representatives
2000	33,871,648	53
1990	29,760,021	52
1980	23,667,764	45
1970	19,971,069	43
1960	15,717,204	38
1950	10,586,223	30
1940	6,907,387	23
1930	5,677,261	20
1920	3,426,861	11
1910	2,377,549	11
1900	1,485,053	8
1890	1,213,398	7
1880	864,694	6
1870	560,247	4
1860	379,994	3
1850	92,597	2
1840	-	2
1830	-	...
1820	-	...
1810	-	...
1800	-	...
1790	-	...
1789	-	...



1. The resident population excludes the overseas population.

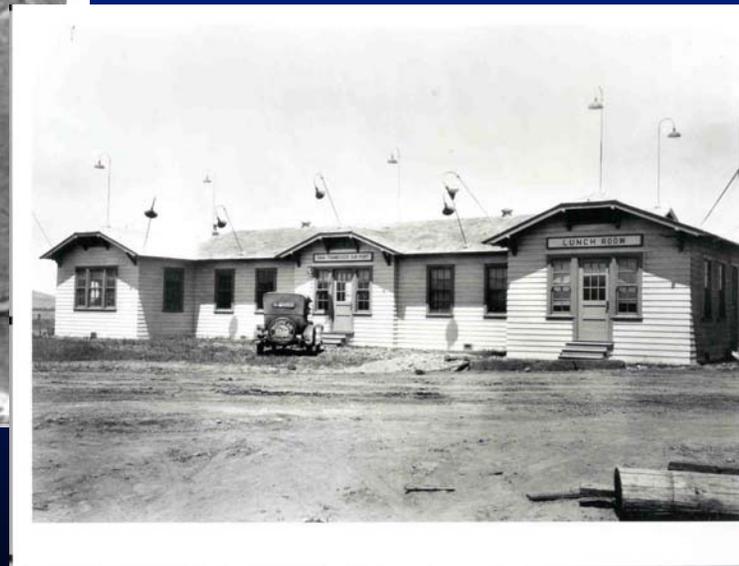
2. Congressional apportionment for each state is based upon (1) the resident population and (2) the overseas U.S. military and federal civilian employees (and their dependents living with them) allocated to their home state, as reported by the employing federal agencies.

**Estimated Population in the Greater Bay Area:  
 1930 ~ 1 Million; 1950 ~ 2 Million;  
 1980 ~ 4 Million; 2000 ~ 6 Million**

# Historical and Philosophical Perspectives: 1927 - 2000



**First Admin. Bldg  
Mills Field Municipal  
Airport of San Francisco  
(1927)**



**Mills Field Municipal Airport of San  
Francisco (1928)**

Photos courtesy of SFO Museum

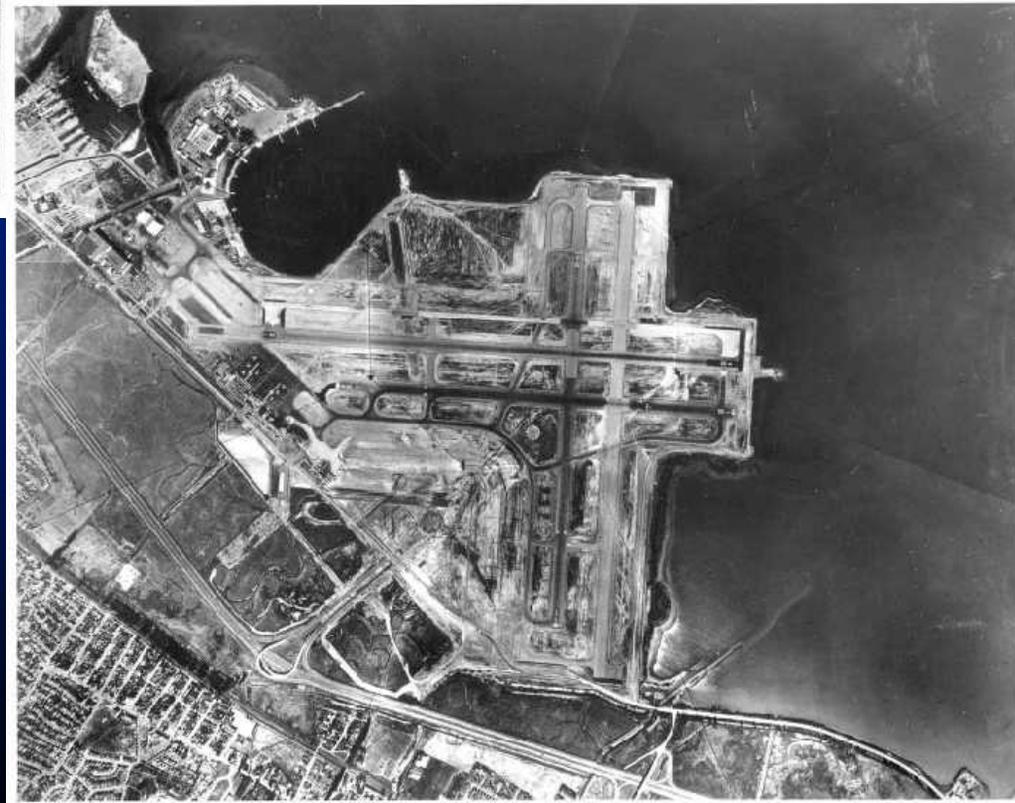
# Historical and Philosophical Perspectives: 1927 - 2000



**Aerial view of SFO in 1952.  
Airport expansion in the 50's  
which has nearly the same  
configuration as present.**

**SFO Expansion Project, 1939**

**Estimated Population 1950  
~2 Million**

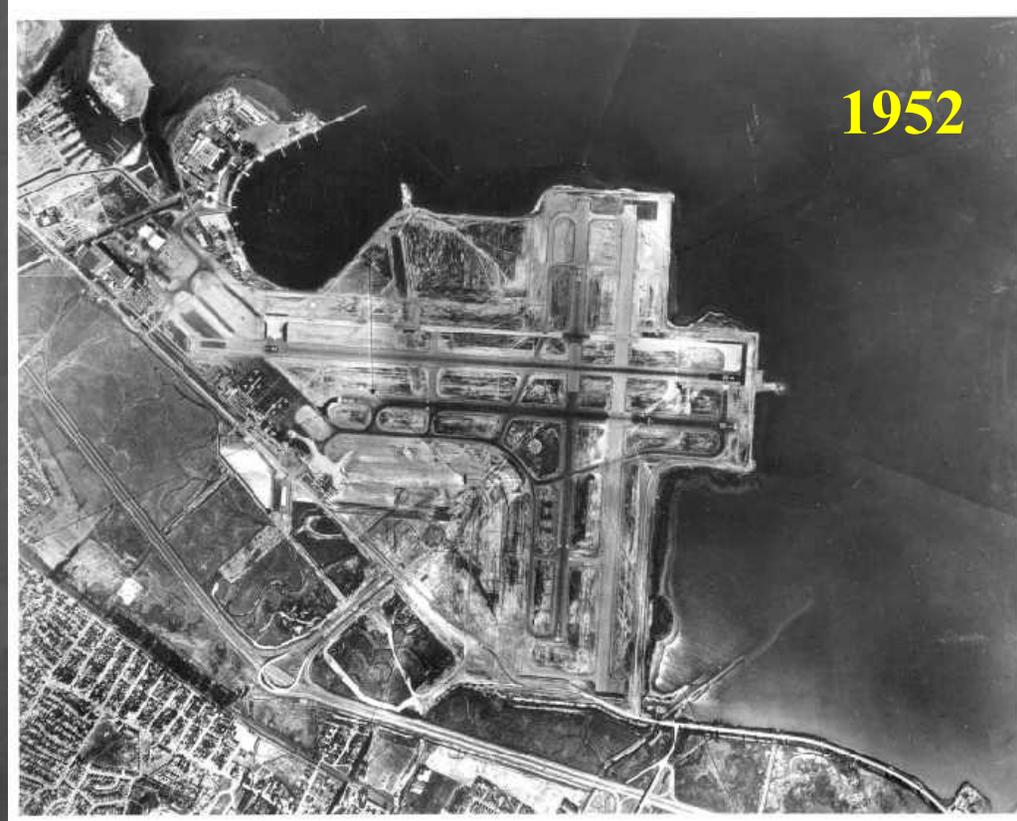


Photos courtesy of SFO Museum

# Historical and Philosophical Perspectives: 1927 - 2000



**Year 2000**



**1952**

**Estimated Population 2000  
~6 Million**

Photos courtesy of SFO Museum

# Historical and Philosophical Perspectives: 1928 - 2000

**Life is NOT static!**

**Changes are necessary to accommodate population and economic growth and to meet the needs of community.**

**The future changes should be decided  
by the community!**

**As members of professional engineering society, our responsibilities are to provide insights and fair evaluations of all proposals, particularly those “**outside-of-the-box**” ideas, and to formulate a solution that would meet the needs of the community but create least disturbances to the existing ecosystem!**

# Issues Related to SFO Runway Expansion

## The propositions:

Population and economic growth, bigger airplanes,  
new runways are needed to meet the demands

## The proposed solution:

“Fill-in” the Bay for runways expansion

## The concerns:

Health and well being of S. F. Bay Ecosystem!

**Uncertainties in the future!!**

## The bottom line:

Can we accommodate runways expansion and  
preserve the ecosystem at “Status Quo”?

# Issues Related to SFO Runway Expansion

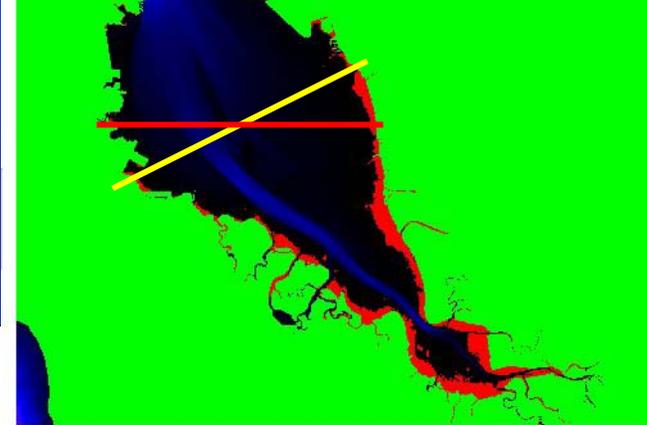
“Fill-in” the Bay for runways expansion

Questions:

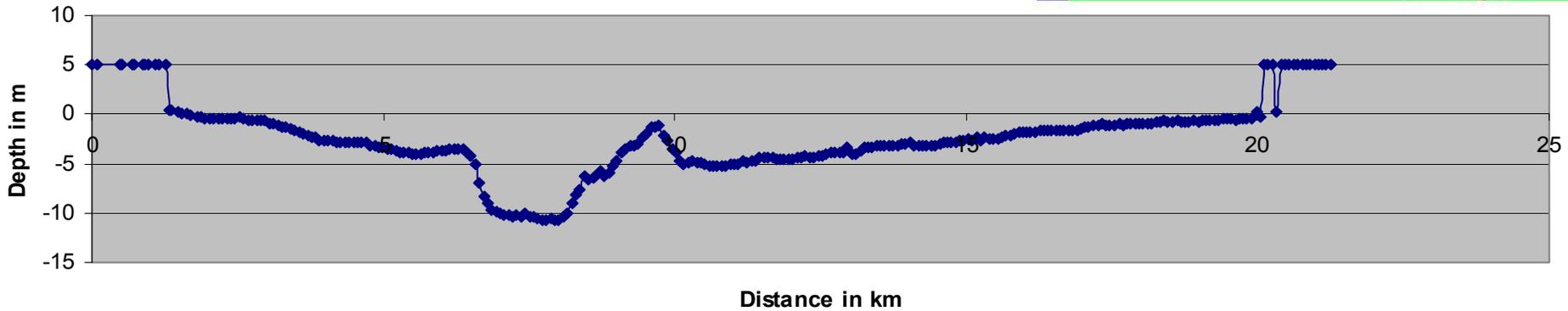
1. Will “fill-in” affect the Hydrodynamics and Sediment Transport?
2. Can we define the regions of influence?  
Local, regional, or bay-wide?
3. Is there a solution that can accommodate runways expansion **AND** preserve the hydrodynamics at “Status Quo”?

(Hydrodynamics and Sediment Transport)

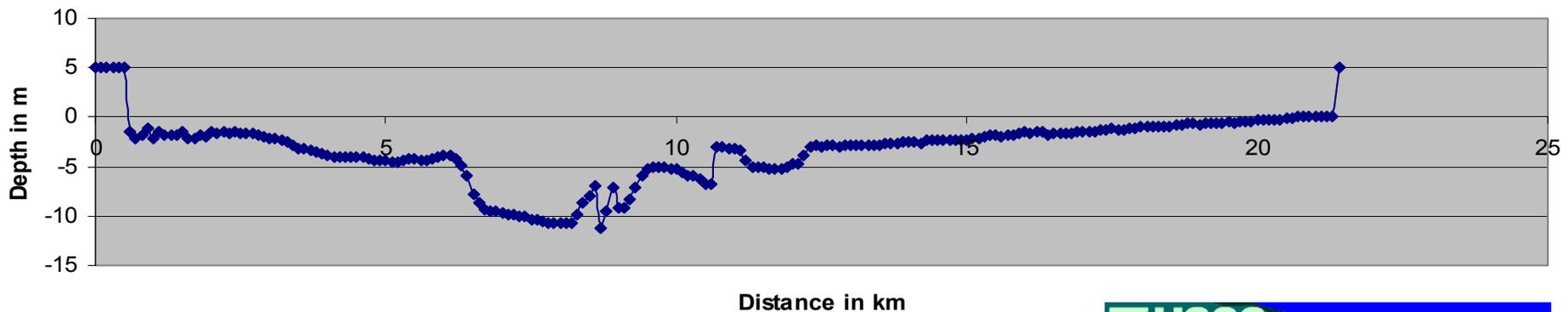
# Geometrical considerations: X-sections



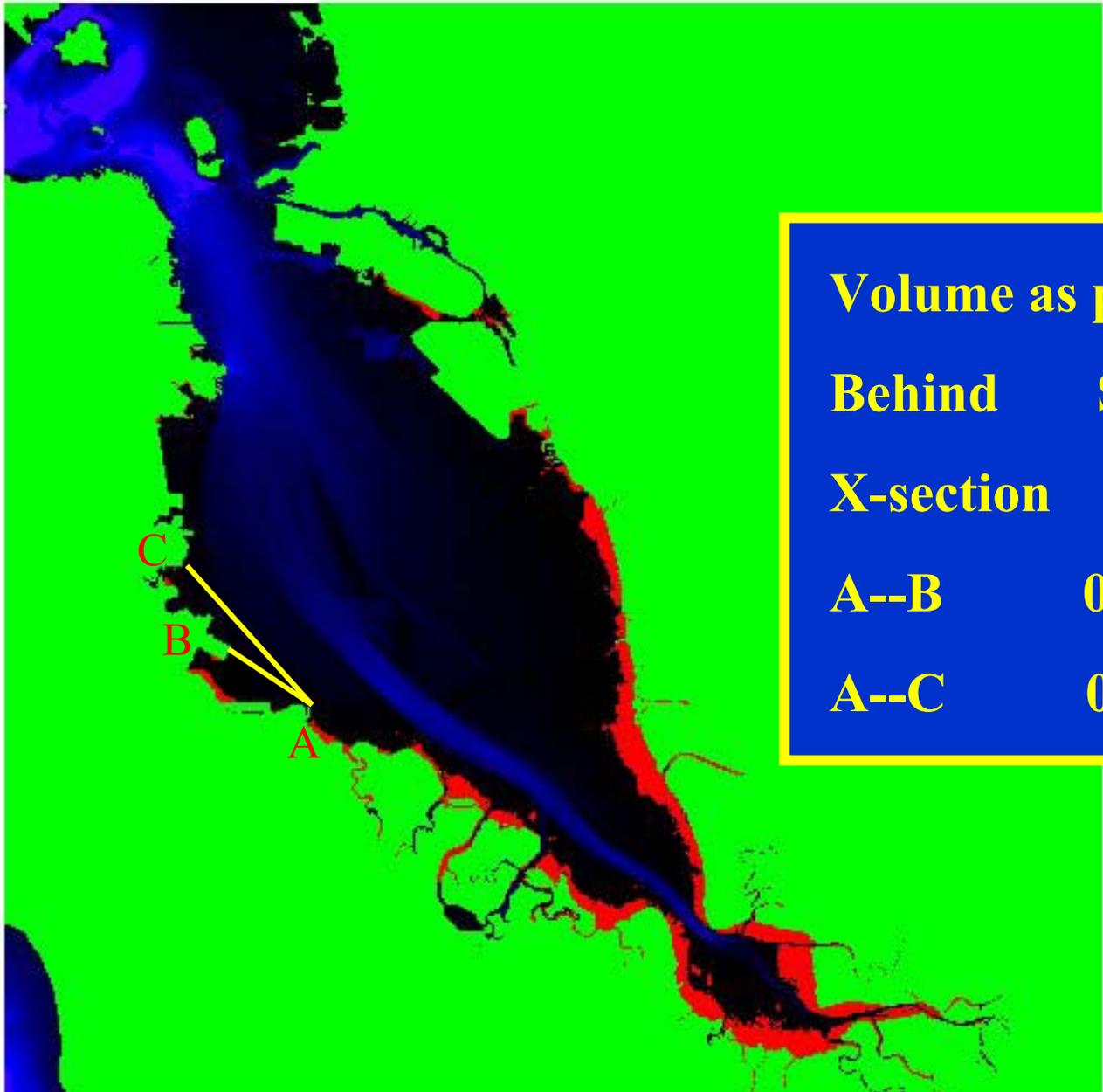
**SFO to San Leandro**



**East-West Cut through Seaplane Harbor**

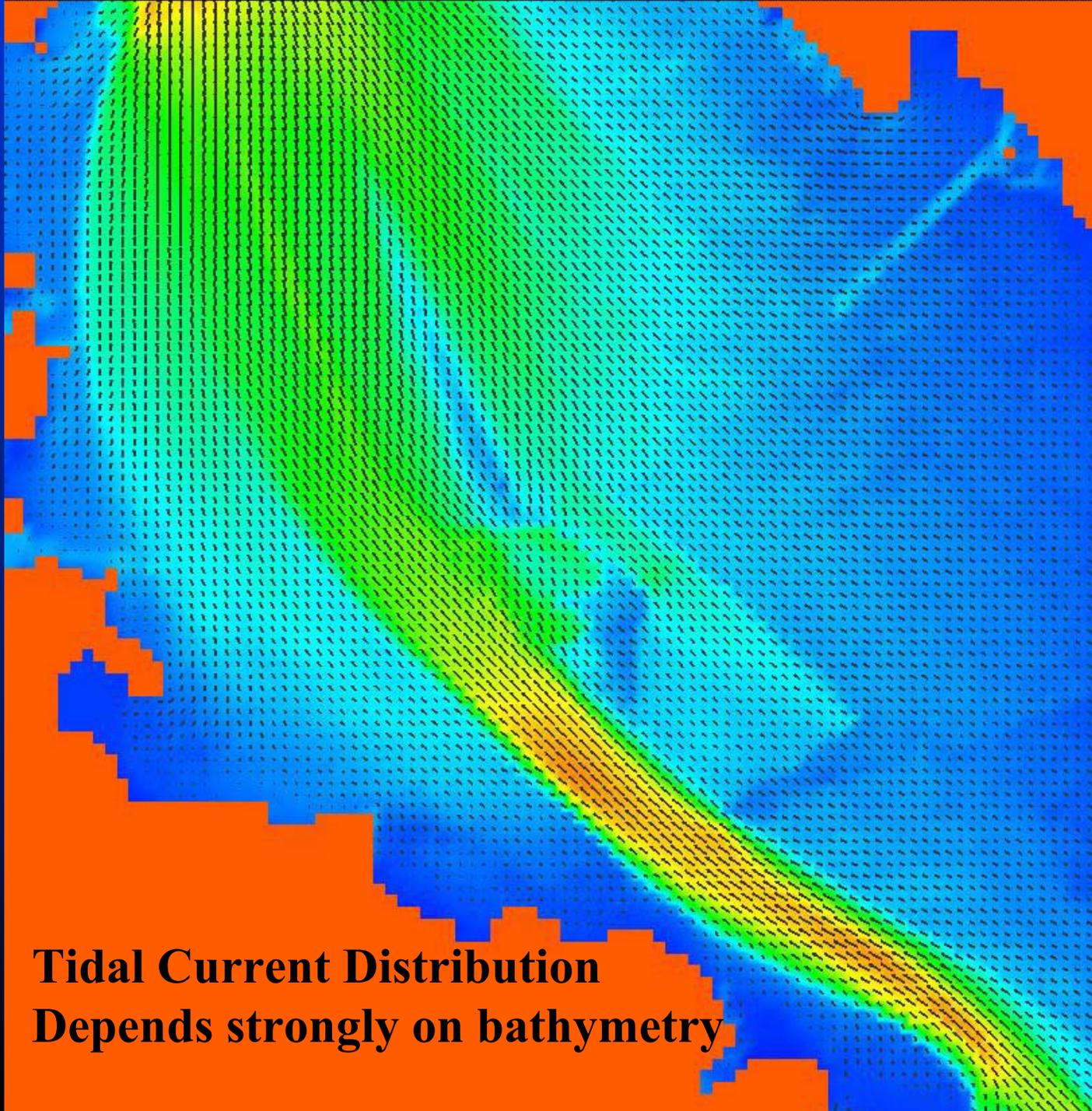


# Geometrical Considerations: VOLUME

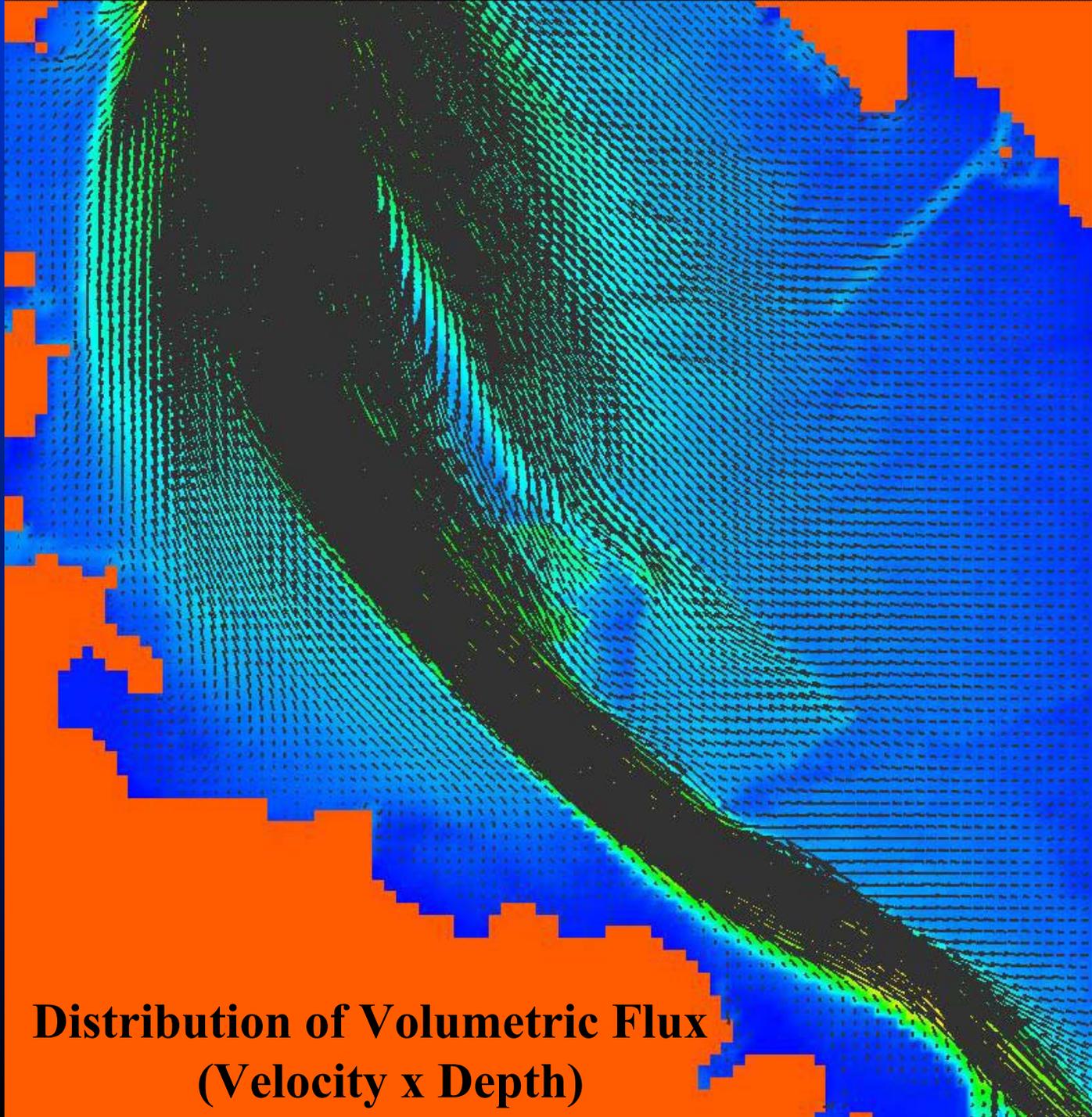


**Volume as percent:**

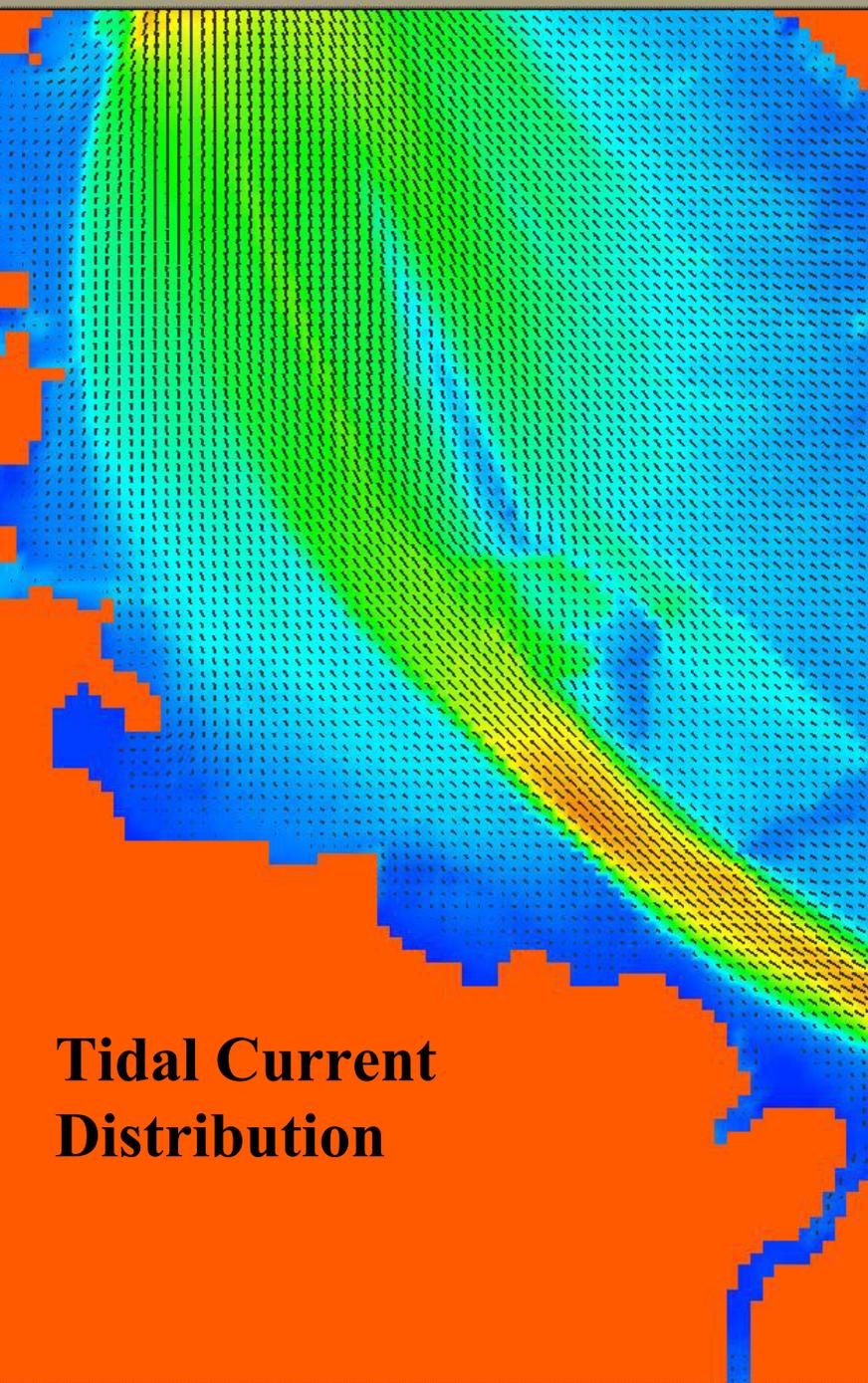
<b>Behind</b>	<b>S. Bay</b>	<b>Whole Bay</b>
<b>X-section</b>	<b>36.5 %</b>	
<b>A--B</b>	<b>0.033 %</b>	<b>0.012 %</b>
<b>A--C</b>	<b>0.098 %</b>	<b>0.036 %</b>



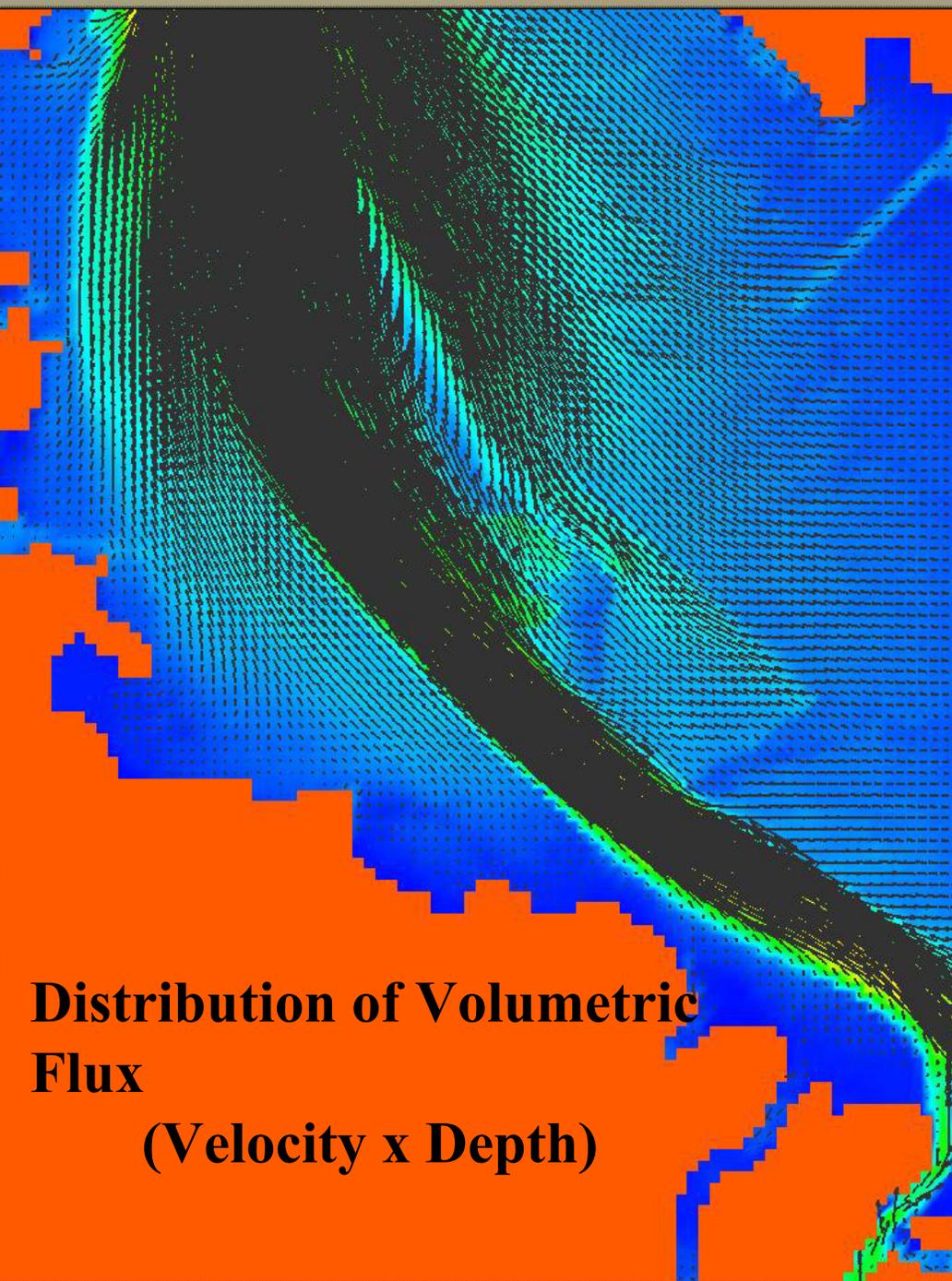
**Tidal Current Distribution  
Depends strongly on bathymetry**



**Distribution of Volumetric Flux  
(Velocity x Depth)**



**Tidal Current  
Distribution**



**Distribution of Volumetric  
Flux  
(Velocity x Depth)**

# An Assessment of Present Knowledge on Hydrodynamics and Sediment Transport

**USGS Long-Term Commitment:**  
**Basic Process Oriented**  
**Interdisciplinary Research in**  
**San Francisco Bay Ecosystem**  
**This Discussion:**  
**20 years of basic research on**  
**hydrodynamics and sediment**  
**transport (and continuing)**

## An Assessment of Present Knowledge on Hydrodynamics and Sediment Transport

### **Major Milestones:**

**1979 -1985 : NOAA/USGS Complete Tidal  
Current Survey and Analysis**

**1990 - 1993 : trim2d & trim3d development  
and applications (Cheng & Casulli)**

**1993 - present : Suspended Sediment Time-series  
(Scheollhamer et al)**

**1996 - Present : Bottom Boundary Layer  
(Cheng & Cacchione)**

**1996 - Present : A Marine Nowcast System installed  
in 1997 (Cheng/USGS/NOAA)**

**1996 -Present : Sediment and Bathymetry Changes  
(Jaffe and Smith)**

# A Marine Nowcast System for San Francisco Bay, California

## The Project -- Integration of Cutting Edge Technologies

- ① Real-Time Field Data -- Collaboration with NOS/NOAA PORTS --Physical Oceanographic Real-Time System
- ① Nowcast\* Procedures and Nowcast Hydrodynamic Numerical Model (Teaching an Old Dog New Tricks!)
- ① Interpretation and Dissemination of Real-Time Field Data and Nowcast Model Results via WWW

<http://sfports.wr.usgs.gov/sfports.html>

\*Nowcast: Assimilation procedure to reproduce observations in the immediate past 24 hrs before **now**, and extending the procedure to predict processes for the next 24 hrs.

# Who are the players:

NOS/NOAA

USGS

S.F. Marine Exchange

OSRP, Fish & Game, CA

# Who are the users:

**Navigation Safety Authorities**

**Ship Skippers and Pilots**

**Environment Protection Organizations**

**Oil-Spill Response and Planning**

**HazMat Cleanup**

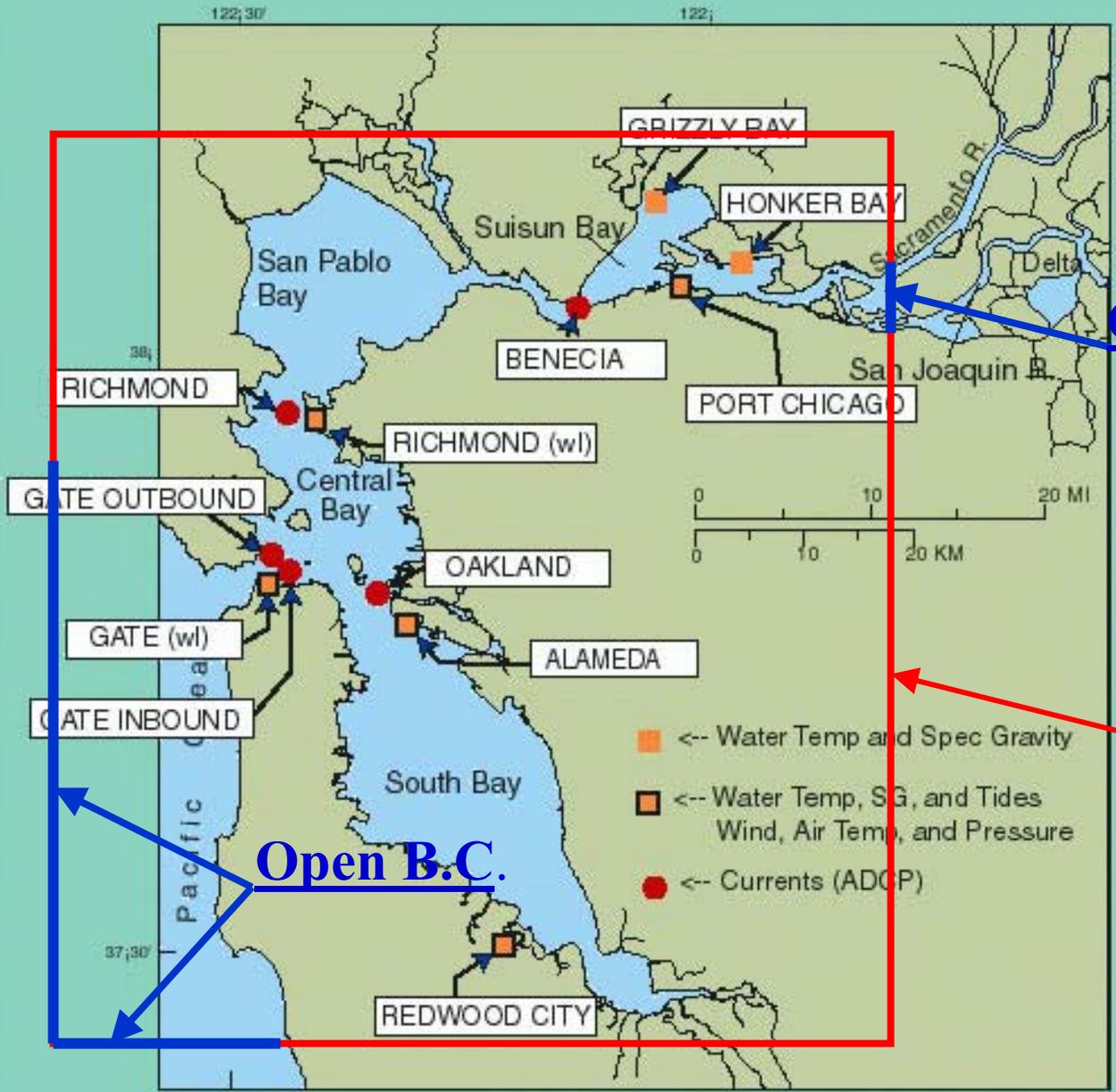
**Scientists and Recreational users**



# San Francisco Bay PORTS: NOS/NOAA, USGS and S. F. Marine Exchange

**PORTS Sensor Locations and Specifications**

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**Open B.C.**

**Model Domain**

**Open B.C.**

**PORTS Sensor Locations and Specifications**

# Concept of **Nowcast**\* Numerical Hydrodynamic Modeling and Data Assimilation

**\*Nowcast:** Assimilation procedure to reproduce observations in the immediate past 24 hrs before now, and extend the procedure to predict processes for the next 24 hrs.

**Conventional Modeling Requirements: Bathymetry, Initial and Boundary Conditions, Model Calibration and Validation**

**Nowcast Objective Kernel is to minimize the difference between the model results and observations in the immediate past 24 hrs.**

$$\mathbf{F} = \sum_{i=1}^M \int_{t_o}^{t_o+24} \left[ \zeta_i^m(t, P_1, P_2, P_3, \dots, P_k) - \zeta_i^o(t) \right]^2 dt + \sum_{j=1}^N \int_{t_o}^{t_o+24} \left[ V_j^m(t, P_1, P_2, P_3, \dots, P_k) - V_j^o(t) \right]^2 dt$$

# Concept of **Nowcast\*** Numerical Hydrodynamic Modeling and Data Assimilation

The optimization procedure defines the **boundary conditions** for the next 48 hours of model simulation centered at **NOW!**

$$\frac{\partial F}{\partial P_k} = 0; \quad k=1,2,3,\dots,K \quad P_k \text{ are perturbations in B. C.s}$$

The nowcast model is run every hour, continuously and repeatedly starting from 24 hours before **now** and ending at 24 hours after **now**.

The Model (**Old Dog**):

TRIM2D (Cheng, Casulli, and Gartner, 1993)

Grid Size: 378 x 426,  $\Delta x = \Delta y = 200$  m on Macator Projection

Total grid pts. = 161,000 ; 48,000 active points.

Computational Efficiency =  $\sim 325$

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# Nowcast Numerical Modeling (Teaching Old Dog New Tricks)

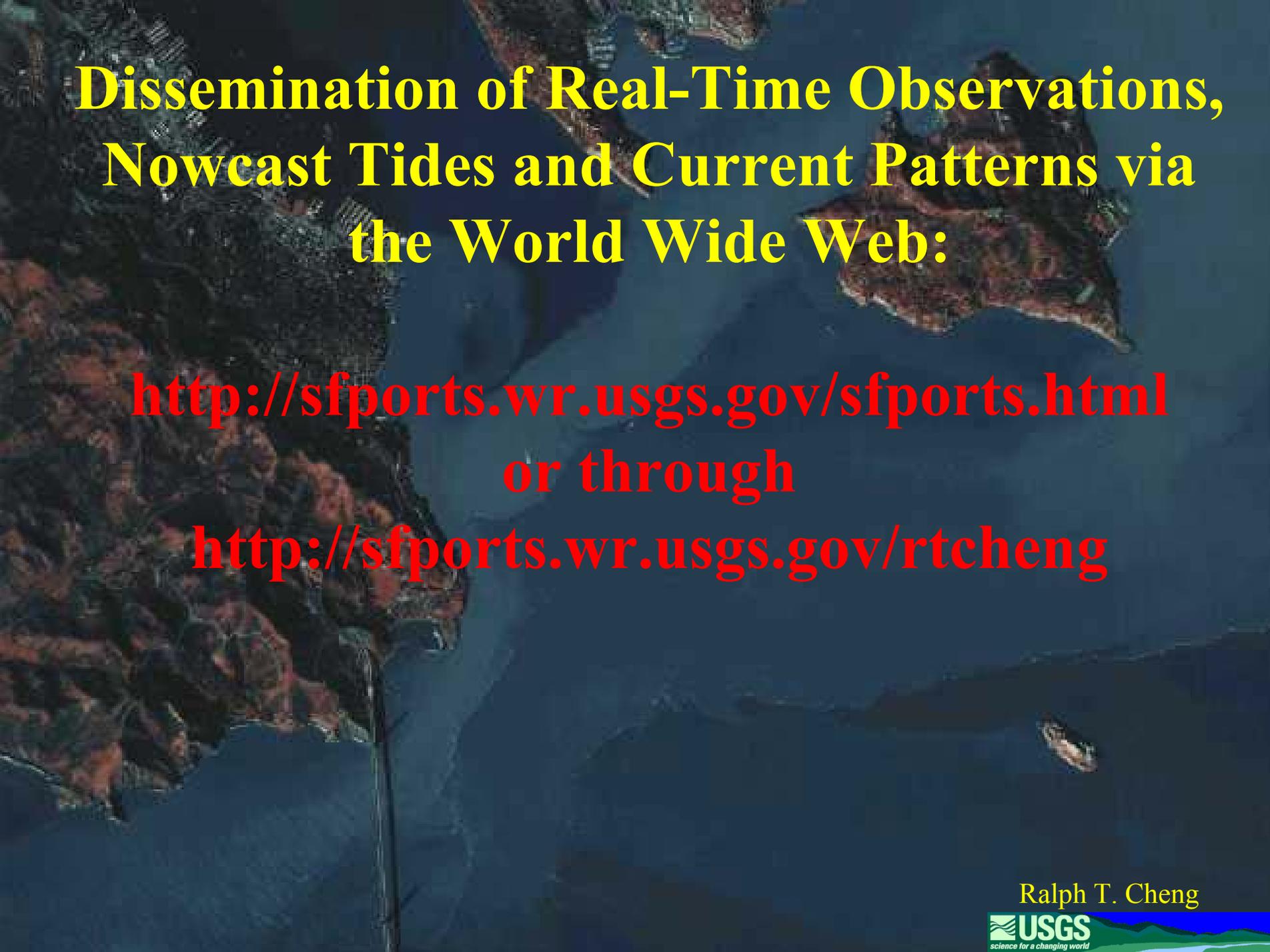
TEACH

Conventional Modeling  
Requirements



New Tricks

Timing! Timing! Timing!

An aerial photograph of a coastal region, likely San Francisco, showing a large bay, several islands, and a city skyline in the distance. The water is a deep blue, and the land is a mix of green and brown. The text is overlaid on this image.

# **Dissemination of Real-Time Observations, Nowcast Tides and Current Patterns via the World Wide Web:**

**<http://sfports.wr.usgs.gov/sfports.html>  
or through**

**<http://sfports.wr.usgs.gov/rtcheng>**

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# Home Page of SFSPORTS

<http://sfports.wr.usgs.gov/sfports.html>

 <p>USGS NOAA</p>	<h2>San Francisco Physical Oceanographic Real-Time System (SFSPORTS)</h2>  <p>Page Title</p> <p>Welcome to the RESEARCH AND DEVELOPMENT PAGE FOR SFSPORTS the production page has moved to =&gt; SFMIX</p>
<p>MAKE A SELECTION</p> <ul style="list-style-type: none"><li>○ Objectives</li><li>○ Map of Stations</li><li>○ Most Recent Data<ul style="list-style-type: none"><li>● Wind &amp; Tides</li><li>● Currents</li><li>● Current profiles</li><li>● Time-Series</li></ul></li><li>○ Model Output<ul style="list-style-type: none"><li>● Current Maps</li><li>● Forecasts/Animations</li><li>● Time-Series</li></ul></li><li>○ Other Resources</li><li>○ Glossary</li><li>○ Feedback</li><li>○ Credits</li><li>○ Admin/Stats</li></ul> <p>or</p> <p>Use a JavaScript Floating Navigation Window</p>	<p><i>A partnership of the Marine Exchange of the San Francisco Bay, the California Office of Oil Spill Prevention and Response, NOAA's National Ocean Service, and the U.S. Geological Survey.</i></p> <p>The objective of this page is to develop techniques for the delivery of real time oceanographic observations to the maritime community and to investigate the use of numerical hydrodynamic models for forecasting purposes.</p> <p>Data inputs now include:</p> <ul style="list-style-type: none"><li>Tides (Water Level)</li><li>Currents</li><li>Winds (see also San Francisco Bay Wind Patterns page)</li><li>Water Temperature</li><li>Air Temperature</li><li>Air Pressure</li></ul> <p>Short term forecasts of water level and currents</p> <p>The data available and presentation techniques will continue to expand at this "experimental" site. Once additions are stable and reviewed they will be ported to the production site maintained by the San Francisco Marine Exchange (SFMIX).</p> <p>Please use the Feedback link to help us improve the data displays and suggest additions.</p>

Agency Logos

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Page Title

Main Contents

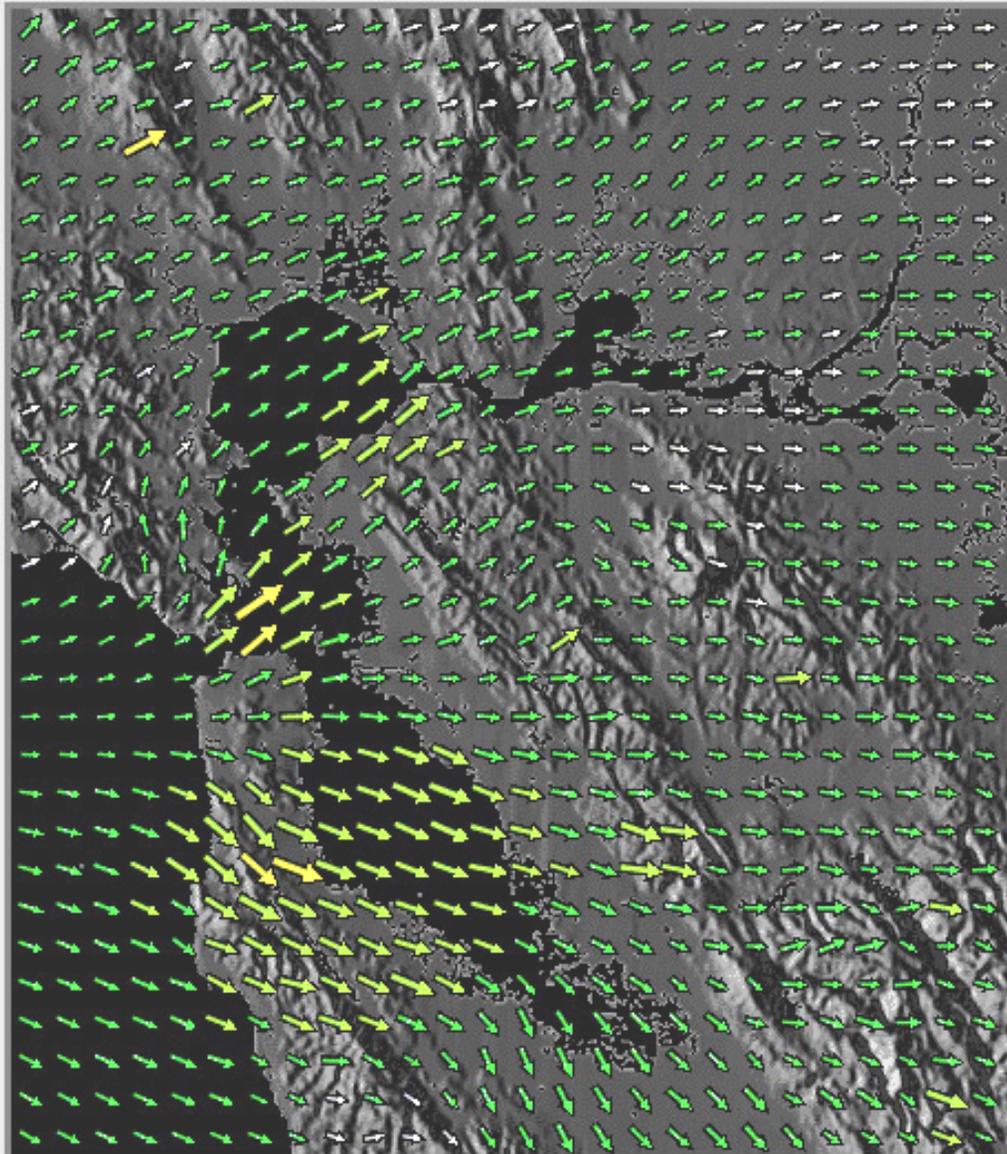
Glossary

Feedback

NOAA/NOS SF PORTS Screen Capture (Most Recent Raw Data)  
Check out our sister site San Francisco Bay Wind Patterns!

[TOP PAGE](#) [GLOSSARY](#) [FEEDBACK](#)

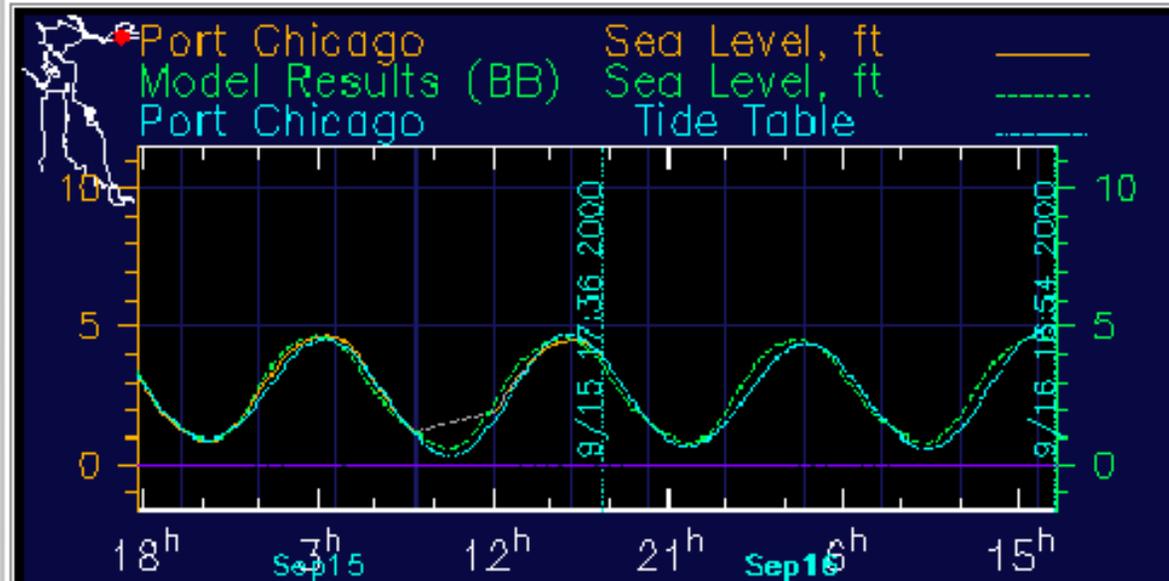
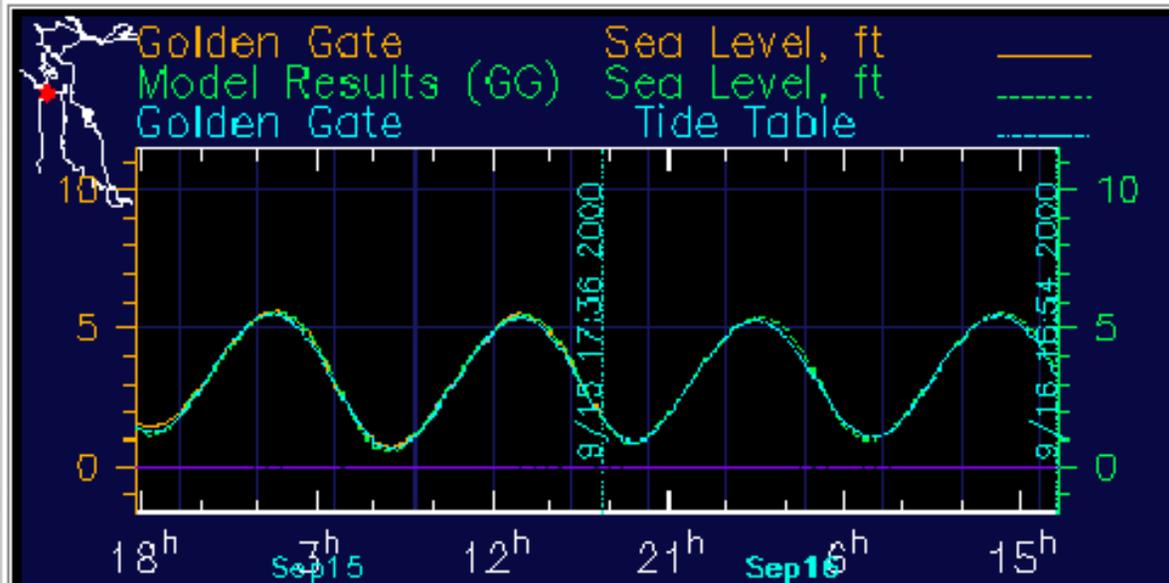
# Typical Afternoon Wind Distribution over San Francisco Bay Region



0 - 4.9 5 - 9.9 10 - 14.9 15 - 19.9 20 - 24.9 >25

# Comparison of modeled and predicted tides with observations

Times in **PDT** -- Water Levels from **MLLW**



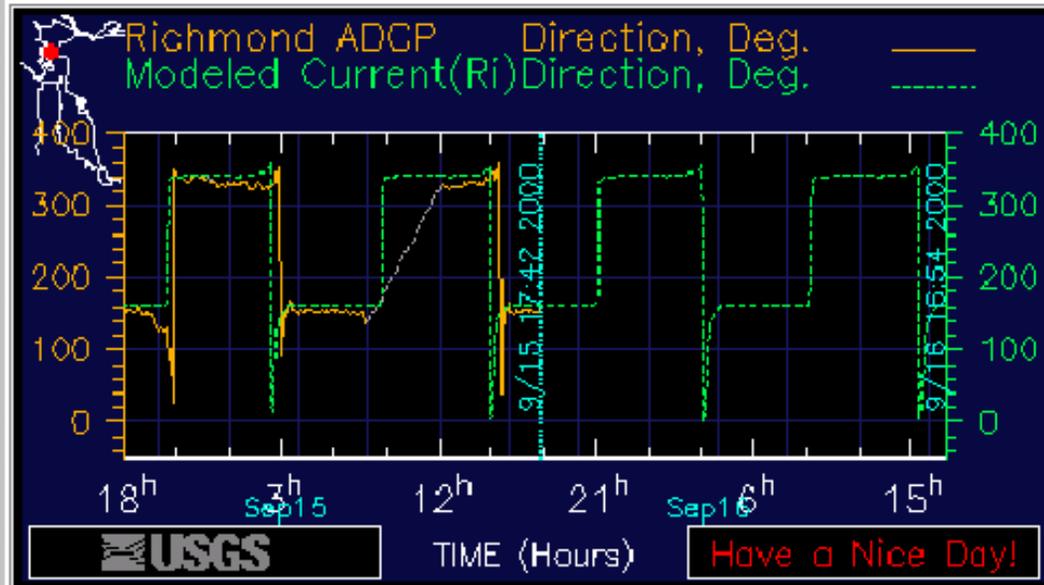
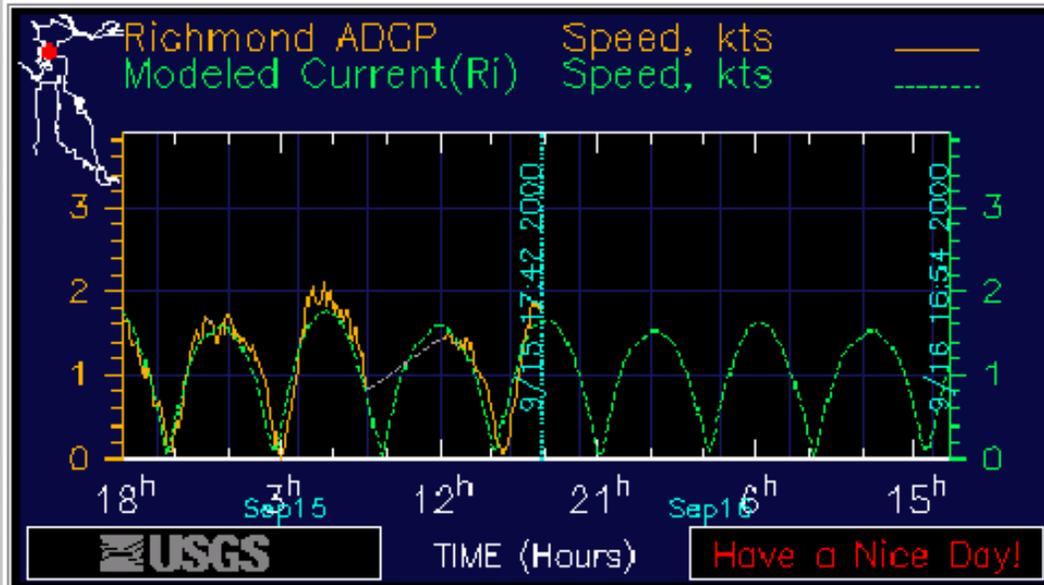
USGS

TIME (Hours)

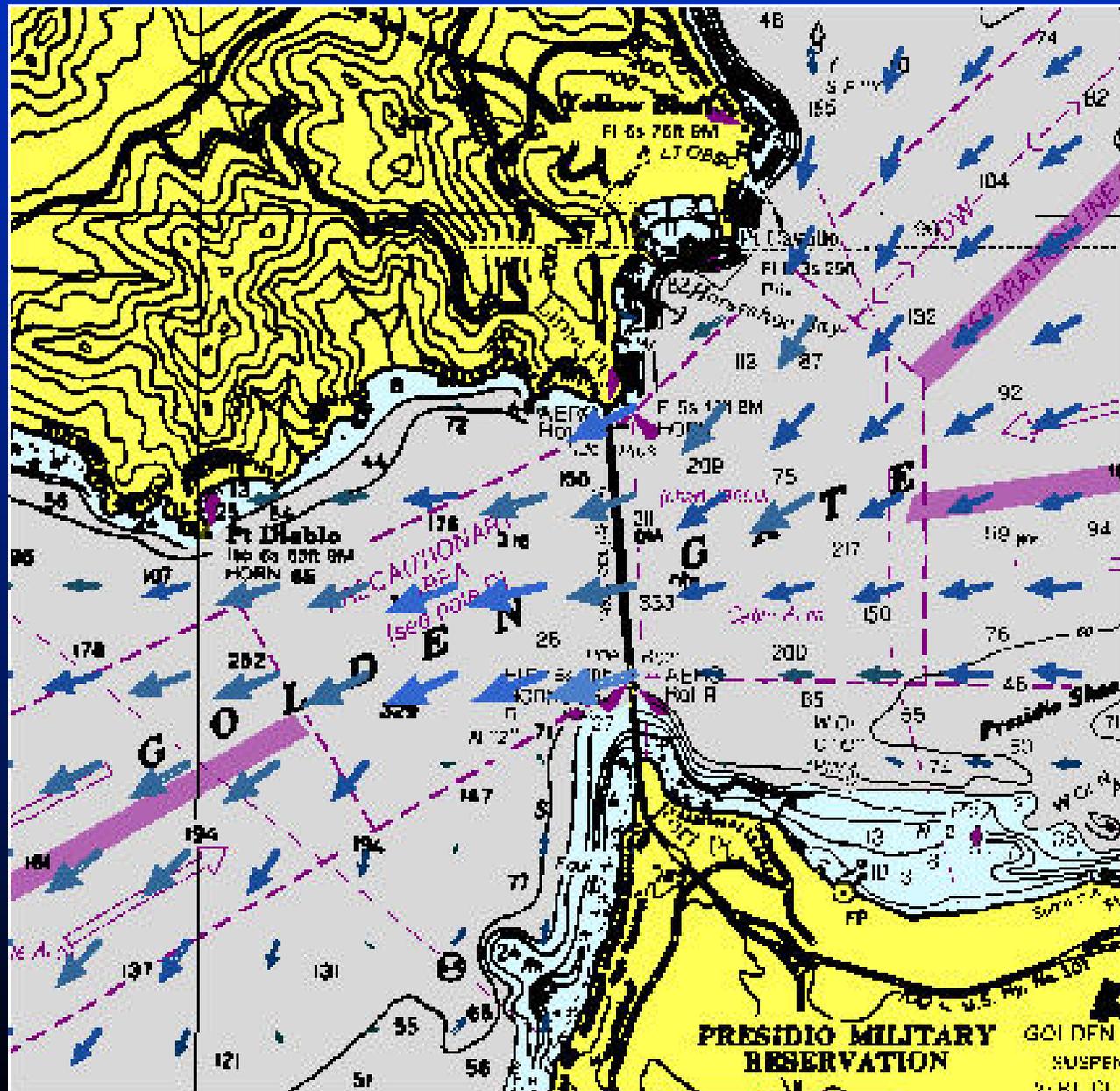
Difference = 0.3ft

# Comparison of Modeled Current Speed & Direction with Observations

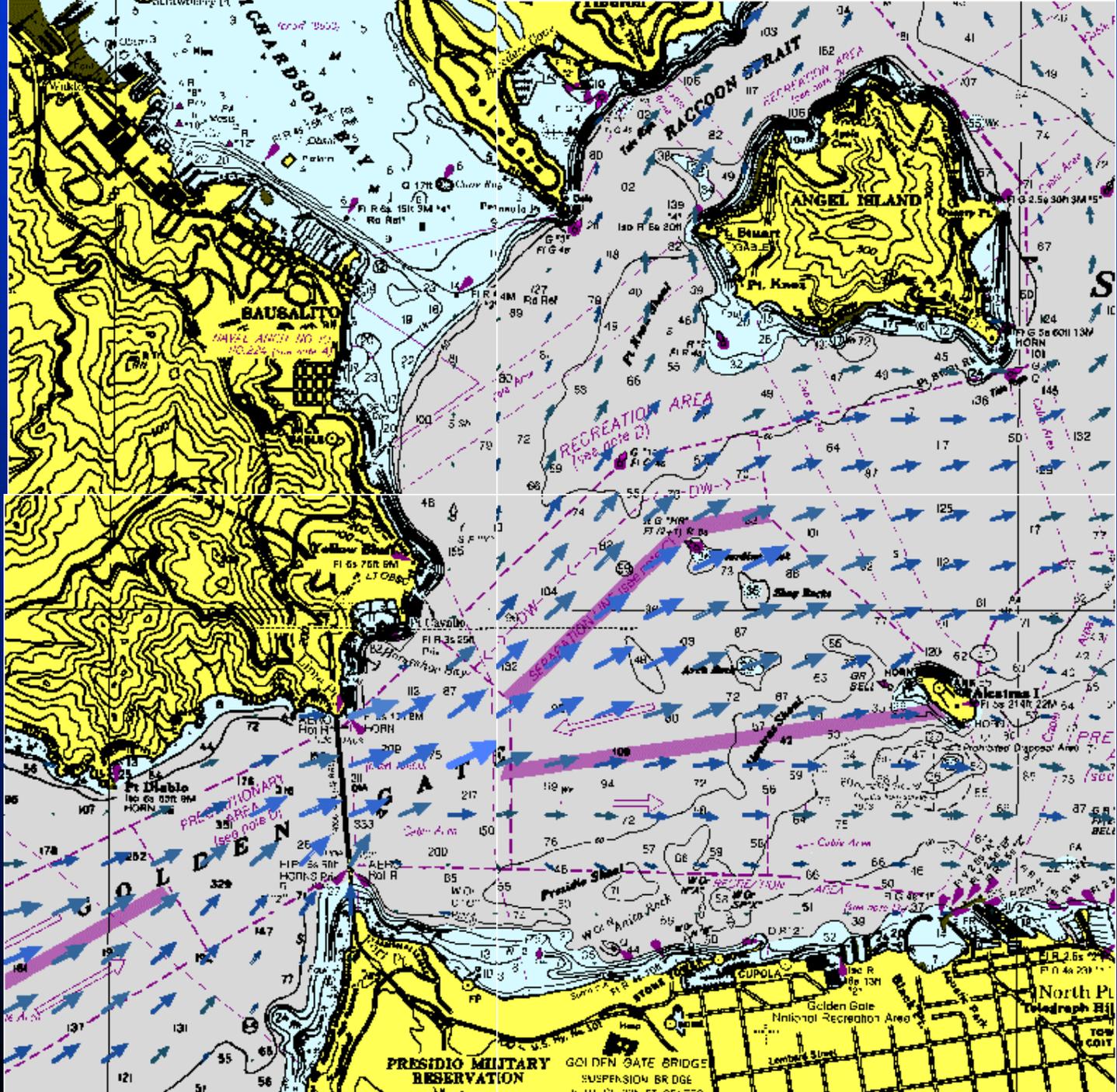
Times in PDT -- Water Levels from MLLW



# Nowcast Numerical Model Results on NOAA Charts



CENTRAL SAN FRANCISCO BAY 21:00 08/02/1999

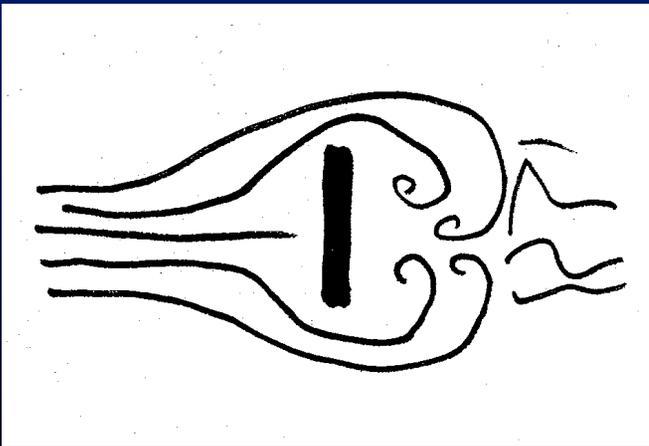


## A Proposed Solution:

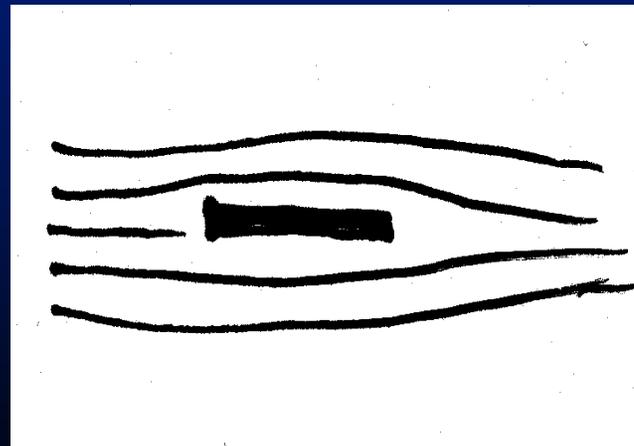
**Objectives: To accommodate runway expansion and keep the changes to the circulation and sediment movements to minimal**

**Solution based on simple hydrodynamics:**

**Build a streamlined “retention-wall” enclosure of runways expansion.**

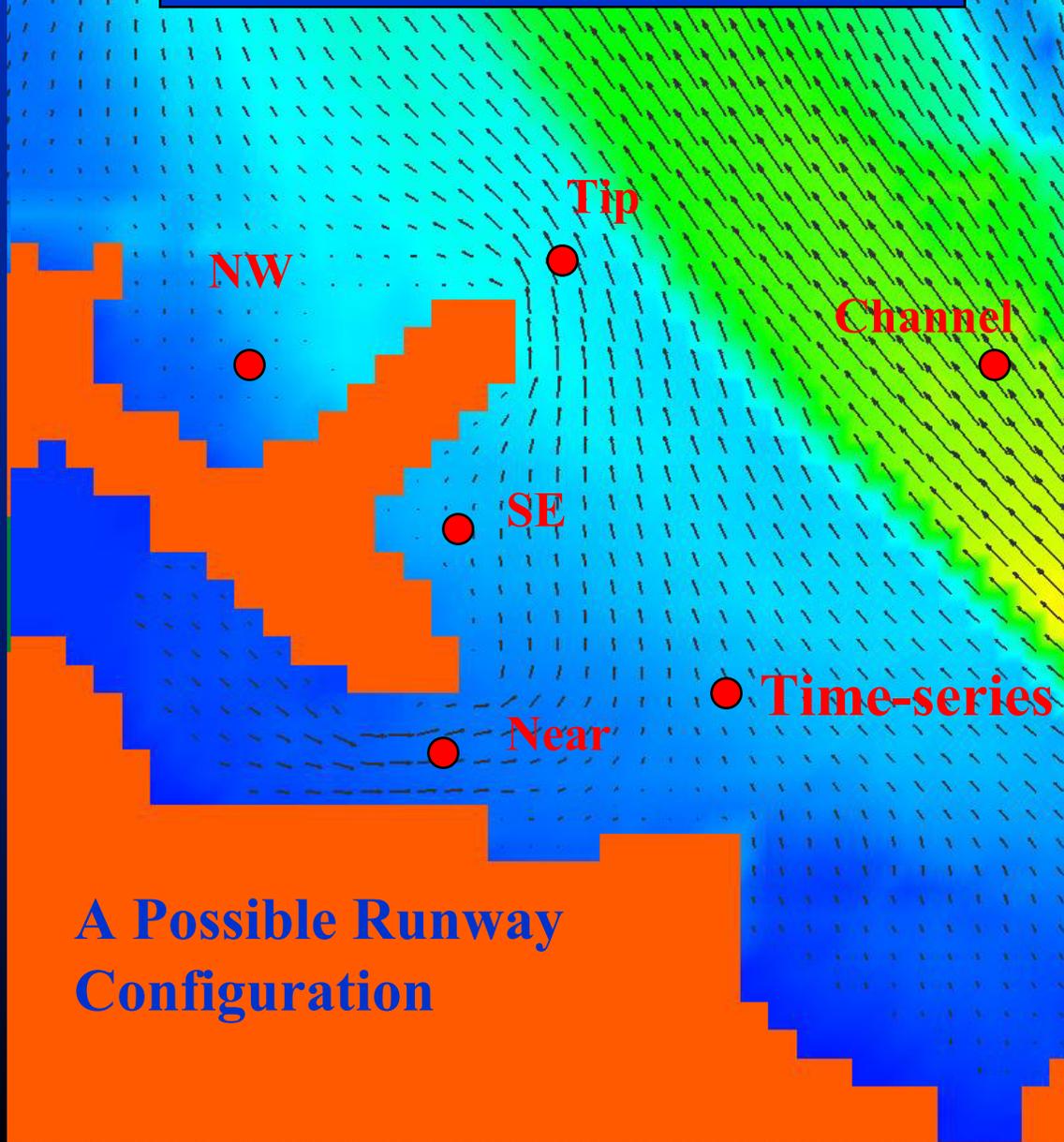


**Blunt Object**



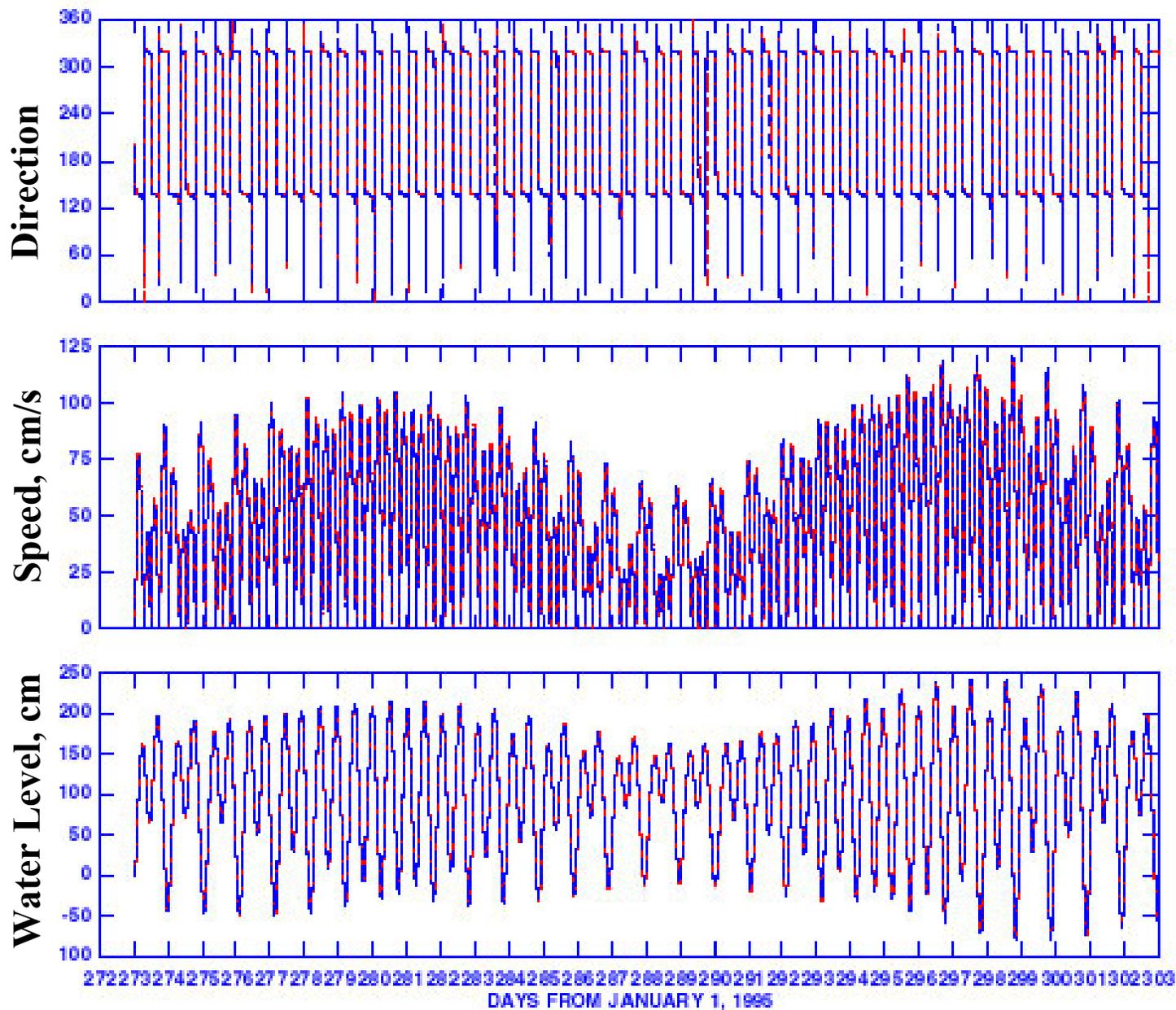
**Smooth Object**

# Tidal Circulation Pattern -- SFO Runway Expansion

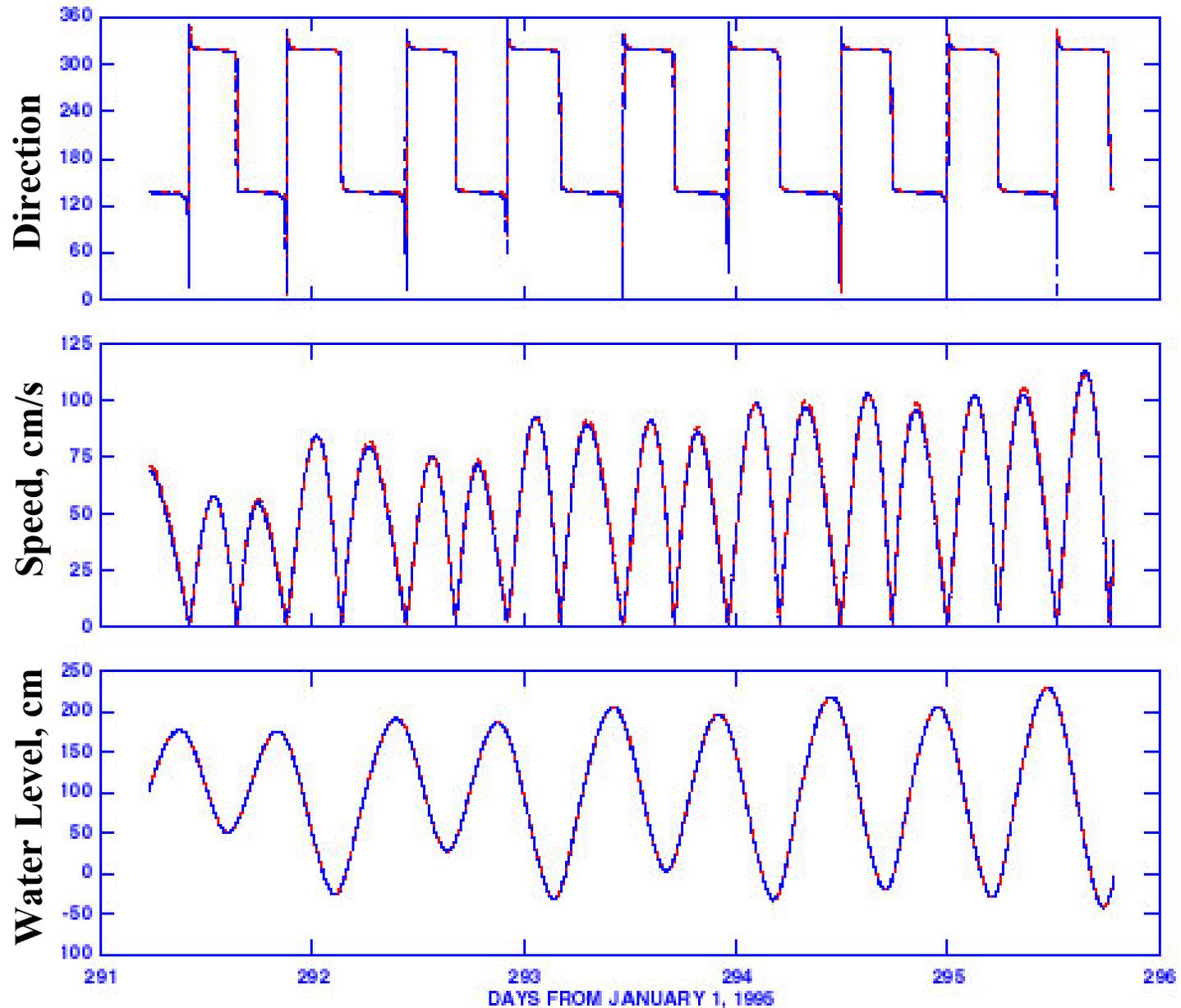


A Possible Runway  
Configuration

# Time-series saved in the channel for Present, Expansion, and Wall

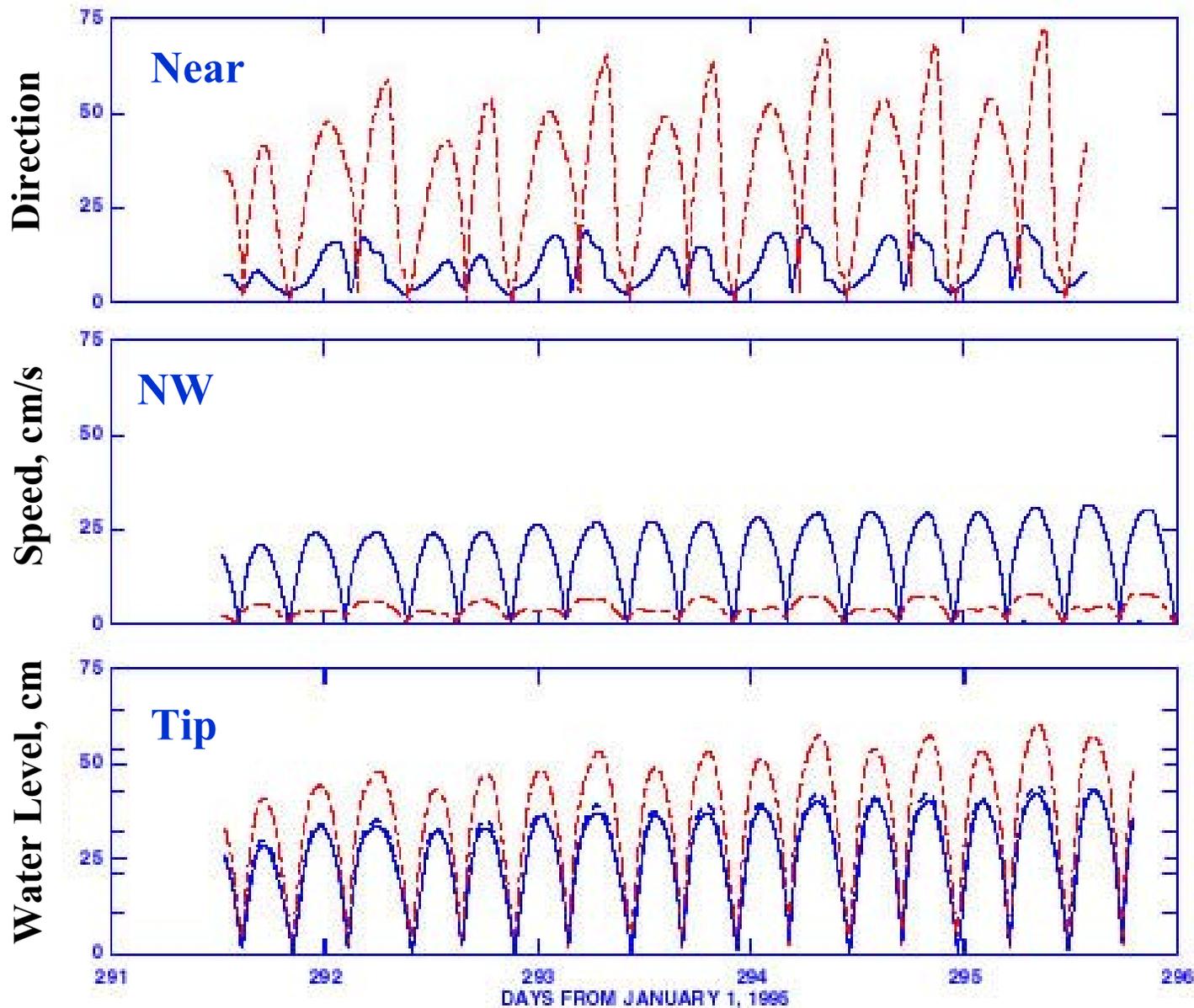


# Time-series in the channel for Present, Expansion, and Wall



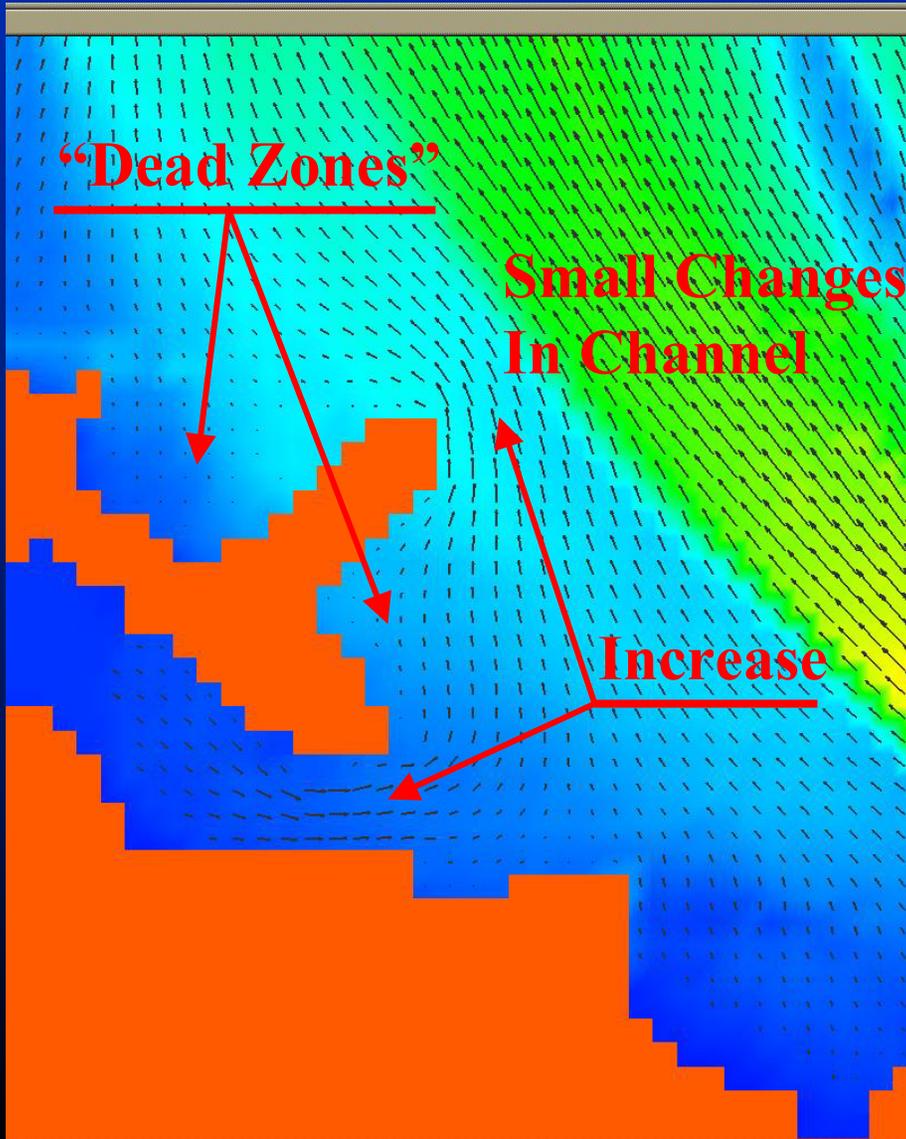
# Time-series saved in at “Near”, “NW”, and “Tip”

Present — Expansion - - - Retention-Wall - - -

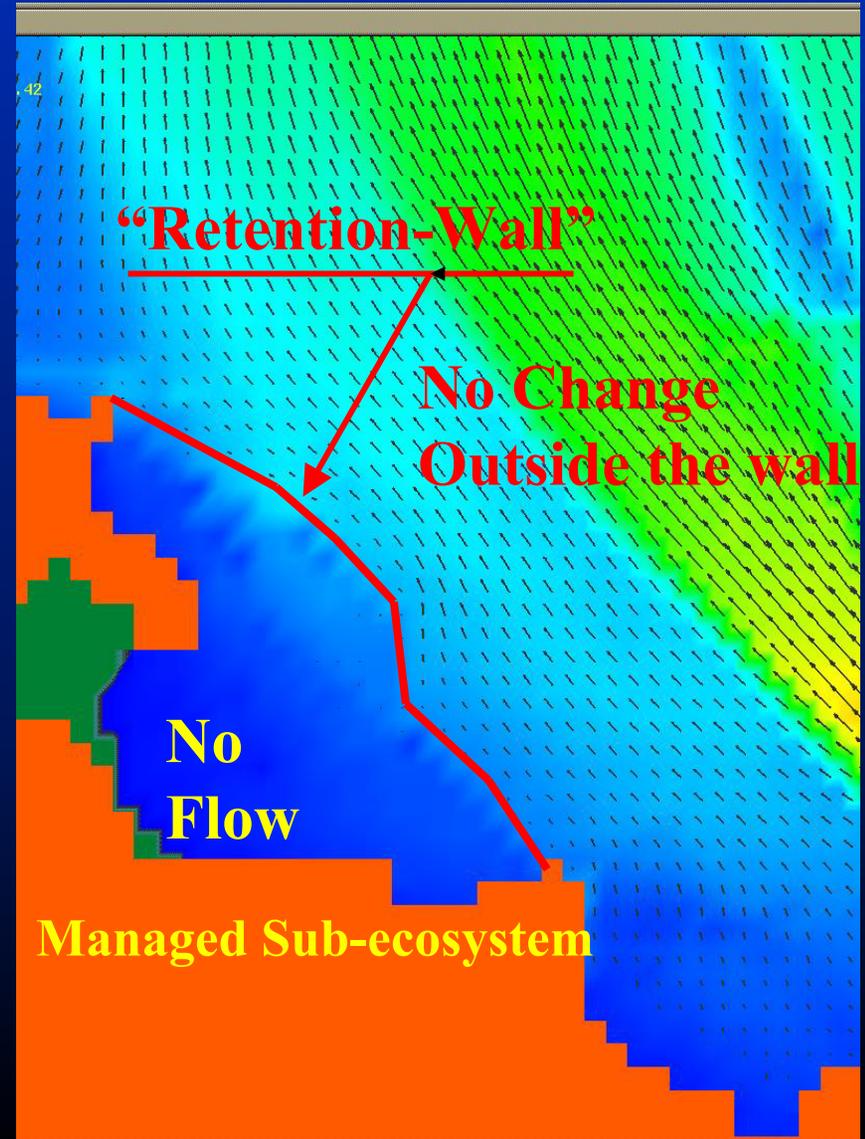


# Numerical Model Simulation of Tidal Circulation Pattern

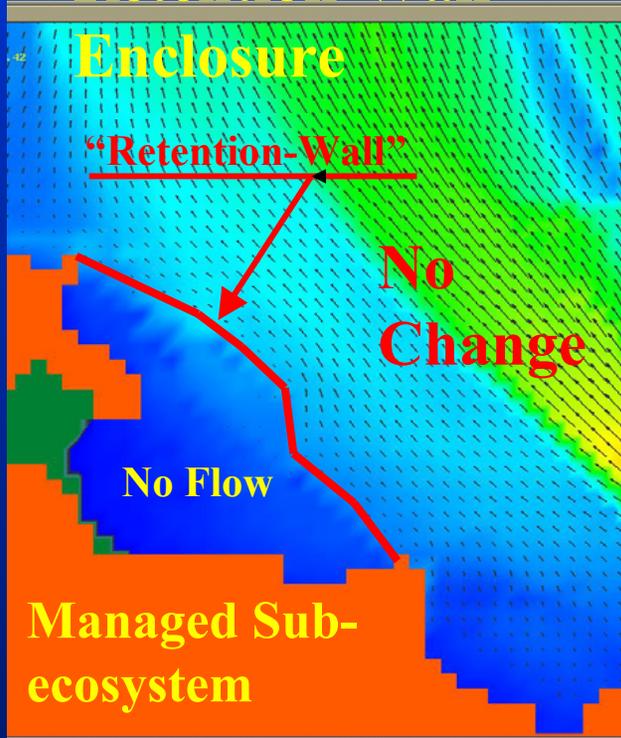
## SFO Runways Expansion



## Retention-Wall Enclosure



## Retention-Wall



## Effects of Retention Wall:

1. Retention wall can minimize **changes** to circulation pattern and sediment transport pattern after runways expansion
2. Build the retention wall before runways expansion, it can be used to contain massive sediment movements during runway construction.
3. System outside of the wall will respond to **future uncertainties** in exactly the same manner as the present system!
4. The isolated area is a very small % of South Bay, rate of transport is slow.
5. Develop innovative strategy to manage the sub-ecosystem!

# **The Bottom Line:**

**The Community must choose from three basic options:**

**1. Do nothing. No runways expansion.**

**Potential consequences: willing to deal with the air-traffic congestion; Limiting economic growth**

**2. Allow runways expansion without protective measure:**

**Potential consequences: Create changes in flow and sediment transport pattern for future years.**

**There are great unknowns: How would the “new” system respond to future UNCERTAINTIES?**

# The Bottom Line:

The Community must choose from three basic options:

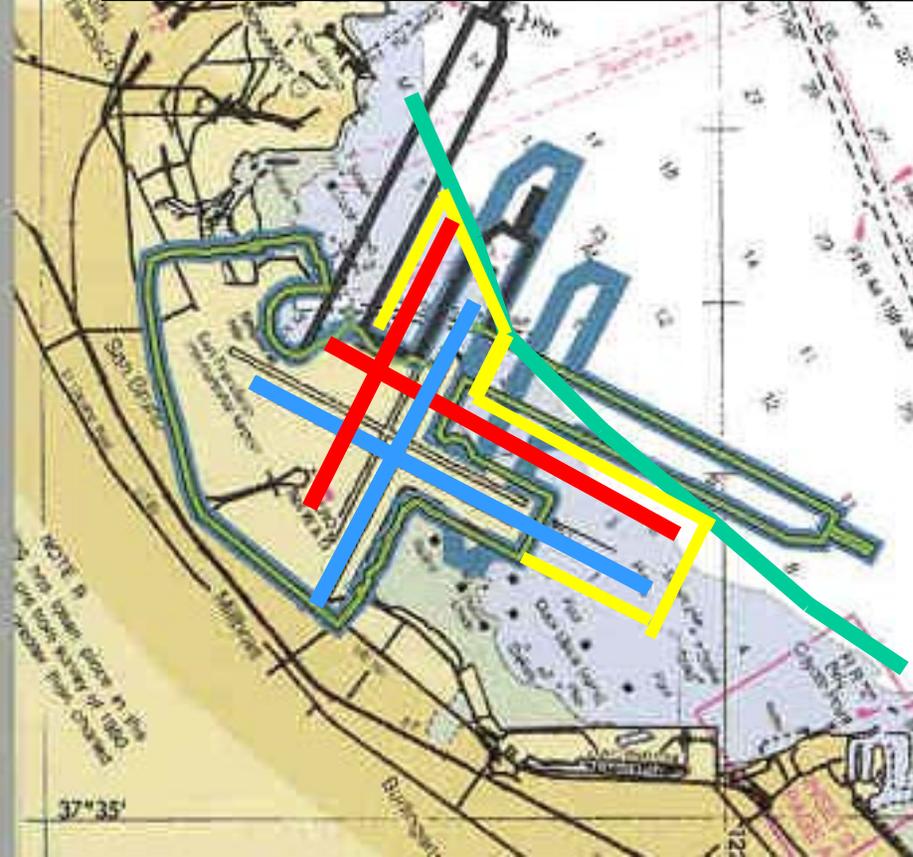
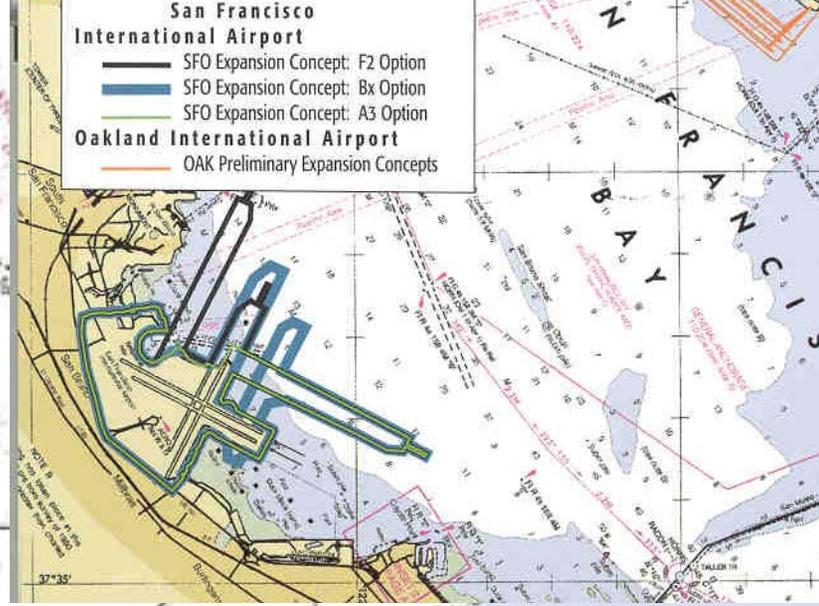
3. Allow runways expansion with a protective retention wall:

The flow pattern and sediment transport outside of the wall is **guaranteed** to remain the same.

Therefore the “new” system would respond to future **UNCERTAINTIES** in exactly the same manner as how the existing system would respond!

**Potential Consequence:** It may require to isolated a larger portion of the bay behind the retention wall; but this area represents a small portion of the Bay with low transport rate. **The benefit >> The sacrifice!!**

	<b>Retention Wall</b>
	<b>“Fill-in” Area</b>
	<b>A Possible New Runways Configuration</b>
	<b>Expansion of existing runway</b>
	<b>New</b>



**A Proposed Runways Expansion with retention wall. Taking full advantage of existing runways, minimum “fill-in” of the Bay.**

## Conclusions:

1. Life is dynamic, changes are necessary to meet community's needs
2. Historical hydrodynamic and sediment data exist, and tools are available for assessing impacts due to SFO runway expansion
4. This proposal illustrates the principles that solutions exist, and it is possible to minimize the impacts due to runways expansion and, at the same time, preserve the SF Bay ecosystem at "Status Quo."

