

Operations and Maintenance Funding Allocation via Navigation Systems Optimization

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Scarce O&M Funding

- **Fiscal constraints are forcing the Corps to make difficult decisions concerning allocation of limited Operations and Maintenance (O&M) funds across the vast portfolio of inland navigation projects.**
- **This is driving the push towards system-based methods to ensure that limited resources are optimally distributed and benefits to the Nation are maximized.**



Waterborne Commerce Data

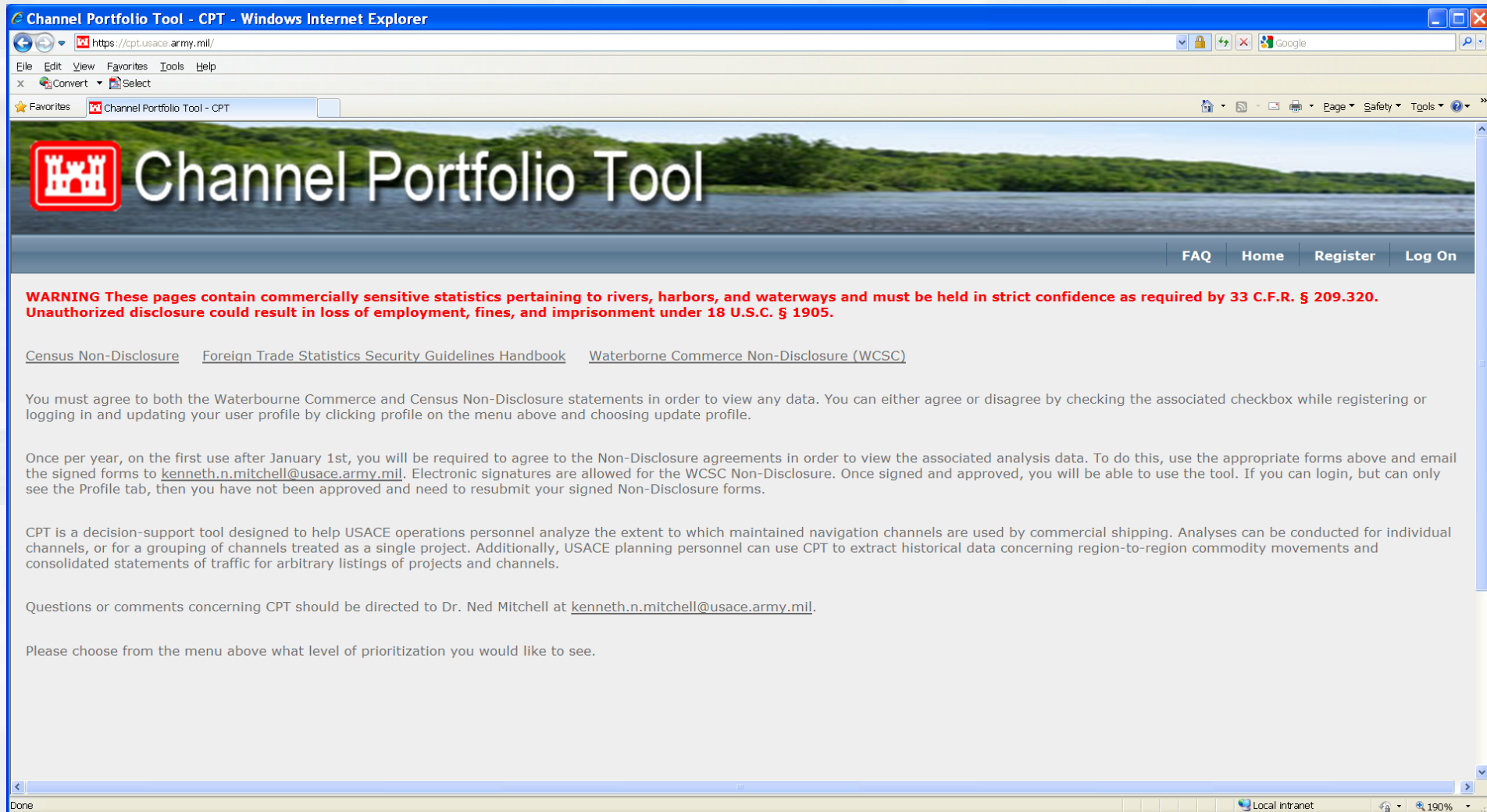
- The Corps' Waterborne Commerce Statistics Center (WCSC) collects and collates data from several sources concerning commercial use of US waterways.
 - ▶ Dock-level, origin-to-destination routing (Corps-use-only)
 - ▶ Includes tons, commodity types, vessel counts, drafts
 - ▶ Aggregated data already published at project level

<http://www.ndc.iwr.usace.army.mil/wcsc/wcsc.htm>

- Corps Ops community has not consistently used this data beyond project-level tonnage and ton-mile metrics for O&M budget development.
- Richness of data source enables advanced, systems-based approaches over and above project-based metrics.



Channel Portfolio Tool (CPT)

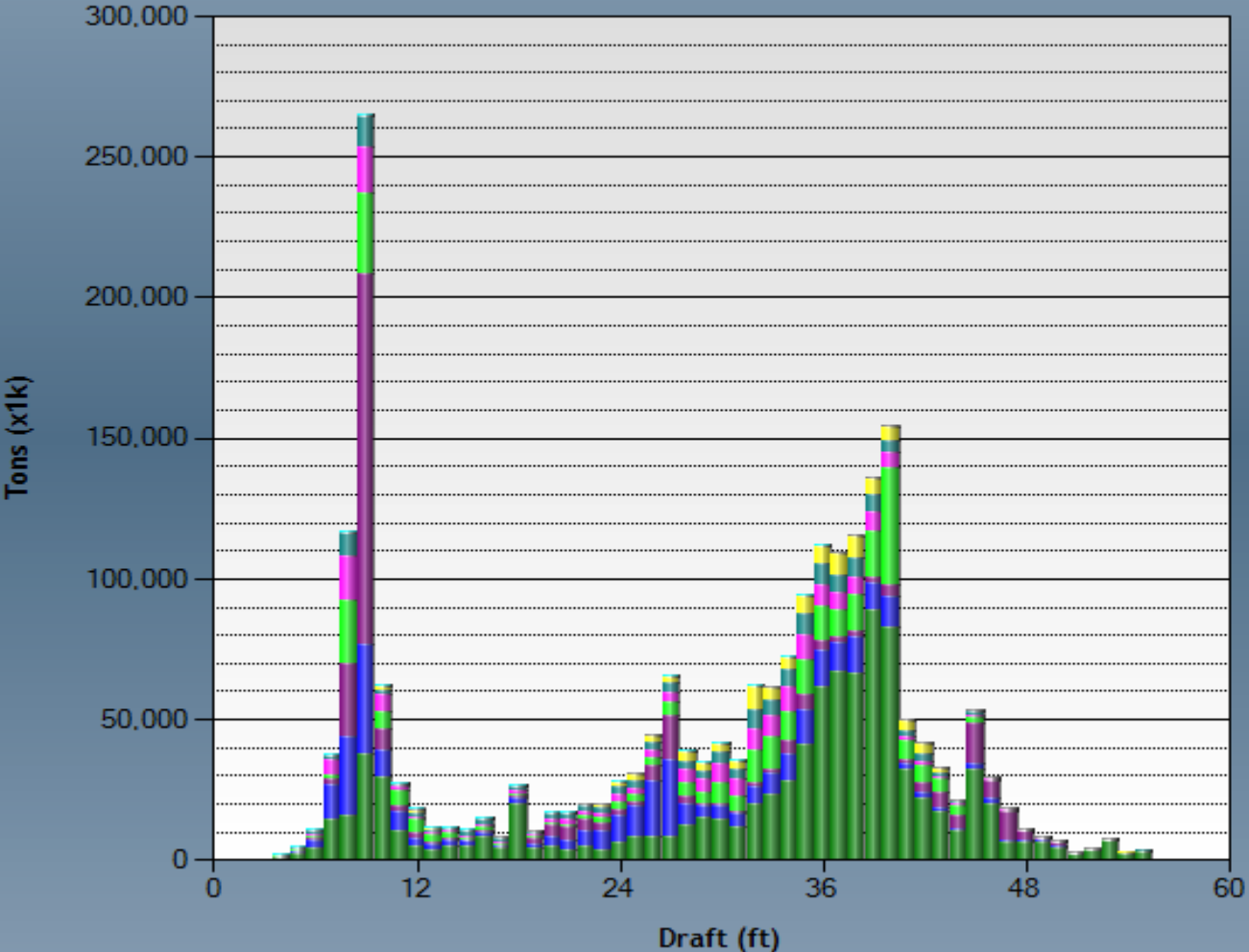


The screenshot shows a Windows Internet Explorer browser window displaying the Channel Portfolio Tool (CPT) website. The browser's address bar shows the URL <https://cpt.usace.army.mil/>. The website's header features a red logo with a white castle icon and the text "Channel Portfolio Tool" in large white letters. Below the header is a navigation menu with links for "FAQ", "Home", "Register", and "Log On". A prominent red warning message states: "WARNING These pages contain commercially sensitive statistics pertaining to rivers, harbors, and waterways and must be held in strict confidence as required by 33 C.F.R. § 209.320. Unauthorized disclosure could result in loss of employment, fines, and imprisonment under 18 U.S.C. § 1905." Below the warning are links for "Census Non-Disclosure", "Foreign Trade Statistics Security Guidelines Handbook", and "Waterborne Commerce Non-Disclosure (WCSC)". The main content area contains a disclaimer: "You must agree to both the Waterbourne Commerce and Census Non-Disclosure statements in order to view any data. You can either agree or disagree by checking the associated checkbox while registering or logging in and updating your user profile by clicking profile on the menu above and choosing update profile." It also states: "Once per year, on the first use after January 1st, you will be required to agree to the Non-Disclosure agreements in order to view the associated analysis data. To do this, use the appropriate forms above and email the signed forms to kenneth.n.mitchell@usace.army.mil. Electronic signatures are allowed for the WCSC Non-Disclosure. Once signed and approved, you will be able to use the tool. If you can login, but can only see the Profile tab, then you have not been approved and need to resubmit your signed Non-Disclosure forms." A description of the tool follows: "CPT is a decision-support tool designed to help USACE operations personnel analyze the extent to which maintained navigation channels are used by commercial shipping. Analyses can be conducted for individual channels, or for a grouping of channels treated as a single project. Additionally, USACE planning personnel can use CPT to extract historical data concerning region-to-region commodity movements and consolidated statements of traffic for arbitrary listings of projects and channels." At the bottom, it says: "Questions or comments concerning CPT should be directed to Dr. Ned Mitchell at kenneth.n.mitchell@usace.army.mil. Please choose from the menu above what level of prioritization you would like to see." The browser's status bar at the bottom shows "Done" and "Local intranet".



Depth-Utilization Profiles

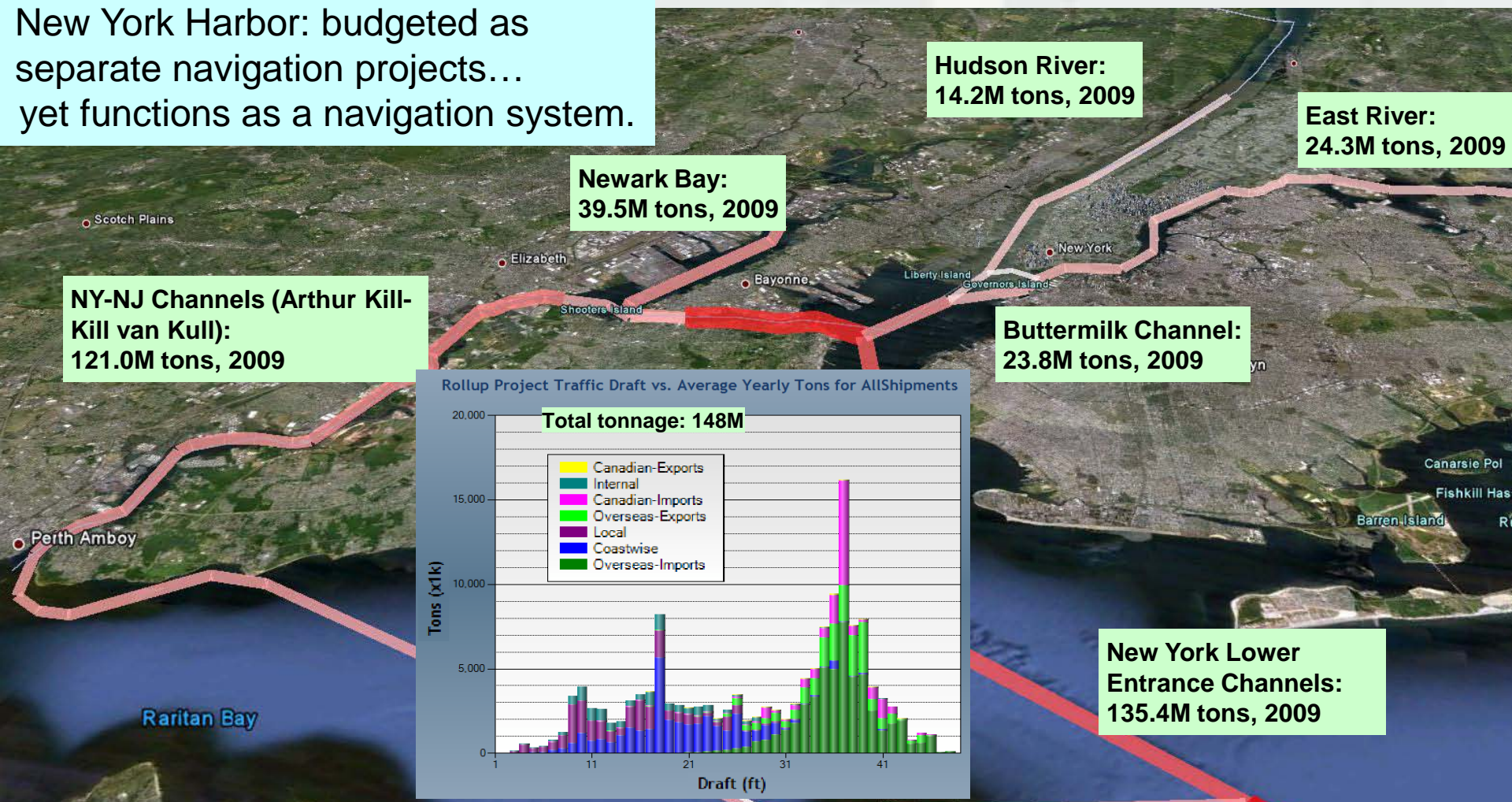
Rollup Division Commodity Draft vs. Average Yearly Tons for AllShipments



- Waste Material; Garbage, Landfill, Sewage Sludge, Waste Water (8)
- Unknown or Not Elsewhere Classified (9)
- All Manufactured Equipment, Machinery and Products (7)
- Primary Manufactured Goods (5)
- Chemicals and Related Products (3)
- Food and Farm Products (6)
- Coal, Lignite & Coal Coke (1)
- Crude Materials, Inedible Except Fuels (4)
- Petroleum and Petroleum Products (2)

CPT and Navigation Systems

New York Harbor: budgeted as separate navigation projects... yet functions as a navigation system.

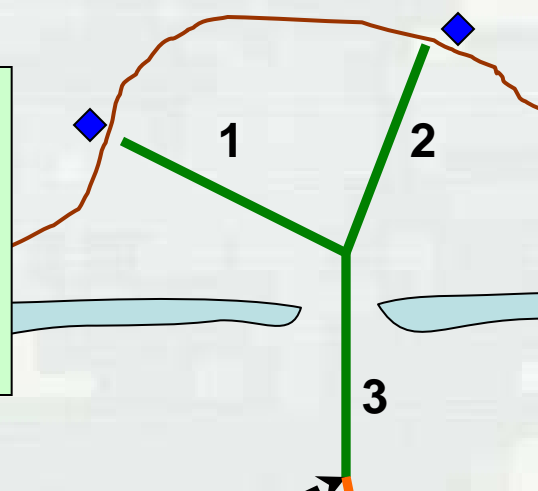


CPT is helping to ensure that Project O&M budgeting considers interdependencies across projects in addition to channel depth-utilization.

Reach	Foreign Tons	Domestic	O&M Dredging Cost
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Consider a simple "system" of two navigation projects. Dredging in each sub-reach will clear channel depths that have historically carried the tonnage levels shown.

5	1.5M	500k	\$9.0M
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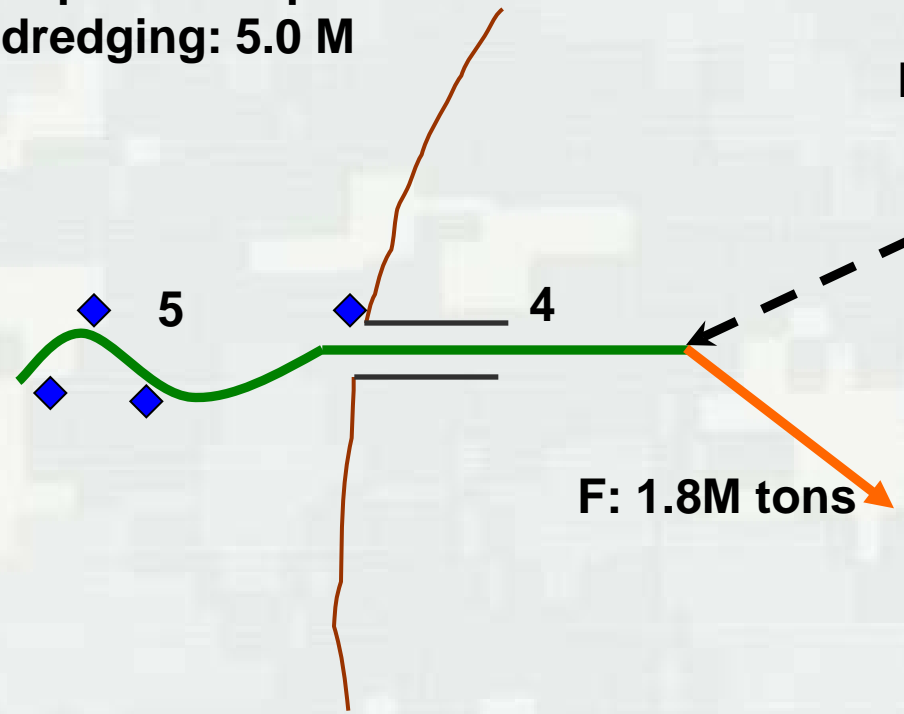


Total system tonnage dependent upon dredging: 5.0 M

O&M Budget Ceiling: \$20M

D: 700k tons

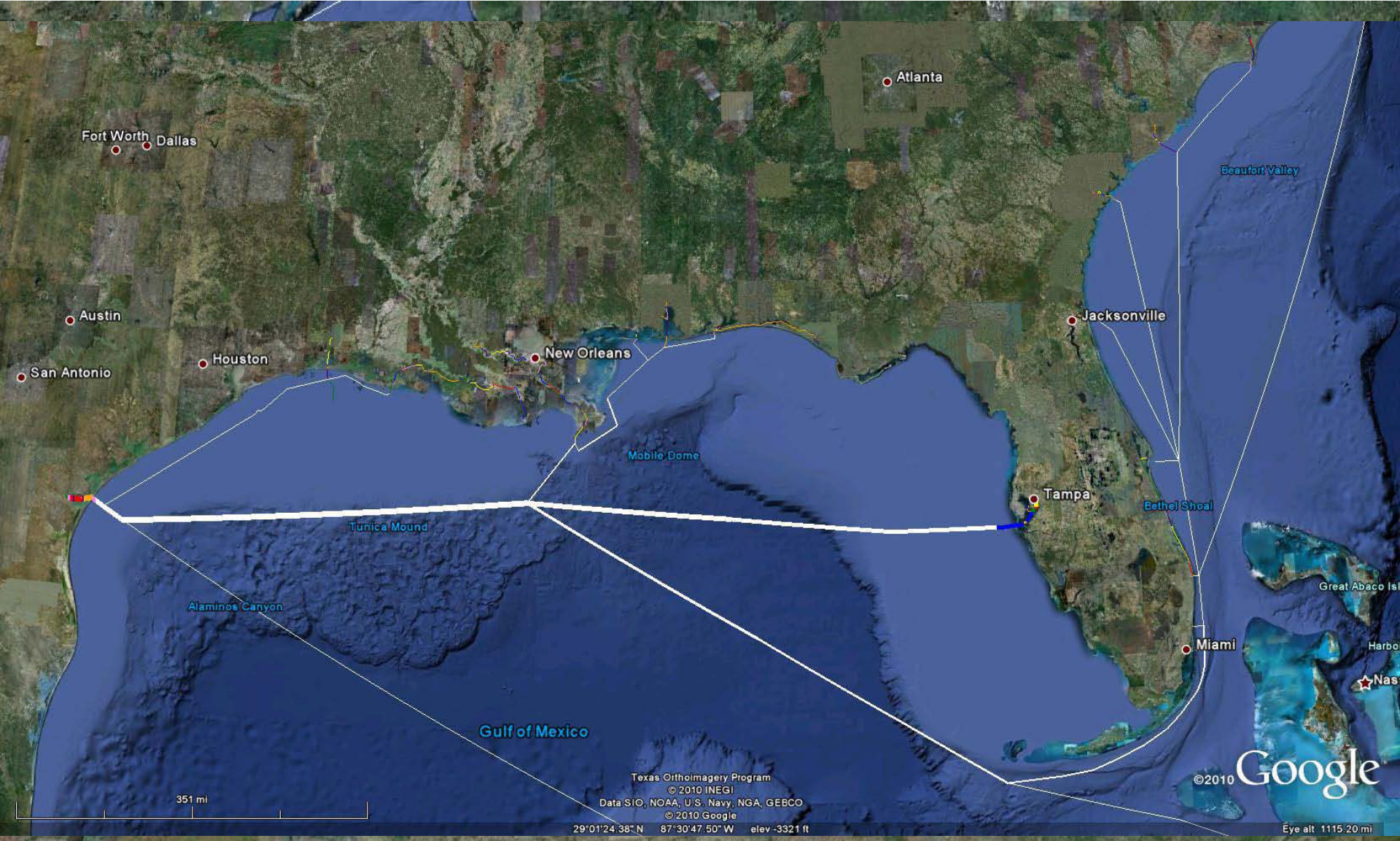
F: 2.5M tons



F: 1.8M tons

Alternatives	Supported Tonnage
Fund: 1,2,3,4 (\$19M); Don't Fund: 5	3.0M
Fund: 1,2,4,5 (\$20M); Don't Fund: 3	1.8M
Fund: 1,3,5 (\$20M); Don't Fund: 2,4	500k
Fund: 2,3,4 (\$16M); Don't Fund: 1,5	2.5M
Fund: 3,5 (\$17M); Don't Fund: 1,2,4	0.0M
Fund: 1,3,4 (\$15M); Don't Fund: 2,5	1.1M

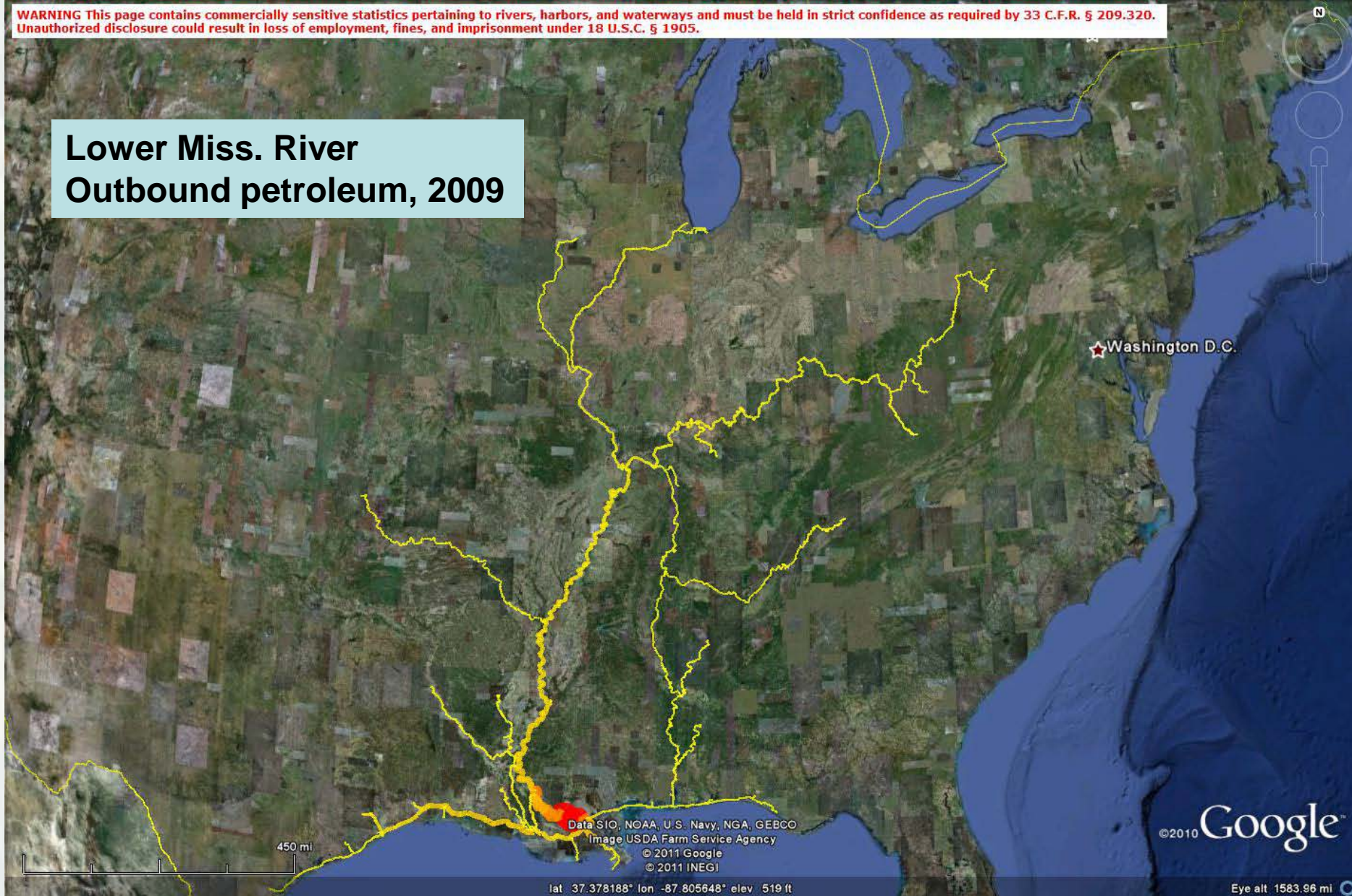
Cargo Shared Across Projects



Visualizing Commodity Flows

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**Lower Miss. River
Outbound petroleum, 2009**



Understanding Navigation Systems

WARNING This page contains commercially sensitive statistics pertaining to rivers, harbors, and waterways and must be held in strict confidence as required by 33 C.F.R. § 209.320. Unauthorized disclosure could result in loss of employment, fines, and imprisonment under 18 U.S.C. § 1905.

**Lower Miss. River
Inbound corn, 2009**

Corps O&M activities must be coordinated in order to realize system-level efficiencies and maximize benefits to the Nation.



450 mi

Data SIO, NOAA
Image USDA Farm Service Agency
© 2011 Google
© 2011 INEGI

lat 37.378187° lon -87.805648° elev 445 ft

©2010 Google

Eye alt 1584.30 mi

Mixed-Integer Program

$$\text{Max } \sum_i \sum_{j < i} b_{ij} x_{ij} \text{ (Program ORD)} \quad (1.0)$$

s. t.

$$x_{ij} \leq d_k, \quad \forall i, j: i < j, \text{ and } k \in S(i, j) \quad (1.1)$$

$$\sum_k d_k \leq x_{ij} + |S(i, j)| - 1 \quad \forall i, j: i < j, \quad (1.2)$$

$$\sum_i d_i c_i \leq B \quad \forall i, j: i < j \quad (1.3)$$

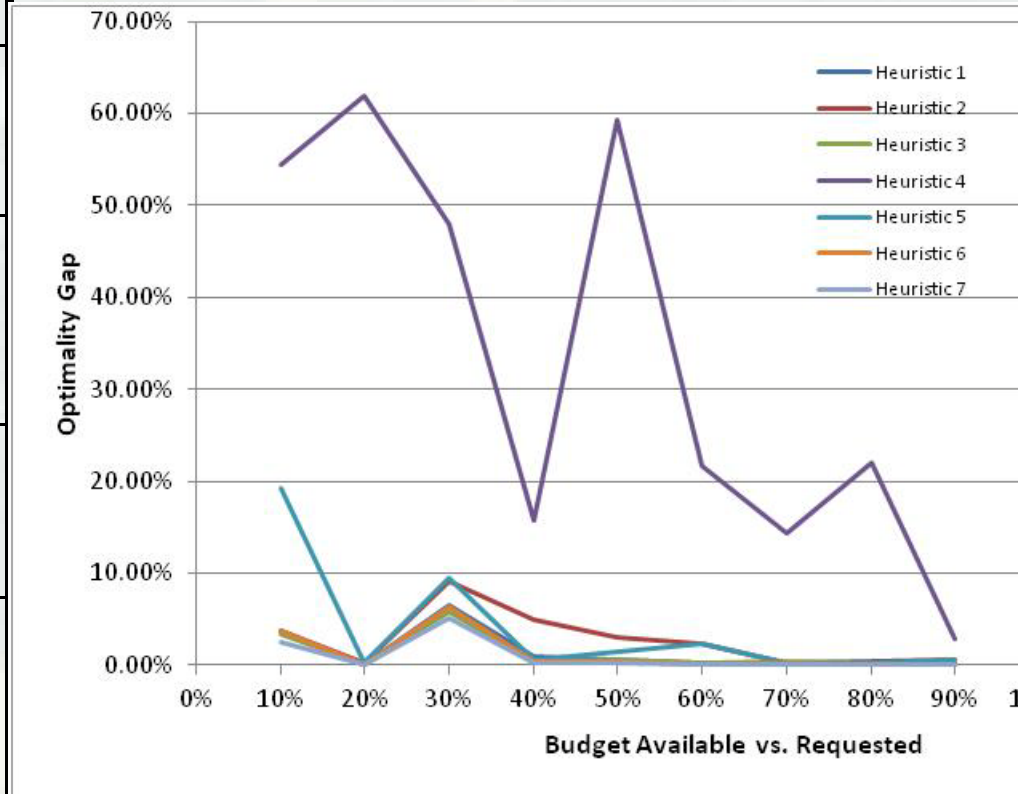
$$d, \text{ binary for all } i; \quad x_{ij} \geq 0, \text{ for all } i, j. \quad (1.4)$$

- x_{ij} = Objective function variable, which is 1 when both port i and j are dredged for the improved benefits; 0, otherwise, where $i \neq j$,
- d_i = Binary decision variable, which is 1 when port i is selected to dredge; 0, otherwise,
- b_{ij} = The maximum increase in the direct capacity between i and j by dredging both port i and j ,
- c_j = The cost for dredging port j ,
- B = The total amount of budget available for dredging projects for a planning period.
- $S(i, j)$ = Set of all projects that are necessary to realize the benefit of b_{ij} . $\{i, j\} \setminus \text{in } S(i, j)$. For example, if a flow from i to j goes through port l, k, m, j , $S = \{i, k, m, j\}$.



Heuristic Measures

Heuristic	Benefit/cost Ratio or other criteria for project k
1	$\frac{\sum_{(i,j):k \in S(i,j)} b_{ij}}{2c_k}$
2	$c_k + \frac{\sum_{(i,j):k \in S(i,j)} b_{ij}}{\sum_{(i,j):k \in S(i,j), i \neq k, j \neq k} (c_i + c_j)}$
3	$\sum_{(i,j):k \in S(i,j)} \frac{b_{ij}}{\sum_{m \in S(i,j)} c_m}$
4	$\frac{c_k \cdot \sum_{(i,j):k \in S(i,j)} b_{ij}}{(c_k + \sum_{\substack{m \neq k \\ m, k \in S(i,j)}} c_m)}$
5*	Dynamic H2
6*	Dynamic H3
7*	MAX{H1,H2,...,H6}



**Budget
Scenario: 6**



Alternate Budget Scenarios

A		B							H	I	J	K			
													I	J	K
	St. Joseph Harbor	\$	2,100						0	0	0	0			
	St. Marys River	\$	3,300						1	1	1	1			
	Straits of Mackinac	\$	2,600						1	1	1	1			
	Turgeon Bay and Lake	\$	3,800						0	0	0	0			
	Michigan Ship Canal												Scenario6	Scenario7	Scenario8
	Tacoma Harbor	\$	2,600						1	1	1	1			
	Traverse City Harbor	\$	2,600						0	0	0	0			
	Tua Harbors (Agate)	\$	3,100						1	1	1	1	5,000,000.00	\$500,000,000.00	\$600,000,000.00
	Warroad Harbor	\$	2,100						0	0	0	0			
AS	Big Sandy Harbor	\$	2,100						1	1	1	1	1	1	1
	Elk River Harbor	\$	3,300						0	0	0	0			
E	Kanawha River	\$	600						1	1	1	1	1	1	1
	Little Kanawha River	\$	2,100						0	0	0	0			
CL	Murkingum River	\$	2,600						0	0	0	0	1	1	1
	Ohio River - LRH	\$	600						1	1	1	1	1	1	1
Cc	Green and Barron	\$	600						1	1	1	1	1	1	1
	Kentucky River	\$	1,600						0	0	0	0			
D	Lau Ure - LRL	\$	2,100						0	0	1	1	0	0	0
	Ohio River - LRL	\$	2,600						1	1	1	1	1	1	1
	Barkley Canal	\$	3,300						1	1	1	1	1	1	1
F	Cumberland and Clinch River	\$	2,100						0	0	0	0	1	1	1
	Cumberland River	\$	2,100						1	1	1	1	1	1	1
I	Cumberland River	\$	2,600						1	1	1	1	1	1	1
	Elk River	\$	1,800						0	0	0	0	1	1	1
	Emory River	\$	2,600						0	0	0	0	1	1	1
	Halston River	\$	2,600						0	0	0	0	1	1	1
	Lan-Project (French Road and Little Pigeon)	\$	2,100						0	0	0	0	1	1	1
L	Lan-Project (Hiwassee)	\$	600						0	0	0	1	0	0	0
New	Obian River	\$	3,300						0	0	0	0	0	0	0
	Tennessee River	\$	2,100						1	1	1	1	0	0	0
	Allegheny River	\$	2,100						0	0	0	0	0	0	0
	Allegheny River Open	\$	3,300						0	0	0	0	0	0	0
	Mananqahela River	\$	3,600						1	1	1	1	0	0	0
	Ohio River - LRP	\$	2,100						1	1	1	1	0	0	0
O	Yaughqahony River	\$	2,600						0	0	0	0	1	1	1
	Lower Mississippi River	\$	2,100						1	1	1	1	1	1	1
Rocl	Momphir Harbor	\$	2,100						1	1	1	1	1	1	1
	Lan-Project (Pidqoon)	\$	2,100						0	0	0	0	0	0	0
S	ST. Francis and 'Anauille Rivers and	\$	2,100						0	0	0	0	0	0	0
Se	White River below	\$	3,300						0	1	1	1	1	1	1
	Wolf River	\$	2,600						1	1	1	1	1	1	1
	Timite River and Bayau	\$	2,600						0	0	0	0	1	1	1
Tor	Atchafalaya River	\$	1,800						0	0	0	1	0	0	0
	Atchafalaya River	\$	2,100						0	0	1	1	0	0	0
	Maroon City to Gulf of								0	0	0	0			
	Barataria Bay	\$	600						0	0	0	0			
	Batan Rouge Harbor	\$	2,100						0	0	1	1			
	Bayau Baouff	\$	2,100						0	0	0	0			
	Bayau Banfauca	\$	2,600						0	0	0	0			
	Bayau Dupre	\$	2,100						0	0	0	0			
	Bayau Graze Tate	\$	2,100,000	148	0	0	0	0	0	0	0	0			



Frequently-Funded Projects

Ashtabula Harbor
Buffalo Harbor
Conneaut Harbor
Erie Harbor
Sandusky Harbor
Toledo Harbor
Indiana Harbor
Channels in Lake St. Clair
Detroit River
Duluth-Superior Harbor
Rogers City, MI
Rouge River, MI
St. Clair River
St. Marys River
Straits of Mackinac
Two Harbors (Agate Bay)
Big Sandy Harbor
Kanawha River
Ohio River – LRH
Ohio River - LRL
Cumberland River Nashville
Tennessee River
Monongahela River
Ohio River - LRP
Lower Mississippi River - MVM
Calcasieu River and Pass
GIWW - MVN
Lower Mississippi River – MVN
Illinois Waterway
Upper Mississippi River -MVR
Upper Mississippi River - MVS
Upper Mississippi River - MVP

Baltimore Harbor
Boston Harbor
Kennebec River, ME
New Haven Harbor
Portland Harbor
Portsmouth Harbor
Buttermilk Channel
New York and New Jersey Channels
New York Harbor
Channel to Newport News
Newport News
Norfolk Harbor
Thimble Shoal Channel
York River
Delaware River Between Philadelphia
Delaware River, Philadelphia to the Sea
Missouri River - NWK
Columbia and Lower Willamette Rivers
Columbia River above The Dalles Dam,
Columbia River between Vancouver, WA
and The Dalles, OR
Multnomah Channel
Oregon Slough
Yaquina Bay and Harbor
Grays Harbor and Chehalis River
Tacoma Harbor
Columbia R. and Trib above McNary
Snake River
Homer
Humboldt Harbor
Kodiak Harbor
Unalaska Island

Honolulu Harbor
Charleston Harbor
(Puerto Rico) - Fajardo Harbor
(Puerto Rico) - Ponce Harbor
Canaveral Harbor
Jacksonville Harbor
Miami Harbor
Palm Beach Harbor
Port Everglades Harbor
Tampa
Bayou La Batre
Black Warrior and Tombigbee Rivers
Gulfport Harbor
Mobile
Pascagoula Harbor
Pensacola Harbor
Three Mile Creek
Brunswick Harbor
Savannah Harbor
Morehead City Harbor
Northeast (Cape Fear) River
Wilmington Harbor
Los Angeles - Long Beach Harbors
Port Hueneme
San Diego Harbor
Brownsville
Corpus Christi Ship Channel
Freeport Harbor
Galveston Harbor and Channel
Houston Ship Channel
Matagorda Ship Channel
Sabine-Neches Waterway



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Questions?

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