Optimizing Freight Transportation System Performance

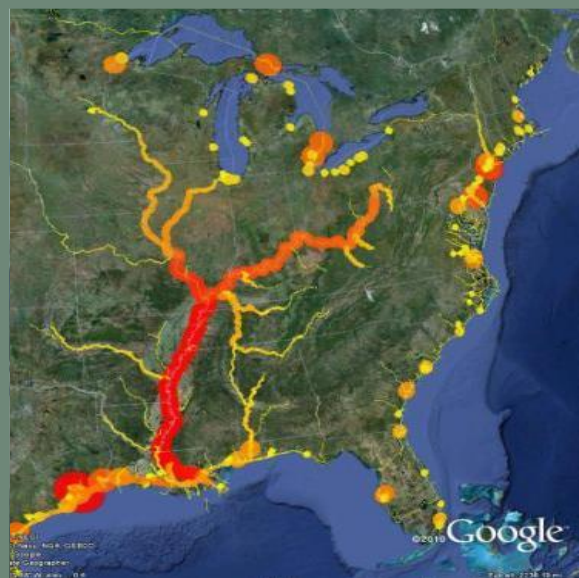
ERDC
Engineer Research and Development Center

Ned Mitchell, PhD

Research Civil Engineer
Coastal and Hydraulics Lab

CMTS-TRB
Washington, DC
June 25th, 2014

US Army Corps of Engineers®



Some Key Points

- The dynamic freight flows through ports, waterways, and the intermodal network are as much a part of the MTS as the physical infrastructure itself.

- When using performance metrics, important to not lose sight of the system-level considerations, across time, space, and again, the freight-infrastructure synthesis.

- Optimization approaches require either a suitable model (i.e. appropriately understood system) or sufficient data to capture system responses to change.

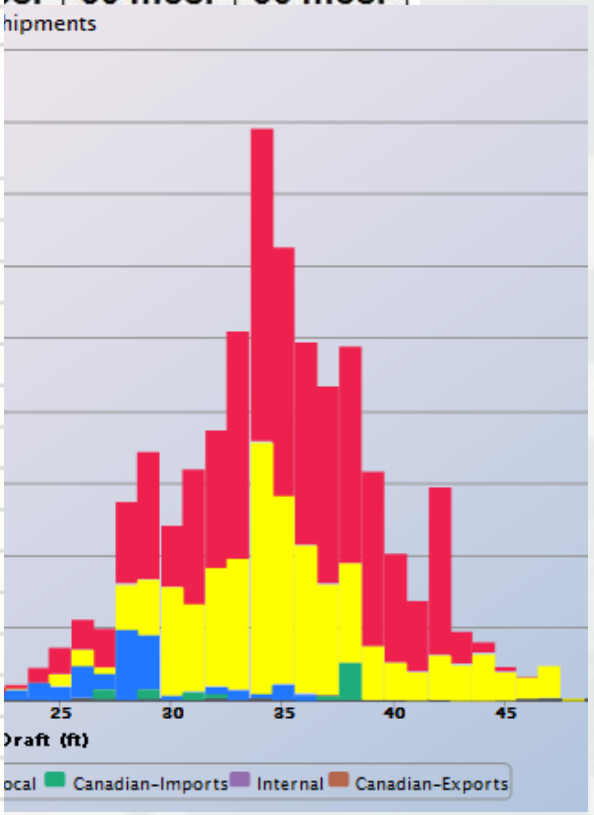
Dredging Work Package Formulation

Target ft (MLL	Draft, ft	Time (Years) 1	1.5	2	2.5	3	3.5	4
-45								
-43								
-41								
-39	45	47.0	39.5	32.2	27.8	25.5	24.6	25.4
-37	44	56.3	48.0	38.0	32.1	29.0	27.7	28.6
-35	43	70.2	60.9	46.3	37.8	33.5	31.7	32.7
-33	42	76.3	71.6	54.1	43.0	37.5	35.1	36.1
-31	41	83.2	86.3	64.9	49.7	42.4	39.1	40.0
-29	40	65.6	73.2	56.8	42.6	35.6	32.6	33.1
-27	39	51.0	62.1	50.2	36.7	29.9	27.0	27.3
-25	38	38.8	49.1	42.4	31.2	24.8	22.1	22.2
-23	37	32.9	43.6	40.7	30.1	23.3	20.4	20.4
-21	36	28.2	38.3	38.0	29.1	22.3	19.1	18.9
-19	35	22.9	31.9	34.1	27.1	20.4	17.1	16.8
-17	34	19.3	27.5	30.6	25.6	19.5	16.1	15.7
	33	15.9	23.0	26.9	23.8	18.5	14.9	14.3
	32	13.8	20.3	24.3	22.7	18.2	14.6	13.8
	31	11.8	17.5	21.5	21.5	17.8	14.3	13.3
	30	10.0	14.9	18.7	19.5	16.8	13.7	12.6
	29	7.5	11.3	14.5	15.7	14.4	11.9	10.8
	28	5.8	8.6	11.3	12.5	12.0	10.3	9.4
	27	4.9	7.4	9.8	11.2	11.4	10.1	9.2
	26	4.0	6.1	8.1	9.4	9.9	9.2	8.5

Table 3. Pseudo BCR (tons/$ (dredging cost))

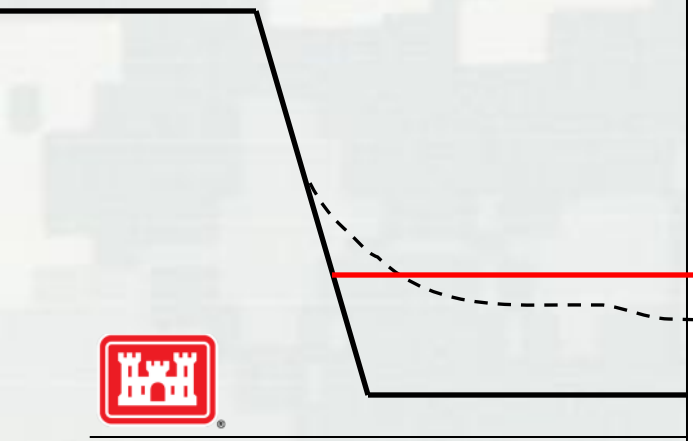
reach specified depth

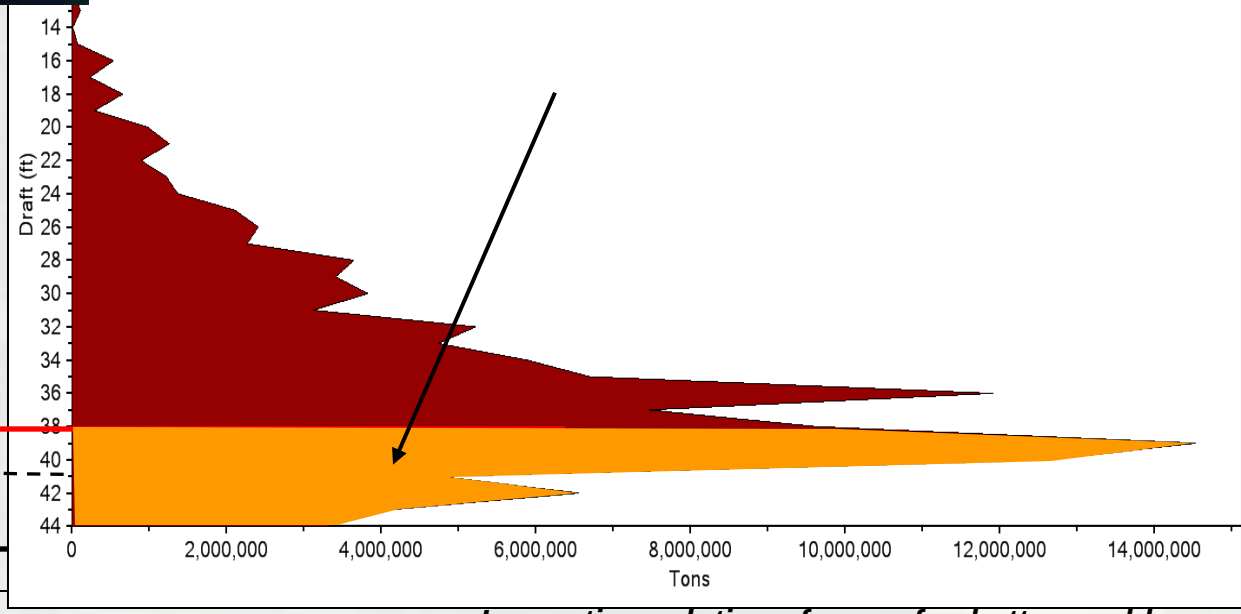
...s.	30 mos.	36 mos.



Depth Utilization Data

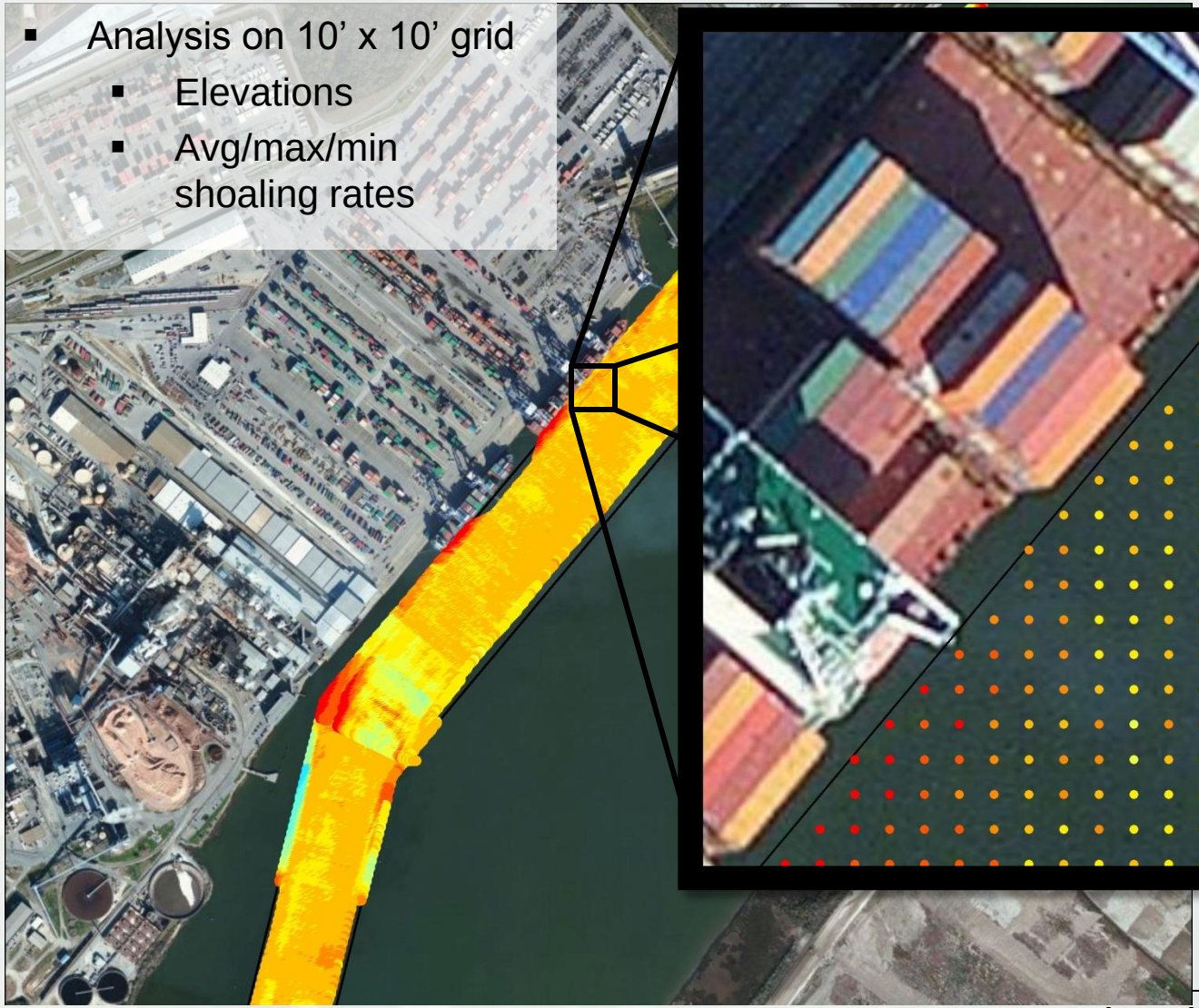
Via Waterborne Commerce data, CPT can generate depth-utilization profiles showing the distribution of cargo across the range of maintained depths for any system of navigation channels.





Detailed Shoaling Data

- Analysis on 10’ x 10’ grid
  - Elevations
  - Avg/max/min shoaling rates



Dredge Fleet Scheduling

- USACE dredging jobs are contracted at the District level
- Industry and Corps-owned dredges are selected based on cost, availability, and ability to execute project dredging requirements.
- Dredging at any one project must be completed during local environmental windows.

Fleet Scheduling Optimization

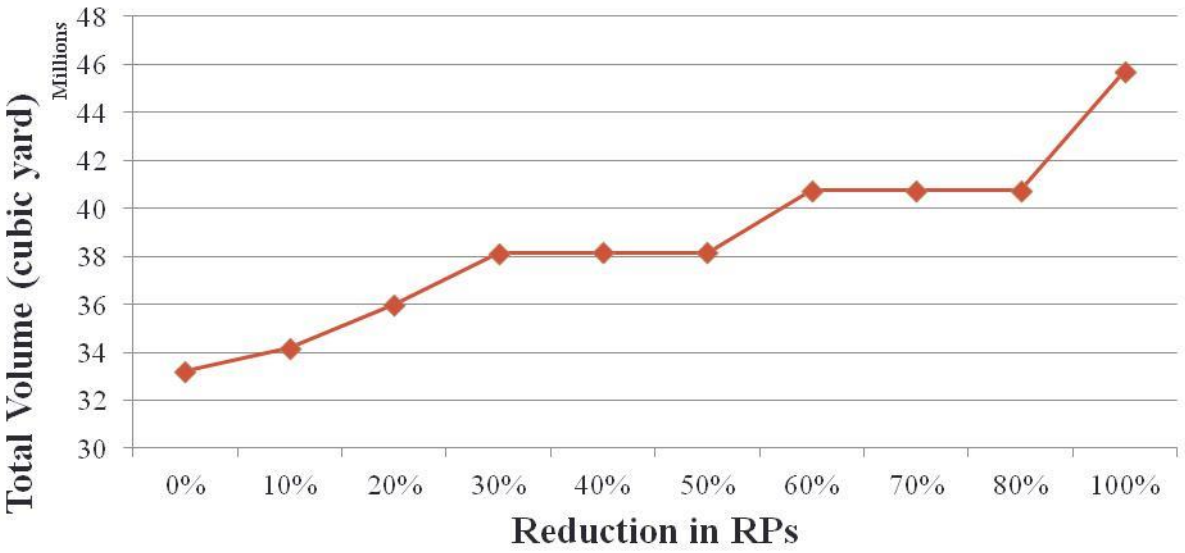
- Constrained resource scheduling problem
- Daily scheduling over a one year planning horizon
- Objective function
  - Minimize total number of active dredge days (dredge time + travel time) to dredge all projects → surrogate for costs
- Model Constraints
  - Each project assigned to a single dredge
  - Dredge can only be assigned to one project at a time
  - Dredge may not work on a project during any applicable restricted period

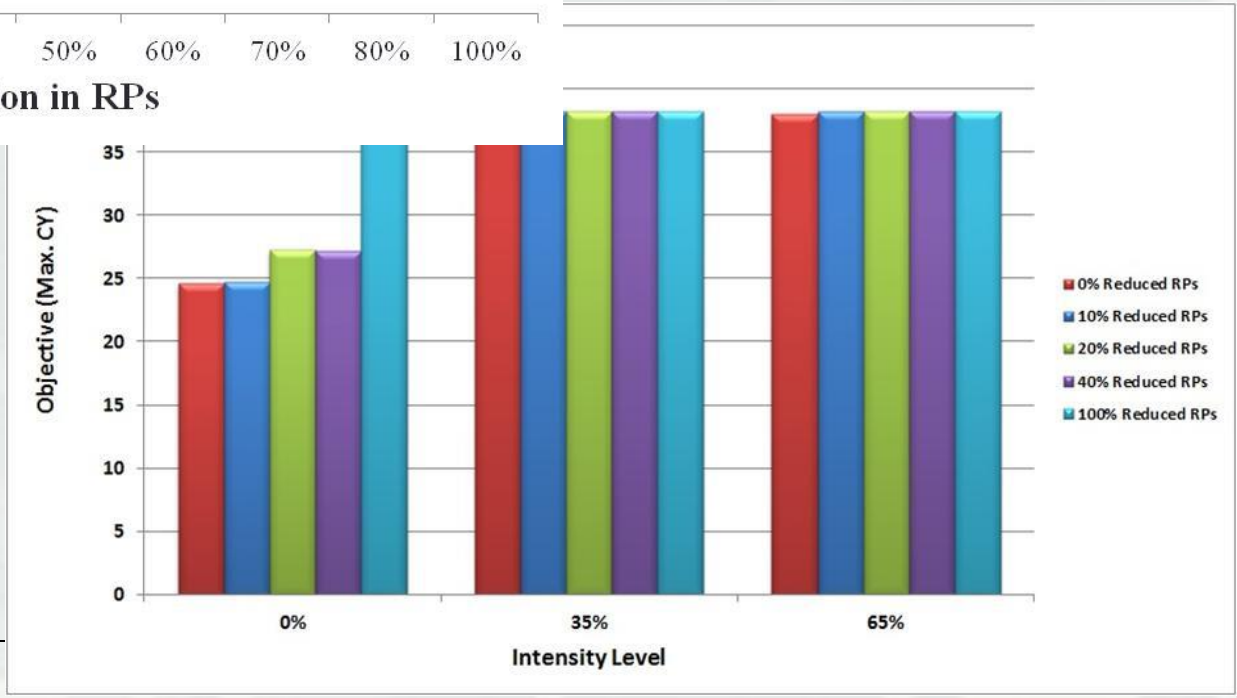
Fleet Scheduling Data Requirements

- Dredging Information System (DIS) used to parameterize dredges and project dredging requirements: http://www.ndc.iwr.usace.army.mil/data/datadrgsel.htm
  - Each dredge given a daily production rate (CY/day)
  - Each project given an average annual dredging requirement (CY)
  - Details concerning contract type, regional unit costs, and seasonal production factors not yet considered in model.

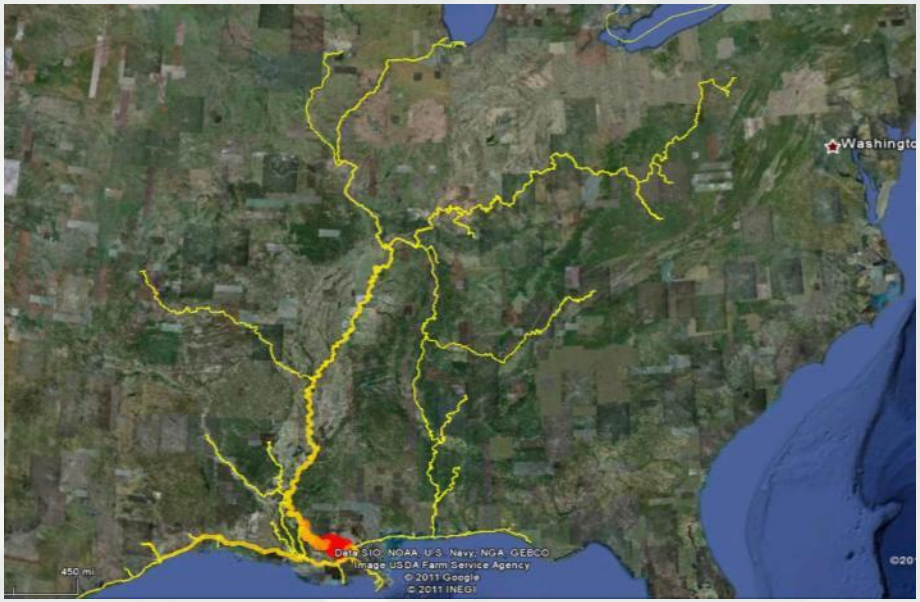
- USACE Threatened, Endangered, and Sensitive Species Protection and Management System used to establish project-level scheduling constraints: http://el.erdc.usace.army.mil/tessp/

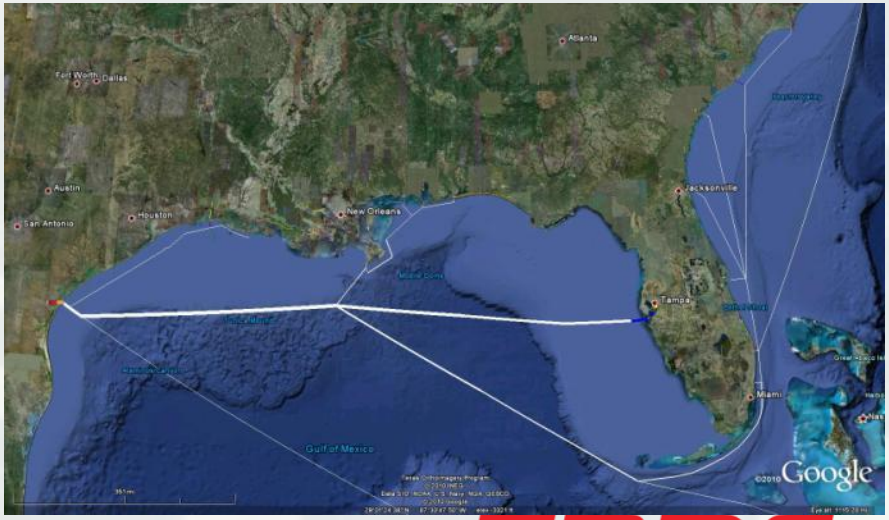
Sensitivity Analysis on Env. Restrictions





Origin-Destination Freight Flows





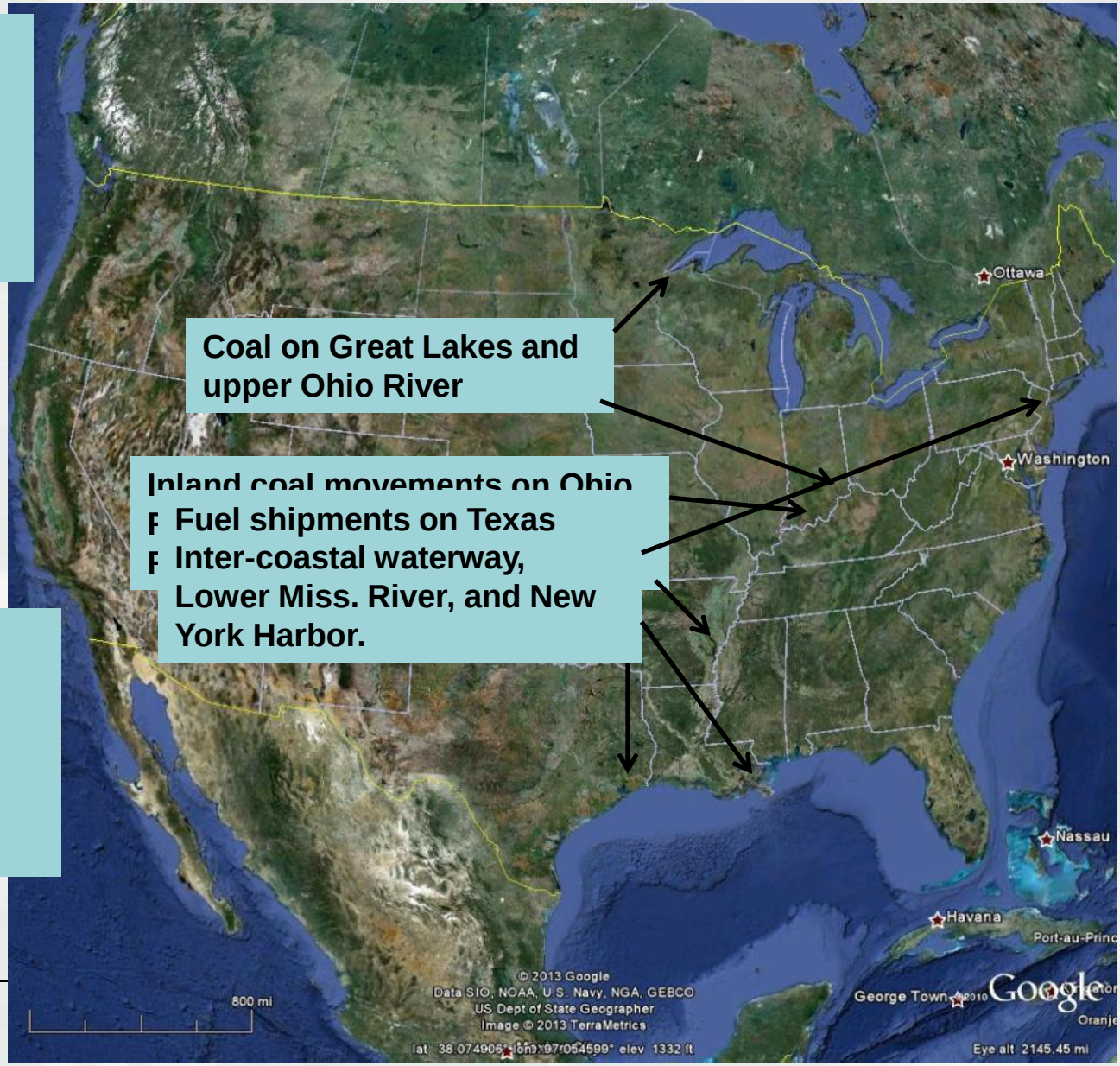
The O-D flows within the WCSC data allow the Corps to evaluate navigation project interdependencies.

This in turn allows for systems-based optimization approaches.

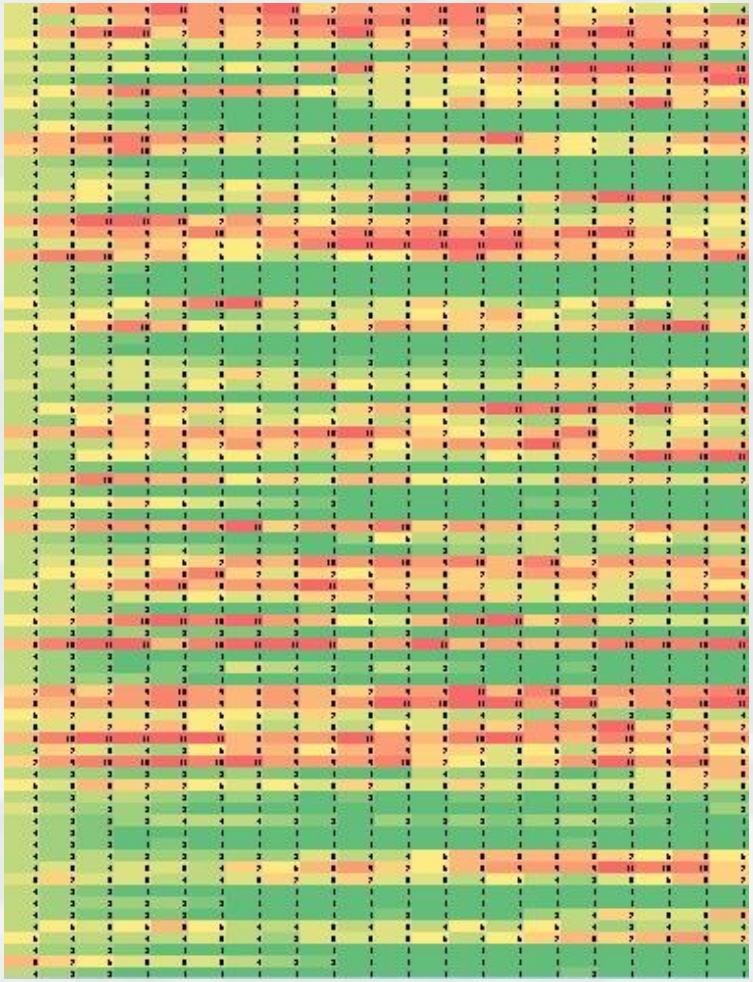
Freight Systems Optimization Example

Formulation includes origin-destination pairs, associated routes, cargo tonnage, and maintenance costs.

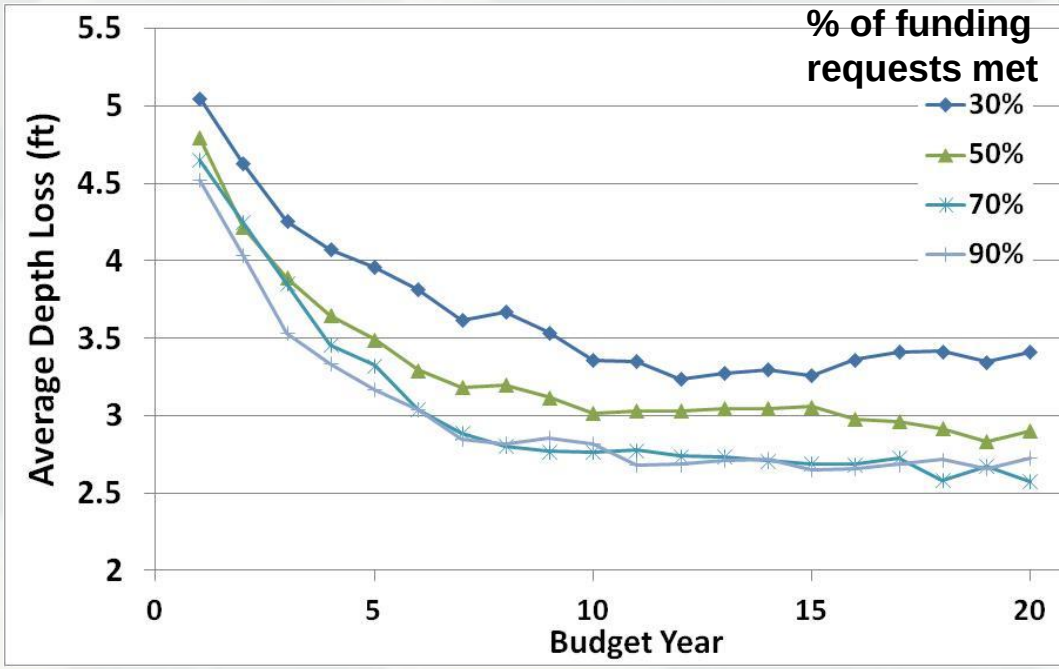
Sample Formulation - Domestic energy commodities (coal and petroleum products): Budget Scenario 13



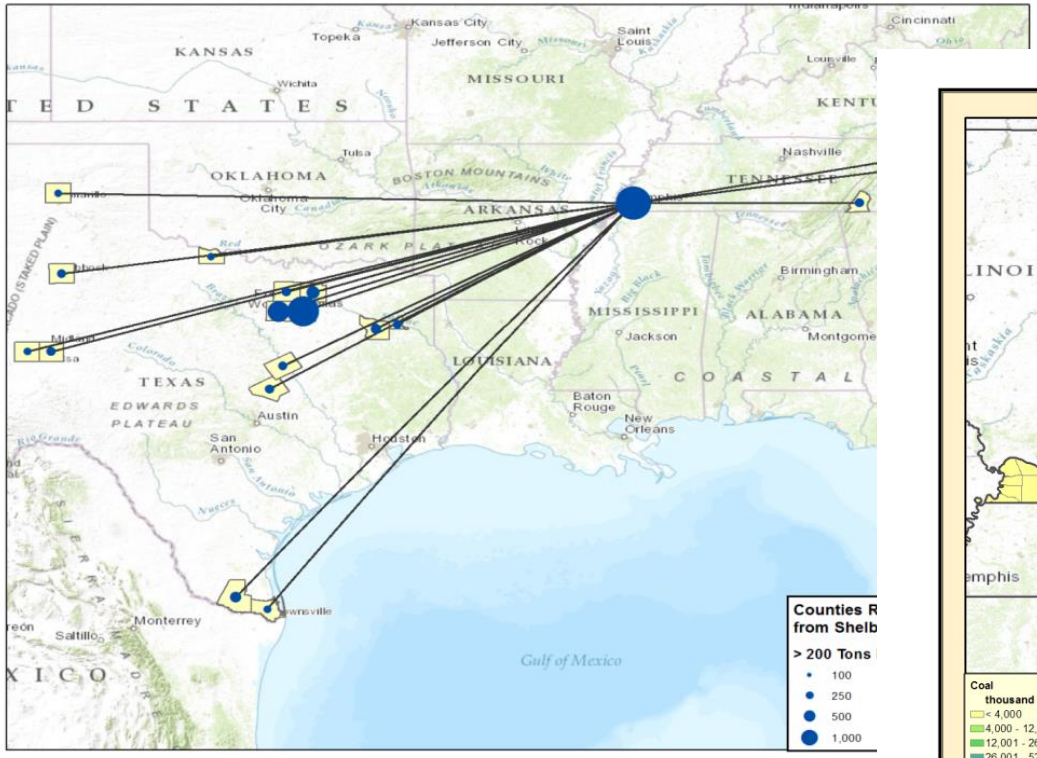
Life Cycle O&M Dredging Optimization

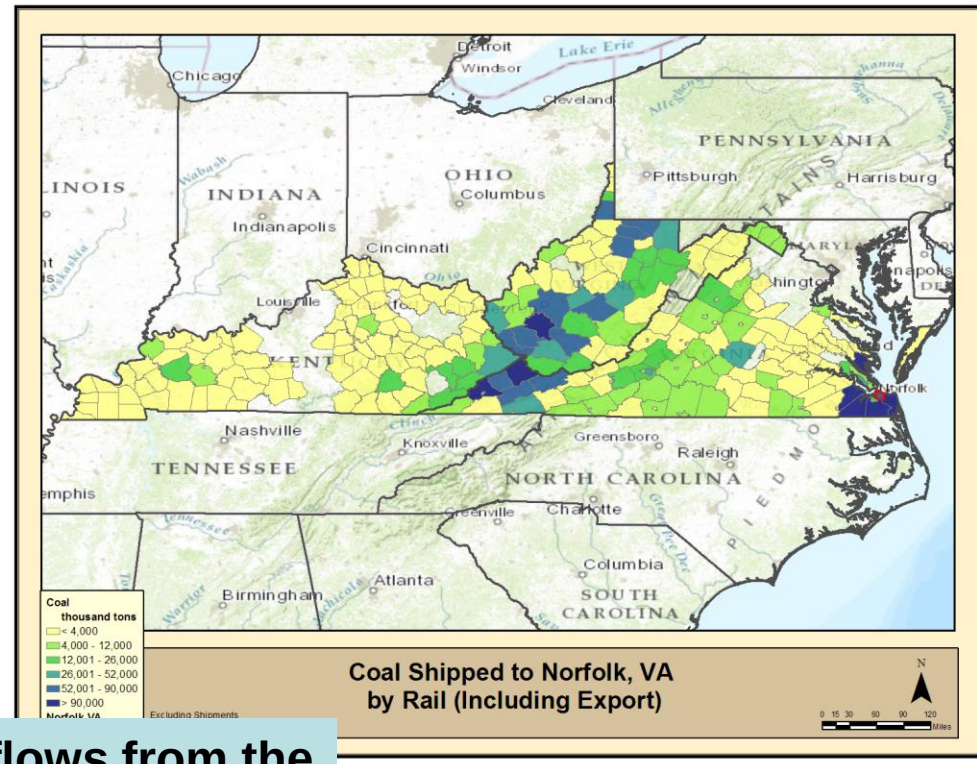


Optimal "sequencing" of maintenance dredging can potentially lead to overall efficiency gains.



ERDC-ORNL Partnership





County-level landside flows from the Freight Analysis Framework (FAF) allow the approach to be extended.

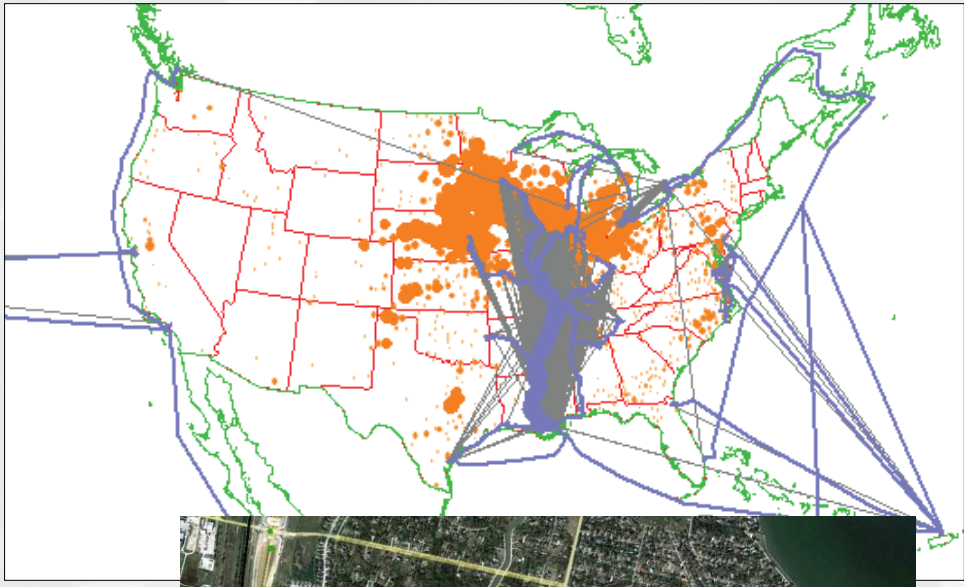
Insight concerning landside capacity constraints.

Towards Freight Fluidity Analysis

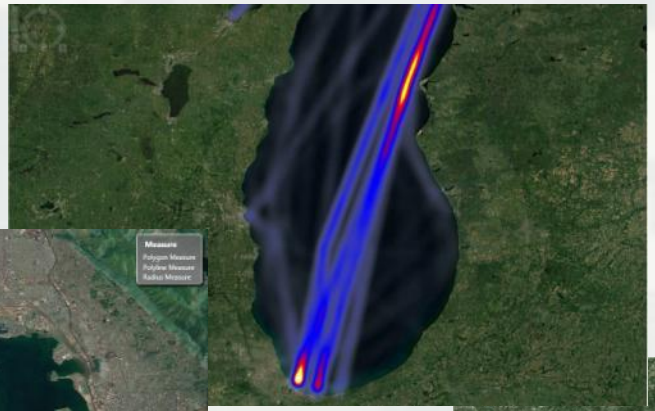
- **Ultimately we seek a means of evaluating the performance of entire intermodal freight supply chains.**

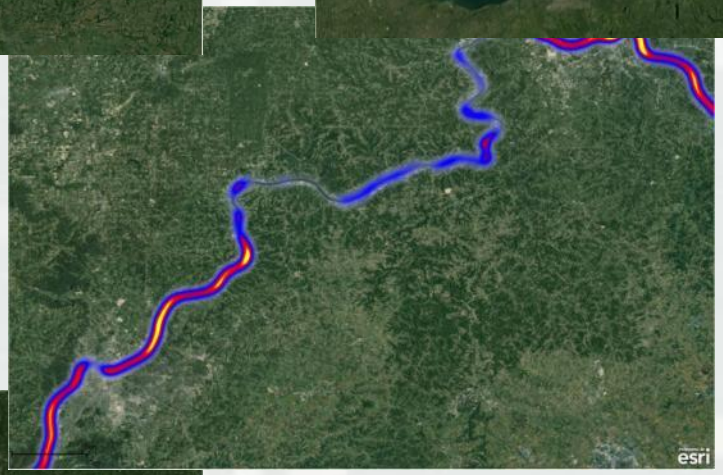
- **Data from across the spectrum help inform this process.**

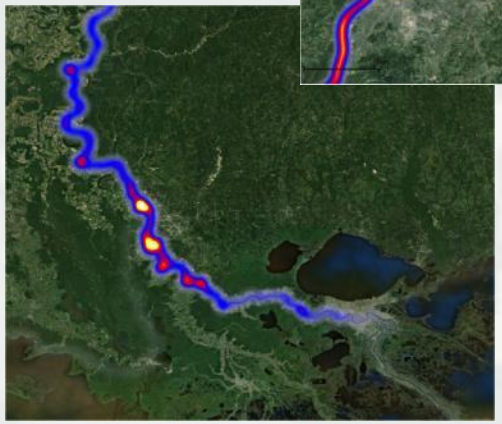
- **Opportunity to merge AIS and GPS probe datasets with traditional reported data to provide a more complete picture of intermodal freight fluidity.**

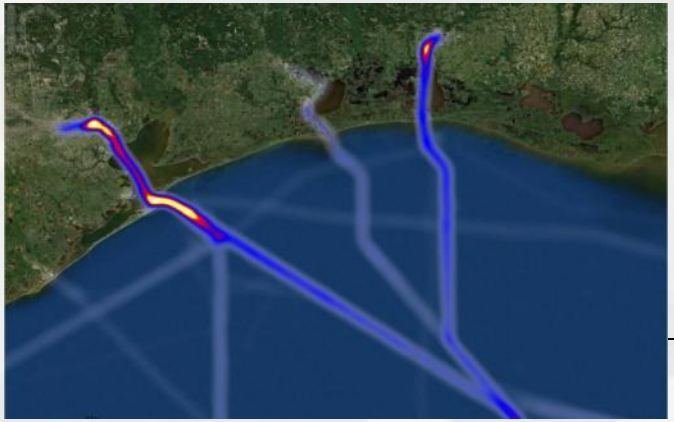


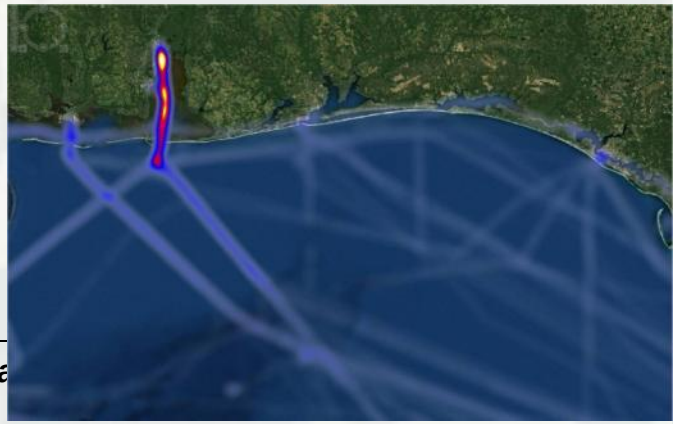
Performance Monitoring via AIS











Performance Monitoring via AIS

- **Automatic Identification System Analysis Package (AISAP)**
  - traffic densities
  - O-D travel times, dwell times
  - fleet characteristics, movements and seasonal variations
  - system response to disruptions
  - Tidal dependence
  - incident investigations
- **Analyses are *scalable* across time and space, so single channels can be monitored for a few hours, or entire coasts can be monitored for years.**