Recent Coastal Structures Asset Management Activities of the Great Lakes Districts of the US Army Corps of Engineers

- USACE Campaign Plan Objective 3c: Deliver reliable infrastructure using a risk-informed asset management strategy.
- LRD Implementation Plan – Goal 3c.1.d

Fully Integrate Asset Management into the Great Lakes Navigation System

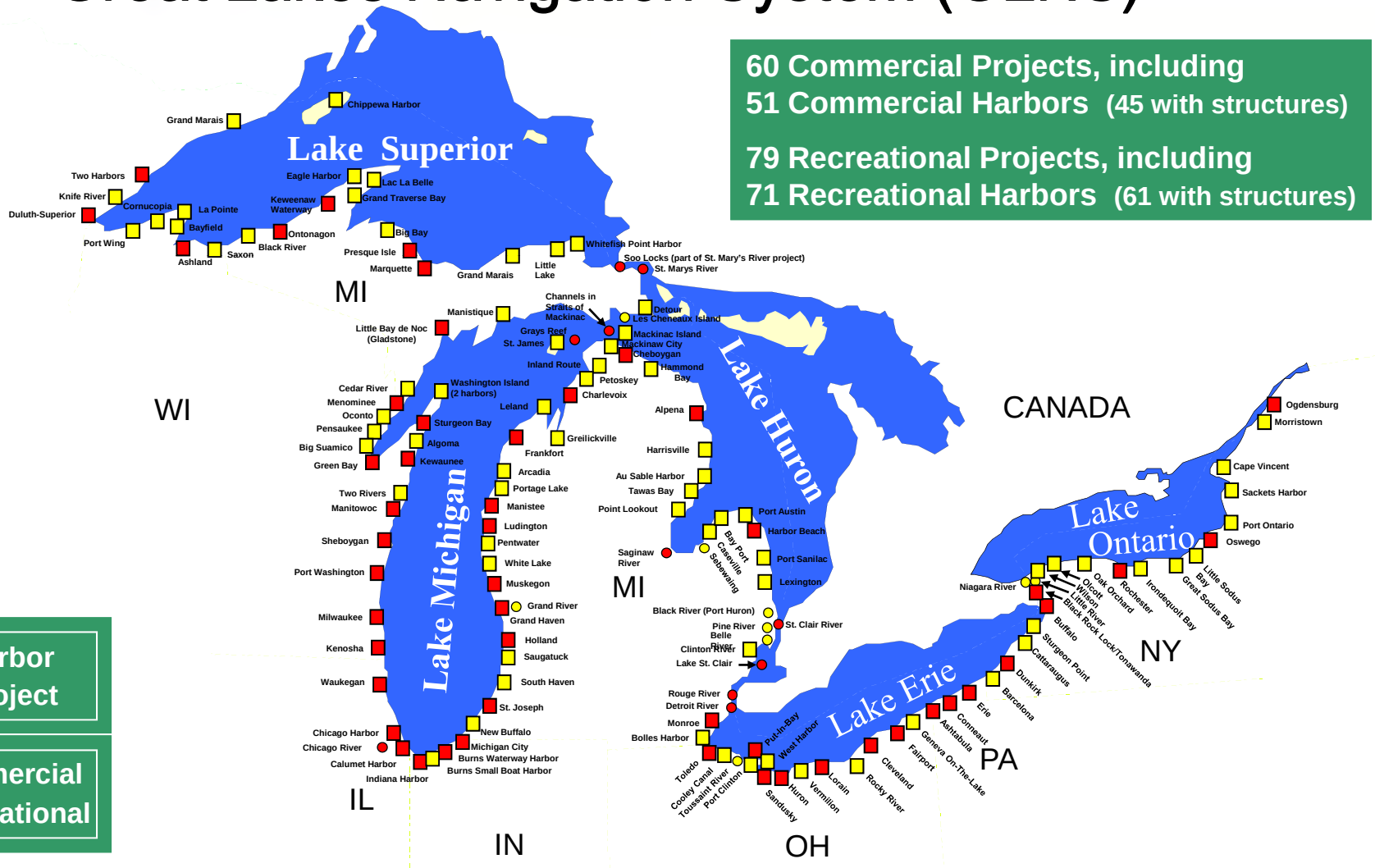
1. Condition Assessments
2. Establish meaningful relationship between condition and structure function, w/ economic consequences

- Navigation Locks and Dams are being addressed separately.

Great Lakes Navigation System (GLNS)

60 Commercial Projects, including
51 Commercial Harbors (45 with structures)

79 Recreational Projects, including
71 Recreational Harbors (61 with structures)



Fed. Harbor
Fed. Project

Commercial
Recreational

Condition Assessments
Where We Are Today

- Great Lakes Regional Breakwater Assessment Team (BAT), including members from LRB, LRC, LRE, Coastal Engineering RTS
- Utilizing modified inspection/structural index forms developed from REMR-OM-24 (Rubble Mound Structures) and REMR-OM-26 (Non-Rubble structures) and guidance in CEM (EM 1110-2-1100, Part VI, Chapter 8 - Monitoring, Maintenance, and Repair of Coastal Projects)
- Assessment of major structure components/parameters – most direct link to structure function
- Converting structural index value to A thru F condition level required per budget EC for Navigation Business Line
- Collecting complete continuous overlapping still photography and video of each structure at each project. Photos are labeled and geotagged for easy reference in Google Earth.

Structural Rating for Rubble or Laid-Up Breakwaters and Jetties

PROJECT NAME: Oswego Harbor, NY		Reach: B
STRUCTURE NAME: West Arrowhead Breakwater		Sta: From 0 To 27
INSPECTION TEAM: Great Lakes Regional Breakwater Assessment Team NAME / OFFICE SYMBOL / PHONE: P. Bijhouwer LRB (716) 879-4377 M. Mohr LRB (716) 879-4168 S. Chader LRB (716) 879-4188 C. O'Connell LRB (716) 879-4143 T. Kroll LRC (716) 879-4188 T. O'Bryan LRE (616) 842-5510 x 25523 D. Wright LRE (313) 226-3573	DATE: 23-Oct-2008	TIME: Begin 0700 End 1600

WAVE HEIGHT (ft) DAY OF INSPECTION:

WAVE ACTION ON STRUCTURE:
A. Overtopping
B. Non-overtopping

WATER LEVEL:
A. High B. Medium C. Low
Beginning Stage: _____ feet
Ending Stage: _____ feet

WEATHER DAY OF INSPECTION:
A. Fair B. Rain
C. Fog D. Storming

TYPE OF INSPECTION: ☑ WALKING ☑ BOATING ☐ OTHER _____ (CIRCLE)

Structural Rating for Rubble or Laid-Up Breakwaters and Jetties

RATING CATEGORIES: Rate all Items (Circle applicable lettered items)	CREST / CAP CR			SEASIDE (or HEAD) SE			CHANNEL / HARBOR SIDE CH		
	Rating 1-5	Damage Length	Comment Numbers	Rating 1-5	Damage Length	Comment Numbers	Rating 1-5	Damage Length	Comment Numbers
Breach: (A) Displaced Cap/Armor (B) Settling Cap/Armor	5	1000	2,(A),(B)						
Core (or Underlayer) Exposure/Loss	5	2700	1	4		1	4		1
Armor Loss: (A) Displaced (B) Settling (C) Bridging	4	1000	2,(A),(C)	4	1000	2,(A),(C)	3		2,(A),(C)
Loss of Armor Contact / Armor Interlock	4	1000		4	1000		4	1000	
Armor Quality Defects: (A) Rounding (B) Cracking (C) Spalling (D) Fracturing	2			3			3		
Slope Defects: (A) Steepening (B) Sliding				3	1000	3	3		3

Rating Guide: If rating ≥4, measure length of damage area and enter in the second column.		
Rating	Damage Condition Level	Description
1	Insignificant	No significant defects - only minor defects or deterioration are evident.
2	Minor	Deterioration is clearly evident, but the structure still appears sound.
3	Moderate	Structure is showing deterioration that may require attention in near future and progression of damage should be monitored & documented. **Any rating of 3 or greater may indicate a need for further investigation.**
4	Serious	A portion of the reach has deteriorated to a condition that repairs are indicated.
5	Failed	General failure of reach.
U	Unknown	Insufficient information is available to rate element
N	Not Present / Not Applicable	Element not present or not applicable to structure
NOTE: Rating descriptions will be defined in follow-up documentation.		

Modified for use by LRD Great Lakes Regional Breakwater Assessment Team – P. Bijhouwer
2008.11.05 GL-BAT STRUCTURAL RATING TABLE - Rubble or Laid-Up.doc

FRONT

Structural Rating for Non-Rubble Breakwaters and Jetties

RATING CATEGORIES: Rate all Items	SUPER-STRUCTURE SP			SUB-STRUCTURE SB			FOUNDATION-STRUCTURE FN		
	Rating 1-5	Damage Length	Comment Number / Deficiency	Rating 1-5	Damage Length	Comment Number / Deficiency	Rating 1-5	Damage Length	Comment Number / Deficiency
Elevation / Alignment	3	4760'	1-a,b,c,d	3	4760'	4-b,c,d			
Structural Integrity	4	4760'	2-b,c,d,g	4	4760'	5-b,c,g	U		
Material	4	4760'	3-b,c,d	4	4760'	6-b,c,	U		
Fill				U					
Scour/Wave Protection							U		
Foundation Soils Support							U		

Rating Guide: If rating ≥4, measure length of damage area and enter in the second column.		
Rating	Damage Condition Level	Description
1	Insignificant	No significant defects - only minor defects or deterioration are evident.
2	Minor	Deterioration is clearly evident, but the structure still appears sound.
3	Moderate	Structure is showing deterioration that may require attention in near future and progression of damage should be monitored & documented. **Any rating of 3 or greater may indicate a need for further investigation.**
4	Serious	A portion of the reach has deteriorated to a condition that repairs are indicated.
5	Failed	General failure of reach.
U	Unknown	Insufficient information is available to rate element
N	Not Present / Not Applicable	Element not present or not applicable to structure
NOTE: Rating descriptions will be defined in follow-up documentation.		

Structure Category Definitions:

- Superstructure: Major separable structural elements which protrude above the normal water line
- Substructure: Major separable structural elements which (if present) are primarily located below the normal water line and above the original ground surface
- Foundation Structure: Major separable structural elements which (if present) are primarily located below the original ground surface

Attach to this form a cross section of the rated structure indicating the specific grouping of structural elements into these categories.

Structural Rating for Rubble or Laid-Up Breakwaters and Jetties

COMMENTS:

FOUNDATION FAULT SUSPECTED IN: (A) Armor Displacement (B) Slope Steepening (C) Slope Sliding

Caused By: (a) Scour (b) Settlement (c) Shear (d) Liquefaction

☑	Item	☐(A)	☐(B)	☑(C)	--	☐(a)	☑(b)	☐(c)	☐(d)	Sta
☐	Item	☐(A)	☐(B)	☐(C)	--	☐(a)	☐(b)	☐(c)	☐(d)	Sta
☐	WARNING SIGNS/GATES									
☐	AUXILIARY STRUCTURES (walkways, stairs, navigation lights, etc.)									
☐	AMOUNT OF DEBRIS IN ARMOR (rubble, trash, logs, etc.)									

SUGGESTED ACTIONS: (IA) Immediate Action (AS) Action Soon (W) Watch (IF) Investigate Further

Comment Number	Suggested Action	Station Location(s)	COMMENTS AND SKETCHES
1			Core stone loss to the water line
2			Cap stones are rotating lakeward due to loss of core material support and displacement of lakeside armor stone.
3			Dive inspection in 2005 noted that substructure stone below the elevation of the laid-up stone had a rounded character. Resulting low shear strength of this material may be a cause of the observed slope failure.

Elevation/Alignment Rating = 5 (settlement, loss of design crest height)

Fill Stone Rating = 5 (complete loss of fill stone)

Scour/Wave Protection = 4 (loss of design slope)

Weighting of ratings to establish overall structural index for rated reach

Rank	Project	Structure	SI	Condition Level
1	Chicago Harbor	Outer B/W - Reach E	4.81	F
2	Cleveland Harbor	West Pierhead	4.80	F
3	Cleveland Harbor	East Breakwater	4.80	F
4	Conneaut Harbor	East Breakwater	4.70	F
5	Oswego Harbor, NY	West Arrowhead	4.59	F
6	Black Rock Channel, NY	Bird Island Pier	4.17	D
7	Cleveland Harbor	Finger Pier	3.99	D
8	Sturgeon Bay Harbor	South Breakwater	3.99	D
9	Milwaukee	North Detached B/W	3.88	D
10	Buffalo Harbor, NY	South Breakwater	3.88	D
11	Cleveland Harbor	East Breakwater, West End Section	3.74	D
12	Calumet Harbor	Detached B/W - Reach C, Section 1	3.60	D
13	Duluth-Superior Harbor, MN, WI	Superior Entry - N. Entrance Pier	3.25	C
14	Marquette Harbor, MI	US Concrete Breakwater	3.00	C
15	Duluth-Superior Harbor, MN, WI	Superior Entry - N. Breakwater	2.52	C

Condition Assessments - Challenges

- Logistics – Fairly Remote Locations and Need for both Water and Land Access
- Funding – Often Lack Funding of Any Kind at Projects to be Assessed, no Central Source of Funds to Complete Assessments
- Time – Multi-District team, availability of boat & operator to access detached structures
- Rating Consistency – among inspectors, reach versus isolated damage area. Consensus ratings from multi-district team used to ensure fairness and consistency.
- Refining the process as we go

Great Lakes Navigation System (GLNS)

- 45 Commercial Harbors with structures
- 3 Commercial Projects with structures
  (Black Rock Channel / Bird Island Pier, Chicago and Detroit Rivers)

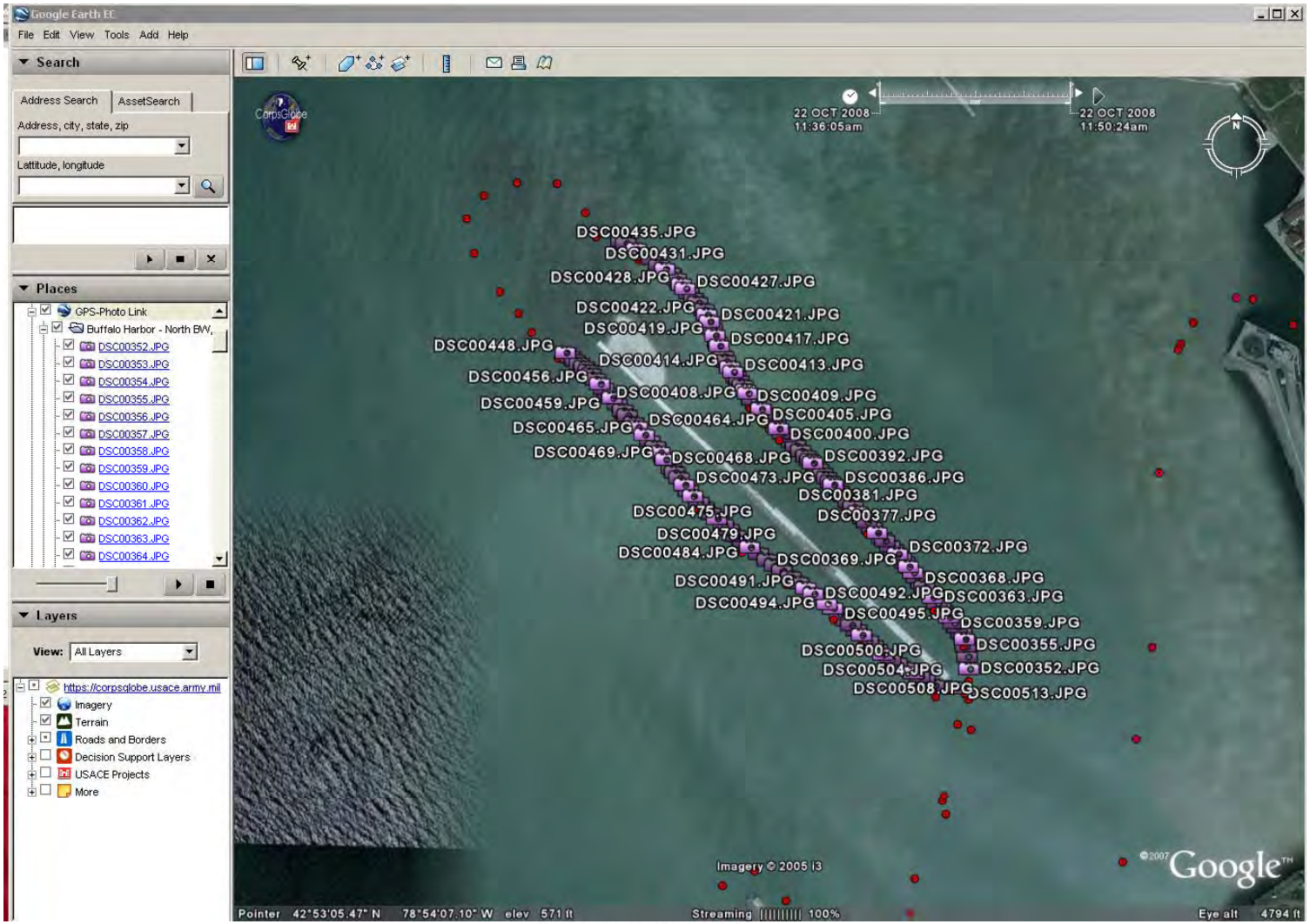
BAT INSPECTION SCHEDULE

- FY08 Project Inspections – 13
- FY09 Project Inspections – 14
- FY10 Project Inspections – 12
- FY11 Project Inspections – 9

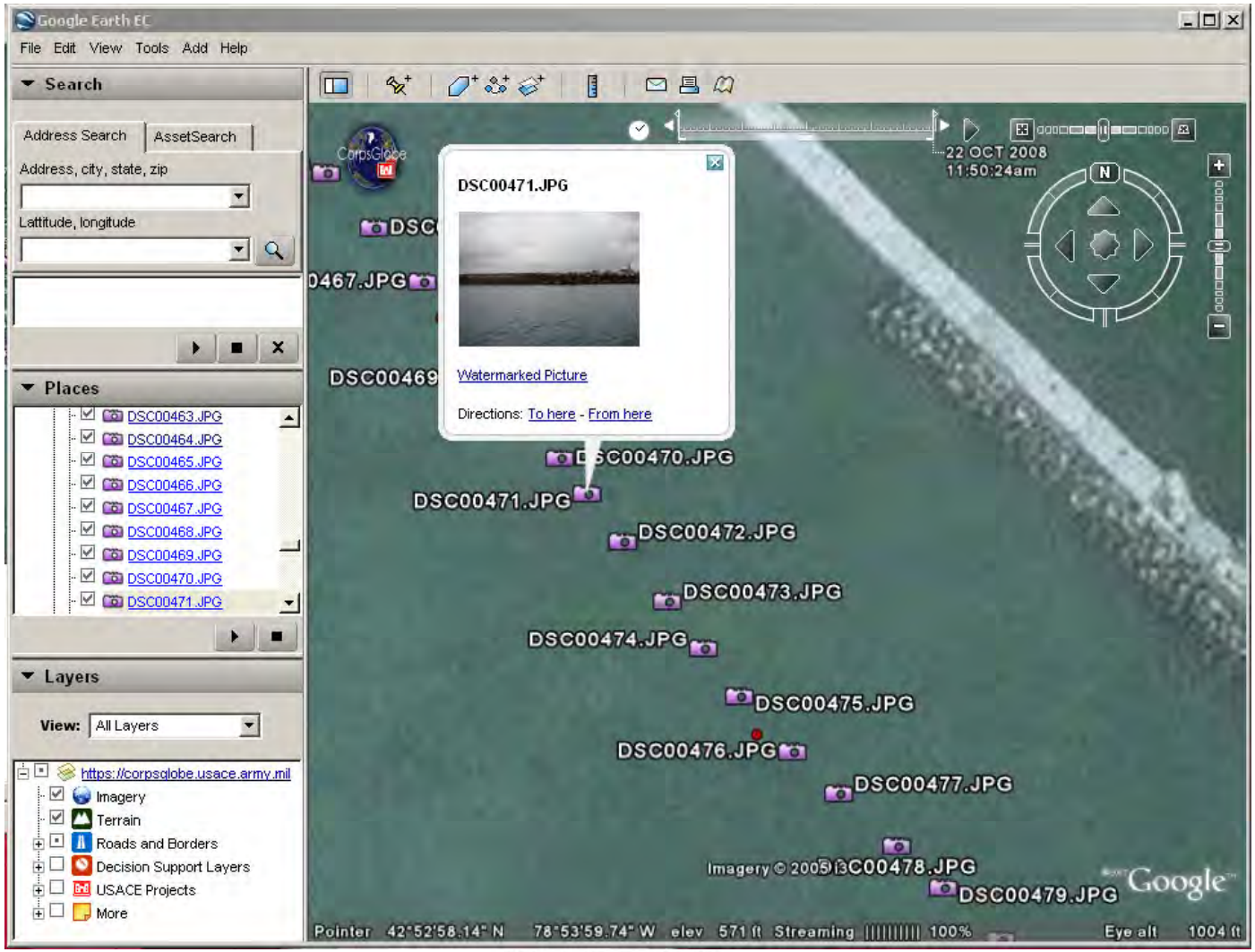
Condition Assessments - Tools

- Production of Geocoded Photo Datasets
  - Digital Camera: Sony DSC-H9, 8MP, 15x Optical Zoom, w/ 8GB memory card. This camera is not currently available, but the Sony DSC-H50 is a 9MP version - $300 + $60 for memory card
  - GPS: Garmin 76Csx in tracking mode, set to record track points to a gpx file on the memory card every 10 seconds - $250
  - Geocoding Software: GPS-Photo Link GIS Pro, from geospatialexperts.com - $329
  - Take a photo of the time display on GPS device at beginning of the session to allow synchronization of camera and GPS time
  - Software interpolates photo locations onto GPS track based on photo time and time/space record of track points

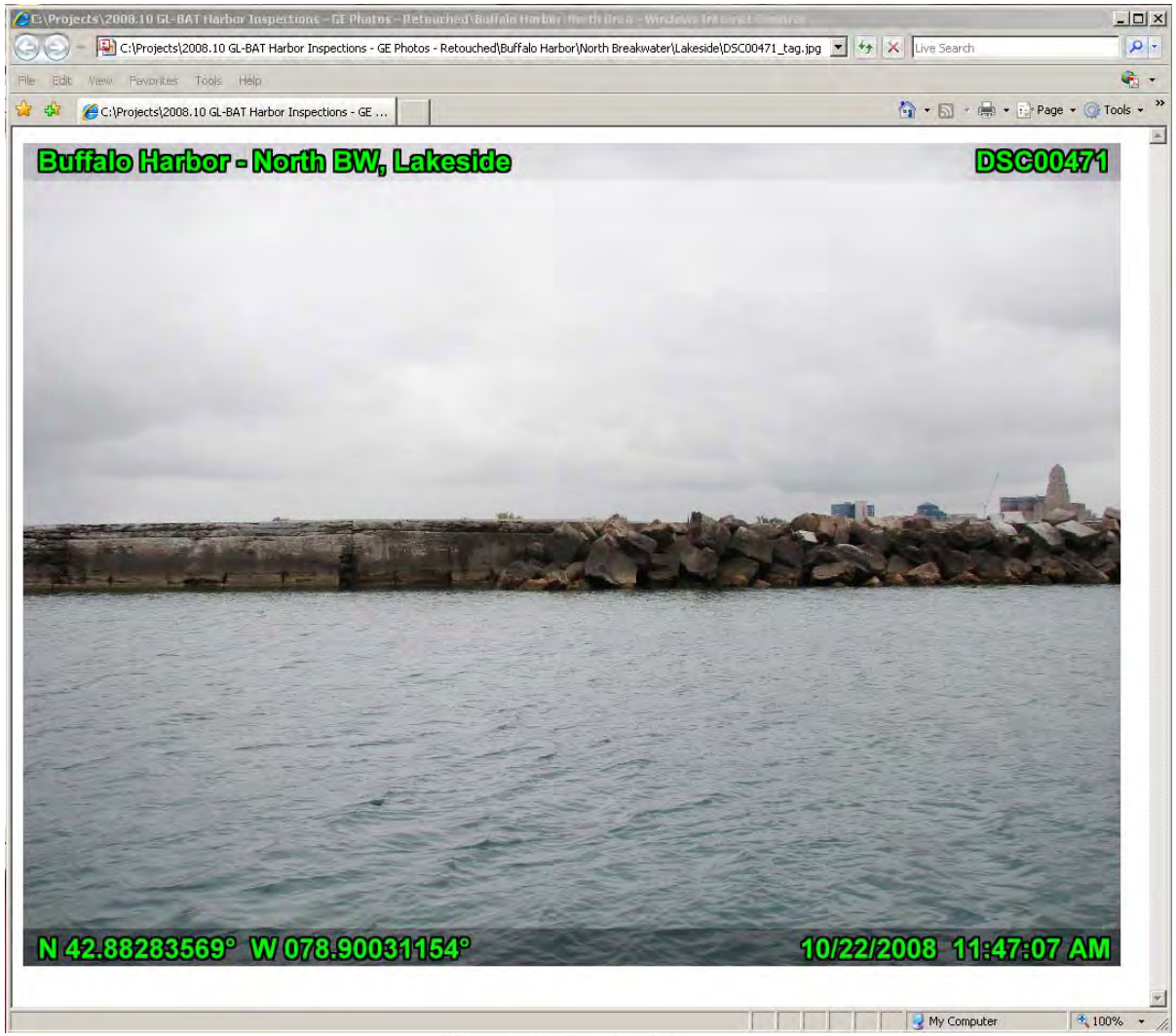
Condition Assessments - Tools



Condition Assessments - Tools



Condition Assessments - Tools



Condition Assessments - Tools

- HHIT (Hand Held Inspection Tool) – latest iteration of HAMMER
  - Hand held device, GPS stamped pictures, voice recording
  - Preloaded with modified REMR structure rating forms currently being used by BAT
  - Immediate input of ratings, GPS linked photo documentation, condition/measurements, report generation
  - ERDC provided a prototype for use during June 09 BAT inspections
- Future data link/upload to COSCA, eCoastal GIS database and/or other asset management tools

Structure Function/Consequences

- Goal – Establish Simple Relationships Between Structure Condition, Function, and Economic Consequences
  - Established transportation cost savings as a function of water depth at all GL commercial harbors/channels, also know cost to shippers associated with delays
  - Relationship between crest height/structure cross section & structure function (wave attenuation)
  - Relationship between wave climate and vessel loading (?), delays to vessel movements in a harbor, damages to moored vessels
  - Relationship between structure condition and harbor shoaling(?)
- Can function and consequences be modeled, applied consistently, and generalized in meaningful ways to allow application on the scale required for asset management?

Structure Function/Consequences

Calumet Harbor, IL & IN

St. Joseph Harbor, MI

Structure Function/Consequences

- Case Study of Risk Based Analysis of Breakwater Condition
  - Completed as part of Great Lakes Navigation System Supplemental Reconnaissance study to demonstrate the economic importance of
  - Looked at one structure (East Breakwater at Cleveland Harbor)
  - Followed risk based methodology
  - Coastal analysis, economic consequences for varying degrees of deterioration, risk model w/ event tree & simulations
- Time and Cost Prohibitive for application to asset management of the full portfolio of Great Lakes Navigation Structures

Structure Function/Consequences

- ERDC has FY09 funding and an established scope of work to map out the process and develop/refine tools to go from condition data to potential economic consequences
  - Process mapping being completed now
  - Risk based analysis
  - Link to/consistent with existing coastal tools (CSMART, COSCA)
  - Final outputs to mirror inland navigation outputs
  - Tools expected to be used in the Google Earth environment, similar to CSMART, ECID
- Cleveland case study could potentially be used to validate outputs

Asset Management of Coastal Navigation Infrastructure
Path Forward

- Complete condition assessments of all GL coastal structures
  - I-Plan goal of 50% of commercial harbor structures by end of FY10 (current plan will exceed that goal)
  - Tentative plans for BAT to complete assessments of all commercial harbor by end of FY11 (time/funds permitting)
  - Recreational harbors next?
- Continue to work with ERDC on process/tool development
  - I-Plan goal to have Great Lakes process & enterprise system deployed by 1st Qtr FY10
- Participation on the National Navigation/Coastal Structures Asset Management Board of Directors
- Integration with other USACE Asset Management Initiatives (FEM)

Acknowledgments

- GL Breakwater Assessment Team Members
  - LRB: Paul Bijhouwer, Michael Mohr (Coastal RTS), Shanon Chader, Colleen O'Connell, Denis Rimer
  - LRC: Tim Kroll
  - LRE: Tom O'Bryan, Dave Wright
- ERDC and Other Collaborators
  - HHIT: Cheryl Pollock, ERDC; Tad Britt, David Bjornberg, Compass Systems
  - COSCA, eCoastal Tools: Mark Penton, Rose Dopsovic
  - ECID, GE CSAM Tools: Jeff Melby, ERDC


Muskegon, MI - 2
GL BAT Inspection
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Questions?