

Revolutionizing America's Waterway and Dam Infrastructure with Composites

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US Army Corps
of Engineers®



North American
Pultrusion Conference



NOTE:
TAMPER GATE
NOT SHOWN

A long time ago in a galaxy far,
far away....

Why Fiber Reinforced Polymer (FRP)?

USACE: Many old, corroded structures w/ limited O&M funds



Downstream View of Tainter Gate

Boggs Dam Tainter Gates Shown (only 40 years old!)
Problem: Low-use, low-funded waterway so lack of maintenance

2021 (Gate4)



Flap Gate

Flap and sluice gate photos courtesy of Mellen & Associates, Inc.



Sluice Gate

Why FRP? Life Cycle Cost Savings

- Findings:
 - GFRP is cheaper/same for first cost vs steel
 - **HUGE Life Cycle Cost savings!**
 - **\$72M LCC savings per Tainter gate!**



Costs from 2023 Felsenthal Tainter Gate Charrette:

Cost Comparison for 3 Gates	COA 1, 2, 3, 4, 5	
Construction Cost (First Cost)		
Description	Total	
COA 0 - Baseline Replace in Kind - All New Steel Gates	\$13,661,608	
COA 5 - New Full FRP Gate Double Skinplate	\$12,413,508	

Cost Comparison for 3 Gates	COA 0, 1, 2, 3, 4, 5	
Life Cycle Cost		
Description	Total	
COA 0 - Baseline Replace in Kind - All New Steel Gates	\$237,311,000 **	
COA 5 - New Full FRP Gate Double Skinplate	\$21,454,000 **	

Who We Are – US Army Corps of Engineers (USACE)

USACE in our Nation's History

This timeline highlights key USACE projects and responses:

- 1812:** Coastal Fortifications
- 1824:** Keeping Waterways Clear. *"clear obstructions on Ohio and Mississippi Rivers and at ports."*
- 1862:** Pacific Railroad Survey of the Southwest
- 1882:** Beginnings of Disaster Response
- 1925:** First Federal Hydroelectric Project: Wilson Dam
- 1936:** Flood Protection
- 1944:** Recreation Program
- 1955:** PL 84-99 Flood Fighting and Repair of Flood Control works
- 1972:** Expanded Regulatory Programs
- 1986:** Coast Staring
- 2001:** Responding to 9-11
- 2012:** Hurricane Sandy Response

<https://www.usace.army.mil/>

U.S. Army Corps of Engineers

Over 247 Years of Service to the Nation

This graphic features a world map with various USACE projects and the Corps of Engineers logo. Key projects include:

- U.S. Capitol Extensions and Dome (1848)
- Washington Monument (1884)
- Lincoln Memorial (1922)
- Panama Canal Completion (1914)
- Bonneville Dam (1937)
- Restoring Power After Hurricane Maria (2018)
- The Pentagon (1943)
- Greater New Orleans Hurricane and Storm Damage Risk Reduction System (2022)

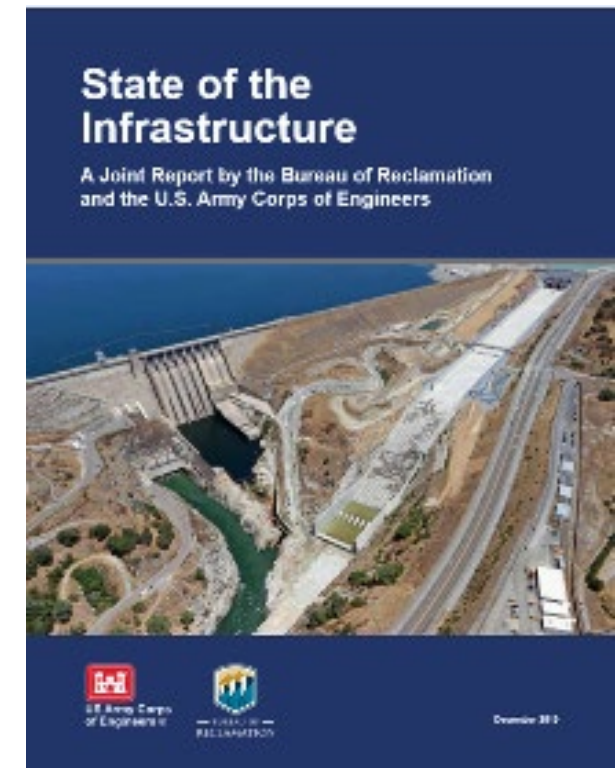
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Mission Areas – The Nation's Engineer



Quick Facts

- **239 Navigation lock chambers at 193 sites**
- **716 Flood risk management dams managed by the Corps at 559 projects**
- **Over 1000 Coastal, Great Lakes and Inland harbors and 25000 miles of channels maintained with 40 States served directly by Corps ports & waterways**
- **Largest provider of federal hydropower meeting 3% of US energy needs with 75 Hydropower projects with 356 generating units**
- **12 million acres of Corps land and water providing recreation opportunities in 43 states including over 9600 Campsites**
- **256 Million Recreation visits per year (more than any other Federal agency in 2020)**



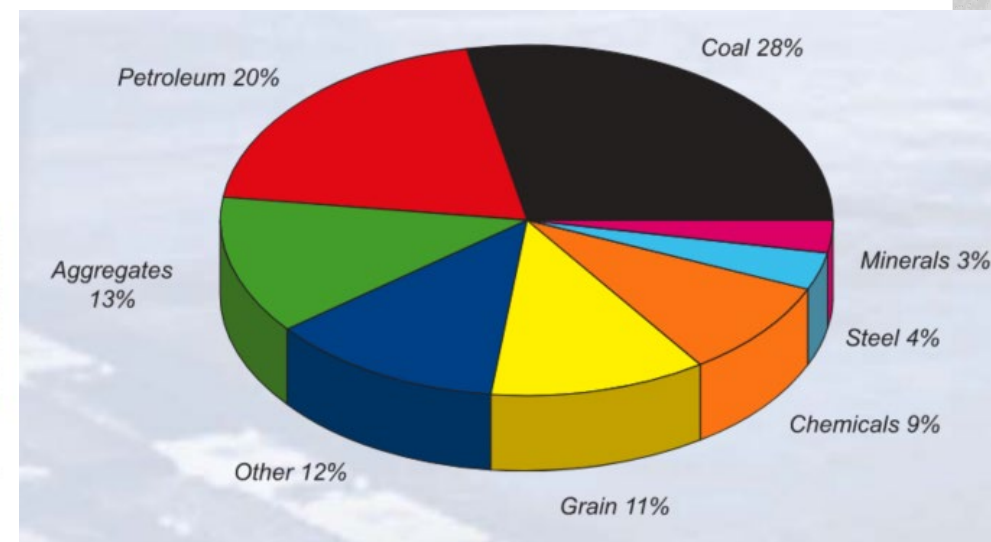
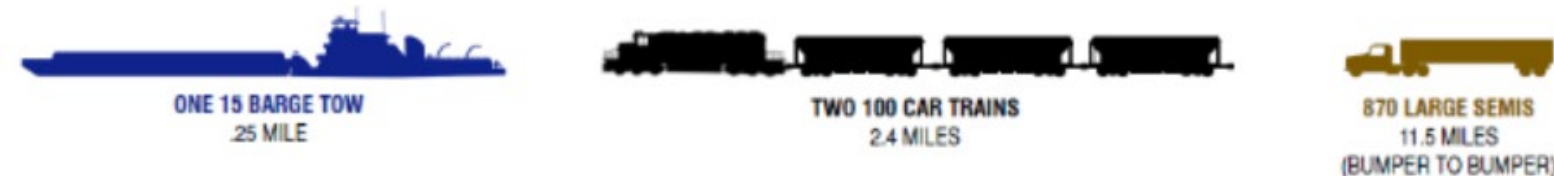
Why Water Transportation? Efficient & Environmental

- Think of USACE like a DOT for Water Transportation
- **Inland Waterway move ~630 million tons of cargo valued at over \$73 billion annually**

Equivalent Units



Equivalent Lengths



Civil Works – Divisions and Districts

Civil Works Directorate
(HQ USACE / Washington, DC)

8

Civil Works Divisions
(minus Transatlantic Division)

1

Civil Works ONLY Division
(Mississippi Valley Division)

37

Civil Works Districts

18

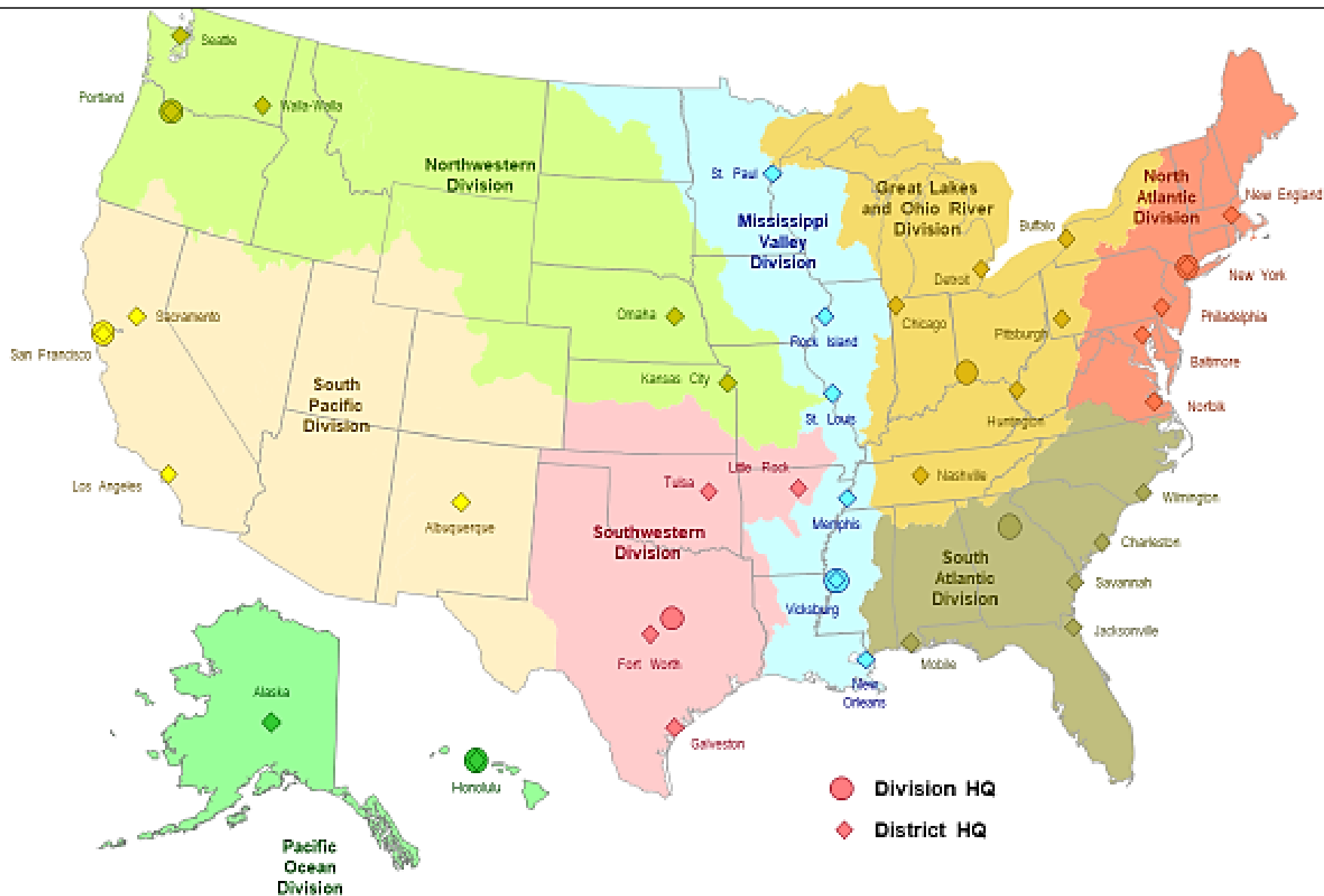
Civil Works ONLY Districts

Watersheds

define Civil Works Boundaries

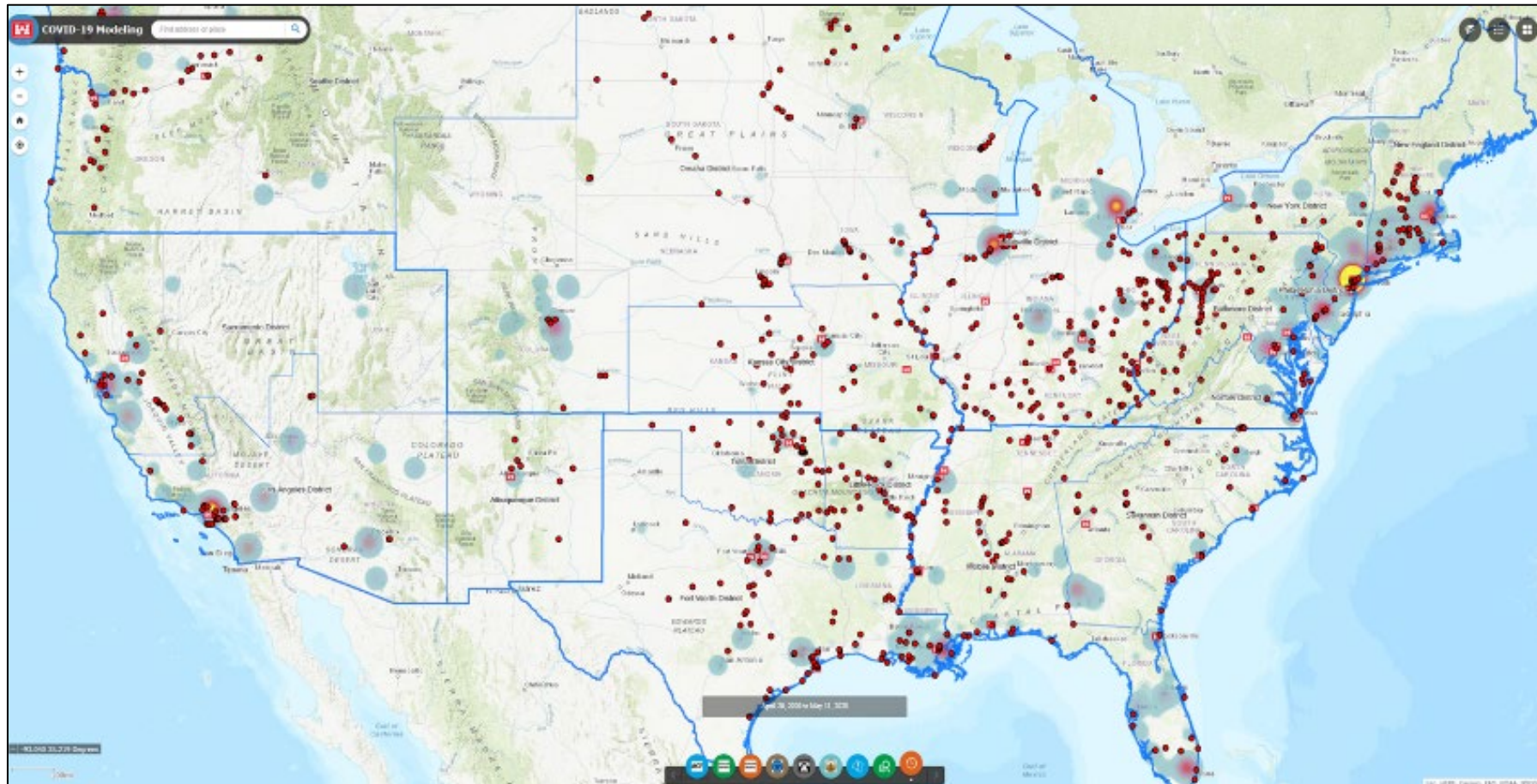
1824

1st USACE Civil Works mission to “clear obstacles on Ohio and Mississippi Rivers and at ports.”



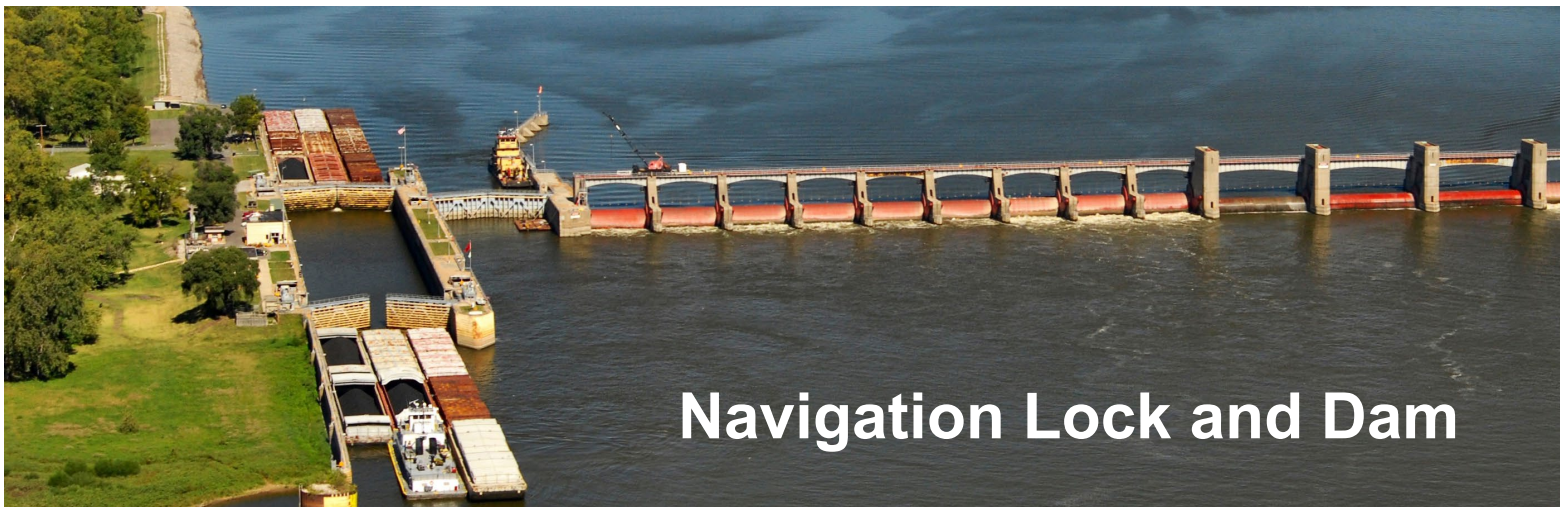
Civil Works Operations

There are over 3000 Mission Essential Civil Works Projects Requiring Continuous Operation to meet the needs of the American People.

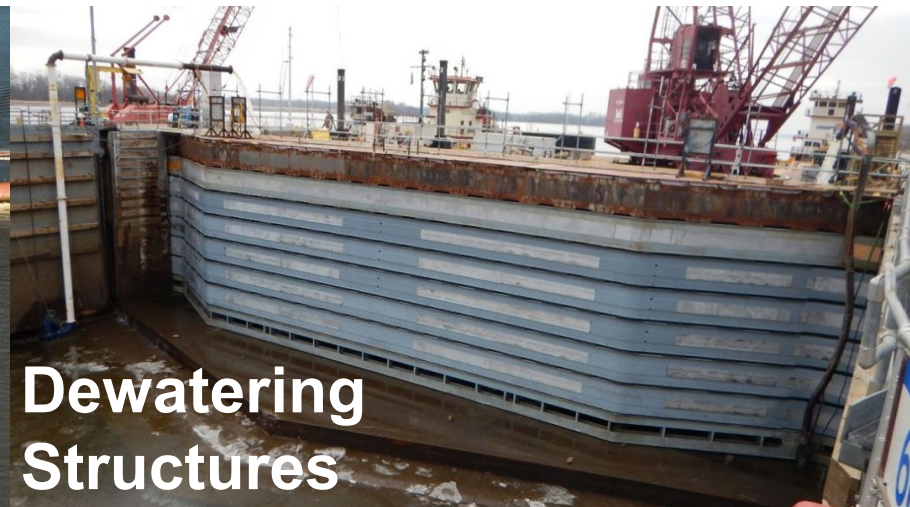


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What USACE Infrastructure Looks Like



Navigation Lock and Dam



Dewatering Structures



Navigation Lock

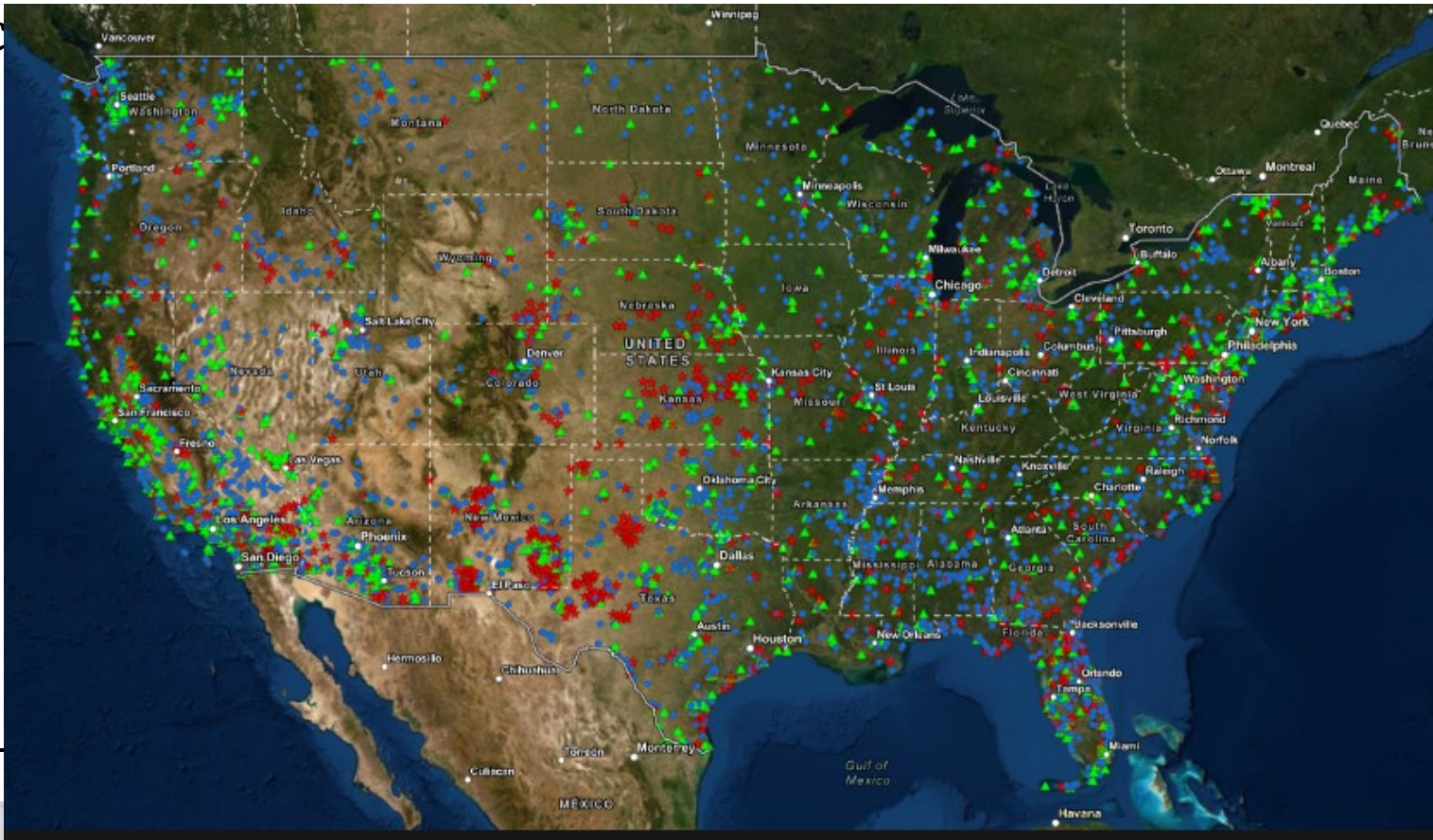


Flood Risk Management Dam

Scale of the Opportunity

13,000 steel structures within navigation and flood risk management portfolios.

Based on 50-year steel design life, USACE on the cusp of replacing 260 hydraulic structures by 1980



Composites – Where We've Been

- 1990's: ACMA and USACE Engineering Research and Development Center begin collaboration
- 2000's: USACE military composite research
- 2010's: USACE Civil Works demonstration projects
- 2020's: USACE Civil Works implementation projects



Thermoplastic Bridge

US Army C

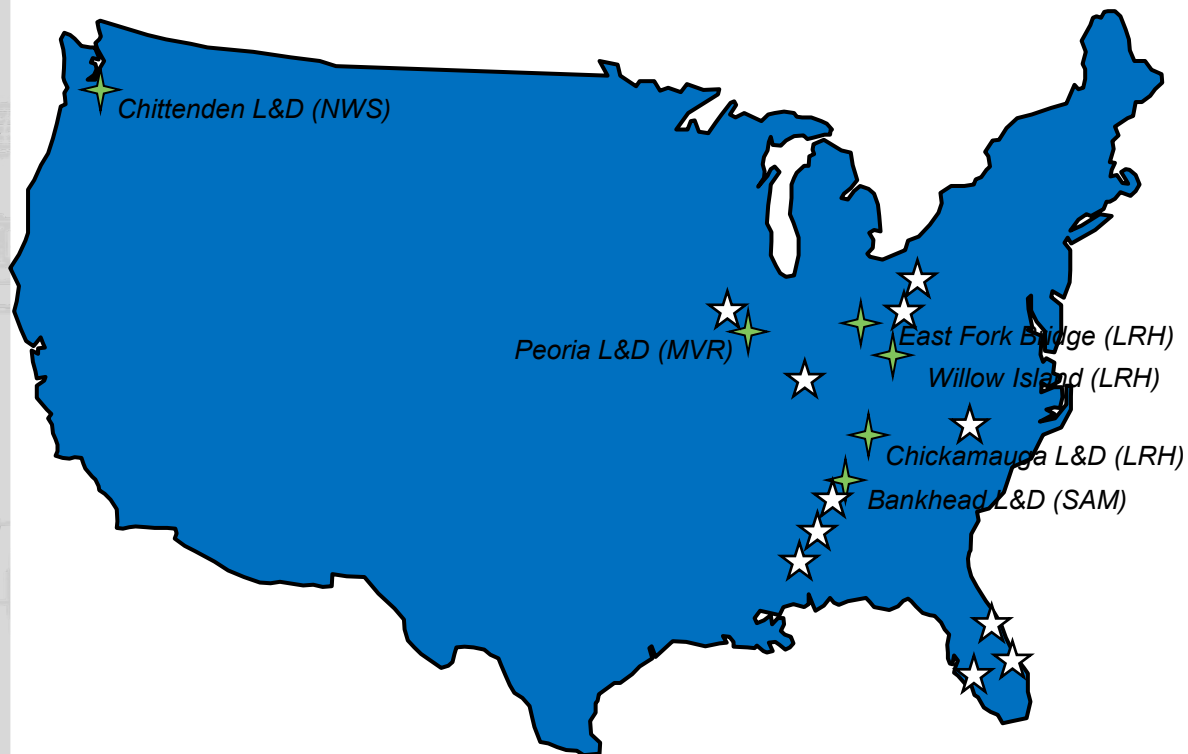
US Army Corps of Engineers – United Facilities Guide Specifications (UFGS)

- UFGS 35 20 15 - FRP Composites for Low-Head **Water Control Structures**
- UFGS 35 59 13.14 20 – Polymeric **Fender Piles**
- UFGS 06 73 01 - Fiberglass Reinforced Plastic (FRP) **Grating**
- UFGS 06 71 33 - Fiberglass Reinforced Plastic (FRP) **Ladders**
- UFGS 06 82 14 - Fiberglass Reinforced Plastic (FRP) **Pipe and Tube Railings**
- UFGS 04 01 20.75 - **Masonry Strengthening** Using Surface Applied FRP Composites
- UFGS 04 01 20.73 - **Masonry Strengthening** Using FRP Bars
- UFGS 04 01 20 - **Rehabilitation** of Reinforced and Unreinforced **Masonry Walls** Using FRP Composite Structural Repointing
- UFGS 04 01 21 - **Rehabilitation** of Reinforced and Unreinforced **Masonry Walls** Using Surface Applied FRP Composites

USACE Demonstration Projects

- Success: 6 Efforts at 6 Locations

Coming Soon: 11 efforts at 10 Locations



★ Completed (District)

☆ Future (District)


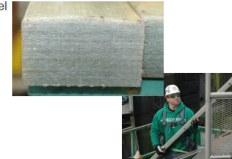

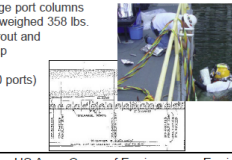
- Peoria L&D (MVR)
- LaGrange L&D (MVR)
- Olmsted L&D (LRL)
- Kerr Scott Lake (SAW)
- Holt L&D (SAM)
- Seldon L&D (SAM)
- Demopolis L&D (SAM)
- Canaveral Lock (SAJ)
- St Lucie L&D (SAJ)
- WP Franklin L&D (SAJ)

Over the Horizon:

- Vicksburg - MVK
- New Orleans - MVN
- Tulsa - SWD

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Completed Projects – Monitoring in Progress

<p>FRP Miter Blocks (H. Chittenden, NWS)</p> <ul style="list-style-type: none"> • Replaced severely corroded steel • Reduced weight, easy to install • Cost competitive with steel • Minimal wear after 4 years • Initial cost avoidance: \$0 • 50-year cost avoidance: \$2M 	<p>Polymer Slides (Bankhead, SAM)</p> <ul style="list-style-type: none"> • Reaction rollers prone to seize • Replaced with UHMW slides • Initial cost avoidance: \$2.7 M (20 gates) • 50-year cost avoidance: \$11M 
<p>FRP Wrap Repair (Chickamauga, LRN)</p> <ul style="list-style-type: none"> • ASR caused cracking in discharge port columns • Steel jackets installed by divers weighed 358 lbs. • Repaired with polymer mastic grout and water-cured FRP composite wrap • Rapid repair – short lead time • Initial cost avoidance: \$430K (30 ports) 	<p>FRP Filler Panels (Willow Island, LRH)</p> <ul style="list-style-type: none"> • Steel panels significantly corroded • FRP panels with pultruded shapes housed in steel frames • Initial cost avoidance: \$48K (12 panels) • 50-year cost avoidance: \$580K 

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Building on USACE Success

Several Demonstration Projects

- ▶ **Illinois Waterway River Dam Wicket Gates (MVR)**
 - 3 prototype wickets installed at Peoria Dam in 2015
 - Excellent performance – no measurable wear/damage
 - Timber wicket gates: more expensive with avg 10-15 year life
 - FRP wicket gates: less expensive with 50+ year life
 - MVR ordered 100+ FRP wicket gates for delivery in 2023 (in production)

50-yr Cost Savings ~ \$20M

- ▶ **East Fork Bridge (LRH)**
 - Corroded steel piles reduced bridge rating
 - 25% of the time and 1/3 the cost of traditional repair

50-yr Cost Savings ~ \$1.2M

- ▶ **Chittenden Miter Gate Contact Blocks**
- ▶ **Joint effort by MVR, LRH, INDC, ERDC, & WVU**



Partners

- Working with partners around the world to share information and best practices



Rijkswaterstaat
Ministry of Infrastructure
and Water Management



MaineDOT



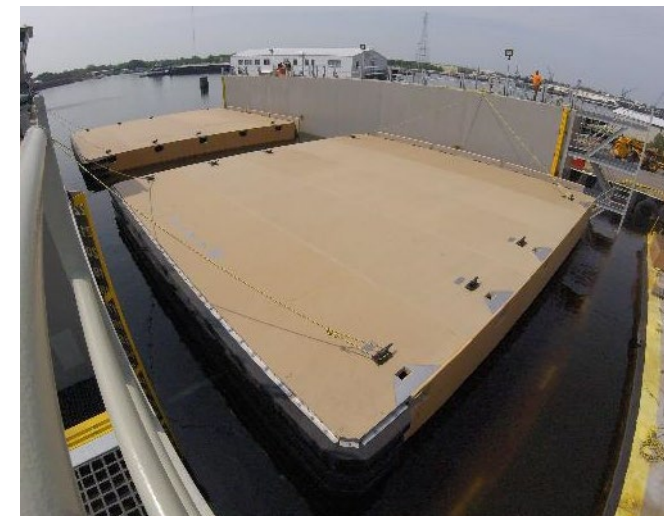
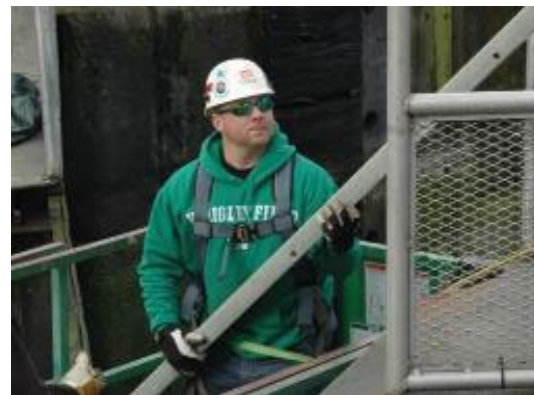
**Photo: ACMA
industry open house
at W.P. Franklin Lock
and Dam in Florida
2/22/23**

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Large Hydraulic Structure Applications



Submarine Berthed at Composite Camels

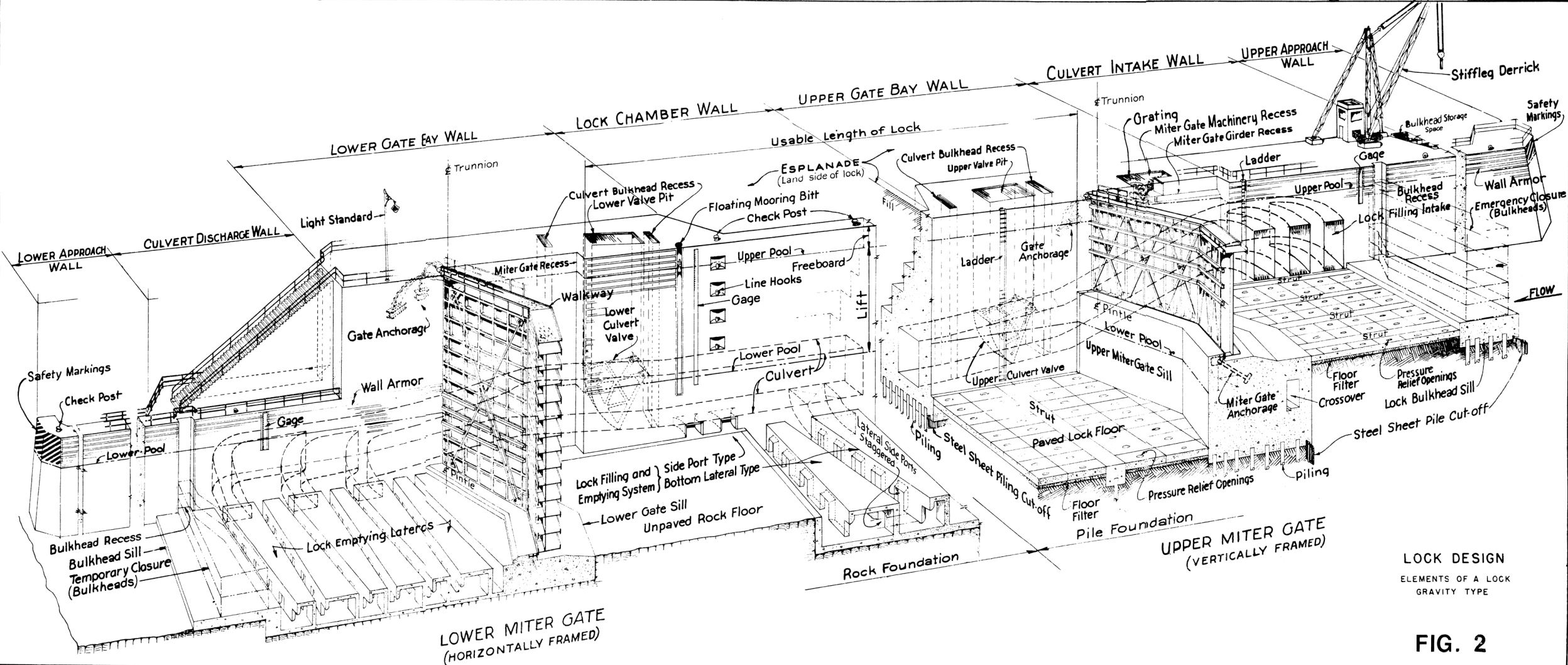


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Opportunities for Pultrusions

- What components can FRP provide better performance and/or reduced maintenance?





LOCK DESIGN
ELEMENTS OF A LOCK
GRAVITY TYPE

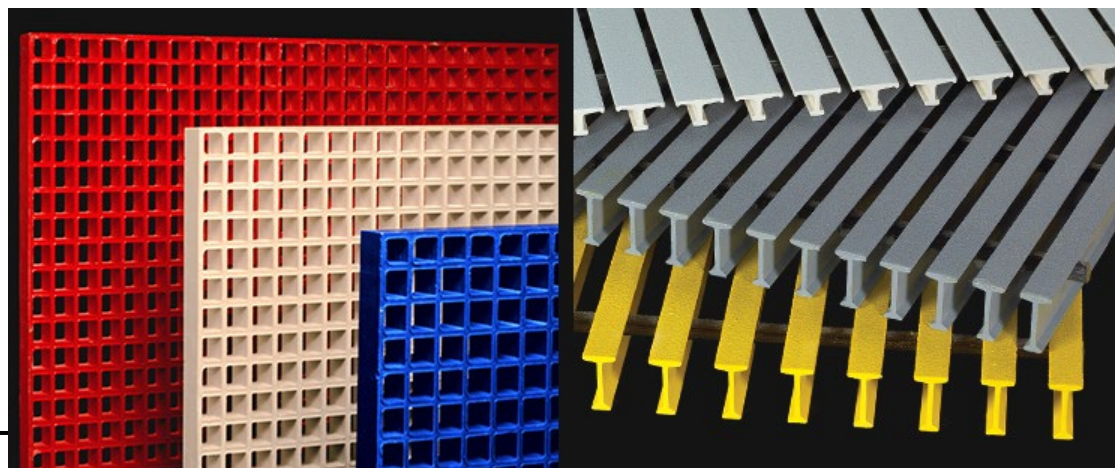
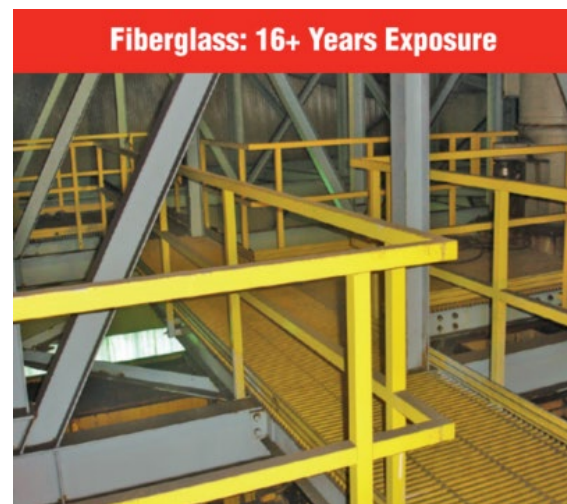
FIG. 2

Brainstorming: Handrail, Grating, Ladders, Trashracks, Valve bulkheads, Floating mooring bits, Sheet Piling, Pipe Piling, Stairs, Bridges, Mooring Cells, Misc Metals, Valves?, Light poles?, Rebar in horizontal concrete, Gates, Guidewalls

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Handrail, Grating, and Ladders

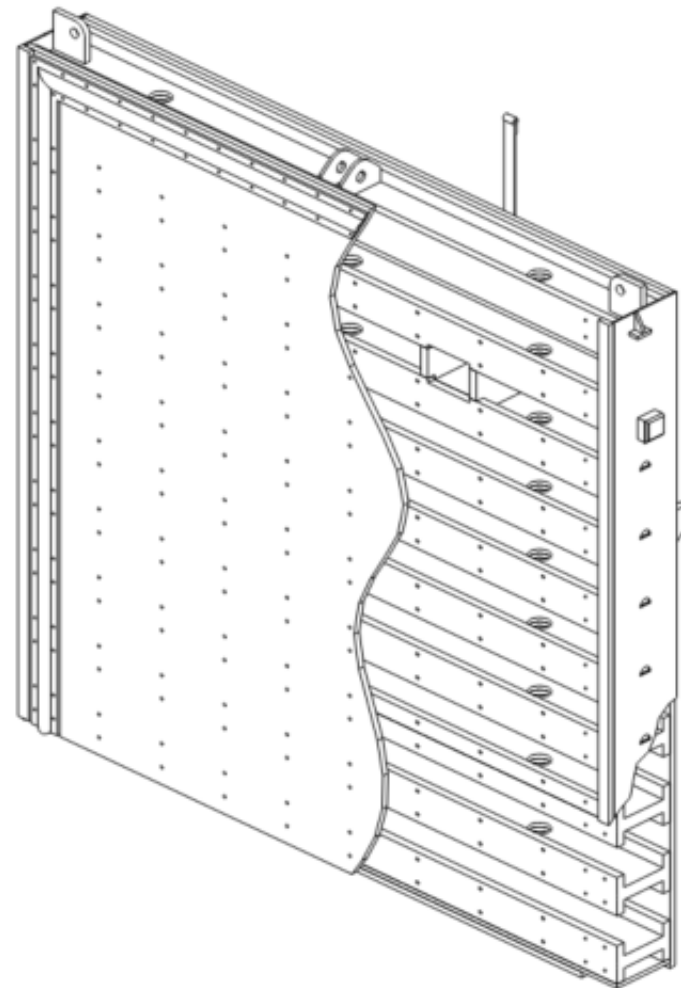
- Readily available, off-the-shelf



Photos courtesy of Strongwell

Inland Navigation Design Center

Trashracks, Valve bulkheads, Floating Mooring Bitts



Hybrid Pultruded & VIP



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Sheet pile and Pipe Pile

- FRP Sheet Piling
- Vinyl Sheet Piling (for more info see: ERDC General Design Guide for PVC Sheet Pile)
- EM 2502 and UFGS spec for FRP & PVC sheet pile complete and in publication
- FRP Pipe Piling



FRP sheet pile



PVC sheet pile floodwall installed
1998 in Jefferson Parish, Louisiana



FRP pipe pile

Mooring Cells, Dolphins, and Fendering



Fendering can include FRP, HDPE, & UHMW-PE

Concrete Reinforcement

- **Fiberglass (GFRP) rebar has been industry adopted by ACI with its own design code (ACI 440_11)**
- **Good application would be horizontal concrete surfaces exposed to salt**



USACE Efforts and Areas for Collaboration

Guidance and Standards

- Industry Standards such as ASCE/SEI 74
- ACMA Manufacturers Accreditation (Quality Control)
- UFGS Specifications
- USACE Design Manual

Education and Training

- Industry Webinars
 - USACE Composite Users' Group (bi-monthly w/ 150+ people)
- Training
 - Inspection, Testing, and Repair
 - Quality Assurance testing of products

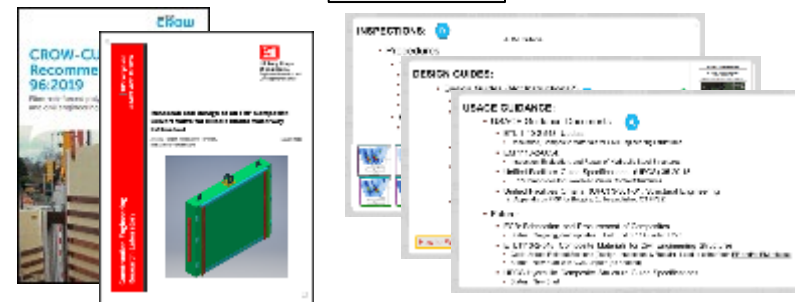
Design Charrettes

- Decision and Design Charrettes

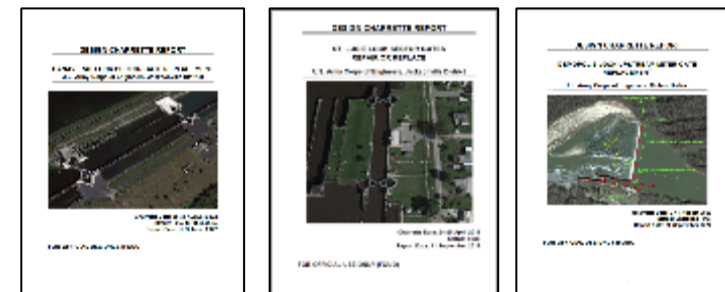
Ownership

- O&M Manuals

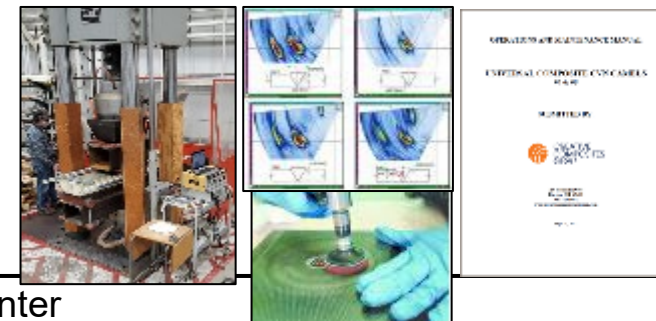
Guidance



Design / Charrette Reports



Inspection, Testing, Maintenance and Repair



How to Get Involved

- Coordinate with USACE (eric.o.johnson@usace.army.mil) and ACMA
- acmanet.org for opportunities to connect
- Signup for contract notices in the market at <https://sam.gov> using keywords “Army Corps of Engineers” and “FRP”

The screenshot shows the SAM.GOV website homepage. At the top, there is a navigation bar with links for Home, Search, Data Bank, Data Services, and Help. The SAM.GOV logo is prominently displayed on the left. To the right, a badge indicates it is the 'Official U.S. Government Website' and '100% Free'. The main content area is divided into two columns. The left column lists various services: Contract Opportunities (was fbo.gov), Contract Data (Reports ONLY from fpds.gov), Wage Determinations (was wdol.gov), Federal Hierarchy (Departments and Subtiers), Assistance Listings (was cfda.gov), Entity Information (Entities, Disaster Response Registry, Exclusions, and Responsibility/Qualification (was fapiis.gov) with a 'NEW' tag), and Entity Reporting (SCR and Bio-Preferred Reporting). The right column features a 'Register Your Entity or Get a Unique Entity ID' section with a description and three buttons: 'Get Started', 'Renew Entity', and 'Check Entity Status'. At the bottom, there is a search bar with the text 'Already know what you want to find?' and a search input field containing 'e.g. 1606N020Q02' and a search icon.

WHERE WE'RE AT

- Completed projects: 4
- Completed design charrettes for viability: 7 (Gate types: lift, miter, sector, Tainter, bulkheads)
- Current contracted projects: 5 (wickets, bulkheads, miter gate contact blocks)
- Funded In-development projects: 4 (lift gate, sector gate, bulkheads, Tainter gate) ~\$20M
- Future FY identified projects: 15 ~\$150M

CONCLUSIONS

- How do we improve on the poor performance of existing gates with the limited O&M money they receive?
- Need a low-to-no maintenance solution!
- Need a cost-effective solution!
- **FRP is an answer!**



Downstream View of Tainter Gate

More Information

- Composites Manufacturing Magazine – Spring 2023



Navigating an Emerging Market

By Susan Keen Flynn

<https://compositesmanufacturingmagazine.com/2023/05/navigating-an-emerging-market/>

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Questions? Comments? Ideas?

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