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Assessment of Sedimentation Affecting Riverine Ports in Louisiana

by

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16. Abstract

Both the Port of Lake Providence and the Port of Madison Parish have suffered in recent years from record highs and lows of the Mississippi River. These events caused unique conditions to occur at both ports including excessive sedimentation at the navigation channel entry from the Mississippi River. This report was prepared in response to SR105, which directed DOTD to prepare a report on potential measures to address the sedimentation at two northeast Louisiana ports, as named previously. Sedimentation and other morphological processes degrade channel depth, which requires investment in either structural controls or periodic maintenance dredging to maintain required depth. Given these ports' primary commodities are related to agri-business, which remains a highly competitive environment, lack of sufficient access to these ports can negatively impact their economies for both import and export commodities. The research team investigated available literature on sedimentation at harbor channels and previous studies conducted by the USACOE for both ports; they also conducted on-site investigations as well as key-person interviews. After this comprehensive process, researchers recommended the following: (1) perform a Least Cost Market Analysis to determine maximum market share potential at each port facility; (2) perform detailed morphological studies of the evolution of persistent shoals at each port facility; (3) evaluate alternative configurations of river training structures; (4) evaluate the construction of a weir near the Mississippi River in the existing chute that bisects Stack Island abutting Hagaman Chute; (5) further investigate the chute and bypass channel into the Mississippi River; (6) develop a dredge operations model for each port facility to determine optimum dredge operations required to maintain uninterrupted port access; and (7) review alternative procurement approaches of maintenance dredging contracts.

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Assessment of Sedimentation Affecting Riverine Ports in Louisiana

A Report Prepared in Response to SR105 2014 Legislative Session

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Executive Summary with Recommendations for Controlling Sedimentation

During the 2014 Regular Session of the Louisiana Legislature, SR105 was passed that directed the Louisiana Department of Transportation and Development (DOTD) to provide by April 1, 2015, a report on potential measures to address the control of sedimentation at a number of northeastern Louisiana ports, specifically the Port of Lake Providence and the Port of Madison Parish. Using the Louisiana Transportation Research Center (LTRC) and its consultants, the following report has been prepared in response to this legislation.

Statistical analysis of the flow of goods through both the Port of Lake Providence and Port of Madison Parish indicates that both are primarily involved in agri-business (storage and transportation of corn, soy beans, sorghum, and liquid and dry fertilizer). Transport of these products via the inland waterways of the United States is generally most cost effective over other modes of transport, primarily due to the combination of the low unit costs for large volumes and the fact that it operates on natural alignments that do not require huge capital investments, such as constructing highways, bridges, or laying rail tracks. Water transport has very large carrying capacities and is most appropriate for carrying bulky goods. However, water-land interfaces occur at ports, which require capital investment during development and require ongoing maintenance costs during operations.

For a port to remain a component of an efficient supply chain, it must be able to meet the demands of the logistics needs. In many cases, this is determined by the frequency of vessel calls, the size of the vessel calling and the berthing capacity of the port. The primary constraint to vessels calling at ports is channel depth. Sedimentation and other morphological processes degrade channel depth, which requires investment in either structural controls or periodic maintenance dredging to maintain required depth, so as not to impede access to the port or negatively impact operations at the port as a component in the supply chain. Production, storage, and transportation of U.S. agricultural goods impact its pricing and dictate how competitive they are regionally and globally. Thus, it is of national importance to develop solutions to ensure the navigability of the coastal and river waterways and their respective ports.

While the location of port and terminal operations on the Mississippi River are at fixed locations, the Mississippi River is a highly dynamic system and is also heavily constrained through a complex system of structures that comprise the Mississippi River and Tributaries Project. As such, sedimentation and morphological changes within the channel can often lead to excessive sedimentation issues in the proximity of port operations on the river. This can lead to access issues, which in turn negatively impacts the economies of the import and export of goods through these ports.

Structural approaches have been evaluated in an attempt to prevent or minimize impacts to port channel access due to sedimentation issues. Often the cost of the construction, operation, and maintenance of these training structures cannot be justified through conventional cost-benefit analysis. In many instances, the costs are too high and the benefits of throughput of the port are too low to realize a positive cost-benefit ratio. The business model of port operations are based on high volumes with low margins. As such, any impediment to port access, not only affects the amount of throughput, as goods shipment shifts to other ports, it also negatively impacts the cost-benefit ratio of any proposed solution by reducing the economic benefit. To some extent, this is somewhat of a chicken or egg situation. If better access to a channel could be guaranteed, would a greater volume of goods move through an individual port and therefore positively impact the cost-benefit ratio?

Recommendation #1: Perform a Least Cost Market Analysis to determine maximum market share potential at each port facility.

Rather than focusing on purely structural approaches to sedimentation issues at the Ports of Lake Providence and Madison Parish, along with other ports operating on the Mississippi River, it is recommended to focus on the cost-benefit ratio. A detailed Least Cost Market Analysis (LCMA) should be conducted for each individual port in order to determine what maximum market share could be realized with uninterrupted port access, plus any potential increases in market share that could be realized with improved (deeper) channel access. This is of particular significance given that growth rate trends over the last five years, show that exports of both soybean and cereals out of the lower Mississippi have far exceeded other U.S. regions. Specifically soybean exports out of the Lower Mississippi outgrew other U.S. exports by over five times.

Recommendation #2: Perform detailed morphological studies of the evolution of persistent shoals at each port facility.

It is recommended that detailed studies of the sedimentation characteristics at each port be conducted to assess the evolution of the morphology of the individual shoals, in order to assess how the morphology changes over time, both long term and seasonally, in response to river stage. Not only would this information better inform alternatives analysis of any potential structural approaches, it will also provide a more detailed analysis of the efficacy of dredging operations at each facility. Conventional cutterhead dredging is expensive, but without a detailed understanding of the shoal reformation rate, it is not possible to determine the best dredging approach to be deployed (cutterhead, side caster, water injection dredge, or other agitation dredging techniques) in order to maintain access.

Recommendation #3: Evaluate alternative configurations of river training structures.

As stated earlier, until a detailed LCMA is conducted for each port in order to optimize the economic benefit at each port facility, it is unlikely a positive cost-benefit ratio could be realized to justify the investment in the construction of additional structural measures. As such, attention should be focused on the cost of maintaining uninterrupted access to the ports. Structural approaches to sedimentation have been evaluated but with mixed results. It is recommended that alternative alignments and configurations of these training structures be investigated to evaluate if any improvements on the reduction of sedimentation could be made and if the cost of construction of these structures could be optimized.

Recommendation #4: Evaluate the construction of a weir near the Mississippi River in the existing chute that bisects Stack Island abutting Hagaman Chute.

The construction of a weir has been evaluated on a preliminary basis by the U.S. Army Corps of Engineers (USACE) as a potential solution for the accumulation of sediment in the harbor basin. The analysis showed that such construction can reduce the influx of sediment into the harbor. It is recommended that this approach be evaluated further to better constrain the overall impacts resulting from the weir construction. In doing so, environmental impacts to a resident habitat can be better examined, along with assessments of physical sedimentation dynamics using hydrodynamic and sediment transport models to reduce risk, as well as a develop a more detailed appraisal of the cost of construction versus the economic benefits realized.

Recommendation #5: Further evaluate the chute and bypass channel into the Mississippi River.

The construction of a weir at a location near its connection to the harbor (per Recommendation #4) will likely have to be coupled, or evaluated in conjunction with a bypass channel. The bypass channel is necessary to help redirect flow into the main stem of the Mississippi River. While the preliminary analysis by the USACE provided some initial positive results, this recommendation needs to be evaluated further with a more detailed analysis better constraining the impacts resulting from such construction.

Recommendation #6: Develop dredge operations model for each port facility to determine optimum dredge operations required to maintain uninterrupted port access.

Detailed dredge production models have successfully been developed for other ports in the region experiencing sedimentation issues, and these have been used to effectively optimize dredging operations, both in terms of equipment and frequency of operations. Once a detailed understanding of the shoal reformation rate has been determined, it will be possible to develop such an operations model for each port in order to determine the optimum combination of equipment and frequency of dredging in order to optimize operation and maintenance budgets for each individual port.

Recommendation #7: Review alternative procurement approaches of maintenance dredging contracts.

Additionally, dredging operations procured by the USACE are typically on a rental type contract for a finite period of performance. Such a procurement strategy does not always result in the lowest unit cost of operations. By switching to alternative dredging operations procurement type contracts, such as a performance based multi-year contract, it is possible to significantly reduce unit costs, therefore making dredging operations more cost effective. In doing so, the approach to dealing with excessive sedimentation issues does not focus on a “silver bullet” fix, but more on a management approach that enables the port operations to “learn to live” with the sediment. This in turn provides for a much more dynamic and adaptive approach to dealing with seasonal trends in sedimentation, trends that a structural approach may not be able to address. Structural solutions that are based on managing extremes like the 2011 flood and 2012 drought are not efficient and these individual historic events should not be the basis of design criteria for a proposed solution. The USACE is being forced to “do more with less” and port operations must look to a greater efficacy in operations and maintenance budgets. Combining this approach with a detailed LCMA will optimize potential economic benefits while reducing operation and maintenance costs, which in turn will realize a more favorable cost benefit ratio. The reality is that the president’s budget promised to increase the USACE budget last summer, but the $4 trillion submitted to Congress in January actually cut the USACE budget. This is further compounded by an additional 4 years of budget cuts since sequestration began in 2011. States are having to fund needed navigation work, which the USACE simply cannot fund. As such, port operators are increasingly looking for Public-Private- Partnerships (P3) to fund navigation maintenance. In the container terminal business model, the costs of navigation works are typically passed on to the consumer in terms of concession additions at the port. Similar restructuring of the funding of navigation works may need to be explored in the future in order to fund essential navigation works through structured “user fees” in order that ports can maintain uninterrupted navigation access and resultant competitive advantages.

Literature Review

Overview of harbor siltation and control measures

Siltation of muds and silts in harbor basins are problems that have been around for as long as harbors have existed, and is related typically to their basic function: to provide shelter by creating low energy quiescent conditions (van Rijn, 2012). In fact many harbor entrances have been found to be difficult for ships to navigate, owing in part to currents, waves, and siltation for coastal or marine ports (van Rijn, 2012). When dealing with inland or river ports, navigation issues associated with the entrance alignment with the main river channel are compounded by excessive currents, rotational flow, shadow zones, and cycles of spring floods and low flow conditions. The amount of sedimentation in ports is strongly correlated to the physical and environmental conditions, as well as the geometric configuration of the port entrance. In inland and river ports additional conditions that can have significant impact influencing the rate of sedimentation include, but are not limited to, the following: (1) the geometric configuration of the entrance, (2) the location of entrance in relation to the main channel thalweg (the deepest part of the channel), (3) the orientation of the entrance in relation, to the main river flow and the potential for local rotational flow or eddies, (4) the presence of any additional access channels connecting the port to the river, (5) flooding depths associated with spring floods, and (6) cycles of spring floods and low flow conditions. Siltation can be experienced at both coastal ports as well as at those located as much as 100 km inland, and can range from 0.1 – 1.5 m/yr (van Rijn, 2012; Headland, 1991; DH, 1989), with required navigation maintenance dredging volumes ranging from 0.1 - 1.1 million metric tons per year. Most of these ports have developed solutions to their problems that use various methodologies to eliminate or more realistically reduce dredging, by attempting to forecast or estimate sedimentation rates using (van Rijn, 2012):

- Laboratory scale models including (where applicable) tidal effects, density-driven effects (saline sea water and fresh river discharges), and sediment deposition effects (using tracer studies);
- Three-dimensional mathematical or numerical models describing the flow patterns, the fluid density patterns and the sediment concentration patterns in the basin (Deltares 2002-2003; DHI, 2014); and
- Simplified semi-empirical methods schematizing the most important physical processes of the siltation in a harbor basin.

Most of the reduction measures to control sedimentation rates in ports with tidal influences have focused on the reduction of the tidal volume exchanged with the port. In areas where tidal exchange is already low, or where ports are either situated up river or are located on estuary channels that introduce sediment, then measures are focused on reducing sediment input to the port (Johnson et al., 2010). Some of these methods practiced and applied to international ports include, but are not limited to (van Rijn, 2002):

- Selection of alternative site (new basin);
- Determination of appropriate nautical depth;
- Improvement of entrance geometry;
- Restriction or closure of lateral entrances to the port;
- Construction of entrance sill;
- Construction of localized current deflection wall;

- Installation of upstream pile screen;
- Installation of silt curtain; and
- Re-suspending systems.

A very common problem contributing to increased sedimentation volumes within sheltered inland river ports is the existence of a side or a back entrance. Using laboratory scale models, Jenkins (1981) studied the effects of various entrance geometries on water exchange volumes to ports that could be characterized as being orientated perpendicular to the main channel flow. The author specifically investigated the effect of projecting "spurs" (training walls) with rounded heads at the corners of the basin and parallel to the main channel. Results showed that a spur at the upstream corner is much more effective in reducing the water exchange than a spur at the downstream corner (Figure 1). The study provided basic recommended lengths of the upstream spur, suggesting that a length of L1= 1/3B (B= width of entrance) yields a significant reduction of the water exchange due to horizontal circulation and thus reducing sedimentation (van Rijn, 2012).

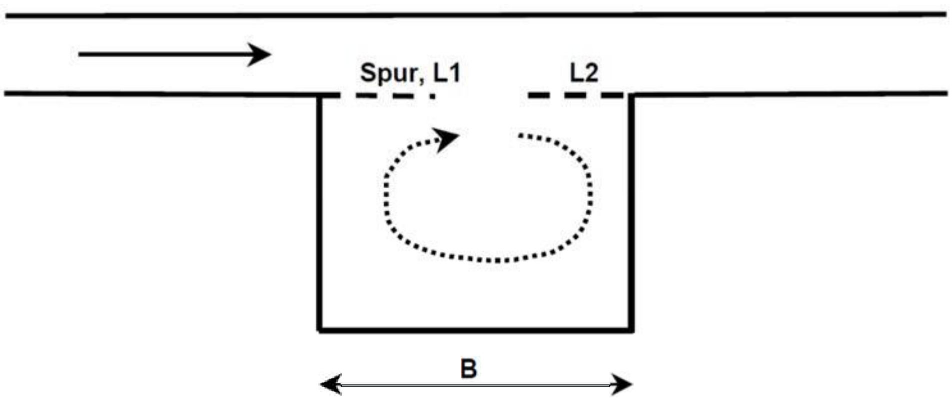

Figure 1 Effect of entrance geometry on water exchange due to horizontal circulation[1]

Additional studies have investigated the effects of entrance orientation, angles to the main flow, and the effect of the entrance coefficient on the reduction/increase of sedimentation volumes. Langedoen et al. (1994) investigated the effects of the shape of the entrance of an interior tidal harbor basin. Booij (1986) studied the effects of various entrance geometry coefficients, and how they enhanced or reduced water exchange and thus sedimentation (van Rijn, 2012).

Sedimentation in a basin with two entrances (one at each end of the basin) is considered to be less compared to that occurring in a singled entrance basin, because in the former case the prevailing currents flow through the basin, thereby keeping the sediments partly in suspension (assuming sufficiently high velocities to maintain sediment in suspension). In a case study in the Bremen Harbor, Germany, Nasner (1997) studied the effect of the closure of a side entrance on the siltation in the Neustädter basin (total area of about 650,000 m^2) and discovered that sedimentation volumes increase after closure of the side channel entrance.

[1] From van Rijn, 2012

However, additional issues at other ports and harbors are presently being addressed, and each port must be studied separately for detailed and more accurate results (van Rijn, 2012; Johnson et al., 2010).

Introductory concepts - physics of sedimentation

Sedimentation is generally used to explain net deposition of sediment in a river or sea bed. Rivers carry sediment of various size classes, ranging from clays and silt, to fine and coarse grained sands and gravel. Rivers generally exhibit a downstream fining trend, whereby at their headwaters they may carry coarse material, such as gravel and coarse sand, but carry only clays, silt, and fine sand as they approach their outlets to the ocean. The Mississippi River falls into this category and exhibits large spatial variations in grain size composition. Another important factor contributing to sediment transport in rivers is the speed (velocity) of the water, as sediment transport is proportional to stream power, or water velocity. In rivers, sediment travels near the bed (bed load) or within the water column (in suspension). The temporal variations of river flow and thus velocity can alter the regime in which sediment is carried through a river system. While principally the modes or regimes of transport are suspended or bed load, the total amount of sediment (sediment load) and the type of sediment (grain size) carried by the river varies as a direct function of the velocity or flow in a river. The classical physical deposition of sediment occurs when the speed of the water is insufficient to carry the sediment in suspension (gravity is acting to slowly settle the particles), and instead the sediment is deposited close to the bed.

Sedimentation trends at the case study ports

For the case study ports (Port of Lake Providence and Port of Madison Parish), a literature search was conducted after meeting with port officials and local stakeholders. The project team was also given access to preliminary studies conducted by the USACE, Vicksburg District, using hydrodynamic and sediment transport models to address specific concerns related to sedimentation in the vicinity of the ports, following the flood of 2011. Electronic copies of the draft documents and presentations were obtained through a Freedom of Information Act (FOIA) request. These reports and presentations are in draft format; therefore, the results from their analysis summarized later in this report are considered preliminary, pending more detailed analysis. Furthermore, project schedule and budgetary constraints limited the researcher's efforts to conduct an extensive and detailed analysis of the specific issues associated with the individual ports, and hence the researcher's analysis and interpretation is guided strongly by these documents, combined with supplemental literature research and cumulative expertise of the project team.

Overview of the Status of the Mississippi River Inland Waterway System

Figure 2 U.S. inland waterway system (Source: USACE)

The Soybean Transportation Coalition studied the U.S. inland waterways (depicted in Figure 2) to determine the status of the infrastructure needs, as it relates to agricultural export / imports. Of note, it was determined that 54% of the Inland Marine Transportation System's (IMTS) structures are more than 50 years old and 36% are in excess of 70 years old.

Additionally, USACE Operations and Maintenance budgets continue to decrease (Table 1), further compounding the reduction of competitively awarded available funds to maintain access to Inland River and Port Terminals, which in turn greatly affects where grain is being produced and exported. The data in the table below includes funds appropriated from the Inland Waterways Trust Fund (in Construction) and the Harbor Maintenance Trust Fund (in Operations and Maintenance).

Table 1 Corps of Engineers budget authority, net (total), $ million—FY 1994–FY 2013[2]

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Unadjusted:																				
General Investigations	183	171	122	153	157	161	165	166	154	134	116	144	204	171	167	193	166	122	125	102
Construction	1304	919	803	1086	1475	1466	1374	1736	1711	1743	1730	1818	3043	2419	3921	6915	2017	1612	1696	1472
Locks and Dams	*338*	*247*	*118*	*101*	*142*	*101*	*160*	*222*	*194*	*145*	*141*	*153*	*218*	*235*	*205*	*222*	*231*	*105*	*101*	*95*
Operations and Maintenance	1689	1644	1731	1866	1845	1753	1854	2049	2173	2105	2030	2371	2375	2052	3376	4403	2661	2461	2945	2398
Locks and Dams	*356*	*349*	*346*	*344*	*346*	*402*	*396*	*406*	*387*	*391*	*395*	*410*	*289*	*382*	*440*	*640*	*472*	*481*	*376*	*330*
Total Unadjusted	3,176	2,734	2,656	3,105	3,477	3,380	3,393	3,951	4,038	3,982	3,876	4,333	5,622	4,642	7,464	11,511	4,844	4,195	4,766	3,972
Indexed:																				
General Investigations	183	165	116	142	143	145	145	144	130	111	88	103	138	110	101	119	99	70	71	57
Construction	1,304	889	761	1,008	1,345	1,316	1,211	1,510	1,443	1,438	1,320	1,302	2,064	1,557	2,378	4,248	1,208	931	961	821
Locks and Dams	*338*	*239*	*112*	*94*	*130*	*91*	*141*	*193*	*164*	*120*	*108*	*110*	*148*	*151*	*124*	*136*	*138*	*61*	*57*	*53*
Operations and Maintenance	1,689	1,590	1,640	1,731	1,683	1,574	1,634	1,782	1,833	1,736	1,549	1,698	1,611	1,321	2,047	2,705	1,594	1,421	1,668	1,337
Locks and Dams	*356*	*338*	*328*	*319*	*316*	*361*	*349*	*353*	*326*	*323*	*301*	*294*	*196*	*246*	*267*	*393*	*283*	*278*	*213*	*184*
Total Indexed	3,176	2,644	2,516	2,881	3,172	3,034	2,991	3,437	3,406	3,285	2,957	3,103	3,813	2,988	4,526	7,072	2,902	2,423	2,700	2,214

The Mississippi Waterway comprises a significant portion of the U.S. navigable inland waterway system and requires significant investment in the operation and maintenance of its infrastructure, including the inland river port terminals that depend on uninterrupted access to the river for their operations. The availability of construction (Inland Waterways Trust Fund) and operations and maintenance funds (Harbor Maintenance Trust Fund) are critical to the sustainability and economic viability of both inland river and port terminals.

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[2] Source: "New approaches for U.S. lock and dam maintenance and funding" Texas transportation institute, 2012

Figure 3 North American rail network and major ports

Figure 4 Railroads track upgrade investment

Figure 5 U.S. grain and oilseed production intensity

Grain is increasingly being transported via rail (Figure 3) as the railroads (Class I, shortline, and terminal) continue to invest in their infrastructure (Figure 4). The outlook for U.S. exports is increasingly dependent on railroads in transporting products to ports for export. This modal shift is unlikely to change unless the U.S. begins to invest more in inland waterways.

The Mississippi Waterway system is a key factor for the use of land for agricultural production and export. Figure 5 shows areas where grain and oilseed production intensity is the highest. It is evident that waterway access is very important to agricultural production. Agricultural products are bulk commodities and, while railroads are increasing their investment to capture market opportunities to move agriculture commodities around the country, waterways still remain best suited for this purpose.

The Soybean Transportation Coalition report is a few hundred pages long and contains a substantial amount of data. One key finding concerned the hours of downtime or outage of locks on the Mississippi River (Figure 6).

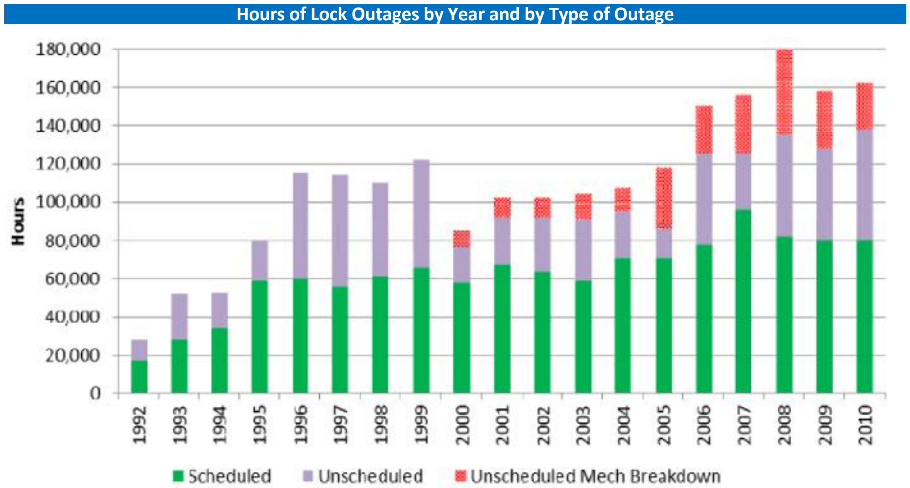

Figure 6 Hours of lock outage by year and type of outage[3]

While impacts to agricultural goods movement from the Port of Lake Providence and the Port of Madison Parish are not impacted by the operations and downtime of the Mississippi River Lock and Dam system (Figure 6), the maintenance of existing infrastructure on the Mississippi River is clearly critically underfunded. As such, the likelihood of construction of new major control structures on the Mississippi River in order to maintain uninterrupted access to these ports is set against a highly competitive and prioritized maintenance program. The likelihood of new structural approaches will have to meet the criteria determined by a conventional USACE cost-benefit ratio, conducted under USACE NED analysis.

Given the increasingly private investment in the railroad network and the fact that public sector funding for inland waterway freight movement infrastructure has been, and continues to be, inadequate, it is therefore no surprise that New Orleans Customs District (which includes both the Port of Lake Providence and Port of Madison Parish) has been losing its share of grain and oilseed exports. In 2003, the New Orleans Customs District had a 60% share of U.S. grain and oilseed exports; by 2013, it had only a 46% share (Table 2). This, however, may change with the operation of the Panama Canal Expansion, predicted for the first quarter of 2016.

Table 2 Shares of U.S. grain and oilseed exports by port district[4]

	Share of U.S. Grain Exports											
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013E	*Gain*
Columbia-Snake	14%	17%	16%	14%	16%	18%	15%	17%	18%	20%	24%	*10%*
Los Angeles, CA	1%	1%	2%	2%	4%	4%	3%	3%	4%	4%	5%	*3%*
Minneapolis, MN	0%	0%	1%	1%	2%	1%	1%	2%	1%	1%	0%	*0%*
New Orleans, LA	60%	55%	51%	54%	49%	46%	51%	49%	47%	51%	46%	*-14%*
Norfolk, VA	1%	0%	1%	2%	2%	2%	2%	2%	2%	2%	2%	*2%*
San Francisco, CA	1%	1%	1%	1%	1%	1%	2%	1%	2%	2%	2%	*1%*
Seattle, WA	8%	11%	13%	12%	11%	13%	12%	11%	12%	11%	10%	*2%*
Total U.S.	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	

Ultimately these relative changes in infrastructure quality impact the best use of land. Careful inspection of the production intensity data shows where there have been increases in production (Figure 7).

[3] Source: Soybean Transportation Coalition report "America's Locks and Dams"

[4] Source: U.S. Census Bureau

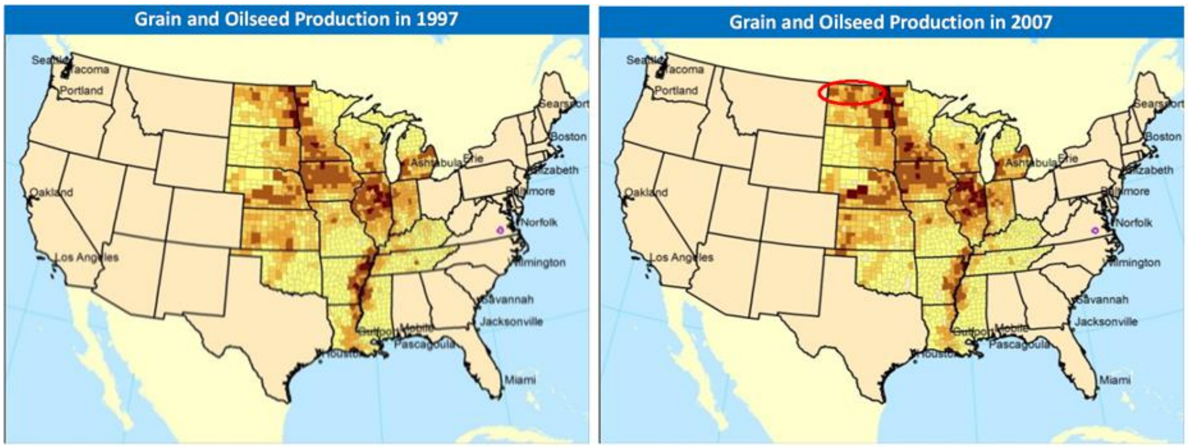

Figure 7 Changes in production intensity of grain and oil seed production[5]

The comparison intensity map substantiates the intuition that investment or dis-investment (via insufficient maintenance) impacts the use of land and therefore the structure of the economy. In the case of agricultural exports via the Mississippi Waterway System, maintenance expenditure trends look to worsen given the recent trends in the USACE's budget.

Overview of Significant and Recent Mississippi River Events

Administered by the Mississippi River Commission (MRC) under the supervision of the Office of the Chief of Engineers, the Mississippi River and Tributaries (MRT) project includes four major elements:

- Levees for containing flood flows;
- Floodways for the passage of excess flows past critical reaches of the Mississippi River;
- Channel improvement and stabilization to provide an efficient and reliable navigation channel, increase the flood-carrying capacity of the river, and protection of the levee system; and
- Tributary basin improvements for major drainage basins to include dams and reservoirs, pumping plants, auxiliary channels, and pumping stations.

The MRT project is the largest flood control project in the world, providing protection to 36,000 square miles of the lower Mississippi valley. The flood control features of the project are designed to control the "project flood"—the largest flood reasonably expected to occur. The MRC developed the present "project flood" in 1956 after a complete review of the adequacy of the MRT project and is larger than the record flood of 1927. The project flood is 11 percent greater than the 1927 flood at the mouth of the Arkansas River and 29 percent greater at the latitude of Red River Landing.

The navigation features of the MRT project seek to facilitate navigation and promote commerce on the nation's most vital commercial artery. Waterborne commerce on the Mississippi River has increased from 30 million tons in 1940 to nearly 500 million tons today. This heavy commercial traffic includes grains, coal and coke, petroleum products, sand and gravel, salt, sulfur and chemicals, and building materials amongst others. However, all of this commerce is contingent on access to the inland river port terminals that line

[5] Source: U.S. Department of Agriculture.

the river. Since the initiation of the MR&T project in 1928, the nation has received a $45 return for every dollar invested, including $306 billion in flood damages prevented.

As summarized in the 2012 Executive Summary of the #387 and #388 Sessions of the Mississippi River Commission:

> The performance of the Mississippi River and Tributaries (MRT) system during the Great Flood of 2011 validated this wise investment. Despite record high flows and stages, not a single life was lost as a result of the flood. Water lapped at the top of floodwalls and levees the length of the river, exerting unprecedented pressure on the backbone of the protection system, but the levees withstood the record stages and pressure due in large part to the operation of the three floodways and the storage capacity provided by the non-MRT reservoirs in the Ohio and Arkansas-White basins. All told, the MRT project prevented in excess of $112 billion in damages, not including potential losses from interrupted business activities and related impacts. One year later, with much of the drainage basin under exceptional drought conditions and river stages plunging to near historic lows more than fifty feet lower than the 2012 highs on the major gauges between Cairo and Red River Landing, the performance of the MRT system is again validating the nation's wise investment, as the navigation channel remains viable.[6]

The following table excerpted from the August 24, 2012 MRC Low Water Inspection Trip Report shows the significance of this event.

Table 3 Mississippi River stage difference between 2011 high water and 2012 low water events

Mississippi River Gauge Location	Difference in River Elevation between 2011 & 2012
Cape Girardeau, MO	39 ft.
Cairo, IL	53 ft.
New Madrid, MO	48 ft.
Memphis, TN	59 ft.
Vicksburg, MS	57 ft.
Red River Landing, LA	50 ft.
New Orleans, LA	16 ft.

2011 Flood conditions/high water stages

The Port of Lake Providence and the Port of Madison Parish, located in northeastern Louisiana were particularly affected from sedimentation deposited historic high water event of 2011. This was primarily due to a secondary levee washout at Bunches Bend, LA. As reported In March of 2011 by AP reporters Mary Foster and Sheila Byrd:

6 www.mvd.usacoe.army.mil/mrc/

> Water from the swollen Mississippi River poured over a century-old levee flooding 12,000 acres of corn and soybeans despite frantic efforts to shore up the structure. This secondary levee washout has contributed to the problem of sedimentation build up at both the Port of Lake Providence and the Port of Madison Parish, although in different ways. However, it should be noted that sedimentation buildup is an annual event at both ports. Downstream officials with the Port of New Orleans said the Coast Guard could close the river to ships as early as Monday, halting traffic on one of the world's busiest commercial waterways. After swamping low-lying neighborhoods in Memphis, Tennessee, earlier this week, the rising water is bringing misery to farms and small waterfront communities in Mississippi, Louisiana and Arkansas. The Corps of Engineers is considering whether to open the Morganza Spillway, which would flood thousands of homes and acres of farmland along a 100-mile stretch in Louisiana to take the pressure off levees and help to protect Baton Rouge, New Orleans and the oil refineries in between. Barges headed south from the nation's heartland to the Port of South Louisiana at Reserve, upriver from New Orleans, would be unable to reach grain elevators. Massive ships that transport U.S. corn, soybeans and other crops would be unable to move. Shipments of Venezuelan heavy of crude oil that come in by tanker to a refinery in Chalmette would be locked out of the river, though most refineries on the river are fed by pipelines. Swollen by weeks of heavy rainfall and snowmelt, the Mississippi River has been breaking records that have stood since the 1920s and 30s. It is projected to crest at Vicksburg on May 19 (2011) and shatter the mark set there during the cataclysmic Great Flood of 1927. The crest is expected to reach New Orleans on May 23.[7,8]

The extreme low water event in 2012 along the Mississippi River and its tributaries caused unique challenges for port operators, barge companies, and the entire maritime community. As reported in a 2012 Associated Press article[9], "A year after the Mississippi River swelled to near historic proportions and flooded farms and homes from Illinois to Louisiana, the level along the southern half is so low that cargo barges have run aground and their operators have been forced to lighten their loads." According to Jim Pogue, spokesman for the USACE:

[7] Foster and Byrd, "Mississippi River flows over Louisiana levee, flooding crops," 5/12/2011
[8] Ibid
[9] "Rivershed drought causes low water levels and economic hardship," Holbrook Mohr, July 16, 2012

> It's remarkable but it's completely normal. You get a low river, you get a high river, but it's completely normal. Also, low water at docks and terminals makes it more difficult to load or unload material, as ships have trouble getting close enough to docks. Companies must get permits to dredge near their docks to find deeper places to load and unload. 2012 is just the opposite of last year. This year sections of Tennessee and regions to the north are experiencing drought conditions. Most areas in the Mid-South are 10 in. or more below normal for rainfall for the year, according to the National Weather Service. Lower-than-normal snowfall levels over the northern plains this winter are also an issue, according to Ryan Husted, a National Weather Service meteorologist in Memphis. Less snow means less water from melted snow making its way into the Mississippi and the rivers that feed it. The record low on the Memphis gauge is -10.7 ft. set during a severe drought in 1988.[10]

That year a stretch of the river about 100 miles south of Memphis was temporarily closed, according to the USACE's spokesman Pogue. Additionally, Pogue stated that the USACE predicted that the river would drop to within about 2 ft. of the record, but was not expected to reach it. At the time, no stretch of the river had been closed, but at least one harbor, in Hickman, Kentucky, had been shut down. Although U.S. Coast Guard officials claimed closings were not imminent, they had reported navigation problems on the river. Reports of towed barge groundings were higher compared with years when the river's water level was normal, according to USCG spokesman Ryan Gomez. Meanwhile barge operators were required to carry less cargo to avoid running aground, resulting in reduced profits per trip.[11] For Big River Rice and Grain, a barge operator-tenant at the Port of Lake Providence, the economic consequence due to less loaded barges equaled over $21 million in lost revenue in 2012, according to Bubba Richardson, manager of port operations for BRRG[12]. At Greenville, Mississippi, Port Director Hart checks the river stages daily during low water events. Low water events on the Mississippi River typically occur during harvest season, a busy time for ports that exports goods from the heart of Mississippi's farmlands including rice, wheat, grain feed ingredients, and fertilizer. A major concern at Greenville and other ports in southern Mississippi and northeastern Louisiana is that entrances to the river could become too shallow, in part due to the build-up of sediment at the intersection of the access navigation channel and the river. When this happens, which occurs on an annual basis, the USACE initiates a rotating dredging operation to allow access to the ports, permitting a deeper draft and enabling heavier loads. As the port director of Greenville, Mississippi, explained, "We seem to be living in a day and age of extremes. We had the flood last year and now we have low water."[13]

[10] "Mississippi River Flooding: one year later, shippers run aground," Holbrook Mohr, 9/15/2012

[11] Ibid

[12] BRRG Bubba Richardson memo to project file, 2/19/2015

[13] Holbrook Mohr, "Mississippi River flooding: one year later, shippers run aground," 9/15/2012

According to a November 22, 2012 USA Today article[15] "a crucial 200-mile stretch of the Mississippi River maybe on the verge of a shutdown to barge traffic, a move that could paralyze commerce on the nation's most vital inland waterway and ultimately drive up prices. Quoting Rick Calhoun, President of Cargo Carriers, (Cargill's barge business) "What's at stake is potentially shutting down one of the most important navigation arteries in the world."" According to both Missouri Governor Jay Nixon and Illinois Governor Pat Quinn, "This is an impending economic crisis that could delay shipment of $7B in commodities in January and February." Both governors, as well as their legislative delegations, asked the White House to intervene. Because of the drought, most vessels on the Mississippi were limited to a 9 foot draft, according to Andrew Carter of Knight Hawk Coal in Percy, Illinois. "If we go down to 6-foot drafts, the river is effectively closed." [14]This fate was narrowly averted during the low water event of 2012. This historic low water event was especially problematic because it coincided with the annual harvest season in both northeastern Louisiana and southeastern Arkansas.[15]

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[11] Ibid

[12] BRRG Bubba Richardson memo to project file, 2/19/2015

[13] "Mississippi River flooding: one year later, shippers run aground," Holbrook Mohr, 9/15/2012

[14] Ibid

[15] "Mississippi River commerce imperiled by low water," USA TODAY staff writers, 11/22/2012

Port Profiles

The Port of Lake Providence (PLP)

Figure 8 Aerial photograph of Port of Lake Providence

The Port of Lake Providence (PLP) is located at mile 484 A.H.P. in the northeast corner of East Carroll Parish, 2.5 miles south of Lake Providence on U.S. Highway 65. The PLP was created by the Louisiana Legislature during the 1958 regular session. The PLP is situated on 284 acres of which 95 are elevated above flood stage, due to the use of hydraulic fill. The main service area of the port extends west from the Mississippi River including several north Louisiana parishes and portions of southeastern Arkansas.

A distinct maritime attribute of the PLP is its slack water harbor and its connection to the extensive inland waterway network of the Mississippi River system. Waterborne barge traffic has access to the port facilities via the Hagaman Chute, a slack water channel approximately 8,200 ft. long and 150 ft. wide. The navigation channel is 12 ft. deep with a USACE authorized maintained depth of 9 ft. Annual sedimentation buildup at the entrance to this channel is an ongoing problem for the port, its tenants and for the

Operations Division of the USACE. Barge fleeting operations are handled by Terral River Services and Big River Rice and Grain.

The major cargo types handled by the PLP are agricultural commodities (corn, soy beans, cotton, milo, wheat, sorghum, and rice), liquid and dry fertilizer, as well as gravel and sand. All of these commodities are heavily dependent on the local markets. The PLP has consistently ranked as a top 25 inland river port according to the USACE Waterborne Commerce Statistics. In an on-site meeting at the PLP in mid-February 2015, Wyly Gilfoil, Executive Director of PLP, stated that the combined cargo handled by the PLP and the Port of Madison Parish would show the fastest cargo growth on the U.S. inland river system.

Highway access is provided by U.S. Highway 65 running north-south linking to Interstate 20 running east-west, located approximately 30 miles south in Tallulah, LA. Through efforts of the Delta Regional Authority (DRA), portions of the former Delta Southern Railroad have been put back into service from PLP north to Lake Village, AR, where it connects with the Union Pacific Railroad. Recently the DRA awarded the PLP $210,000 to extend a rail spur within the port to Myriant's succinic acid bio-refinery as well as Bungee and Big River grain terminals. A south bound reconnection to the Kansas City Southern railroad at Tallulah has yet to be implemented but this project is a priority for the port, the parish and the affected tenants.

Existing facilities include the Bunge Grain Elevator (1.2 M bushel capacity) and associated barge loading equipment, (built in the early 1960s); the recently constructed Big River Rice and Grain Terminal (completed 2014), a general storage yard and six 1-M gallon liquid storage tanks, a general cargo pier and ramp, 30-ton crawler crane, on-site truck scale and the recent Myriant Technologies $145-M bio-refinery that opened in 2014. This sophisticated plant uses various waste-based biomasses to produce succinic acid and associated chemicals.[16]

Analysis of existing flows to identify cargo volumes at the Port of Lake Providence

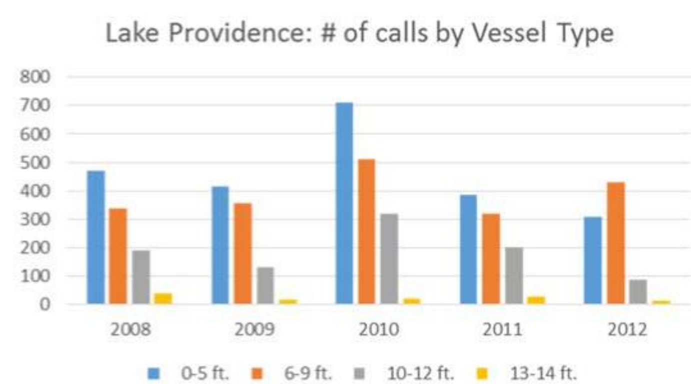


Figure 9 Vessel draft characteristics at PLP

Vessel traffic at PLP is dominated by vessels with draft of 9 ft. or less (Figure 9). The authorized depth of the channel is 9 ft.

Food and farm products account for almost all goods being exported from the port (Figure 10). Soybeans, corn, rice, and wheat made up 98% of all outbound shipments[17]. Inbound goods into the port consist mostly of chemical related products (50%) and crude materials (38%).

[16] Port of Lake Providence Port Commission website
[17] Percentages reflect averages of total inbound/outbound goods between 2008 and 2012

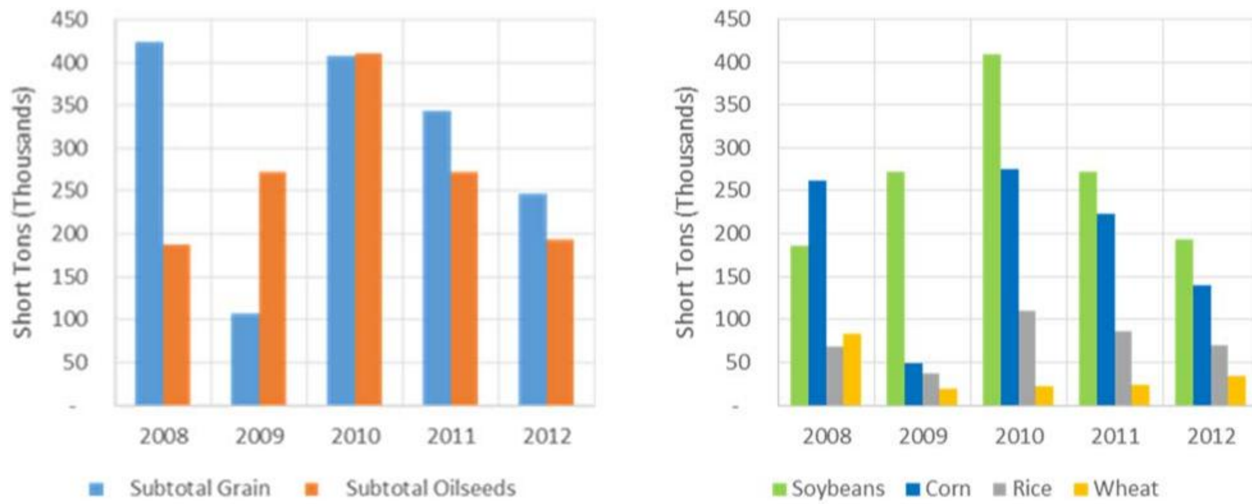


Figure 10 PLP exports: food & farm products: grain and oilseeds (left), grain and oilseeds: soybeans, corn, rice, and wheat (right)

The Port of Madison Parish (PMP)

Figure 11: Aerial photograph of Port of Madison Parish

The Port of Madison Parish (PMP) is located on the Mississippi River at river mile 457 AHP, in northeast Louisiana, six miles north of Tallulah on U.S. Highway 65. The port was created by the Louisiana Legislature by Act 369 of the 1966 session. Maritime cargo handled by the Port of Madison Parish is driven by local markets and is primarily agricultural in nature. When originally created, the port was envisioned to be a fully operational marine terminal and industrial park with roads, railroads, water, sewer, natural gas, and electrical infrastructure. The port's site totals 266 acres. The main maritime tenant is Terral River Services (TRS), which serves as the port's stevedore. TRS is a river transportation service company specializing in the bulk storage and handling of dry and liquid materials along the Mississippi River, the Gulf Intracoastal Waterway (GIWW) and the inland waterways of Louisiana and southern Arkansas. Services offered include: terminal dock operations, custom barge operations, barge cleaning, barge repair, bulk material storage and bulk material handling. The sedimentation at the port occurs downstream of the TRS dock, forming a sandbar approximately 200 yards long[18]. Bunge North America (BNA) also has a major grain elevator and storage facility at the port. This facility includes sixteen concrete storage silos, with thirteen interstices and four storage tanks with a total capacity of 3.1 M bushels. Their grain elevator complex on-site, which

[18] Project Meeting Memo at Port of Lake Providence, 2/20/15.

experienced a dust explosion in 2010, which significantly impacted their business. It also has seven steel, liquid-fertilizer storage tanks at the rear of their property with a capacity of 8.84-M gallons.[19]

Other tenants at the port include Complex Chemical Co. Inc. (CCCI), a family-run business that produces a variety of chemicals including ethylene, diethylene, triethylene glycol, viscosity index modifiers, brake fluid, and anti-freeze products. CCCI exports approximately 650 – 750 rail tank cars per month. Although the plant was destroyed by a 2010 tornado, it has subsequently been rebuilt and expanded. The expansion is projected to include increased exports estimated at between 800 – 900 tank cars per month. The nation's leading farmer-owned cooperative, global energy, grains and food company, CHS Inc., bought the fertilizer business and related assets of Teral River Services in February 2014. Jimmy Sanders, a Cleveland, Mississippi based agri-business company, has become one the nation's leading farm supply distribution businesses with over 100 locations in the South. The company includes agricultural chemical distribution, seed production and sales, bulk handling of fertilizer, and precision agricultural services, including their Opti-Gro program. Helena Chemical Company is one of the nation's leading foremost distributors of crop protection and crop production services for agricultural and ornamental turf, forestry, aquatics and vegetation management markets. The port owns a general cargo pier that is operated by Terral River Services (now owned and operated by CHS, Inc.). Bulk cargo handled at this facility includes aggregates, lime, dry and liquid fertilizers, cottonseed and grain. The port owns a 110-ton crane with an 8-yard bucket, a conveyor belt (36 in. wide and 200 ft. long) that connects to two storage pads measuring 136 yards by 100 yards and 250 yards by 72 yards, respectively. The port also has a general cargo ramp which is operated by Terral River Services. The port owns truck scales and a freight rail spur (4.2 miles in length) that connects to the Delta Southern Railroad (DSRR) which provides a weekly service to the KCS Class I railroad at Tallulah (approximately 7 miles downriver). Existing tenants want more frequency of service from the DSRR, but little progress has been made in the improvements of frequency of service.

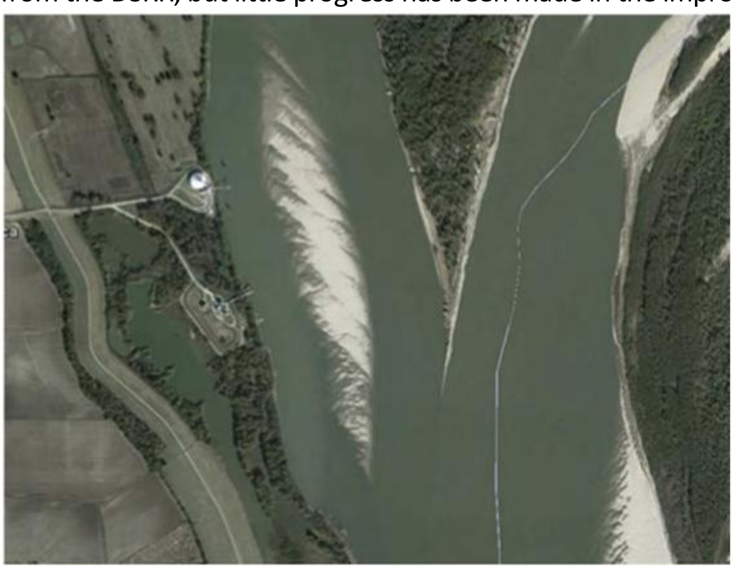


Figure 12 Bunge North America, Goodrich Landing, Transylvania, LA

To complement their existing grain terminals at the Port of Lake Providence and the Port of Madison Parish, Bunge North America built a grain elevator with two concrete silos and one steel tank at Goodrich Landing, located in Transylvania, LA. This facility has a total capacity of 1.85-M bushels.

[19] http://seaport.findthedata.com/1/8913/Bunge-North-America-Tallulah-Louisiana

Analysis of existing flows to identify cargo volumes at the Port of Madison Parish, LA

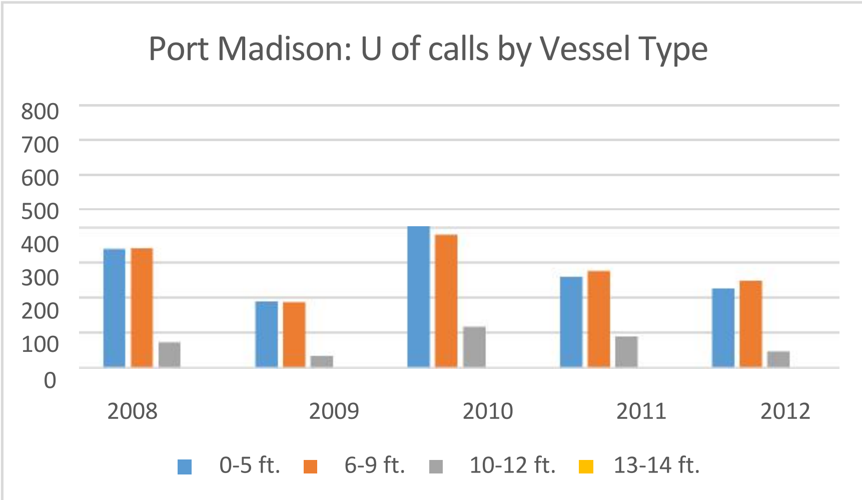
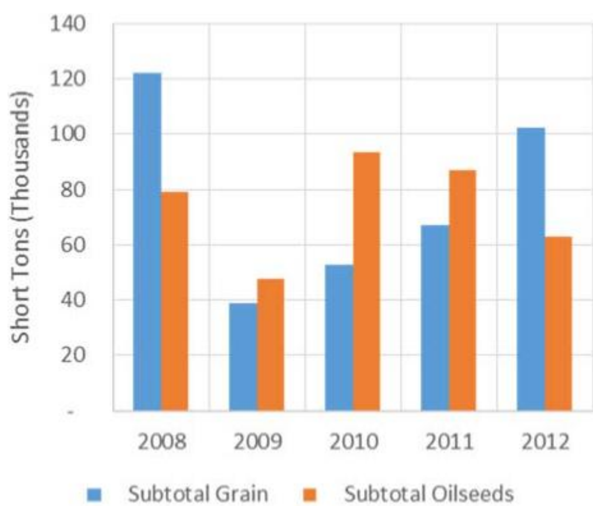


Figure 13 Vessel draft characteristics at PMP

Commodities at the Port of Madison Parish are very similar to those handled at the Port of Lake Providence but in much smaller volumes (Figure 13).

Food and farm products account for almost all goods exported from PMP (Figure 14). Soybeans, corn, rice and wheat make up 91% of all outbound shipments[20]. Inbound goods consist mostly of crude materials (67%) and chemical-related products (19%). Though in very small volumes, grain accounts for almost all food and farm product inbound moves.



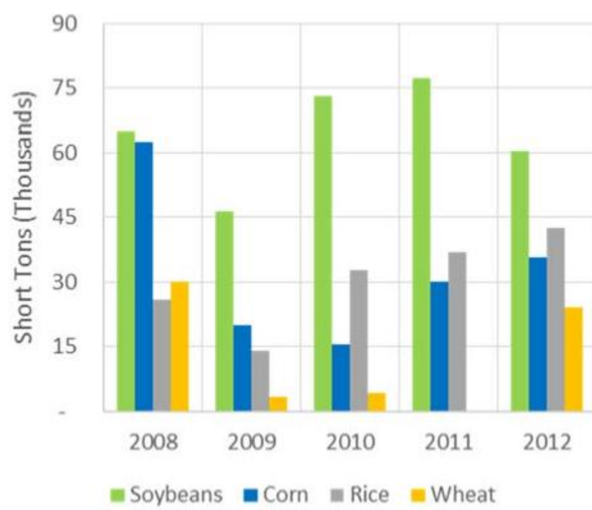


Figure 14 PMP exports: food & farm products: grain and oilseeds (left), grain and oilseeds: soybeans, corn, rice, and wheat (right)

[20] Percentages reflect averages of total inbound/outbound goods between 2008 and 2012.

Table 4 Waterborne Commerce Statistics: total tons of both inbound and outbound cargo

	2009	2010	2011 (flood)	2012 (drought)	2013
Port of Lake Providence	634,676	1,348,703	895,876	732,807	1,595,342
Port of Madison Parish	326,831	734,557	560,780	443,258	445,617

Source: USACE

Table 5 Row crop summary for Northeast Louisiana District 2010 – 2014

Year	Acres Harvested	TP	Corn Acres	Cotton Acres	Rice Acres	Sorghum Acres	Soybean Acres
2010	1,084,807	80,214,893	355,000	141,000	110,300	886,000	412,500
2011	1,114,936	87,624,691	410,000	155,700	54,700	1,647,000	365,500
2012	1,156,173	106,178,733	387,500	123,500	42,600	1,755,000	440,000
2013	1,165,235	122,689,664	492,000	57,500	45,100	1,604,000	420,500
2014	971,700	97,272,000	272,000	NA	66,500	1,575,000	614,000

Source: LSU Department of Agriculture

The regional market served by both ports is primarily agricultural, with the largest row crop being soy beans. Corn represents the second most significant row crop. While cotton historically has been a significant regional commodity, in the last 5 years, its acreage has diminished by over 60%. The associated storage and gin infrastructure has also been reduced. Until recently, there were seven operating gins in East Carroll Parish. Today, there are three. Both these ports are prime examples of the shift in market forces. PLP has two large cottonseed sheds that are currently vacant (each 21,000 sq ft.) and have not been used for at least 10 years. This vacant capacity is replicated at PMP, with approximately 100,000 sq ft. of cottonseed warehouses not being used for its intended purpose.

Economies of Agricultural Product Transport on the Lower Mississippi River

The previous statistics show the dominance of Lower Mississippi River ports versus other U.S. ports. Historically, the inland waterway system of the United States has been used for export cargo in particular agricultural commodities, liquid and dry bulk products, chemicals, and crude oil. Transportation of bulk goods via water is generally most cost effective over other modes of transport because of the greater carrying capacity of water born goods movement. Furthermore, particularly south of St. Louis, there are no locks or dams to navigate during transport. Additionally, this method of transport does not require the huge capital investments needed to construct highways and bridges or laying rail tracks. However, water and land-based modes of transport interface at ports, which require capital investment during development.

For a port to remain commercially and financially viable, it must handle a critical volume of goods, and, thus, an annual threshold number of vessel calls at the port must be achieved. Goods will ultimately reach their destination, whether or not the most efficient supply chain is chosen. Over short distances, trucking provides an alternative mode of transport over waterways. For a port to remain a component of an efficient supply chain, it must be able to meet the demands of the logistics needs of a particular cargo. In many cases, this is determined by the frequency of vessel calls, size of the vessel calling, and the berthing capacity of the port. Optimally, larger vessels allow for fewer calls, allowing more efficient berthing as waiting windows are reduced. The primary constraint to larger vessels calling at ports is the channel water depth.

Coastal ports typically have deeper depths than upland river ports. Sedimentation and other morphological processes may degrade channel depth, and may require periodic dredging for maintaining the required depth for navigation. Production, storage and transportation of U.S. agricultural goods impacts pricing and dictate how competitive they are in the global marketplace. Thus it is of national importance to develop solutions to ensure the maintained navigability of the coastal and inland river waterways and uninterrupted access to the ports located on these waterways.

Significant volumes of agricultural goods are exported through the coastal ports of Louisiana, particularly through the New Orleans and Baton Rouge Customs District. These agricultural products are grown and harvested within the state or in states along the Mississippi River valley. For ports located within 70 miles from the point of harvest, agricultural goods destined for export are trucked via road as the preferred mode of transport to the point of export at the river ports (such as the Port of Lake Providence and the Port of Madison Parish), where they are consolidated at storage facilities and then moved in much larger shipments to coastal ports for exports.

Cargo flow analysis and commodity trend outlooks indicate substantial handling of agricultural products out of the Ports of Lake Providence Madison Parish, with the dominant vessels size calling at both ports requiring a shallow draft access of 5 ft. or less.

As shown in Figures 10 and 14, the export of goods from both ports is predominantly food and farm products, including grains and oilseeds. Corn, rice, and wheat make up the grains and oil seeds that amounts to over 350,000 tons in 2012. In the same period, soybean shipments amounted to over 250,000 tons. In terms of growth rates over the last five years, exports of both soybean and cereals out of the lower Mississippi have been better than other U.S. regions. Specifically, soybean exports out of the Lower Mississippi outgrew other U.S. exports by over five times. The underlying driver for demand for these agricultural products lies in global population growth and the overall demand for food and animal feed.

Potential for Lower Mississippi River growth in throughput and increase in economic impact: *Why improved access to inland river terminals is critical*

Growth of international import and export[21] trade at the national level was compared to that of the New Orleans Custom District as a whole, as well as a subset of ports, but excluding major ports on the Lower Mississippi, south of Baton Rouge.[22] This analysis highlights the potential for volume growth and increase in market share, assuming that access to the inland river port terminals can be guaranteed.

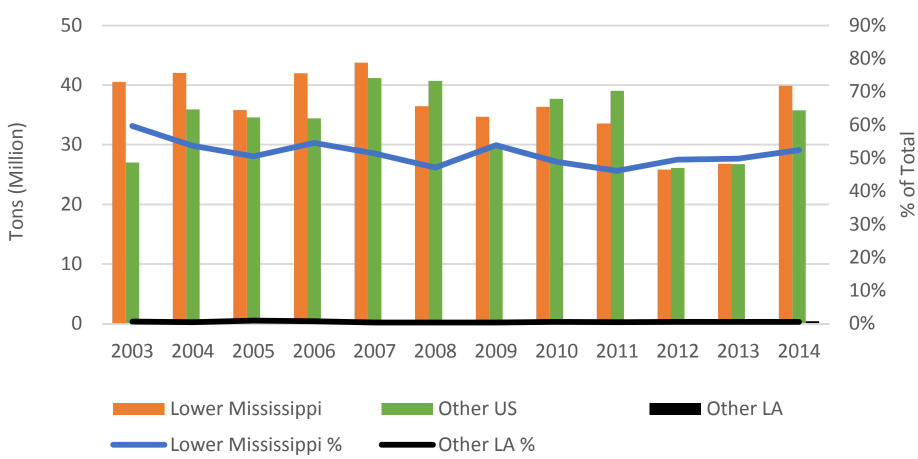


Figure 15 Cereal exports on the Lower Mississippi River 2003-2014

Cereal Exports on the Lower Mississippi historically matches U.S. export volumes. After a lean period in 2012-13, volumes appear to be recovering (Figure 15). There has been only weak growth nationally, primarily due to the 2012-13 drought. The New Orleans Customs District appears to have recovered some share, while the other Louisiana Ports (not including the Lower Mississippi South of Baton Rouge) also appear to be trending higher. Projected regional trends show a positive growth of 0.5 – 1.5% growth per year. This sector appears to have recovered from the drought of 2012-13. Furthermore, 2014 was a record crop year for many commodities, which are reflected in the higher export volumes. However, the movement of goods on the Mississippi River still continues to face competition from rail and West Coast ports. Local production and shipment of sorghum exports (used for feed) increased dramatically in 2014 as a result of Chinese restrictions on corn, although appreciation in the U.S. dollar could potentially negatively impact export volumes.

Soybean exports on the Lower Mississippi have maintained steady volumes in recent years and the Lower Mississippi handles approximately double the volume of other gateways (Figure 16). Soybean remains a

[21] Corn, rice, wheat, and soybeans

[22] Port of Baton Rouge, the Port of South Louisiana, Port of New Orleans

strong export commodity at the national and more recently Louisiana District level and the Mississippi River is still the dominant export gateway. Soy production in Arkansas and northern Louisiana has increased and has become increasingly more concentrated in the southern U.S. states. Projected regional trends show a positive growth of 1.5 – 3.0% per year.

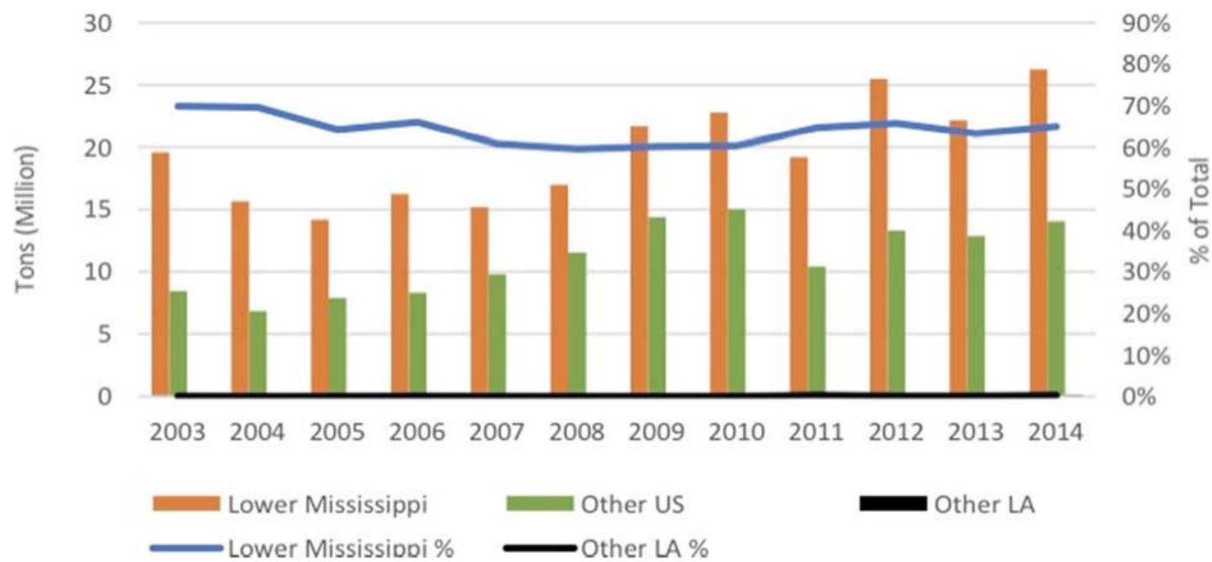


Figure 16 Export commodities through LMR and other U.S. ports

Existing efforts to resolve sedimentation at upriver Louisiana ports

Annual dredging activity at the Port of Lake Providence and Port of Madison Parish

Historically, inland river ports used federal earmarks to fund the cost of dredging by the USACE. With the elimination of earmarks in 2010, the USACE has used other funding sources to fund their ongoing dredging activity at a series of ports in the region. Through special appropriations to the USACE, a 24-in. or 36-in. cutterhead dredge has historically been deployed on a rotational to a series of ports in southeastern Arkansas, southwest Mississippi and northeastern Louisiana. The ports include Yellow Bend, Arkansas; Greenville, Mississippi; Rosedale, Mississippi; Port of Lake Providence, Louisiana; Port of Madison Parish, Louisiana; Vicksburg, Mississippi.

In any year, maintenance dredging activity is based on both the availability of funds and dredging equipment.[23] This method has proven not to be effective at keeping pace with sedimentation issues. Increased funding will be required to expand maintenance dredging operations at these ports in order to improve the effectiveness of maintaining the required navigation depth access. USACE operational budgets are continually being reduced (see Table 1) and as such, additional funding requests to support expanded maintenance operations are being denied, due to lack of available funds.

Recommendation

It is unknown at this stage what the shoal reformation rates are at each location. A detailed series of bathymetric data is needed to determine the timeline of the evolution and morphology of the shoal formation, as shoal reformation rate is a primary consideration on the dredging equipment most suited to the application. Historically, hydraulic cutterhead dredges are deployed by the USACE on a rental contract basis. Cutterhead dredges are used because they are the most commonly available type of equipment available in the U.S. domestic dredge fleet. They are also the most expensive to use, typically operating at approximately $85,000 per day for a 24-in. dredge. A booster pump, if required would be approximately $16,500/day and an average pipeline cost is $0.55/lf/day. This combination of equipment may also not necessarily be the most efficient dredging technique to be deployed. However, without a detailed understanding of the shoal reformation rate it is impossible to recommend the most efficient dredging technique. Side cast and water injection dredges are frequently used as agitation dredging techniques that rely on a current to transport the re-suspended sediment downstream. They are particularly suited to small inlet maintenance dredging and port terminal dockside shoal maintenance. Upon initial inspection, they have the potential to be deployed at these ports. However, more detailed analysis on the shoal reformation rate, morphology, and sediment characteristics are needed to make such a recommendation. Bottom profiling, a technique used to establish a "pay-surface elevation" after clam shell dredge operations, has also been used as a maintenance dredging technique on West Coast Ports. This is a rather crude technique, but relatively simple and inexpensive to operate and could be readily deployed by a local contract, external to conventional USACE maintenance contracting. However, more detailed information regarding the morphology of the shoal and sedimentation is required to make a more detailed evaluation.

[23] Project Meeting Memo, 2/18/2015

River training structures at the Port of Madison

Both ports are located on the outer bank of the Mississippi River. A series of training dikes were built by the USACE on the east bank of the Mississippi River across from both ports. Training dikes are a common method to maintain the main channel clear of sediment, as they ensure that even at transient water conditions, the velocity in the main channel is sufficiently high to keep sediment in suspension. The training dikes near the Port of Madison Parish General Cargo Dock were built to help maintain the channel depth, and perhaps assist in preventing the build-up of sediment downriver of the dock. These training dikes have had minimal or no impact to date on sedimentation buildup downriver of their general cargo pier. More specific analysis for both ports is reported in the following section.

To better understand the regional and local hydrodynamic conditions affecting both the Lake Providence Port and the Port of Madison Parish, the project team obtained draft reports published by the USACE that documents hydrodynamic and sediment transport modeling studies conducted by the USACE at both ports. These reports have been extensively reviewed and summarized below.

These studies were conducted by the USACE Vicksburg District and were obtained in draft form through an FOIA request. The Port of Madison Parish reports and analysis was conducted by Pinkard and Alexander in April 4, 2014 (here forth PA2014) and evaluated (1) prevailing hydrodynamic conditions at various river flow regimes, (2) manipulation of existing training dikes, and (3) evaluation of additional measures to reduce sedimentation rates in proximity of the port.

Initial geospatial analysis of the sedimentation patterns suggested that the physical pro-gradation of the left descending bank, immediately upstream of the port location, be the primary cause of excessive sedimentation. The shelf of the west bank upstream of the port extended riverward by nearly 250 ft. from 2008-2013, and is heavily vegetated with semi-submerged willow growth. On the upstream side of the east bank, training dikes were constructed to prevent erosion. The combination of the training dikes directing flow toward the port, and the west bank point bar migrating riverward, was studied by the PA2014 report using the surface hydrodynamic model RMA2, coupled with the sedimentation model SE2D.

Hydraulic model simulations included a discharge rate of 680,000 cfs (which is higher than average flow conditions but still below flood stage) and included a simulation with and without the training dikes, in order to attempt to isolate the effect of the training the dikes themselves. Results demonstrate that while the training dikes did increase flow in the main channel, the increase in the magnitude of the flow was relatively small, and could not account for the sedimentation problems at the Port of Madison Parish. Therefore, at their present elevation of (+53 ft.) and length (200 – 300 linear ft.), the current configuration of the existing training dikes did not significantly affect currents or flow changes in the region. Additional simulations were conducted to assess the effect of extending the length and/or raising the crown elevation of the dikes. This subsequent analysis revealed the following:

- With an elevation +60 ft. (an increase of +7 ft.), length of dikes maintained at current length and modeled at a discharge 455,000 cfs (below average flow conditions), the water velocities directly over the dikes increased by 2-3 fps.

- With an elevation +65 ft. (an increase of +12 ft.), length of dikes maintained at current length, and modeled at a discharge 455,000 cfs, the crown of the dikes were exposed above the water surface, under this scenario, The velocity in the main channel velocity increased 0.2 - 0.6 fps, while the velocity near the port increase by 0.5 – 2 fps.
- When dike elevations were kept at the same height (+65 ft.), but the lengths increased by 250 ft., and modeled at a discharge of 455,000 cfs, there was a uniform velocity increase of 0.5 - 0.6 fps adjacent to dikes in main channel.

Recommendation

Since the study only evaluated the length and height of these training dikes, it would be recommended to also investigate the orientation of the dikes in relation to the prevailing velocity vectors in the river. Orientation of the dikes in a more oblique angle to the flow may potentially deflect the downstream sediment transport sufficiently downstream and past the mouth of the port. It is recommended to further evaluate the impact of the orientation of such training structures on sedimentation patterns in proximity to the access channel to the port. Additionally, training structures aligned at more oblique angles to the flow of the river typically would also not need to be as long and, as such, could provide a more cost effective alternative to other alternatives evaluated to date.

Effects of pre- and post-dredging of the shoal immediately in front of the Port of Madison

The authors investigated the effects of the simulations detailed above and the effects of modifications to geometry of the dikes on the dredging operations. As part of the analysis, they performed maintenance dredging of the shoal near the port, and compared the sedimentation patterns pre-and post-modification of these structures. The results indicated:

- Deposition in the main channel and in the proximity of the dikes remained the same after dredging, while deposition at the port was increased.
- Increasing the elevation and extending the length of the training dikes increased the required dredging volumes to maintain channel access for both pre- and post-dredged shoal conditions.

The simulations outline above resulted in slightly different sedimentation patterns and hence differing dredging operation needs. The above analysis has led to the following preliminary conclusions by the authors:

- *The present configuration of the training dikes does not significantly contribute to sedimentation.*
  The main channel is wide enough that the length ratio of the training dikes to the available channel is low and hence velocities do not change appreciably to affect sedimentation.

- *There is less deposition when the berm is in place.*
  It is proposed that this is likely due to the fact that with a shoal in place (no pre-dredging of the area in front of the port), the eddy forming in front of the port produces overall higher velocities potentially limiting the sedimentation at that location.

- *Upstream vegetation and changes in shoreline morphology contribute to slack water conditions at port*.
  The pro-gradation of the upstream west bank into the river channel, and the dense vegetation deflect water away from the port, and promote more flow inertia as the water passes by the port, resulting in stronger eddy currents and therefore increasing sedimentation.

- *Raising and/or extending the training dikes will increase sedimentation in the vicinity of the port.*
  This is perhaps the most significant effect of the analysis, as more flow is now constricted to flow in the main channel as a result of the structures. This creates a rotational horizontal flow toward the port and in combination with the pro-gradation of the upstream west bank results in increased sedimentation.

River training structures at the Port of Lake Providence

In a similar approach to the Pinkard and Alexander 2014 study on sedimentation issues, at Madison Parish Port, they performed similar hydrodynamic and sedimentation analysis for the Port of Lake Providence. The study evaluated existing conditions and the effects of seasonal flood cycles on sedimentation at the port and then proposed some solutions to address sedimentation issues at the port. The initial investigation was to evaluate and mitigate navigation conditions and maintenance by performing the following modifications.

First, the effects of closing the Stack Island Chute were investigated, which connects the port channel to the main river channel at an upstream location approximately 5.5 miles upriver. This investigation was proposed due to the fact that visual inspection of aerial photography clearly reveals that the chute carries a lot of sand into the port channel. The chute is a shallow channel and therefore has an active bed load transport component even at moderate flows. Additionally, up channel connection with the main river provides the hydrostatic pressure, i.e., a higher stage at the beginning of the chute, to drive discharge through the port channel, which is the primary location where sedimentation occurs presently. This analysis made the following conclusions:

- Closing the Stack Island Chute would produces less sedimentation in the harbor channel.
- However, the presence of a large concentration of an environmentally threatened species (the Fat Pocketbook mussel) precludes the viability of this as a solution. Any closures associated with the Stack Island Chute must be coordinated with the Louisiana Department of Wildlife and Fisheries.
- The viability of closing the chute as a proposed solution is further compounded by the fact that a court decision that places Stack Island in Mississippi, not Louisiana, thereby introducing jurisdictional complications.

The alterative solution that was evaluated was to divert the lower part of the Stack Island Chute directly into the main channel, and close the Chute immediately downstream of the diversion channel, eliminating any communication between the Stack Island Chute and the harbor channel. Modeling revealed the following:

- Upstream velocities in Stack Island Chute are the same with or without implementation of the diversion channel, assuming it is designed with a realistic opening similar to the one that was evaluated.
- Downstream of the diversion, the water velocity peaks over the closure plug but there were no major high flow/velocity changes that could be considered abnormal or as a contributing factor to the sedimentation.
- Evaluation of scour/deposition simulations showed that with the diversion channel in place, there was less deposition at the confluence of the harbor channel and the Mississippi River. Additionally, sedimentation in the harbor channel was eliminated.
- An evaluation of the impacts of flood conditions on sedimentation, determined that deposition during overbank flooding events, when the flow is no longer channelized and confined within the Chute or Harbor Channel, is the same with or without the implantation of the diversion channel alternative.
- Hence the diversion channel has no additional effect on sedimentation from flood events, but does eliminate routine sedimentation issues at the port.

In an analysis similar to the evaluation of upstream training structures at the Port of Madison Parish, the authors also evaluated placement of multiple dikes upstream of the port entrance to the main stem of the Mississippi River. Their analysis revealed the following results:

- The two dikes immediately upriver from the harbor channel (dikes #5 and #6), were evaluated during low discharge conditions of 317,000 cfs. The training dikes diverted the high velocity flow lines from the higher flow scenario approximately 100 ft. away from harbor entrance, and resulted in no additional increase in sedimentation.
- Installing all six dikes produced only small improvements from the previous analysis, resulting in only localized velocity increases over the crown lengths of the dikes of up to 1 fps above the present/existing conditions, again without any additional increases in sedimentation.
- Evaluating a hardened shoal between dike #6 and the harbor channel, with all six dikes and the shoal in place resulted in a significantly strengthened eddy in the entrance channel, which is expected to trap and impound significantly more sediment compared to present conditions.
- At high flow conditions, there were no significant velocity spikes observed over the six dikes.

Finally, since there were locally significant modifications to the river morphology from 2008 to 2013, the authors evaluated the same scenarios but with an updated model bathymetry to reflect more recent post 2011 flood conditions. The report states that with all six dikes in place and an up-to-date bathymetry, the simulation suggests a reduced need for training structures near the port entrance.

Recommendation

Based on the above analysis to date, it is apparent that the diversion of the Stack Island Chute is potentially the most viable solution for the sedimentation issues at the Port of Lake Providence and merits further detailed evaluation.

Proposed Recommendations

Statistical analysis of the flow of goods through both the Port of Lake Providence and the Port of Madison Parish show that both ports are primarily involved in agri-business (storage and transport of corn, soy beans, sorghum, and liquid and dry fertilizer). Transport of these product types in the U.S. is typically via the Inland Waterway System, which is generally the most cost-effective transport mode, primarily due to the combination of low unit costs for large volumes. However, water and land based modes of transport interface at ports, which require capital investment during development and require on-going maintenance costs during operations.

While the location of port and terminal operations on the Mississippi River are at fixed locations, the Mississippi River is a highly dynamic system and yet is also heavily constrained through a complex system of structures that comprise the Mississippi River and Tributaries Project. As such, sedimentation and morphological changes within the channel can often lead to excessive sedimentation issues in the proximity of port operations on the river and can lead to access issues, which in turn negatively impacts the economies of the import and export of goods through these ports. It is clearly of national economic importance to develop solutions to ensure the reliable uninterrupted navigability of the coastal and river waterways and maintain the competitive advantage of these ports.

Structural approaches have been evaluated in an attempt to prevent or minimize impacts to port channel access due to sedimentation issues. Often the cost of the construction, operation, and maintenance of these training structures cannot be justified through conventional cost-benefit analysis. The costs are too high and the benefits of throughput of the port too low to realize a positive ratio. Port operations are based on an economic model founded on high volumes with low margins. As such, any impediment to port access not only affects the amount of throughput, as goods shipment shift to other ports, but it also negatively impacts the cost-benefit ratio of any proposed solution by reducing the economic benefit. This could be regarded as somewhat of a chicken or egg situation. If better access to a channel could be guaranteed, would more volume of goods preferentially move through an individual port, generated increased revenue and therefore positively the cost-benefit ratio, which in turn has the potential to result in a positive cost-benefit ratio and justify the investment in structural and/or non-structural control measures?

Recommendation #1: Perform a Least Cost Market Analysis to determine maximum market share potential at each port facility

Rather than focusing on purely structural approaches to sedimentation issues at the Ports of Lake Providence and Madison Parish, along with other ports operating on the Mississippi River, it is recommended to focus on the cost-benefit ratio. A detailed Least Cost Market Analysis (LCMA) should be conducted for each individual port in order to determine what maximum market share could be realized with uninterrupted port access, plus any potential increases in market share that could be realized with improved (deeper) channel access. This is of particular significance given that growth rate trends over the last five years, show that exports of both soybean and cereals out of the lower Mississippi have far exceeded other U.S. regions. Specifically soybean exports out of the Lower Mississippi outgrew other U.S. exports by over five times.

Recommendation #2: Perform detailed morphological studies of the evolution of persistent shoals at each port facility

It is recommended that detailed studies of the sedimentation characteristics at each ports be conducted to assess the evolution of the morphology of the individual shoals, in order to assess how the morphology changes over time, both long term and seasonally, in response to river stage. Not only would this information better inform alternatives analysis of any potential structural approaches, but it will also provide a more detailed analysis of the efficacy of dredging operations at each facility. Conventional cutterhead dredging is expensive, but without a detailed understanding of the shoal reformation rate, it is not possible to determine the best dredging approach to be deployed (cutterhead, side caster, water injection dredge, or other agitation dredging techniques) in order to maintain access.

Recommendation #3: Evaluate alternative configurations of river training structures

As stated earlier, until a detailed LCMA is conducted for each port is conducted in order to optimize the economic benefit at each port facility, it is unlikely a positive cost-benefit ratio could be realized to justify the investment in the construction of additional structural measures. As such, attention should be focused on the cost of maintaining uninterrupted access to the ports. Structural approaches to sedimentation have been evaluated but with mixed results. It is recommended that alternative alignments and configurations of these training structures be investigated to evaluate if any improvements on the reduction of sedimentation could be made and the cost of construction of these structures be optimized.

Recommendation #4: Evaluate the construction of a weir near the Mississippi River in the existing chute that bisects Stack Island abutting Hagaman Chute

The construction of a weir has been evaluated on a preliminary basis by the USACE as a potential solution for the accumulation of sediment in the harbor basin. The analysis showed that such construction can reduce the influx of sediment into the harbor. It is recommended that this approach be evaluated further to better constrain the overall impacts resulting from the weir construction. In doing so, environmental impacts to resident habitat can be better examined, along with assessments of physical sedimentation dynamics using hydrodynamic and sediment transport models to reduce risk, as well as a develop a more detailed appraisal of the cost of construction versus the economic benefits realized.

Recommendation #5: Further evaluate the chute and bypass channel into the Mississippi River

The construction of a weir at a location near its connection to the harbor (per recommendation #4) will likely have to be coupled, or evaluated in conjunction with a bypass channel. The bypass channel is necessary to help redirect flow into the main stem of the Mississippi River. While the preliminary analysis by the USACE provided some initial positive results, this recommendation too, needs to be evaluated further with more detailed analysis better constraining the impacts resulting from such construction.

Recommendation #6: Develop dredge operations model for each port facility to determine optimum dredge operations required to maintain uninterrupted access

Detailed dredge production models have successfully been developed for other ports in the region experiencing sedimentation issues, and these have been used to effectively optimize dredging operations, both in terms of equipment and frequency of operations. Once a detailed understanding of the shoal reformation rate has been determined, it will be possible to develop such an operations model for each port in order to determine the optimum combination of equipment and frequency of dredging in order to optimize operation and maintenance budgets for each individual port.

Recommendation #7: Review alternative procurement approaches of maintenance dredging contracts

Additionally, dredging operations procured by the USACE are typically on a rental type contract for a finite period of performance. Such a procurement strategy does not always result in the lowest unit cost of operations. By switching to alternative dredging operations procurement type contracts, such as a performance based multi-year contract, it is possible to significantly reduce unit costs, therefore making dredging operations more cost effective. In doing so, the approach to dealing with excessive sedimentation issues, does not focus on a "silver bullet" fix, but more on a management approach that enables the port operations to "learn to live" with the sediment. This in turn provides for a much more dynamic and adaptive approach to dealing with seasonal trends in sedimentation, trends that a structural approach may not be able to address. Structural solutions that are based on managing extremes like the 2011 flood and 2012 drought are not efficient and these individual historic events should not be the basis of design criteria for a proposed solution. The USACE is being forced to "do more with less" and port operations must look to a greater efficacy in operations and maintenance budgets. Combining this approach to a detailed LCMA will optimize potential economic benefits while reducing operation and maintenance costs, which in turn will realize a more favorable cost benefit ratio. The reality is that the President's budget promised to increase the USACE budget last summer, but the $4 trillion submitted to Congress in January actually cut the USACE budget. This is further compounded by an additional 4 years of budget cuts since sequestration began in 2011. States are having to fund needed navigation work which the USACE simply cannot fund. As such, port operators are increasingly looking for Public-Private- Partnerships (P3) to fund navigation maintenance. In the container terminal business model, the costs of navigation works are typically passed on to the consumer in terms of concession additions at the port. Similar restructuring of the funding of navigation works may need to be explored in the future in order to fund essential navigation works through structured "user fees" in order that ports can maintain uninterrupted navigation access and resultant competitive advantages.

Attachment 1: *Statement of the Mississippi River Commission, Extreme Low-Water Condition*

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MISSISSIPPI RIVER COMMISSION
VICKSBURG, MISSISSIPPI

August 24, 2012

Statement of the Mississippi River Commission Extreme Low-Water Condition

Exceptional drought conditions persist across much of the Mississippi drainage basin. River stages threaten historic low-water marks just one year after the Mississippi River and Tributaries (MR&T) project passed the largest flood in the recorded history of the river. On the river gauges at Memphis, Vicksburg, and Natchez, river fluctuations exceed 55 feet between the 2011 highs and the 2012 lows to date. Such wide variations in stages over successive years have never before been witnessed (enclosure). Those same fluctuations highlight the daunting challenges confronting river engineers as they attempt to protect surrounding lands from devastating floods while balancing the waterborne commercial needs of the nation.

The severe low-water conditions coincide with the height of the harvest season. A safe and reliable marine interstate system on the Mississippi River is an absolute necessity at this critical time when the nation is trying to move its bountiful agricultural product for export. Since June, when weather forecasts indicated low-river stages, the Corps of Engineers has intensively managed dredging assets, executed emergency dredging contracts, and closely coordinated with the U.S. Coast Guard, the river navigation industry, port authorities, and local, state, and federal partners to ensure a safe and reliable marine interstate system on the Mississippi River. Even with this intense effort, many small ports and harbors, which function as the exit and on ramps for the marine interstate system, remain closed or restricted because of the low water.

If not for the timely passage of the 2011 emergency supplemental bill on December 23rd, which included funding to remove flood-induced sediment from channels, ports, and harbors, the Corps of Engineers would not be in a position to facilitate waterborne commerce on the Mississippi River without major impacts to other authorized projects around the nation. Without supplemental appropriations, the deep-draft navigation channel below Baton Rouge would have experienced continued restrictions, greatly affecting import and export activity along the nation's busiest shipping corridor. The emergency funding designed to help the nation recover from devastating floods is now also enabling the nation to maintain commerce despite extreme low-water stages.

Since 1879, the seven-member Presidentially appointed Mississippi River Commission has developed and matured plans for the general improvement of the Mississippi River from the Head of Passes to the Headwaters. The Mississippi River Commission brings critical engineering representation to the drainage basin, which impacts 41% of the United States and includes 1.25 million square miles, over 250 tributaries, 31 states, and 2 Canadian provinces.

Listening, Inspecting, Partnering and Engineering since 1879

The United States is a maritime nation. As such, the Mississippi River Commission strives to help maintain the nation's global economic competitiveness by ensuring a reliable navigation channel and the commercial viability of ports and harbors, mitigating flood risks to enable economic activity near our waterways, protecting environmental habitat, and facilitating recreation. An adequate and systematic approach to address dredging needs, particularly at small ports and harbors on a regular basis, remains elusive. This commission will do all in its power to assure that the nation remains focused on a maritime system that provides an efficient, environmentally sustainable method to transport goods to market where they can feed the world, energize our economy, build our infrastructure, and provide essential inputs for economic activity.

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Low-Water Inspection Trip Report

Mississippi River	Difference in River Elevation between 2011 & 2012
Cape Girardeau, MO	**39 feet**
Cairo, IL	**53 feet**
New **Ma**dr, **id MO**	**48 feet**
Memphis, TN	**59 feet**
Vicksburg, MS	**57 feet**
Red River Landing, LA	**50 feet**
New Orleans, LA	**16 feet**

August 20, 2012
-8.5 feet on Memphis Gage

May 10, 2011
47.87 feet on Memphis Gage

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