Source: USACE Institute for Water Resources

Figure 20: Primary and Secondary East and Gulf Coast Ports

Channel Depth Comparisons

An important capacity consideration is the vessel size a port can accommodate. Along with other factors, channel width and depth establish the maximum size vessel that can call at a port. West Coast ports such as Seattle, Oakland, Los Angeles and Long Beach all have 50-foot or greater channels. Northeastern ports such as Baltimore and New York[13] have or will soon have 50-foot channels. In the Southeast, Norfolk has 50 feet. Below Norfolk along the Southeast and Gulf Coasts there are no ports with 50-foot channel depths. However, Miami is scheduled to have a depth of 50 feet by 2014 and Charleston can already accommodate, at high tide, ships that require a depth of 50 feet. Figure 21 shows channel depths at selected ports around the country.

[13]The Bayonne Bridge presents and air draft restriction for the largest vessels calling at some of the container terminals in New Jersey and Staten Island. The Port Authority of NY/NJ is planning to raise the Bayonne Bridge and expects to complete that work in 2016.

Source: USACE Institute for Water Resources

Figure 21: Main Channel Depths at Selected Ports

Additional Capacity Factors

Other factors affecting port capacity include productivity, storage area, stacking height rules, operating hours and the capacity of surrounding highways, railroads, intermodal connectors to move containers to and from ports, and trained personnel to operate expanded terminals. Ports such as LA/LB have made tremendous strides in increasing productivity through measures such as facility upgrades and scheduling.

U.S. Port Capital Investment Plans

The Nation's ports are making significant investment of their own. The American Association of Port Authorities recently conducted a survey of their members regarding capital improvement plans. Table 6 shows planned investments over the next 12 years total over $21 billion.

Table 6: Preliminary results of AAPA U.S. port authority infrastructure spending survey - 2012-2016

Port's Projected Capital Expenditures 2012-2016	Projected Private Sector Capital Expenditures at ports 2012-2016	Port's Local Share of Security Expenditures Since 9-11	Port's % of Annual Budget for Security
$16,218,000,000	$21,418,000,000	$1,429,000,000	10.3% (average)

Source: American Association of Port Authorities

Summary of Primary and Secondary Port Capacity

There is little benefit to providing deeper channels if terminals do not have capacity to accommodate larger vessels. Overall, the North Atlantic, South Atlantic, Gulf and West Coast ports have substantial inherent capacity. They have adequate capacity in their birth, cranes and container yards to accommodate near-term growth. That growth can be achieved through more intensive use of existing terminals, cranes and berths. The existence of aggregate reserve capacity does not preclude slot shortages at ports and terminals that receive more than their share of growth.

Competition from Other North American Ports

IWR also examined the capacities for a number of ports outside the U.S. that can be viewed as competition to U.S. ports. When congestion reached a peak in Long Beach in 2004, for example, some cargo had been diverted to Lorenzo Cardenas and Manzanillo in Mexico.[14] U.S. West Coast ports have become understandably concerned about the diversion of traffic to Prince Rupert in British Columbia, which began operations in 2007.[15] It boasts an ice-free, 115-foot deep harbor and is about 1,000 nautical miles closer to Asian ports (two-days shipment time) than Southern California ports. The Canadian National Railway Company's rates from Prince Rupert to Chicago are approximately $300 per container lower than Burlington Northern Santa Fe Railway and Union Pacific intermodal rates to Chicago from Los Angeles. Canadian National Railway Company has also been investing heavily to widen tunnels, reinforce bridges and build sidings along the route from Prince Rupert to Chicago. (The steepest grade between Canada's Pacific Northwest and its Chicago end points is 1 percent in the Rockies). Prince Rupert is planning to quadruple its capacity to approximately 2 million TEUs with its Phase 2 Expansion project.[16]

Competition from South American Ports

China continues to propose investments in ports (a deepwater bulk port in Brazil) and overland infrastructure (a rail connector proposed for linking Colombian coal fields on the Atlantic side of the country to a Pacific port) in South America. These investments would improve the competitive position of Brazil as an ore and soybean exporter and Colombia as a coal exporter.

Transshipment Centers

The Port of Freeport, Bahamas has been viewed as a potential transshipment port, or hub, for cargo, similar to Singapore and other transshipment centers. The terminal is approximately 100 miles east of Miami, was opened in 1997 and is used primarily as a transshipment point serving the U.S. East Coast and global trade routes. It is able to handle large containerships given its

[14] Delays at U.S. Ports May Push Nippon, Maersk to Canada, Mexico, Bloomberg January 13, 2005.

[15] Remarks of Chairman Richard A. Lidinsky, Jr. Federal Maritime Commission at the Canada Maritime Conference Montreal, Canada September 21, 2011

[16] U.S. Army Corps of Engineers, Institute for Water Resources. *IWR Container Ports Capacity Report 2012 (draft).*

53-foot channel depth and proximity to Southeast ports. The 2012 Port Capacity Analysis indicates that Freeport has adequate capacity to handle future growth. Container Yard capacity appears to be its most constrained facility resource. However, the faster transshipment turnover it provides to carriers encourages future volume growth and improved berth capacity utilization.

Inland Waterways and Their Role in U.S. Export Trade

The inland waterways comprise rivers, waterways, canals, and the locks and dams that provide some 12,000 miles of commercially navigable waters. The flotillas of towboats and barges that operate on this system carry approximately 15 percent of the nation's domestic freight. Figure 22 shows how the inland waterways link the heartland of the U.S. to the coast.

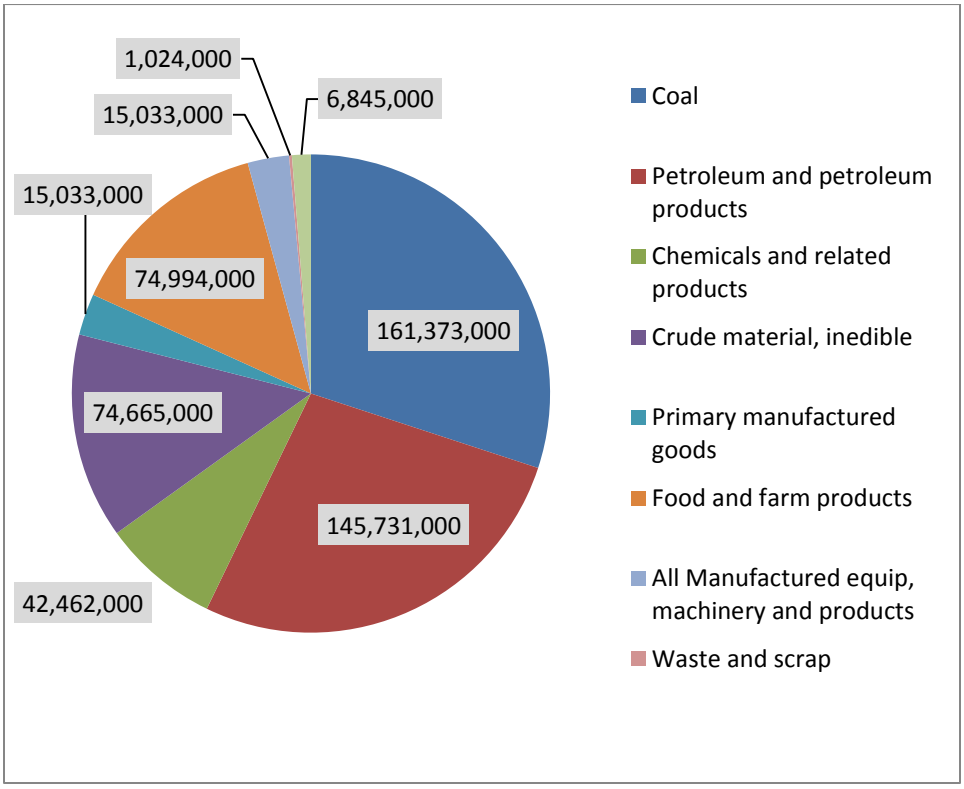
Source: USACE Institute for Water Resources

Figure 22: The Inland Waterway Connection: Linking the Heartland to the Coasts

The biggest role of inland waterways in the export market has been in the global trade for grains and coal. U.S. producers of these commodities face stiff global competition. Investments in competing world ports are tapping production regions that were previously expensive to reach or nearly inaccessible. Examples include coal mines in Mongolia, deep water ports in Brazil for the export of soybeans, and rail lines from eastern coalfields in Colombia to the Pacific Ocean.

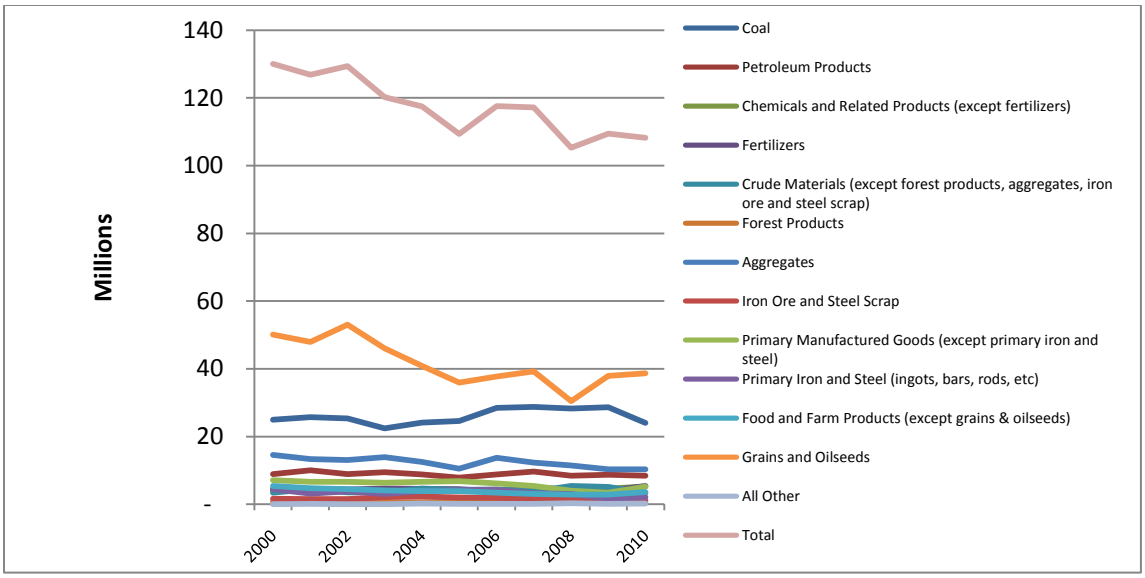
Shallow draft river systems handled 523 million short tons of cargo in 2009, while coastal systems handled an additional 168 million short tons. Including lake, intraport and intraterritorial movements, the system moved some 857 million short tons—actually a decrease

in activity due to the severe recession during that year. The system typically handles more than a billion tons per year. The cargoes are mostly bulk commodities and raw materials such as coal (28% of the tonnage), petroleum (37%), grain and farm products (10%), chemicals (5%), aggregates, steel, and fertilizer (Figure 23). The Mississippi River System is the primary conduit for cargoes from the nation's Midwest grain belt to Gulf ports. Figure 24 shows traffic on the Mississippi has been declining over the last decade.



Source: USACE Institute for Water Resources, Waterborne Commerce Statistics Center

Figure 23: Total 2009 U.S. Internal Traffic by Commodity (short tons)



Source: USACE Institute for Water Resources, Waterborne Commerce Statistics Center, Waterborne Commerce Statistics

Figure 24: Tonnage (short tons) by Commodity Shipped on the Mississippi River 2000-2010

U.S. government export forecasts indicate near term growth in grain and coal exports that level off over the next 20 years[17]. These forecasts indicate that the U.S. will remain the single largest participant in the global grain trade, while U.S. coal producers will continue to hold a marginal position in the global market. Grain producer forecasts see most of their exports being shipped from the Center Gulf region around New Orleans, with about one-half of the increase in grain exports transiting the Panama Canal[18].

A Strong Intermodal System

The challenge will always be wise stewardship – maintenance and enhancements that anticipate future needs and uses. Foresighted planning, policy and investment are all required. The railroad industry responded to Staggers Act de-regulation in the 1980s by trimming capacity and becoming more efficient and more profitable. This return to profitability allowed railroads to invest heavily in main line expansion and terminal capacity; however, concerns persist over the railroads' ability to match demands. Public-private partnerships (like the Heartland Corridor Project (see Figure 31 on page 41) have already occurred and more partnerships of this nature may be required in the future.

A healthy trucking industry is vital to the freight transportation network, often accounting for the first and last leg of each freight shipment. These legs have become longer as railroads abandoned rural country elevators and coal load outs in favor of fewer and larger terminals capable of handling unit and shuttle trains. This has meant more miles travelled by trucks on rural roads, faster deterioration of roads and bridges, and more maintenance expense for public

[17] USDA 2011
[18] Panama Canal Expansion: Impact on U.S. Agriculture, Informa Economics, September 2011.

highway agencies. Repair work on the nation's highways and bridges was given a boost from American Reinvestment and Recovery Act funds, but experts suggest many more billions of dollars are required to bring the system up to safe and efficient standards.

Inland waterways in the U.S. are the most advanced and extensive in the world, greatly aiding in the economic development of vast expanses of interior North America and conferring benefits to U.S. consumers of electricity, agricultural products, construction materials, petroleum products and steel – nearly everyone. The inland waterways complement a web of highways and rail lines to form a national multi-modal freight transportation system – an engineering and logistical marvel built, redesigned, improved and expanded throughout the Nation's history. As a national freight network, it efficiently serves the largest and the smallest communities in the U.S. from coast to coast and allows goods produced far from ocean ports to reach and compete in global markets. Like any other piece of infrastructure, the freight network goes largely unnoticed until it becomes unreliable or is no longer there. The flexibility of the U.S. freight network has allowed each mode to cover for the other during service interruptions. Many segments of the freight community are concerned that this capability is largely played out just at a time when new opportunities are opening in the global market place.

U.S. Ports Served by Inland Waterways

Many of the major coastal ports in the U.S. are located on or connected to inland waterways. Ports served by inland waterways exported 346 million tons in 2010.[19] The Gulf Intracoastal Waterway (GIWW) and the Lower Mississippi River (including Lake Charles off the Calcasieu River) served ports that accounted for 72 percent of inland waterborne exports in 2010.

The Port of New York, NY and NJ and ports on or served by the Columbia-Snake, Great Lakes and Tennessee-Tombigbee-Black Warrior waterways account for most of the remaining share of exports from ports served by inland waterways. Ohio, Upper Mississippi, McClellan-Kerr-Arkansas (MKARNS), and Missouri river ports do not export directly, but reach the export market through ports on the Lower Mississippi River. Ports served by the GIWW – Houston, Corpus Christi, Texas City, Beaumont and others – are dominated by the petroleum and petrochemical trades; the Port of New York by containers; Great Lakes by ports; Mobile, the Lower Columbia River and the Lower Mississippi ports by dry bulk trades like coal, grains and ores, along with a wide variety of other commodities. When viewed from the perspective of the ability of inland waterways to support enhanced export opportunities that a global fleet of larger ocean going vessels represent, those inland waterways that serve a hinterland with desirable export commodities are of particular interest. This directs focus to the Upper Mississippi, Illinois, Ohio (and its tributaries), and the Columbia-Snake rivers and the Great Lakes and the ports they serve.

[19] These major ports are selected from among the top 150 ports by tonnage as identified by the USACE Waterborne Commerce Statistics Center.

Port and Waterway Infrastructure

The state of port infrastructure at both the point-of-shipment in the U.S. and at the point of destination can be limiting factors. For grains, Pacific Northwest, Center Gulf (Lower Mississippi River) and Texas Gulf terminals are capable of accommodating the loading of large vessels of any size. Each is configured to handle grain in large volumes by rail and river at the PNW, largely by rail in the Texas Gulf, and mostly by river in the Center Gulf region. Ports in Northeast Asia receiving grains are currently maintained at depths compatible with current Panama Canal depths and the depths of nearly all U.S. ports. Though capital investments are planned for some of these ports, at the current time they act as a limiting factor to the same extent as the depth of U.S. ports.

Deep draft ports handling ores and coal in Northeast Asia are designed to handle the largest ore and coal carriers. Only LA/Long Beach, Oakland, and Seattle/Tacoma on the West Coast and Baltimore and Norfolk on the East Coast have depths of 50 feet or more, limiting the potential use of fully loaded vessels drafting 50 feet to these four ports. In fact, the new Panama Canal locks are too small to handle the largest of the ore and coal carriers, making it a limiting factor on an Atlantic or Gulf Coast trade route to Asia. China continues to propose projects and make investments in ports (a deepwater bulk port in Brazil) and overland infrastructure (a rail connector proposed for linking Colombian coal fields on the Atlantic side of the country to a Pacific port) in South America that allow them to maximize their use of these vessels. These investments improve the competitive position of Brazil as an ore and soybean exporter and Colombia as a coal exporter relative to the U.S.

Interestingly, the reliability of lock and dam structures is linked to both highway and rail performance in a demonstration of the interconnected nature of the transportation system. Lock outages at the Nation's aging system of locks and dams have experienced a sharp increase over the last 20 years. Much of this is related to outages either for scheduled or unscheduled lock repairs. Carriers face lost opportunities and increased costs due to these disruptions that delay service, while shippers face potential disruptions to their operations and increased transportation costs as they seek ways to work around lock facilities either closed to traffic or experiencing major congestion as traffic moves through smaller auxiliary chambers (when available). During closure events, shippers will seek alternative overland routes, which can cause congestion on these routes (rail or truck).

Surface Transportation System

The maritime aspects of trade, whether domestic or foreign, inland vessel or ocean going ship, are part of a multi-modal system for the movement of bulk commodities from point of production to point of consumption. A complete examination of the inland system's capability to accommodate future flows of traffic also needs to consider the capability of other parts of this multi-modal system. Whether truck, rail, barge, Lake Vessel or ocean freighter, each mode

is dependent upon the other if the system is to operate efficiently. When this occurs, more markets are available to producers and the nation enjoys the benefit of the efficiencies incurred.

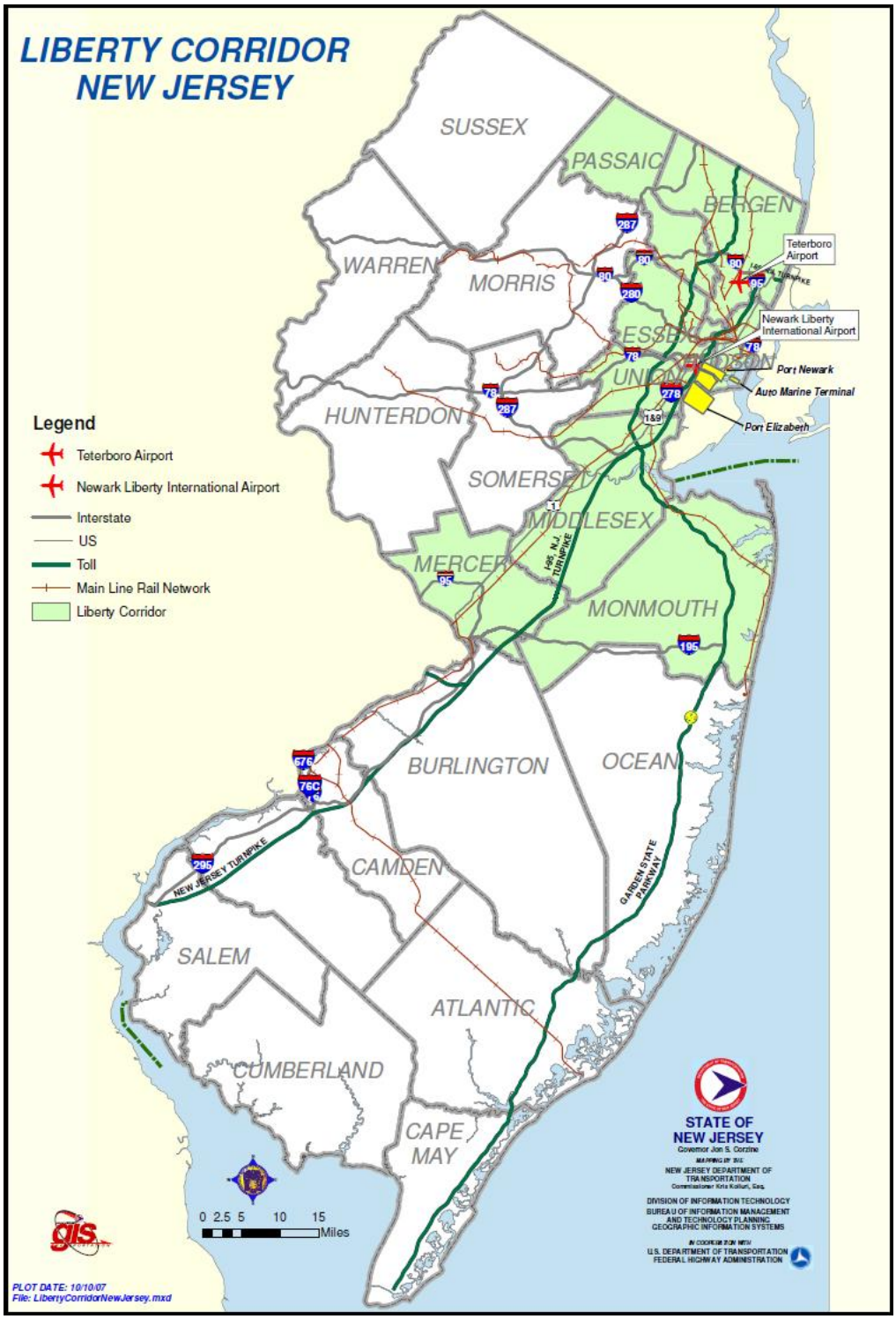
Much of the information presented in this discussion relies upon the *Study of Rural Transportation Issues,* a report prepared for the U.S. Department of Agriculture and the U.S. Department of Transportation and published in 2010.

Truck

The trucking industry carries nearly three quarters of all agricultural products and is the sole mode of freight service for more than 80 percent of all communities in the U.S. Trucks are critical to the efficient movement of goods in the U.S., often making the first and/or last move in most supply chains, including those for coal and grains. This highly competitive industry has over 691,000 companies (over half of which own one truck), keeping truck rates relatively low. Operating costs are 95 percent of revenue, making trucking firms' rates sensitive to increases in operating costs, whether from fuel prices or operating requirements stemming from a patchwork of local, state and Federal regulations.

The capacity of this mode is dependent upon: 1) drivers, 2) trucks and 3) roads. The availability of drivers can in the short run be constrained due to the need for training and licenses. National laws dictate driver requirements, such as daily hours in service, licensing, or identification and security requirements. Trucks are currently available in great numbers; some 3,000 trucking companies went out of business during the recession. Carrying capacities are determined by payload dimensions and highway and bridge weight restrictions. The Federal government sets weight and size restrictions on the Interstate Highway System and fixes the maximum width, while placing limits to the restrictions that states can place on highways designated as part of the National Highway Network.

To increase capacity and remove bottlenecks, states are developing "corridor" projects. In New Jersey, the Liberty Corridor of New Jersey is a multi-modal transportation system tying ports, highways, airports and rail lines together to make critical connections and clear chokepoints. Figure 25 below depicts the Liberty Corridor.



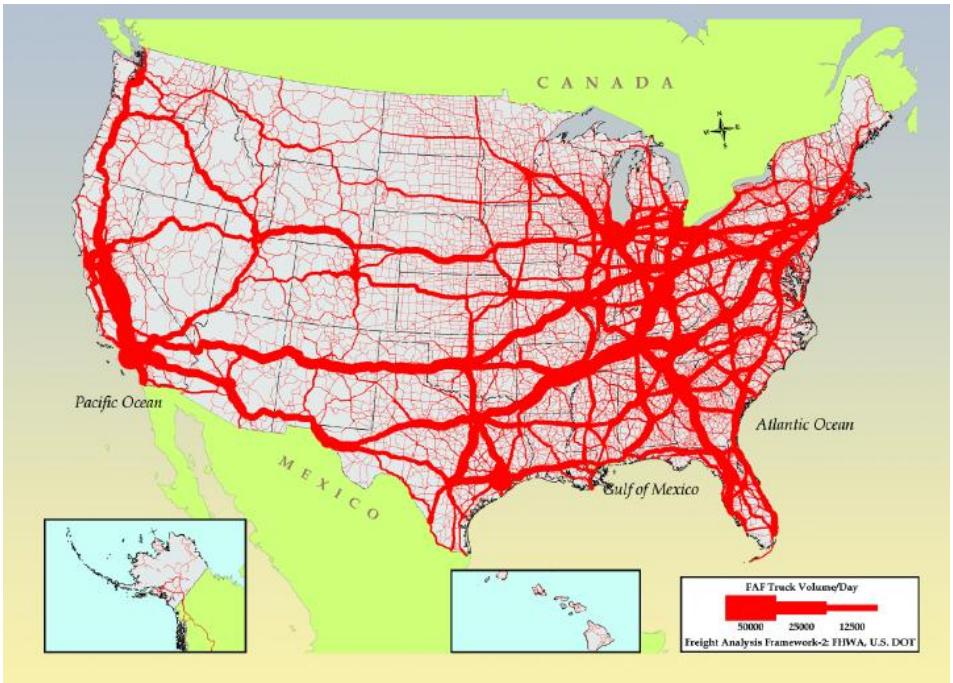
Source: New Jersey DOT

Figure 25: Liberty Corridor, New Jersey

Road condition, which can lead to the weight restrictions mentioned above, and congestion are also limiting factors on the mode's capacity. The U.S. Department of Transportation, Federal Highway Administration's *2010 Status of the Nation's Highways, Bridges, and Transit: Conditions*

& Performance, January 2010, reported that over half of all vehicle miles travelled are on highway pavement providing less than good rides and more than a quarter of the Nation's bridges are structurally impaired or obsolete.

Most observers do not report roadway congestion as a problem for grain and coal shippers, since most miles are travelled in rural areas. Congestion issues can become an issue for grain and coal shippers when hauling long distances to terminals near urban areas and could be a major issue in the event of lock outages should the shipper decide to truck around the obstacle and need to take a route through urban areas like St. Louis, MO or Cincinnati, OH. (See Figure 26, for a description of average daily long-haul truck traffic.)



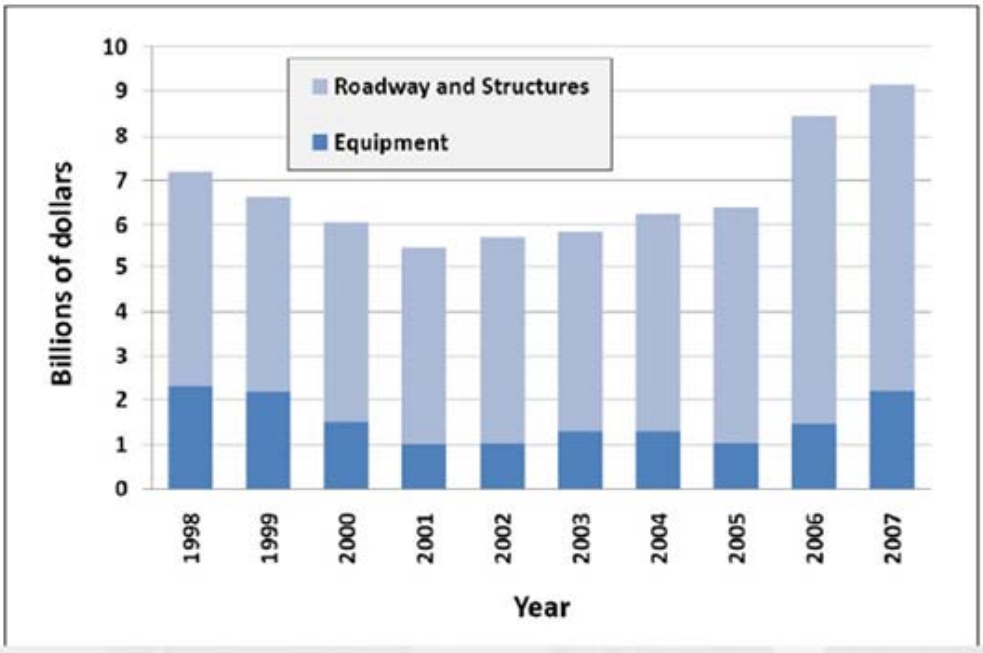
Source: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, Version 2.2. 2007

Figure 26: Estimated Average Daily Long-Haul Truck Traffic on the National Highway System (2005)

Rail

U.S. railroads have steadily increased investments in both road and equipment. The $9 billion invested by the railroads in 2007 was a 27 percent increase over what was invested in 1998. Western railroads, spurred by growth in Northeast Asia, increased capital expenditures by nearly a third over this timeframe (see Figure 27). These investments build capacity and improve performance of their land bridge between West Coast ports and production areas in the interior and consumer markets in the Midwest and East Coast. These investments allow West Coast ports to compete with Gulf Coast ports for grain (and potentially coal) export shipments out of the U.S. to Asia and improve the overall U.S. position globally in both the grain and coal export markets. Proposed coal terminal facilities on the Columbia River near Portland in Oregon and

Washington and at Cherry Point in Washington State (each with planned annual throughput capacity of roughly 30 million tons and representing an investment in excess of $500 million) are indicators of the private sector's view of the potential that exists in the Asian coal market. These terminal facilities would provide the capability of handling coal in the volumes required by *Panamax* or *post-Panamax* vessels of any kind. Railroad investments are made possible by the financial health of the major rail carriers. A return to profitability for the industry was made possible by the Staggers Act of 1980, which deregulated railroads. Deregulation allowed the railroads to abandon low revenue lines, initiate mergers that removed redundancies, change terms of service, and initiate differential pricing for service. With the elimination of excess capacity and introduction of efficiencies like the shuttle train, railroads' return on investment improved dramatically, allowing them to invest in high-use, high-return rail lines. Revenues rose while rates fell over the 20 years following Staggers. It was only in the early 2000s that rates began to rise as traffic grew at a pace faster than railroads could add capacity. Rates continued to increase until the recession that began in December 2007.



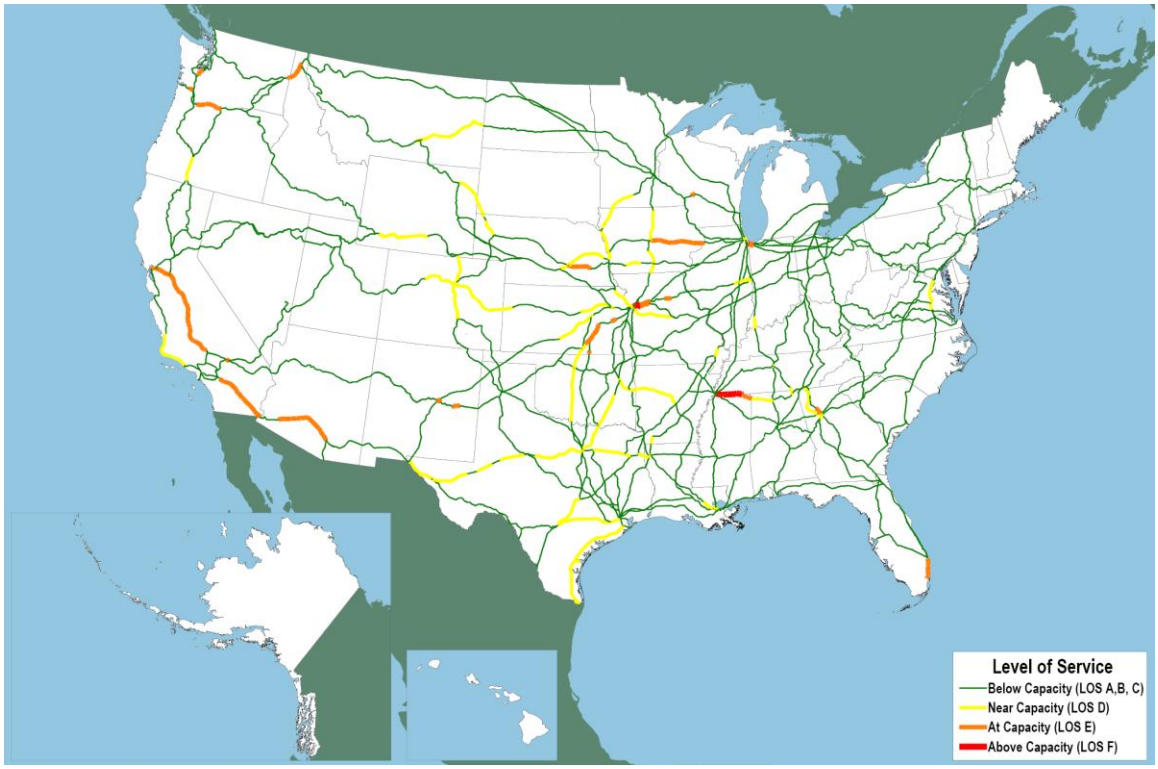
Source: AAR, Analysis of Class I Railroads

Figure 27: Class I Railroad Capital Expenditures

Railroad service and pricing revolve around the railroads' efforts to improve speeds and efficiency, and to shift costs. They have done this by investing in access lanes to the ports (like the Alameda Corridor), in more equipment, more track, and more unit and shuttle trains, and by abandoning some feeder lines. Some of the cost risks have been shifted to the shipper. In the coal market entire trains are now owned by the shipper, while grain shippers often own the cars. Collection costs have been shifted to the coal producer and to the farmer, leading some of them to move goods by truck a longer distance on rural roads to terminals that load out unit and shuttle trains. In addition to placing an additional cost burden on the producer, state and

local governments need to cover the additional maintenance costs on rural highways. A similar phenomenon is occurring with the relatively new container trade for grains where farmers must travel to find empty containers and then transport them to often distant assembly points near large population centers.

Efficiency gains allowed railroads to move 171 percent more traffic than in 1980 despite having fewer miles of track. The railroads have made massive investments, and have adequate locomotives, cars and operators. The map below (Figure 28) shows major rail lines and the capacity of each relative to the traffic each carried in 2007. Many lines in the grain producing area are near capacity, with a number of connecting lines at capacity and one line along the Tennessee-Mississippi border over capacity. With economic recovery and the return of higher traffic volumes, many of these near capacity lines could become bottlenecks, particularly if the Panama Canal expansion and advent of larger oceangoing vessels encourages the movement of grains to the Gulf. Eastern railroads do not indicate widespread capacity issues with one important exception in Virginia.



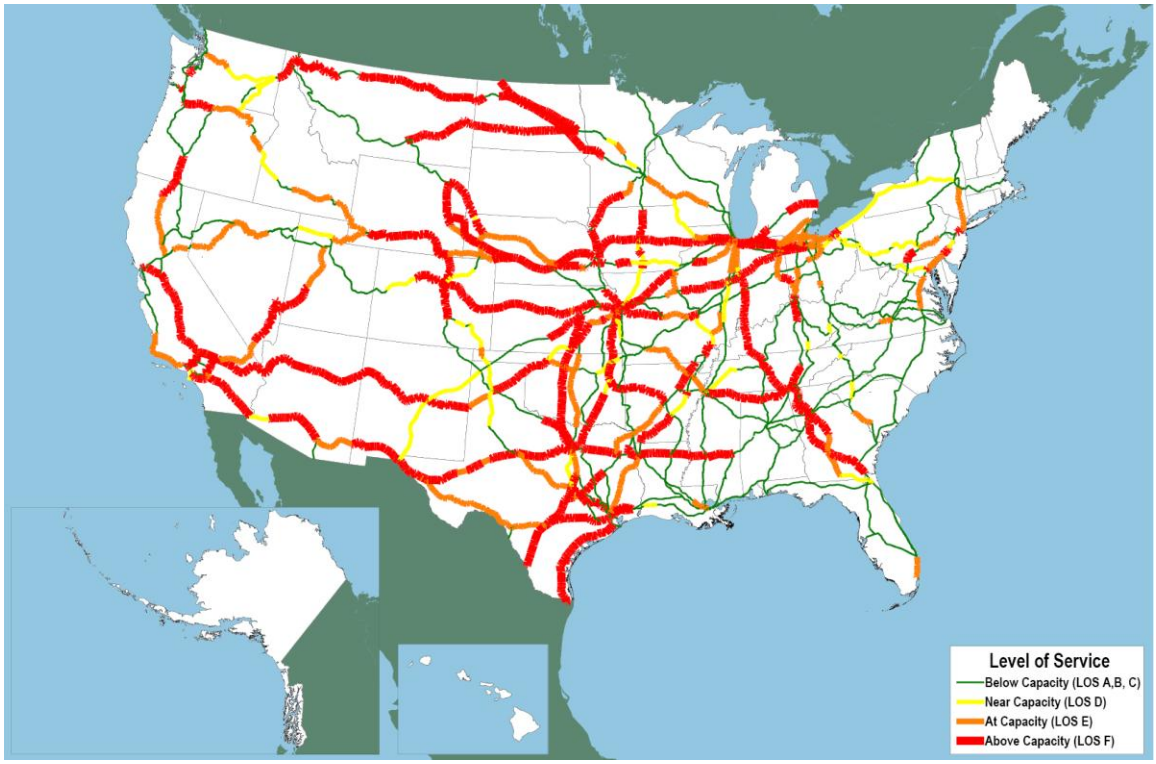
Note: Level of Service (LOS) A through F approximates the conditions described in Transportation Research Board, *Highway Capacity Manual 2000*

Source: "National Rail Freight Infrastructure Capacity and Investment Study"-Cambridge Systematics, Inc. 2007

Figure 28: 2007 Rail Performance

Some analysts project major bottlenecks throughout the system by 2035, others see rail demand easing. Nevertheless, it is apparent that periods of bottlenecks, especially for grain given the seasonal nature of its movement, may occur are likely unavoidable and reason for

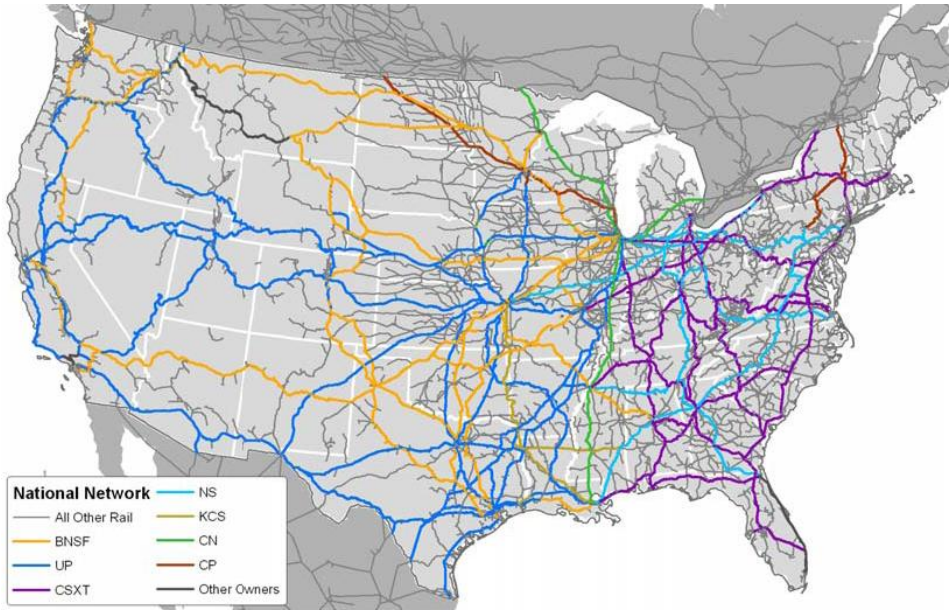
concern if the U.S. is to remain a reliable supplier of grain to the world. Without rail capacity improvements, Cambridge Systematics, Inc. projected widespread rail congestion by 2035 (Figure 29). This analysis shows that 45 percent of primary corridor mileage will be below capacity, 25 percent near or at capacity, and 30 percent above capacity. The analysis is dependent upon traffic forecasts and trade volumes that return to rates of growth experienced before the recession of 2008/2009. It is important to note that peak or seasonal flows are not considered.



Note: Level of Service (LOS) A through F approximates the conditions described in Transportation Research Board, *Highway Capacity Manual 2000.*

Source: "National Rail Freight Infrastructure Capacity and Investment Study"-Cambridge Systematics, Inc. 2007

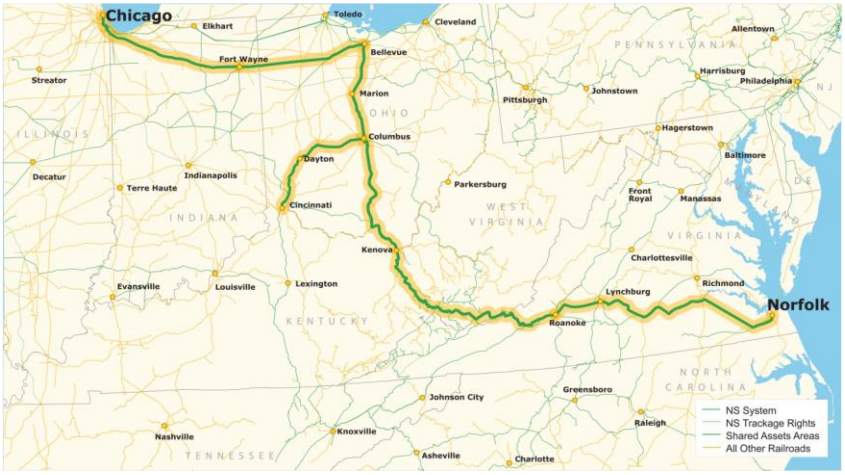
Figure 29: Potential Rail Performances in 2035



Source: "National Rail Freight Infrastructure Capacity and Investment Study"-Cambridge Systematics, Inc. 2007

Figure 30: Railroad Freight Network

Figure 30 describes the national railroad freight network. The Heartland Corridor (Figure 31) is a public-private partnership between the Norfolk Southern Railway (NS) and the Federal Highway Administration and three U.S. states to improve railroad freight operations.[20] The plan was developed to facilitate more efficient travel on NS rail lines between the Norfolk, VA port region to Columbus, OH and Chicago, IL. The project goals increase tunnel clearances to permit the operation of double-stacked. The Crescent Rail Corridor (Figure 32) is also operated by the Norfolk Southern Railway. The Crescent Corridor will run along Interstate 81 and will be an intermodal corridor between Louisiana and New Jersey.



Source: Norfolk Southern (MARAD Panama Canal Expansion, Phase 1 Report)

Figure 31: Heartland Corridor

[20] Norfolk Southern opens Heartland Corridor. Railway Gazette International, September 9, 2010.

Source: Norfolk Southern (MARAD Panama Canal Expansion, Phase 1 Report)

Figure 32: Crescent Corridor

Chapter 3: Evaluating Capacity Maintenance and Expansion

The desirability for maintenance and expansion of the Nation's navigation transportation capacity is derived from the demand for transportation services. This demand is tied to population and income, as shown in chapter 1. Forecast growth of population and income imply growth in trade and the demand for transportation services. However, it is difficult to predict the extent of this future growth, and when and where it will happen.

As suppliers of transportation services compete, they seek economic advantage. Advantage is gained in deep draft navigation through more efficient vessels, cargo handling techniques, and inter-modal connectors. The greatest manifestation of this has been the innovation of containerized cargo and the container vessel.

Since the introduction of the container in 1956,[21] containerized trade has grown to tens of millions of TEUs per year. This growth in containerized trade has led to the building of vessels designed to carry them. The increase in the size of container vessels can only be described as phenomenal—growing from a fleet size of just 6.375 million TEUs in 1990 to an estimated 32.185 million TEUs in 2012.[22] Maximum vessel size has increased from about 7600 TEUs in 2000 to about 14,000 TEUs in 2012 with 18,000 TEU vessels on order for delivery in 2013. These large vessels present economic efficiencies largely through reduced fuel consumption per ton mile. This becomes also an environmental opportunity as reduced fuel consumption per TEU results directly in reduced emission per TEU.

This chapter reflects on the future need for capacity at the Nation's ports and inland waterways resulting from the deployment of *post-Panamax* vessels in the world fleet. It qualitatively considers the likely forecast scenarios to impact each port or region and considers the scenario most likely to prevail in the future given our current understanding of the industry and whether a port or region has a need for additional maintenance or expansion to be able to meet the needs of the forecast scenario.

Market Responses

The Panama Canal expansion is expected to be completed in 2014. The expansion has been called a "game changer." Its influence will be great, yet there is uncertainty regarding the

[21] Levinson, Marc. 2006. The Box – How the Shipping Container Made the World Smaller and the World Economy Bigger. Chapter 1, page 1.

[22] World Container Traffic - Drewry Annual Reports; End Year Fleet Size - CI Market Analysis: Container Leasing Market 2010 as quoted in World Shipping Council, Container Supply Review May 2011.

specifics of how and when the game will change. There are three primary responses expected from the expansion.[23]

West Coast Diversions

West Coast ports serve as an alternative to the Panama Canal. The intermodal land bridge formed by the rail connections to West Coast ports provides a faster connection from and to Asian markets. Typically the land bridge is estimated to be five to six days faster, an advantage that can't be entirely made up on an all-water route through an expanded Panama Canal. However, with the expansion of the Panama Canal, the cost of using the all-water route from Asia to the East Coast is reduced and may be enough to off-set the increased transit time and result in traffic diverting from West Coast to East Coast ports in some cases.

Transshipment

Ports in the U.S. and Caribbean that are currently capable of receiving the largest of the *post-Panamax* vessels, when fully loaded, become deepwater transport hubs for vessels of all sizes. On the West Coast, these large vessels can call at Seattle, Oakland and LA/LB. On the East Coast, large vessels can or will be able to call at Norfolk, New York/New Jersey, Baltimore and Miami. These ports and *post-Panamax* ready ports in the Caribbean serve as transport hubs. The largest vessels unload at the hub and smaller feeder vessels deliver to ports with less channel capacity.

Agricultural Exports

The Panama Canal enlargement may make shipment of Midwest grains and other goods through Gulf ports to Asian markets more attractive than existing routes. That may, or may not, increase total U.S. exports of these products. However, it would increase barge traffic down Mississippi tributaries to the Gulf of Mexico.

There is uncertainty in these market responses. Details of when *post-Panamax* vessels will arrive in large numbers, at which ports they will call, how deep vessels will draft and, consequently, how deep and wide navigation channels and other related navigation infrastructure must be are uncertain. Another key uncertainty is the future Panama Canal Authority (ACP) toll structure. It should be noted that deepening U.S. ports to service *post-Panamax* vessels that transit the Panama Canal enhances the ability of the ACP to benefit through increases in its toll structure. In fact, it may be possible for the ACP to extract a majority of the transportation cost savings benefits on routes that use the canal, limiting the cost savings associated with the use of larger vessels through the canal that will be available to carriers, shippers, producers or consumers. A careful understanding of this is required when choosing which ports to deepen and how to finance the project.

[23] This scenario discussion in this chapter owes a great debt of gratitude to the work presented in the MARAD *Panama Canal Phase I* report.

Another key uncertainly is the role that transshipment hubs in the Caribbean or on U.S. shores could play in transferring freight from large vessels to smaller feeder vessels. Transshipment might offer cost savings to cargo headed for ports that are not *post-Panamax* ready. However, transshipment hubs add time and extra handling and additional exposure to the harbor maintenance tax, costs that may exceed the benefits of using a larger vessel.

As noted, reduced costs for an all-water route from Asia to the East Coast could cause a shift of some market share from the West Coast ports to the East Coast. However, given the expected overall increase in trade, it is not a zero sum game. Even if West Coast ports were to lose some market share, they will still see an increase in cargo moving through their ports. Moreover, West coast ports and their rail partners are investing heavily to increase the capacity and efficiency of the intermodal land bridge to ensure it remains competitive and retains market share.

It should be remembered that the opportunities for reduced costs available to U.S. agricultural exports through the use of larger bulk carriers are also available to its competitors in international markets.

Impact Scenarios

Impact scenarios have been derived by varying the three expected market responses. Using non-quantified descriptors of high and low for each response, eight scenarios were developed.

Table 7: Impact Scenarios

Post-Panamax Vessel Impact Scenarios			
	West Coat Diversion	Transshipment	Agricultural Exports
Scenario 1	H	H	H
Scenario 2	H	H	L
Scenario 3	H	L	H
Scenario 4	H	L	L
Scenario 5	L	H	H
Scenario 6	L	L	H
Scenario 7	L	L	L
Scenario 8	L	H	L

Scenario One – Under this scenario significant traffic is diverted from the West Coast ports and the intermodal land bridge to the East Coast ports. Transshipments are high, either at *post-Panamax* ready U.S. ports or Caribbean ports. The impact on agricultural exports is also high resulting in more grain being exported through U.S. Gulf ports.

Scenario Two – Under this scenario significant traffic is diverted from the West Coast ports and the intermodal land bridge to the East Coast ports. Transshipments are high, either at *post-Panamax* ready U.S. ports or Caribbean ports. The impact on agricultural exports is low with little impact on grain being exported through U.S. Gulf ports.

Scenario Three - Under this scenario significant traffic is diverted from the West Coast ports and the intermodal land bridge to the East Coast ports. Transshipments are low, large vessels use *post-Panamax* ready U.S. ports but other ports are served by smaller vessels. The impact on agricultural exports is also high resulting in more grain being exported through U.S. Gulf ports.

Scenario Four - Under this scenario significant traffic is diverted from the West Coast ports and the intermodal land bridge to the East Coast ports. Transshipments are low, large vessels use *post-Panamax* ready U.S. ports but other ports are served by smaller vessels. The impact on agricultural exports is low with little impact on grain being exported through U.S. Gulf ports.

Scenario Five - Under this scenario little traffic is diverted from the West Coast ports and the intermodal land bridge to the East Coast ports. Transshipments are high, either at *post-Panamax* ready U.S. ports or Caribbean ports. The impact on agricultural exports is also high resulting in more grain being exported through U.S. Gulf ports.

Scenario Six - Under this scenario little traffic is diverted from the West Coast ports and the intermodal land bridge to the East Coast ports. Transshipments are low, large vessels use *post-Panamax* ready U.S. ports but other ports are served by smaller vessels. The impact on agricultural exports is also high resulting in more grain being exported through U.S. Gulf ports.

Scenario Seven - Under this scenario little traffic is diverted from the West Coast ports and the intermodal land bridge to the East Coast ports. Transshipments are low, large vessels use *post-Panamax* ready U.S. ports but other ports are served by smaller vessels. The impact on agricultural exports is low with little impact on grain being exported through U.S. Gulf ports.

Scenario Eight - Under this scenario little traffic is diverted from the West Coast ports and the intermodal land bridge to the East Coast ports. Transshipments are high, either at *post-Panamax* ready U.S. ports or Caribbean ports. The impact on agricultural exports is low with little impact on grain being exported through U.S. Gulf ports.

Over time the uncertainties with the market response to the Panama Canal improvements will be reduced as experience replaces expectation. IWR does not consider transshipment hubs likely to serve as the primary avenue of foreign imports or exports. As shown in Figure 33, the all-water route to the East Coast already adds 8 to 12 days to delivery. The Panama Canal toll

will take a part of the transportation cost savings. A transshipment hub would add more cost and further increase delivery time. As noted in Chapter 2, the railroads are investing heavily, which will help maintain their competitiveness. These factors seem to weigh against the development of any substantial transshipment hub. In the absence of transshipment centers, *post-Panamax* vessels will call at the ports that are able to accommodate them, and the number of times that they call at each of these ports, their sailing drafts and other dimensions will become known.

However, this kind of a hub and spoke model has reduced airline passenger costs and air freight costs, so the option may be deserving of more analysis. Overall, it could be more economical for some routes and would involve less Federal spending and fewer adverse environmental impacts. The potential barriers include the cost to alter port facilities to accommodate transshipment, additional cargo handling costs, higher shipping costs due to cabotage, and the harbor maintenance tax.[24]

Source: Parsons Brinckerhoff, 2011 (MARAD Panama Canal Expansion, Phase 1 Report)

Figure 33: Travel time comparisons from Asia to Pacific and Atlantic Coast destinations

Getting Ready for *post-Panamax* Vessels

The U.S. population is expected to increase 32 percent from 313.4 million people in 2011 to 412.2 million in 2042, as shown in chapter 2. The two regions expected to grow the most by

[24] GAO, Freight Transportation: Short Sea Shipping Shows Importance of Systematic Approach to Public Investment Decisions, GAO-05-768 (July 2005).

2030 are the South at 43 million and the West at 29 million. IHS-GI has forecast U.S. imports to grow from $2,666 billion in 2011 to $12,444 billion in 2042 to support this population growth. Exports are projected to increase from $2,088 billion to $14,831 billion over the same time period.

San Pedro Bay TEU traffic, representative of West Coast port expectations, is expected to grow to 36.7 million TEUs by 2030. On the East Coast containerized tonnage is expected to grow from 65.66 million tons in 2012 to 146.3 million tons by 2029.

Gulf Coast containerized tonnage is expected to grow from 29.6 million tons in 2012 to 64.6 million tons by 2029.

One-half of the growth in Center Gulf bulk exports is expected to use the Panama Canal and it is projected that the Center Gulf will increase its share of total U.S. exports over the next 10 years. These exports will transit the Mississippi River to the Port of New Orleans.

Carriers are expanding their fleet of vessels with larger ships to serve the current and future global demand. By 2030 p*ost-Panamax* vessels could represent 62 percent of the total TEU capacity of the container vessel fleet. *Post-Panamax* vessels are already calling at some U.S. ports and will call with increasing regularity in the future. The challenge is to invest in capacity expansion in the right places, at the right time, and in the right way in response to the Panama Canal improvements.

> The term "*post-Panamax* ready" has to be defined for individual ports. Even as the *post-Panamax* fleet varies in length, width and sailing draft, so too will the required land side facilities, turning basins, channel depths and widths vary at each port to accommodate the characteristics of the specific fleet calling at that port. It is not necessary to be able to accommodate the larger classes of *post-Panamax* vessels to be considered *post-Panamax* ready.

For this report, a port is be considered "*post-Panamax* ready" if it has a channel depth of about 50 feet net of allowances for usable tide, as well as sufficient dock and crane capacity. U.S. West Coast ports at Seattle, Oakland, Los Angeles and Long Beach all have 50-foot channels. Northeastern U.S. ports at Baltimore and New York have or will soon have 50-foot channels. On the Southeast coast, Norfolk has a 50-foot channel. Below Norfolk along the U.S. Southeast and Gulf Coasts, there are no ports with 50-foot channels, although Charleston with a 45-foot channel depth and nearly 5 feet of tide can accommodate most *post-Panamax* vessels. This is also a region with high forecast population and the associated potential for trade growth. To respond to these needs, Miami is deepening their channel and will soon have 50-foot channel depth.

In order to prevent ports from becoming the limiting component of the navigation system, the vision for the system must extend beyond the major ports to include lower tier ports. New, large vessels are typically deployed on the longest and largest trade service – Asia to Northern Europe. The "smaller" vessels on that service are forced to re-deploy to the next most efficient service for that vessel size. This cascading continues until the most marginal vessels in the fleet

are forced to be scrapped. Cascading typically increases average vessel size for each trade service, placing demands on the port infrastructure to support larger capacity vessels. For U.S. ports to be ready to take advantage of *post-Panamax* vessel opportunities, major ports not only need to be "*post-Panamax* ready," but second tier ports need to be "cascade ready" as they in turn have the opportunity to take advantage of larger vessels that begin to service their trade. For the purposes of this report IWR defines "cascade ready" as a channel depth of 45 feet.

Table 8 shows major U.S. ports and their channel depth tidal range by region.

Table 8: U.S. Ports with Channel Depths and Tidal Range by Region

State	Project	Coast	Region	Depth, ft	Neap Tidal Range, ft	Present Container Port	Post Panamax Ready
MA	BOSTON HARBOR, MA	Atlantic	NE	40	8.7	Yes	N
MD	BALTIMORE HARBOR AND CHANNELS	Atlantic	NE	50	0.6	Yes	Y
ME	PORTLAND HARBOR	Atlantic	NE	35	8.3	Yes	N
NJ	NEWARK BAY (HACKENSACK AND PASSAIC RVS) NJ	Atlantic	NE	50	4.5	Yes	Y
NY	BAY RIDGE AND RED HOOK CHANNELS, NY	Atlantic	NE	40	4.0	Yes	N
NY	BUTTERMILK CHANNEL	Atlantic	NE	40	4.0	Yes	N
NY	EAST RIVER	Atlantic	NE	40	6.5	Yes	N
NY	HUDSON RIVER CHANNEL	Atlantic	NE	45	4.0	Yes	N
NY	NEW YORK HARBOR	Atlantic	NE	50	4.0	Yes	Y
NY	NYNJ CHANNELS (ARTHUR KILLKILL VAN KULL)	Atlantic	NE	50	4.2	Yes	Y
PA	DELAWARE RIVER, PHILADELPHIA TO THE SEA	Atlantic	NE	40	5.0	Yes	N
PR	SAN JUAN HARBOR, PR	Atlantic	NE	39	0.6	Yes	N
RI	PROVIDENCE RIVER AND HARBOR	Atlantic	NE	40	4.0	No	N
VA	CHANNEL TO NEWPORT NEWS, VIRGINIA	Atlantic	NE	50	2.1	Yes	Y
VA	NORFOLK HARBOR, VIRGINIA	Atlantic	NE	50	2.1	Yes	Y
VA	THIMBLE SHOAL CHANNEL, VA	Atlantic	NE	50	2.2	Yes	Y
	DEL R PHILADELPHIA TO TRENTON	Atlantic	NE	40	7.3	Yes	N

	DELAWARE RIVER AT CAMDEN	Atlantic	NE	40	5.7	Yes	N
FL	CANAVERAL HARBOR FL	Atlantic	SE	41	2.9	Yes	N
FL	JACKSONVILLE HARBOR FL	Atlantic	SE	40	1.7	Yes	N
FL	MIAMI HARBOR FL	Atlantic	SE	42	2.2	Yes	N
FL	PORT EVERGLADES HARBOR	Atlantic	SE	42	2.2	Yes	N
GA	BRUNSWICK HARBOR, GA	Atlantic	SE	36	6.0	No	N
GA	SAVANNAH HARBOR	Atlantic	SE	42	6.3	Yes	N
NC	MOREHEAD CITY HARBOR NC	Atlantic	SE	45	2.7	No	N
NC	WILMINGTON HARBOR NC	Atlantic	SE	42	3.9	Yes	N
SC	CHARLESTON HARBOR SC	Atlantic	SE	45	4.7	Yes	With tide
AL	MOBILE HARBOR	Gulf	Gulf	45	1.3	Yes	N
FL	MANATEE HARBOR	Gulf	Gulf	40	0.9	Yes	N
FL	PANAMA CITY HARBOR	Gulf	Gulf	36	1.2	Yes	N
FL	TAMPA HARBOR FL	Gulf	Gulf	43	0.9	Yes	N
LA	CALCASIEU RIVER AND PASS	Gulf	Gulf	40	0.6	No	N
LA	MISS RIVER BATON ROUGE TO GULF	Gulf	Gulf	45	1.2	Yes	N
MS	GULFPORT HARBOR, MS	Gulf	Gulf	36	1.4	Yes	N
MS	PASCAGOULA HARBOR	Gulf	Gulf	42	1.2	Yes	N
TX	BARBOUR TERMINAL SHIP CHANNEL	Gulf	Gulf	42	1.0	Yes	N
TX	BAYPORT SHIP CHANNEL	Gulf	Gulf	42	1.0	Yes	N
TX	BRAZOS ISLAND HARBOR	Gulf	Gulf	42	1.0	No	N
TX	CORPUS CHRISTI SHIP CHANNEL	Gulf	Gulf	45	1.0	No	N
TX	FREEPORT HARBOR	Gulf	Gulf	45	1.0	No	N
TX	GALVESTON HARBOR AND CHANNEL	Gulf	Gulf	45	1.0	No	N
TX	HOUSTON SHIP CHANNEL	Gulf	Gulf	45	1.0	Yes	N
TX	SABINENECHES WATERWAY	Gulf	Gulf	42	0.6	No	N
TX	TEXAS CITY CHANNEL	Gulf	Gulf	45	1.0	No	N
AK	ANCHORAGE HARBOR, AK	Pacific	Pacific	35	23.2	Yes	N
CA	LOS ANGELESLONG	Pacific	Pacific	53	2.2	Yes	Y

	BEACH HARBORS						
CA	OAKLAND HARBOR	Pacific	Pacific	50	3.1	Yes	Y
CA	PORT HUENEME	Pacific	Pacific	36	1.9	No	N
CA	SAN DIEGO HARBOR	Pacific	Pacific	47	2.4	No	With tide
CA	SAN FRANCISCO HARBOR	Pacific	Pacific	40	2.4	N/A	N
OR	COLUMBIA RIVER AT MOUTH, OR AND WA	Pacific	Pacific	48	4.9	Yes	Y
OR	COOS BAY OR	Pacific	Pacific	37	3.8	Yes	N
WA	C AND LW RIVERS BELOW VANCOUVER WA AND PORTLAND OR	Pacific	Pacific	43	1.8	Yes	N
WA	GRAYS HARBOR, WA	Pacific	Pacific	36	4.9	Yes	N
WA	SEATTLE HARBOR, WA	Pacific	Pacific	50	4.0	Yes	Y
WA	TACOMA HARBOR	Pacific	Pacific	51	4.4	Yes	Y

Source: USACE Institute for Water Resources

The need for capacity expansion is likely to be the most critical along the U.S. Southeast and Gulf Coasts. This is indicated by the growth in population and trade as well as the lack of current capacity. South of Norfolk there are no ports that are fully *post-Panamax* ready. The ports of Savannah, Charleston and Miami are at various stages of capacity expansion. Successful development at these ports would fill the critical need on the Southeast coast. However, there may be a need for "cascade ready" expansion at some of the smaller ports.

There are 10 deep draft navigation projects along the Gulf Coast with container yards and related infrastructure. Depths of these projects range from 36 to 47 feet. None of these ports is considered *post-Panamax* ready. Several ports in the Gulf are under study to deepen their channels to be better prepared for larger drafting vessels, including the Mississippi River from Baton Rouge to the Gulf and the Texas ports of Freeport, Corpus Christi and Island Harbor in Brownsville. A recently completed study of a proposal for Sabine Neches estimated that deepening its channel to 50 feet would cost more than $1 billion and would yield a positive economic return. On the Gulf coast the lack of channel depth is exacerbated by the small tidal window, which is generally one to two feet.

There may also be opportunities at other ports around the country to increase the width of channels and turning basins to accommodate the longer, wider design of new container vessels.

How Much Depth Is Needed?

In the past, larger vessels have always meant deeper drafts. This is the nature of bulk vessels and for a time held for container vessels as well. However, recent designs in container vessels have tended towards longer, wider vessels with "U" shaped as opposed to "V" shaped hulls. Maersk, the largest carrier in the world, has recently introduced two classes of these new

designs. The *Maersk Triple E*, scheduled to begin deployment in 2013 will carry 18,000 TEUs. Its physical dimensions are 1,300 feet long, 194 feet wide with a design draft of 47.6 feet. This compares to the *Emma Maersk*, formerly the largest containership in the world, a 15,000 TEU capacity vessel with a 51 foot draft. The second vessel design may be of more interest. Maersk's SAMMAX vessel, designed to take advantage of the expanded Panama Canal for the South American trade, was designed to carry 7,450 TEUs.[25] Maersk has ordered 16 of these vessels. Two were put into service in 2011. The vessels measure 984 feet long and have a beam of 147 feet. Their design draft is only 39 feet. Maersk claims these vessels are 8 percent more efficient than other vessels of similar capacity. If these designs prove to be effective there will likely be other intermediate sizes designed for other markets.

Weight Trade and Volume Trade Services

The maximum capacity of container vessels can be limited by either the maximum vessel sailing draft or by the number of containers they can carry. Depending upon the weight of cargo in the containers, this limit can either be by weight (maximum draft) or volume (slot capacity). That is, lighter cargo will draft less than heavier cargo for the same number of containers. This can be measured by cargo density, i.e., the average weight per container on a vessel expressed as metric tons per TEU. Cargo density is expected to vary dependent upon the commodities handled by different trade routes. Vessels operating on trade routes from foreign ports that typically ship lighter commodities are expected to have lower cargo densities and thus will arrive at U.S. ports drafting less than their design draft. Other factors that can affect containership loading include limitation due to line of site and lashing requirements.

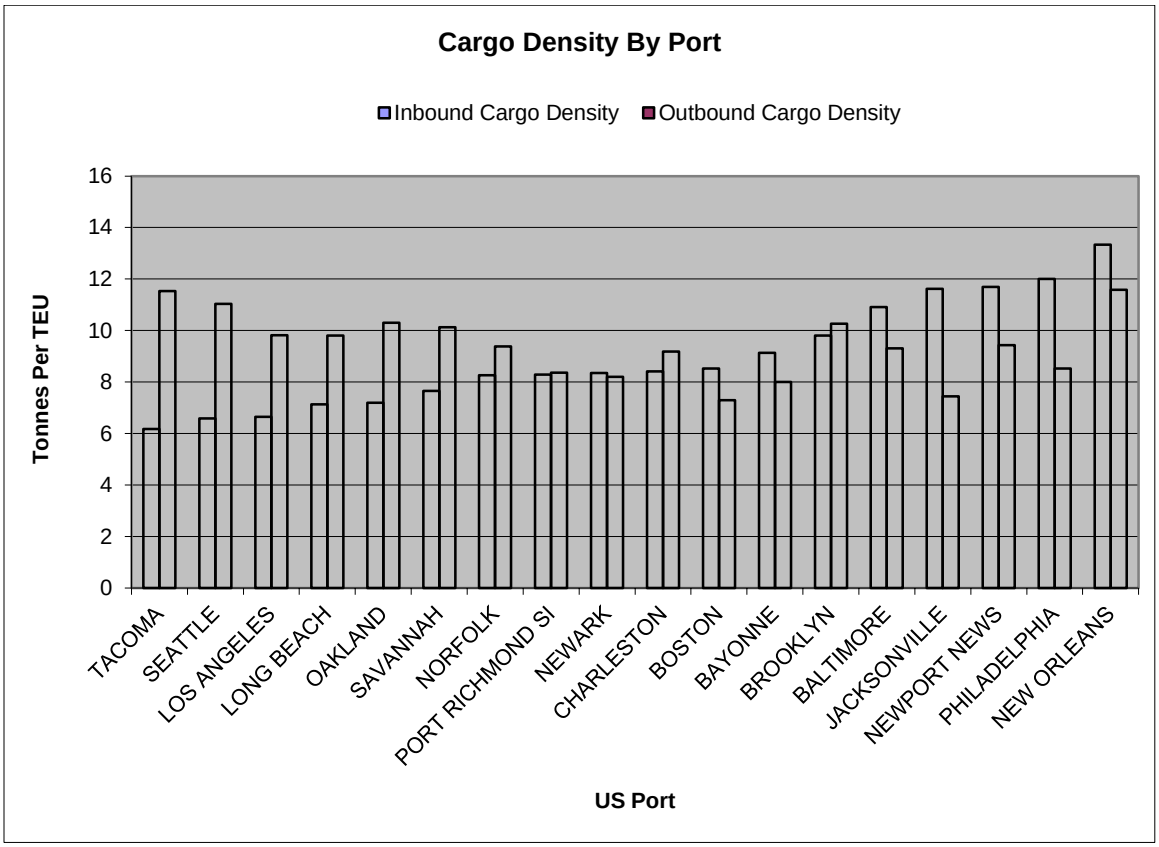
IWR has performed an analysis of vessel trade data for U.S. ports to examine the issues of cargo density by port, trade route and vessel class. The methodology involved use of two comprehensive data sources: 1) information collected on waterborne commerce by IWR's Waterborne Commerce Statistics Center (WCSC) and 2) automated identification system (AIS) data on global container vessel movements, previously acquired from the private maritime data provider Lloyd's Register–Fairplay, now IHS Fairplay. AIS data allows analysis of container vessel movements over time to determine trade routes, but does not contain any information on cargo transfers. WCSC data supports analysis of cargo transfers by weight and volume at U.S. ports, but does not provide information on global vessel movements. Combined, the two data sources provide a picture of historical vessel movements and can be used to estimate cargo density of container vessels by vessel class and trade route.

The cargo density analysis was carried out utilizing AIS 2006 to 2008 data and WCSC 2006 to 2009 data. AIS data was matched with WCSC data for the period 2006-2008 to provide cargo transfer information that could be analyzed at the service level. WCSC data for the full period of availability (2006-2009) was analyzed at the trade region level for movements between U.S. regions, Asia and Europe.

[25] Save the Cape, Inc. Panamax, Post-Panamax, and Sammax. A Primer on Ship Size.

The analysis was oriented towards examination of cargo density and arrival drafts. The results confirm the existence of weight and volume trades.

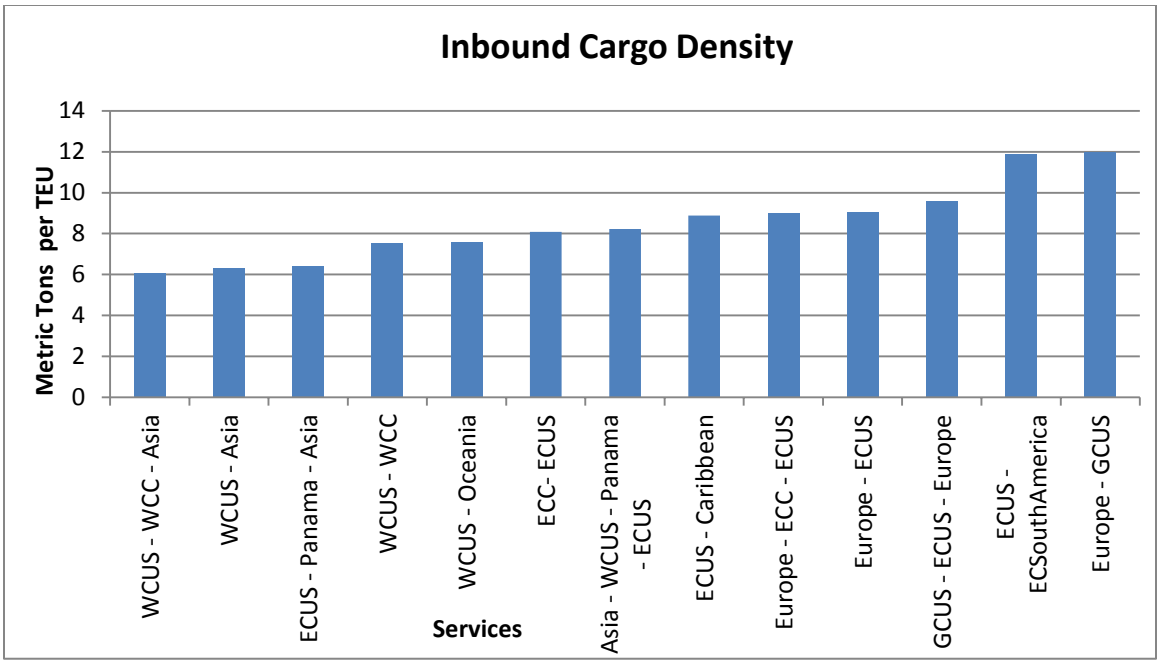
Figure 34 shows the average cargo density, in metric tons per TEU, based on WCSC data from 2006 through 2008, at a selection of U.S. ports. As can be seen from the figure, inbound cargo density is significantly lower at the West Coast ports, where traffic is primarily from Asia. This suggests that vessels arriving at these ports are volume limited, rather than weight limited.



Source: USACE Institute for Water Resources

Figure 34: Cargo Density at U.S. Ports

Using AIS data, it is possible to characterize vessel movements as being part of services, depending upon where they travel. As shown in Figure 35, there is a clear indication of volume and weight trades, based on inbound cargo density, with volume trade predominant on the West Cost – Asia services and weight trade predominant on East Coast / Gulf Coast – Europe services.



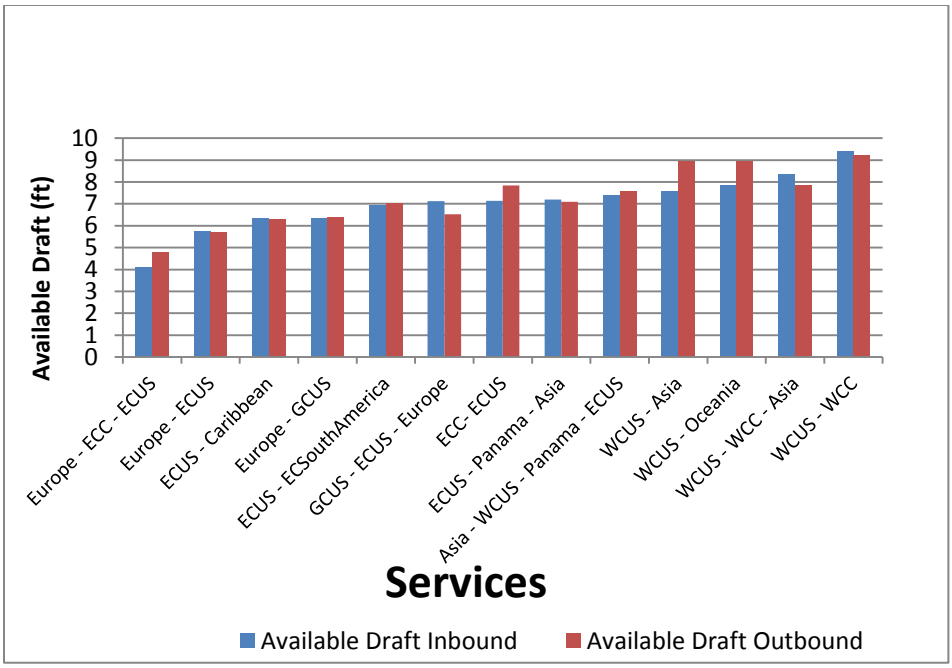
Source: USACE Institute for Water Resources

Figure 35: Average Cargo Density by Service

Trade regions in Figures 35 and 36 are abbreviated as follows:

- WCUS – West Coast United States
- WCC – West Coast Canada
- ECUS – East Coast United States
- ECC – East Coast Canada
- GCUS – Gulf Coast United States

In order to further explore the issue of weight vs. volume trades, the arrival and departure draft of the vessels making calls at U.S. ports for which services were identified was compared with the maximum draft of the particular vessel, leading to an "available draft," i.e. the maximum draft less the arrival or departure draft. This serves as an indication of the degree to which the particular vessel is utilizing all of its draft. As can be seen from Figure 36, services for U.S. East Coast ports tend to have lower available draft on arrival and departure than do services using West Coast ports. The increased available outbound draft for West Coast ports is likely due to returning empty boxes. WCSC data does not provide information on shipment of empties, so this cannot be verified through the currently available data, but is consistent with expectations.



Source: USACE Institute for Water Resources

Figure 36: Available Draft (maximum design draft less average sailing draft) by Service

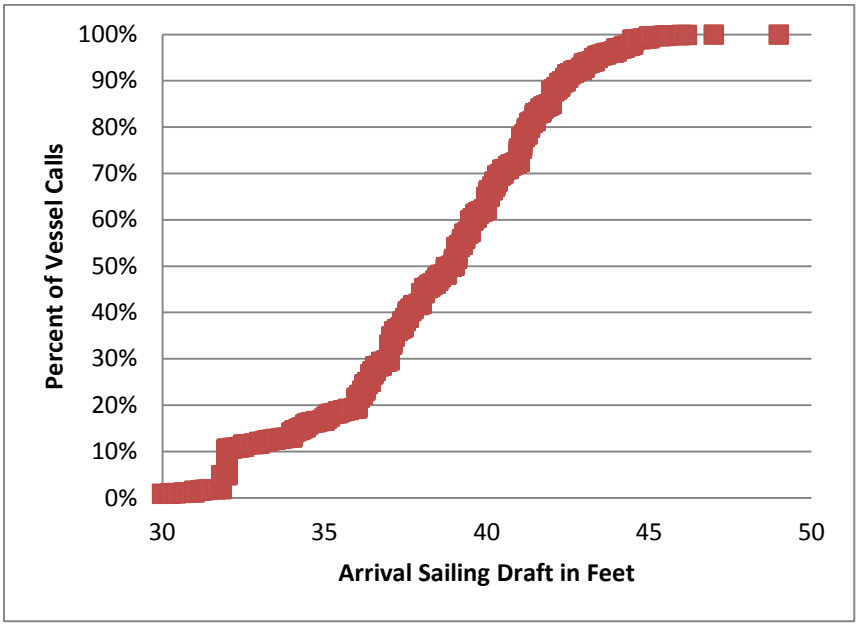
Examining direct trade between U.S. ports and Europe and Asia, using WCSC data, as shown in Table 9, the inbound cargo density is lowest for the West Coast – Asia trade, highest for the East Coast – Europe Trade. Deployment of the largest vessels on the West Coast - Asia Trade is also seen.

Table 9: Cargo Density and Available Draft By Trade Region, WCSC Data

Number of Calls	Vessel Class	Average Cargo Density (tonnes/TEU)	Average Available Draft (ft)	U.S. Port Trade Region	Foreign Port Trade Region
1483	Post-Panamax Generation 2	5.76	8.54	West Coast North America	Asia
268	Post-Panamax Generation 1	6.02	8.25	U.S. Atlantic	Asia
3383	Post-Panamax Generation 1	6.11	8.09	West Coast North America	Asia
3019	Panamax	6.16	6.25	West Coast North America	Asia
1093	Panamax	6.23	6.1	U.S. Atlantic	Asia
743	Sub-Panamax	6.46	3	West Coast North America	Asia
410	Post-Panamax Generation 1	8.48	7.35	U.S. Atlantic	Europe
1947	Panamax	9.07	4.71	U.S. Atlantic	Europe
1191	Sub-Panamax	9.39	2.86	U.S. Atlantic	Europe

Source: USACE Institute for Water Resources

To illustrate the importance of cargo density to sailing draft, Figure 37 shows the arrival draft for 2,479 *post-Panamax* vessel calls at the San Pedro Bay ports from 2006 through 2008. Only 12 vessel calls recorded an arrival draft of greater than 45 feet in the WCSC data.



Source: USACE Institute for Water Resources, Waterborne Commerce Statistics Center

Figure 37: Arrival Drafts of *post-Panamax* Vessels at LA/LB from Asia

Analysis of both the WCSC and AIS data sets clearly shows the existence of weight and volume trades, with vessels arriving at the West Coast of the U.S. from Asia at lower cargo densities than vessels arriving on the East Coast from Europe. Vessels arriving from Asia to the West Coast show greater available draft, most likely due to the lower cargo density.

Inland Waterways

USACE supports the safe, reliable, efficient, and environmentally sustainable movement of vessels on 12,000 miles of inland and intracoastal waterways. The waterways are the primary artery for half of the nation's grain and oilseed exports, 20 percent of coal for utility plants, and 22 percent of domestic petroleum movements.[26] USACE's role includes maintaining the 191 commercially active lock sites with 238 chambers that allow tows to "stair-step" through the nation's heartland.

This Center Gulf region, served by the Mississippi River and its navigable tributaries, could be a beneficiary of an expanded Panama Canal for exports. The Lower Mississippi is currently maintained to a depth of 45 feet. A 50-foot deep Panama Canal will allow current *Panamax* vessels transiting the Canal to be loaded to their full draft of 42 feet to 45 feet, a significant improvement over the current 39.5 feet. For the vessels with a 45 foot draft leaving New

[26] Grier, David. USACE Institute for Water Resources, The Declining Reliability of the U.S. Inland Waterway System.

Orleans at 39.5 feet heading for Asia, transportation cost saving gained by loading to 45 feet will be about $0.05 per bushel.

USACE completed the UMR-IWW System Navigation Feasibility Study in December 2004. In 2008, the *Re-evaluation of the Recommended Plan: UMR-IWW System Navigation Study – Interim Report*, a re-evaluation of the feasibility report recommended plan, was completed. Economic models of the river system were developed as part of this study and were used to assess the ability of the current system to handle potential increases in river traffic resulting from shift of mode benefits to Asia.

Informa Economics, Inc. estimates that the larger, more efficient *Cape* class ships reduce the cost of the movement of grains to northeast Asia by an all-water Panama Canal route by $0.31 to $0.35 per bushel of grain.[27] Assuming the Informa grain forecast and the re-evaluation report non-grain forecasts (163 million short tons in 2020), not all potential demand could be accommodated in 2020 with the current system infrastructure. However, using the alternative analysis assuming the Informa grain forecast and no growth in non-grain (87 million short tons), all potential traffic could be accommodated without waterway infrastructure efficiency improvements.

Beyond the sensitivity to non-grain traffic growth, several points regarding the accommodated/ unaccommodated traffic conclusions should be emphasized: (1) The time horizon for these conclusions is 2020. With additional traffic growth beyond 2020 there would be a greater magnitude of unaccommodated traffic (in the case of Informa grain and re-evaluation report non-grain), or an eventual state where at least some traffic would no longer be accommodated (in the case of Informa grain and no growth in non-grain). (2) The only constraint to traffic accommodation that has been considered is inland waterway infrastructure. In particular, landside infrastructure and deep-water port infrastructure have not been addressed in making inland waterway accommodated/unaccommodated traffic conclusions. (3) The determination that traffic can be accommodated in the future does not mean that it will be accommodated at existing cost levels. Given the willingness to pay for water transportation, some increases in cost can be incurred before shippers make the decision to no longer use the waterway. Any increase in traffic over the lock and dam portion of the system will result in additional congestion and cost. (4) The implementation timeframe for the subset of authorized UMR-IWW improvements that is sufficient to address improved waterway efficiency and "capacity" from a system perspective is no earlier than the mid 2020s.

Summary

The deployment of *post-Panamax* vessels will have impacts throughout the Nation's freight transportation system. To prepare for these vessels, ports will seek to widen and/or deepen

[27] Panama Canal Expansion: Impact on U.S. Agriculture, Informa Economics, September 2011. Note: This estimate of transportation cost savings assumes a Cape class vessel.

their channels and turning basins. Whether the port is preparing to be *post-Panamax* ready or cascade ready will depend on the specific needs and opportunities of the individual port. An analysis of population and trade growth, coupled with a survey of current port capacities, has shown the Nation's most critical needs are along the Southeast and Gulf Coasts.

The export of agricultural and other bulk commodities depends on the inland waterways. A comparison of the current system capacity with forecast increases in agricultural exports indicates adequate capacity through 2020 and possibly beyond. To take advantage of these export opportunities will require the maintenance of inland waterway capacity that serves these exports. The impact of *post-Panamax* vessels is not anticipated to necessitate the expansion of inland waterway locks.

Chapter 4: Environmental Impacts of Capacity Expansion

Chapter Purpose and Approach

The purpose of this chapter is to describe the existing environmental footprint of ports, waterways, and intermodal links to inform future possibilities and then compare modernization impact possibilities in regions of the United States that are most likely to be adversely impacted.

Potential environmental impacts and mitigation needs are important aspects of planning for port and waterway modernization in response to increasing international freight transport, intermodal container-based shipment in larger oceanic vessels, and Panama Canal enlargement. Although much investigation of modernization needs has transpired, as attested to in previous chapters, the environmental impacts have received much less attention. Mitigation costs can be substantial. At the Port of Savannah, for example, mitigation costs are about 45 percent of the total estimated harbor expansion cost.[28] Environmental rules and permit requirements have become more stringent as their benefits became clearer. Emphasis on effective environmental impact mitigation is expected to continue, if not increase, and to be an essential consideration in determining modernization costs and net benefits.

Possible adverse environmental impacts are based on indicators of potential impact sources and vulnerabilities of human populations and natural and cultural resources. Consistent with environmental goals established in the National Environmental Policy Act (NEPA), the vulnerability metrics were selected to indicate potential impacts on public health and safety (including the social inequity of many impacts), the sustainability of important resource heritage, and environmental services that support commercial, recreational, and other uses of natural marine, estuarine, freshwater and shore resources. The impact-source metrics indicate regional rates of freight transport growth based on regional population growth over the next three decades, the unused capacity of ports compared to percent growth in regional population, harbor expansion needs for acceptance of the largest *post-Panamax* vessels, and possible effects of Panama Canal enlargement. While specific port and waterway environmental assessments and impact statements were consulted, they were not uniformly available or comparable across regions. The Indicators were selected based on their national comparability across regional ports, reliability (mostly Federal databases), and representativeness. More detailed information can be found in a supporting IWR report.[29]

[28] Mayle, M. C. and M. Landers. 2012. Corps, GPA: Deepen river to 47 feet. Savannah, GA: Savannah Morning News, April 12, 2012.

[29] Cole, R. A., J. Y. Chung and S. B. Komlos 2012. The past environmental footprint and possible future environmental impact mitigation needs of port and waterway modernization in the United States.

The Environmental Footprint

Despite much improvement of impact mitigation since more stringent and comprehensive environmental laws were passed, the cumulative effects of adverse impacts from transportation system development and operations have left a significant environmental footprint. These impacts also interact with other sources of impact to degrade environmental quality. In the following subsections, the environmental footprint is first placed in perspective by geographic comparison to other sources of impact. Then the nature of past sources of the environmental footprint is summarized.

The Environmental Footprint

Much of the conterminous United States has been altered by land and water development and use. The change has been beneficial for the most part, but a large fraction of the Nation's natural environment has been replaced with substantially different qualities that have compromised important natural services in support of human welfare. About 13 percent of the conterminous United States is now reserved for light use in parks, wildlife refuges, and wilderness areas where most natural qualities prevail.[30] Another 56 percent is more intensively used for forest management, grazing and other use that sustains many natural qualities except where management is lax. Many natural qualities have been lost from the 27 percent used for intensive crop culture and rural residential development. The remaining 4 percent is densely urban or used for rural transportation. It includes the geographical area of landside port, highway and railroad impact, which is about 1.6 percent in total. Relatively few natural qualities remain in the footprint of these densely impacted areas.

Despite many benefits, human use and transformation of the landscape has come at significant environmental cost. It has cumulatively degraded some commercial and recreational use of resources.[31] It has contributed to health and safety concerns[32] and to probable or possible extinction of at least 240 American species, and the decline of many more.[33] While the freight transportation system has directly impacted a small percent of the total impacted area of the conterminous United States, the effects often are intense, extend well beyond directly impacted areas, and sometimes interact synergistically with other sources of adverse environmental impact.

The geographical impact of land and water use described above provides a high-altitude perspective that misses the growing scarcity of wetland and open-water environments, which are disproportionately impacted by ports and waterways. Wetlands have been reduced from

[30] Lubowski, R. N., M. Vesterby, S. Bucholtz, A. Baez, and M. J. Roberts. 2006. *Major Uses of Land in the United States, 2002/EIB-14* Economic Research Service/USDA, Washington D. C.
[31] Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: Synthesis report. Island Press, Washington DC.
[32] Frumkin, H. Editor. 2010. Environmental health: From global to local. John Wiley & Sons, Inc. San Francisco, CA.
[33] Master, L. L., B. A. Stein, L. S. Kutner, and G. A. Hammerson. 2000. Vanishing Assets. Chapter 4 *In* B. A. Stein, L. S. Kutner, and J. S. Adams (Editors). Precious Heritage: The status of biodiversity in the United States. Oxford University Press, New York, NY

about 11.1 percent to about 5.3 percent.[34] During the past decade, tidal wetlands have been further reduced by the cumulative effects of rising sea level, channelization, sediment deprivation, other human impact, and hurricanes.[35] Now they are especially scarce, making up only 0.3 percent of the conterminous United States.

Open waters comprise 5.3 percent of the conterminous United States, including the American portion of the Great Lakes and coastal oceanic waters to the 12-mile territorial limit.[36] Without the Great Lakes and artificial reservoirs, the non-tidal inland waters of the conterminous U. S. amount to less than 1 percent of the total, much of that in lakes. The remaining free-flowing streams and rivers have become increasingly scarce and are now about 0.5 percent of the total area.[37]

Despite improvements in recent decades, freshwaters have been hit hard by physical, chemical and biological changes. Reservoir construction has increased the Nation's total open-water area in total while reducing the area of free-flowing water. Numerous non-native aquatic species are well established and some have costly effects.[38] Nearly 50 percent of streams and lakes remain unnaturally contaminated with nutrients, sediment, heavy metals and synthetic organic compounds.[39] As a consequence of these changes, about five times as many freshwater species as terrestrial species went extinct.[40] [41] Species extinction and imperilment is concentrated in areas with active ports and waterways, especially along the Pacific Coast, Southeastern Coast, and in states bordering the Ohio, Tennessee and Mississippi waterways.[42] [43]

Impacts of Transportation System Infrastructure

Development of highways, railroads and other land transportation infrastructure converted about 50,000 square miles (1.6 percent) of natural landscape to uninhabitable area for native species.[44] Freight transport has diverse environmental impacts.[45] Perhaps more damaging than

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[34] Dahl, T. E., and G. J. Alford. 1996. History of Wetlands in the conterminous United States. Pages 19-26 In J.D. Fretwell, J. S. Williams and P. J. Redman (Editors). National water summary on wetland resources. U. S. Geological Survey Water Supply Paper 2425. Washington D. C.

[35] Dahl, T. E. 2012. Status and Trends of Wetlands in the Conterminous United States 2004 to 2009. U. S. Fish and Wildlife Service. Washington, DC

[36] U. S. Census Bureau. 2012a: Table 358. Land and water area of states and other entities, 2008. 2012 Statistical Abstract of the United States. Department of Commerce. Washington, DC

[37] See Cole et al. 2012 for documentation

[38] Pimentel, D., S. McNair, S. Janecka, J. Wightman, C. Simmonds, C. O'Connell, E.Wong, L. Russel, J. Zern, T. Aquino and T. Tsomondo. 2001. Economic and environmental threats of alien plant, animal and microbe invasions. Agriculture, Ecosystems and Environment 84:1-20.

[39] U.S. Environmental Protection Agency, U.S. Army Corps of Engineers. 2007. The Role of the Federal Standard in the Beneficial Use of Dredged Material from U.S. Army Corps of Engineers New and Maintenance Navigation Projects. EPA842-B-07-002. Office of Water, U.S. Environmental Protection Agency, Washington, DC 20460

[40] Ricciardi and Rasmussen 1999

[41] Cole, R. A. 2009. The sustainability of freshwater species and water resources policy in the United States. USACE Institute for Water Resources 09-R-9. U. S. Army Corps of Engineers, Alexandria, VA

[42] Master et al. 2000

[43] Stein, B. A., L. S. Kutner, G. A. Hammerson, L. L. Master, and L. E. Morse. State of the states. Chapter 5 *In* B. A. Stein, L. S. Kutner, and J. S. Adams (Editors). Precious Heritage: The status of biodiversity in the United States. Oxford University Press, New York, NY

[44] Lubowski et al 2006