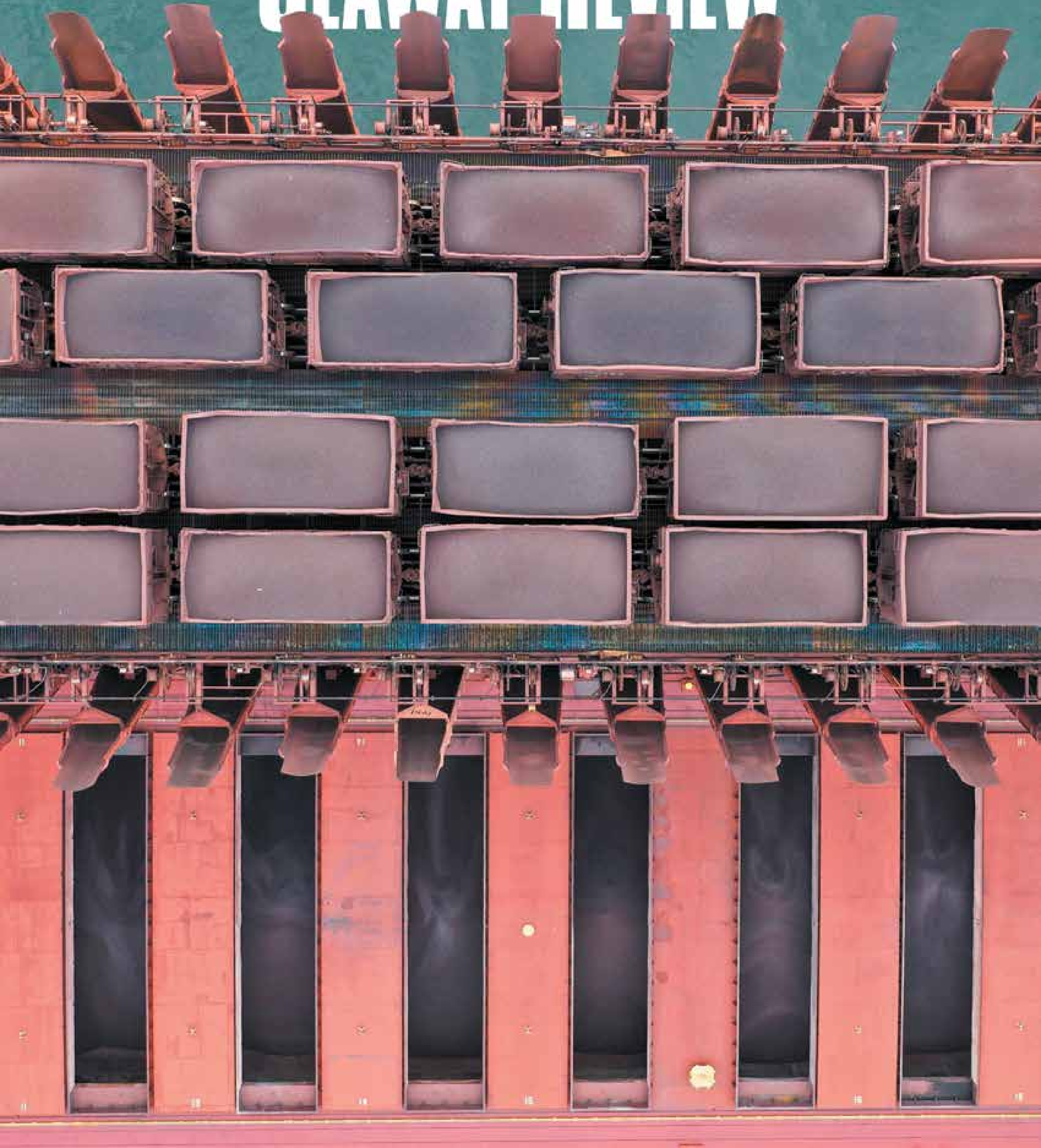
VOLUME 48 JANUARY-MARCH 2020 NUMBER 3

GREAT LAKES SEAWAY REVIEW



Lock-based ship design

Planning ships for cargo, trade routes

RICHARD A. MUELLER, *President/CEO, NETSCo., Inc.*
NICK HUNTER, *Naval Architect, NETSCo., Inc.*

In the early stage of ship design, all parties involved must have a clear understanding of where the vessel is intended to travel and how it intends to get there. Especially in the Great Lakes region, this decision involves the transit of one of the many canals or locks that scatter our waterways. Most notably, the Soo Locks and St. Lawrence Seaway drive vessel design and impact shipping traffic. In some cases, decisions made more than 100 years ago continue to impact vessel designs and trade capabilities today.

Early locks and canals

For thousands of years, mankind has not only been shipping goods across the water but manipulating waterways to better serve their shipping needs. Locks and canals have deep-seated roots in nautical shipping and farming that can be traced back to early Mesopotamia. The first canals that we know about were built around 4000 B.C., where the earliest farmers diverted rivers and waterways for irrigation.

As the popularity of canal irrigation increased, so did the number of uses. Ancient Indian farmers, around 3000 B.C., developed the first techniques to dam rivers and create reservoirs and holding ponds. However, it wasn't until the Romans, who are credited with inventing the flash lock, that shippers began using these dams and reservoirs to transit canals that may not otherwise have been navigable.

The earliest flash lock was essentially a dam with a single gate that could be opened, allowing a boat to transit through the dam with a "flash" of water. Clearly, it took some skill to safely maneuver a boat through a flash lock, but, even to this day, there are still some operable flash locks on the Wey Navigation in England.

Today's traditional lock is called a pound lock. The first pound lock was developed in China around 984 A.D., when naval engineer Qiao Weiyue enclosed a dammed reservoir with two sets of gates, allowing water to be pumped in and out to control the level.

After eliminating the water flash, the Chinese saw longer vessel lives, increased cargo capacity and more navigable waterways. By combining locks and canals, rivers that may have been too shallow to navigate were now viable shipping routes, opening additional trading routes from coastal to inland areas.

On the Great Lakes

In the United States, successful canal projects were being completed leading up to, and during, the War of 1812; however, the Great Lakes region didn't see its first canal project completed until 1825. Construction on the Erie Canal began in 1817 in Rome, New York and was completed in seven years. When it was constructed, the Erie Canal was the second longest canal in the world and connected the Hudson River in Albany to Lake Erie in Buffalo.

Vessels carrying weight-limited products, like taconite, salt and stone, have a more lucrative outlook in the Seaway's lock-based ship design.

Today, the canal—now a part of the New York State Canal System—is 363 miles long and includes 36 locks. The benefits of the canal were immediately seen in places like New York City, where the canal contributed to the city's economic success. Between 1820 and 1870, New York City's population exploded, growing by nearly a million people, many of whom were benefitting from the maritime trade occurring on the Erie Canal.

Shippers found that transportation on the canal was extremely efficient, and they capitalized on the method. The Erie Canal, like many canals built at that time, was constructed with a towpath atop the canal bank. This towpath allowed mules or horses to walk alongside the channel and draw a barge through the canal effectively.

Early canal barges and packet boats were sized based on the canal's locks and ranged from 60- to 80-feet long, 14-feet wide and generally drawing a draft of around 3.5 feet. These barges carried grain, gravel, lumber, produce and even tourists and immigrants.

An enlargement of the Erie Canal was completed in 1918. The locks grew from 98 by 17.5 by 6 feet to 300 by 43.5 by 9 feet. These current dimensions came to define the iconic Erie Barge Canal Boat image we have in our minds today. With long, slender hulls and proud, rounded bows, it is clear that these boats were built to maximize the space within the locks.

As ship design advanced, a new, modern fleet of steel vessels with deep transverse framing and no longitudinal stiffening saw great success. These canal barges could carry more than 1,000 tons and were soon self-propelled, or pushed by tugs, eliminating the need for the towpaths and mules.

Welcoming the Welland

After the completion of the Erie Canal in 1825, merchants transporting goods into Lake Ontario from the west still had a major obstacle to overcome: Niagara Falls. With trade flowing into the area, the need for a navigable waterway around the Niagara River intensified.

Completed in just over 10 years, the Welland Canal allowed ships to bypass Niagara Falls and eliminated any need for portaging cargo up the Niagara Escarpment. The Welland Canal saw a second, third and fourth enlargement project in 1846, 1887 and, finally, 1935. The lock sizes of the Fourth Welland Canal, completed in 1935, allowed the passage of vessels up to 740 feet long, 78 feet wide, with a 26.5-foot draft, again, directly influencing the design of canals soon to come.

With the popularity of the Erie Canal in the late 19th Century, increased demand for an additional navigable waterway between Lake Ontario and the Atlantic Ocean led to the proposal of a third canal system. This lock and canal system would be located along the St. Lawrence River, allowing ships to bypass the river's rapids and dams. The new canal system would replace and harmonize older lock and canals while including new hydroelectric power generating dams.

Impacting fleets today

The formation of the International Joint Commission in 1909 marked the beginning of a 50-year journey that would lead to the St. Lawrence Seaway opening in 1959. As the design for the St. Lawrence Seaway was taking shape in the 1950s, it was a natural choice to size these new locks based on the design of the canal built only twenty years earlier.

During design development of the Seaway, two basic lock sizes were evaluated.

One set of proposed dimensions replicated the Welland Canal's lock sizes, while the second approach was based on the Panama Canal lock size. At 965 by 106 by 39.5 feet, mimicking the Panamax dimensions would have excessively inflated construction costs of the Seaway. Many people today express regret at the final selection of lock size, saying that basing the Seaway on the Welland Canal, instead of the Panama Canal, made it economically insignificant before construction was even complete. While this criticism might be an exaggeration, the sizing of the Seaway has certainly influenced the region's ship design and economy.

The St. Lawrence Seaway has influenced ship designs, shipbuilding and commercial contracts around the world for the last 60 years. Not only are Great Lakes ships evaluated on their suitability to navigate the Seaway, but overseas constructions and designs are required to conform to these dimensions if they're intending to trade on the Lakes.

"Seawaymax" dimensions have limited what vessels and products can be considered commercially viable on the Lakes. Volume-limited products, like cars and containers, are not a large part of the regional economy—partly due to the Seaway's dimensions. As oceangoing containerships and ro-ro ships continue to get larger, the Seawaymax vessel remains relatively the same.

The business case for the volume-limited cargo ships is built around economies of scale, and with the Seaway's draft and beam restrictions, their return on investment potential is limited. Alternatively, vessels carrying weight-limited products, like taconite, salt and stone, have a more lucrative outlook in the Seaway's lock-based ship design.

Lock-based ship design tends to create narrow, shallow vessels with full, boxy shapes to use as much of the lock volume as possible. For instance, consider a vessel's length to beam ratio; a vessel's L/B is generally indicative of its powering and directional stability.

Since 1977, the worldwide vessel market has seen this ratio steadily decreasing, as there have been great efforts to reduce costs and increase propeller efficiencies. Both concerns can be addressed by increasing the beam, compared to the vessel's length. Both a 1,000-foot freighter sized to fit through the Soo Locks and a Seawaymax vessel, generally have L/B ratios between 9.0 and 9.5. Outside of the Great Lakes, however, ships designed for general ocean voyages tend to have L/B ratios ranging from 4.0 to 6.5. These ships can increase their breadth until they reach an optimized ratio suited for their intended voyage and trade.

Lock-based ship design tends to create narrow, shallow vessels with full, boxy shapes to use as much of the lock volume as possible.

The decisions and designs contemplated 50 to 100 years ago are still impacting our vessels' designs and operations today; and likely well into the future. Some impacts are negative, like limiting viability of breakbulk cargoes, while some impacts are positive, like providing economic access to inland cities and regions. Either way, we must not take for granted the manmade waterways that allow the Great Lakes region to continue contributing to the world's economy.

In the next edition, we'll explore some of the high-tech improvements and design modifications that are working to maximize the efficiency and effectiveness of ships using our locks and canals. ■