



**SAULT STE. MARIE,
ONTARIO**

**U.S.
HYDROELECTRIC
PLANT**

**SOO LOCKS
ADMINISTRATION
BUILDING**

**SABIN
LOCK**

**DAVIS
LOCK**

**POE
LOCK**

**MACARTHUR
LOCK**

**NORTH
CANAL**

**SOUTH
CANAL**

**INTERNATIONAL
BRIDGE**

**SAULT STE. MARIE,
MICHIGAN**

SOO LOCKS

Vital Infrastructure Demands Long-Term Planning, Consistent Maintenance

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The Soo Locks serve as a linchpin for maritime navigation in the heart of North America, connecting Duluth, MN, on western Lake Superior with other ports such as Chicago, Detroit, and Cleveland—and ultimately with the rest of the world through locks further east, the St. Lawrence Seaway, and the Atlantic Ocean.

The U.S. Army Corps of Engineers operates and maintains the Soo Locks, oversees dredging contracts to keep shipping channels open to large vessels, and conducts marine surveys in part to ensure these transportation arteries are free of obstructions.

Indeed, facilitating marine navigation is one of the Corps' most important missions. The Soo Locks at Sault Ste. Marie, MI, are a prime example of economically vital infrastructure that aids marine commerce. Massive freighters loaded with cargo such as iron ore, coal, or grain are efficiently raised or lowered using gravity flow by means of a lock, then continue on their way to faraway ports with minimal disruption.

Marine transport is more fuel efficient and emits lower emissions than transport by trucks or rail, according to studies by the U.S. Department of Transportation's Maritime Administration and the Minnesota Department of Transportation. For example, a Great Lakes carrier travels 607 miles on one gallon of fuel per ton of cargo, compared to a train traveling 202 miles per gallon per cargo ton and a truck 59 miles.

The Soo Locks sit on the U.S.–Canadian border about 300 miles north of Detroit. This impressive engineering feat bypasses the St. Marys Rapids and connects Lake Superior with the 63-mile-long St. Marys River and ultimately Lake Huron. The elevation drop through the locks is 21 feet. Two of the four Soo Locks are active—the Poe, built in 1968, and the MacArthur, built in 1943. The complex also includes hydropower plants that provide power for the locks and other Soo Area Office facilities, with surplus electricity being sold to a northern Michigan utility company.

Steel mills and power plants in the Midwest, as well as various European ports, are frequent destinations of freighters up to 1,000 feet long that load up with iron ore, lumber, and grain from the resource-rich areas of northern Minnesota, Wisconsin, and Michigan and coal transported by rail to Lake Superior from western states.

The Corps tallied 4,422 cargo carriers with 74.5 million tons of freight passing through the locks during the 2010 navigation season. The 2010 total for all vessels traversing the locks, including pleasure boats, fishing vessels, and other non-cargo vessels, was 10,015.

Corps economists estimate that an unscheduled 30-day lock closure would result in an economic impact to industry of \$160 million. Half of all steel produced in the United States is manufactured with domestically mined ore, and more than 90 percent of the iron ore mined in the United States travels through the Soo Locks, according to the Soo Locks Limited Reevaluation Report, completed in April 2002 to provide economic justification for construction of a new lock. Steel-dependent industries contribute 10 percent to the total U.S. Gross Domestic Product, according to the report, prepared by Michigan State University's Department of Resource Development. Besides iron ore, major commodities moving through the locks include coal, limestone, and grain, the last of which is often exported to other countries.

Stewardship of such vital infrastructure involves more than just maintenance and repairs to lock components.

Protecting the infrastructure from those who would deliberately harm it and cause an unforeseen locks closure also is a concern.

For example, a sudden halt to the transport of coal—often coming from Wyoming, Colorado, and Montana—to upper midwest power plants could lead to power outages; and domestic manufacturing could be compromised by an interruption of iron ore. In that light, security improvements are an ever-evolving requirement that must keep pace with the times and technology.

“Security enhancements are a continuous process,” said Greg Longoria, Chief, Security & Law Enforcement for the Corps’ Detroit District. “Aside from the obvious protection of the facility, it’s important to remember that equipment over time degrades. Ice, snow, and fluctuating temperatures all contribute to equipment degradation. As technology evolves, advancements and improvements of various types of equipment arise and this in turn helps to facilitate the overall security process with increased efficiency.”

Routine wear-and-tear necessitates maintenance to lock components, which also are susceptible to degradation due to harsh winter conditions present in a northern climate. Bitterly cold temperatures, heavy ice conditions, and freeze-thaw cycles take their toll on steel and concrete structures. Critical components exposed to the elements often are equipped with specialized steam and electric heating coils to ensure continuous operation during winter navigation periods. These heating systems add another level of complexity that is not present at many other locks and dams, said Kevin Sprague, Soo Area Engineer.

The Poe and MacArthur handle all the vessels passing through the Soo Locks annually. Only the Poe has the necessary dimensions to pass all Great Lakes vessels currently in operation (1,200 feet long, 110 feet wide, 32 feet deep). In the event the Poe is out of service, about 65 percent of the Great Lakes fleet carrying capacity would be unable to pass through the Soo Locks.

Discussions have been underway for decades about building greater redundancy into the system. The Water Resources Development Act of 2007 authorized construction of a new lock to replace the existing outdated Davis and Sabin locks, at a projected cost of \$580 million.

In 2009, ground was broken, and coffer dams were built on the upstream and downstream ends of the Sabin Lock. The full project is expected to take up to eight years once construction resumes; however, funding is not expected in the near future.

If construction began today, it would still be many years before a new lock was operational. Because the funding is not certain, the Detroit District is focusing on taking good care of existing infrastructure. The approximately \$100

million Soo Locks Asset Renewal Plan emphasizes modernizing the Poe and MacArthur locks; it also addresses needs at the power plants and surrounding infrastructure.

Asset Renewal Plan jobs that have been completed include:

- **REPLACING POE LOCK FULL-FLOW GATE LATCHES (\$500,000).** The original-equipment light-duty latches installed in 1968 were replaced with full-flow gate latches in 2009 that can function reliably in cold weather. Had they not been replaced, an uncontrolled flow in the lock chamber could have potentially torn the gates from their anchorages.
- **PURCHASING A SECOND SET OF STOP LOGS FOR THE POE LOCK AT A COST OF \$4.6 MILLION.** When repairs must be made inside the lock chamber, the metal, 110-foot “logs” are stacked to serve as a dam that keeps water out to make room for the workers to repair the chamber or gate. The additional set of stop logs also allows workers to isolate the downstream dewatering gates for repairs.
- **REPLACING OLD, CORRODED STEAM LINES FOR THE MACARTHUR AND POE LOCKS.** The MacArthur lines were installed in the World War II era, the Poe lines in the late 1960s. Corrosion and erosion within the lines led to unsafe “blowouts” in certain areas of the system, prompting excessive and costly emergency maintenance. This \$6.6 million job has resulted in increased reliability of wintertime lock operations while also ensuring a reliable supply of steam heat to maintenance workers in the cold winter months. “Without being able to heat the downstream miter gates with steam, we would not be able to swing the gates into the gate recesses,” Sprague said. This is because ice buildup on the gates would make them too large to close securely.
- **SANDBLASTING AND PAINTING GATE 6 OF THE POE LOCK AND REPLACING A FAILING COATING TO PREVENT CORROSION.** This job was recently completed at a cost of \$600,000. The Soo crew had previously learned a hard lesson when structural steel on gates 2 and 5 had corroded to a failed state due to an old and worn coating.

Jobs close to starting or already underway include:

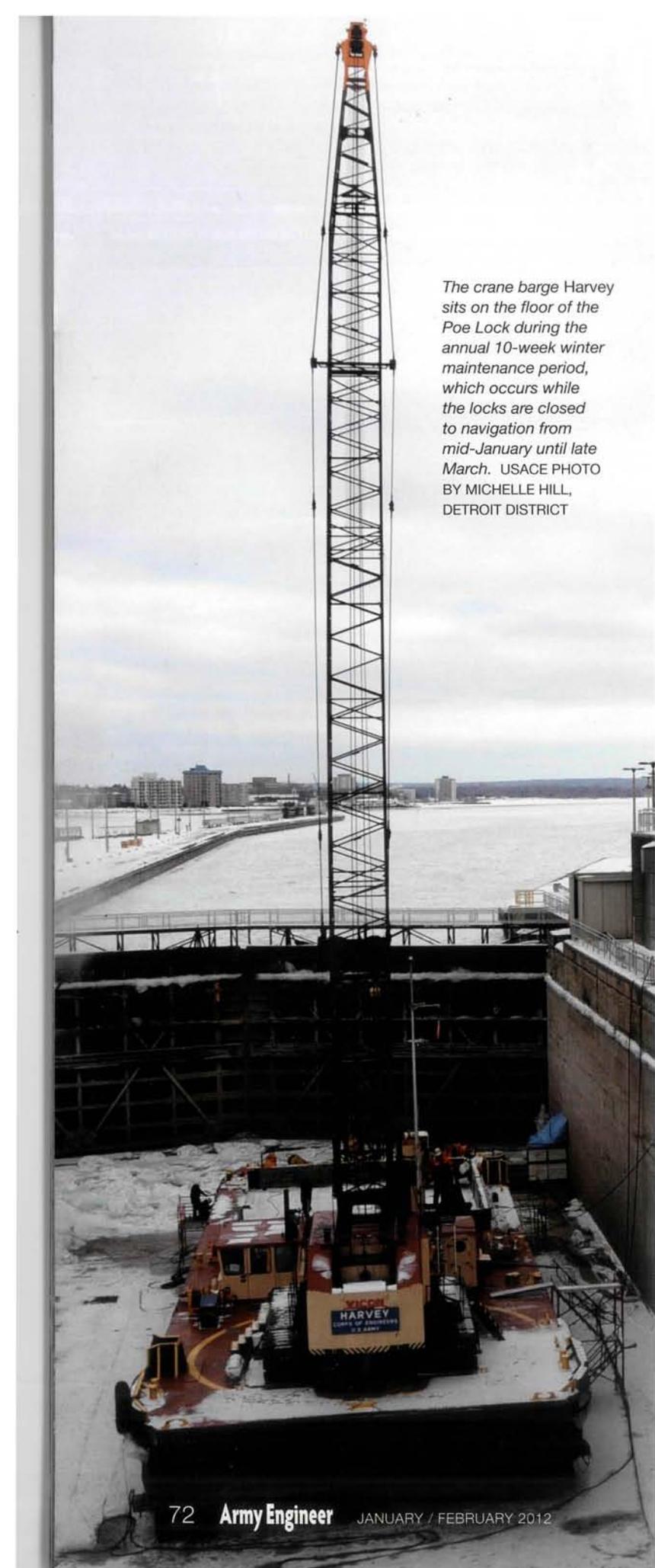
- **REPLACING THE POE LOCK’S MORE THAN 40-YEAR-OLD HYDRAULIC SYSTEM.** The job entails replacing 24 separate hydraulic power units with four, each equipped with a redundant pump and motor to reduce the likelihood of any service interruption. The hydraulic pumps operate gates, gate latches, and valves. Currently, many unscheduled lock outages are attributable to the

aged system's lack of redundancy and the difficulty in finding spare parts for obsolete technology. This job is underway and expected to be completed in 2013. Materials cost was \$3 million; system installation will be performed by Corps employees.

- **REPLACEMENT OF 10 GATE ANCHORAGES IN THE POE LOCK AND 12 IN THE MACARTHUR LOCK (\$2.8 MILLION).** The anchorages have shown signs of fatigue cracks that could lead to a catastrophic failure. To illustrate the possible serious consequences of not performing this repair, the Corps estimates a Poe anchorage assembly failure could lead to a 75-day unscheduled closure of the locks and an economic impact to industry of \$320 million.
- **CONSTRUCTION OF A CRIB DAM NEAR THE MAIN POWER PLANT (\$4.1 MILLION) TO REPLACE WHAT WAS SUPPOSED TO BE A TEMPORARY CRIB DAM CONSTRUCTED 60 YEARS AGO.** The old crib dam is made of a wood frame, which is subject to decay and is backfilled with stone. It separates the channel carrying water into the main power plant from the downstream tailrace of the old power plant.
- **REPLACING THE POE'S 1970S-ERA AIR COMPRESSORS WHICH KEEP ICE FROM FORMING AT THE LOCK GATES AND MOVE ICE FROM THE GATE AREA THROUGH THE USE OF AN AIR BUBBLER PIPING SYSTEM.** Parts are difficult to obtain for the European-manufactured compressors. The modernization is expected to cost roughly \$7 million. This project is partially funded and expected to begin in 2012.
- **DEVELOPING A PLAN TO UPGRADE THE MACARTHUR LOCK'S ENTIRE ELECTRICAL INFRASTRUCTURE AND CONTROLS, WITH WHICH OPERATORS CONTROL GATES, VALVES, AND WARNING LIGHTS, AT A COST OF \$5.5 MILLION.** The MacArthur Lock's electrical infrastructure problems have increased each year, and it is very difficult to find replacement parts. The design of the upgrade was completed in November 2011. The actual upgrade itself, which is expected to increase the lock's safety, reliability, and supportability, will be completed as funding allows.
- **REPAIRING AND SHORING UP THE WEST CENTER PIER IN THE APPROACH CHANNEL TO BOTH THE POE AND MACARTHUR LOCKS, A JOB THAT IS PARTIALLY COMPLETED.** Vessel operators frequently use this pier as a mooring area while they await their turn to pass through the locks, as well as a place to tie up when fog closes the river to navigation. Workers will fill cavities that have formed underneath the concrete cap, and line the pier face with steel sheet. Larger mooring bollards will replace the existing ones which do not meet current loading standards. The same type of work will eventually need to be done to the Southwest Pier.



A Soo Area Office inspection team checks out the Poe Lock lower gate to assess needed maintenance. USACE PHOTO BY MICHELLE HILL, DETROIT DISTRICT



The crane barge Harvey sits on the floor of the Poe Lock during the annual 10-week winter maintenance period, which occurs while the locks are closed to navigation from mid-January until late March. USACE PHOTO BY MICHELLE HILL, DETROIT DISTRICT

The Soo Asset Renewal Plan includes these additional projects: replacement of Poe Lock gate 1; sandblasting and applying new coating to gates 2, 3, and 4; and rehabilitating the electrical infrastructure, which dates to 1968.

A high-priority need that is not yet funded involves stabilizing the stone walls in the Rock Cut Channel of the St. Marys River. The channel was created in 1908 by the quarrying of bedrock to sufficiently deepen and widen the channel for the river's downbound vessels. (The channel was subsequently deepened in 1931 and 1960.) The quarried stone was stacked on either side of the channel and after 40 years has become unstable, with stones up to 10 tons in size falling into the channel. If stabilization is not performed, the channel could be taken out of service. This would force downbound vessels to use a channel currently used only by upbound vessels, resulting in delays and increased costs. The project is expected to cost at least \$10 million, but the cost could be much higher when the final design is determined.

Other needed improvements include installing new pier lighting, replacing MacArthur Lock bevel gears, and replacing high-voltage power cables currently suspended beneath a footbridge and susceptible to degradation from the elements with new underground cables.

The amount of work to be done is considerable; the trials of Mother Nature make the tasks even more daunting. Additionally, much of the work must be done during the 10-week closure of the locks, from mid-January until late March, when Northern Michigan's blustery, bitterly cold weather and short daylight hours present challenges.

Sprague said the worst winter he has seen was 1994-95. "It was 20 below zero on Christmas Eve and it never got above zero degrees during the day for six weeks."

The 70 Soo Area Office workers that are typically involved in winter maintenance work know how to dress properly and keep an eye out for trouble. "They all check each other," Sprague said.

Workers construct a large fabric structure that is rolled across the lock chamber on steel bridges that are placed after the last ship transits the lock for the season. Scaffolding is erected near work areas, with the top and sides enclosed, and steam heat is pumped in. This enables workers to perform jobs like placing concrete, painting, or welding that cannot be done in bitterly cold temperatures.

The shifts usually last 10 hours, and most work is done by Corps employees, although a few jobs are contracted out. Sandblasting and painting are among the labor-intensive jobs that require round-the-clock work, Sprague said.

Some of the equipment and components needed for Soo infrastructure, such as air compressors and bevel gears,

A diver prepares to descend into the Poe Lock to seal leaks in the stop logs, timbers that serve as buffers inside the lock gates for tight-fitting vessels. USACE PHOTO BY MICHELLE HILL, DETROIT DISTRICT

cannot be ordered quickly. There can be a six-month to one-year lead time, which further underscores the importance of careful planning.

“The Soo Locks are a high priority for the Corps of Engineers,” said LTC Mike Derosier, Detroit District Engineer. “The Poe Lock alone has the highest economic consequence for an unscheduled outage of any lock in the Corps. It is imperative that we continue to invest in this critical piece of navigation infrastructure.”

Detroit and the other Corps districts on the Great Lakes—Chicago and Buffalo—are among seven districts in the sprawling Great Lakes and Ohio River Division (LRD) based in Cincinnati. LRD stretches from western Lake Superior as far south as northern Alabama and northwest Georgia, and eastward to southern Lake Ontario in New York State. The division directs federal water resource development in the Great Lakes and Ohio River basins with infrastructure valued at more than \$80 billion.

The Detroit District and LRD, like the entire Corps of Engineers, help energize a huge economy in a vast nation. Budgetary, economic, and climate uncertainties are among many variables that force planners and engineers to stay focused, be flexible, and devise timely, sound solutions. The critical nature of the Soo Locks and Great Lakes Navigation System demands nothing less. **AE**



A Corps of Engineers laborer prepares timbers for installation inside a lock gate. The timbers serve as fenders, preventing hull damage as vessels glide into the locks or are tied up to piers waiting to enter the locks. USACE PHOTO BY MICHELLE HILL, DETROIT DISTRICT

