Sault Ste. Marie
A Project Report
# Table of Contents

**Tables**

4

**Preface**

5

**Foreword**

7

**Documentation**

9

- Introduction
- False Starts: Water Power at the Soo Until 1894
- New Hopes: Clergue Comes to the Soo, 1894–1896
- Vacillation and Delay: Planning the Hydroelectric Plant, 1896–1898
- Decision: Finishing the Design, 1898–1900
- Construction: Building the Hydro, 1898–1902
- Problems: The Hydroelectric Plant in the Lean Years, 1903–1913
- Solutions: The Repair and Expansion of the Soo Hydro, 1913–1926
- Epilogue: Sault Ste. Marie and the Hydroelectric Plant

**Additional Use of the Powerhouse**

95

- Market Analysis
- Historical Interpretation
- Recommendations
- Architectural Treatment

**Notes**

103

**Bibliography**

125
Tables


III. The Power Canal of the Michigan Lake Superior Power Company

IV. The Sault Ste. Marie Hydroelectric Plant and Other Medium to Large Hydroelectric Plants, c. 1903

V. Primary Contractors Involved in the Construction of the Michigan Lake Superior Power Company Hydroelectric Plant

VI. Expansion of Clergue's Industrial Empire, 1895–1898

VII. The Consolidated Lake Superior Company in 1903

VIII. Leaks and Shutdowns for Leak Repair at the Sault Ste. Marie Hydroelectric Plant

IX. The Turbine Installation at Sault Ste. Marie, 1902 to Present

X. The Generator Installation at Sault Ste. Marie, 1903 to Present

XI. Average Annual Output in Horsepower and Kilowatt Hours of the Michigan Lake Superior Power Company Hydroelectric Plant (after 1913 the Michigan Northern Power Company Hydroelectric Plant), from 1903 through 1935
Preface

In 1977 the Historic American Engineering Record (HAER) of the National Park Service completed an inventory of industrial and engineering sites in Michigan's Upper Peninsula. Included in the inventory was this turn-of-the-century powerhouse and canal at Sault Ste. Marie.

Charles K. Hyde, the inventory director, was impressed by the historic significance and excellent condition of both the power canal and the hydroelectric plant. Following his recommendation, HAER fielded a summer project at Sault Ste. Marie in 1978. The purpose of the project was two-fold: to thoroughly document the powerhouse's history and to provide a plan for making greater use of the structure, large parts of which had been empty since 1963. HAER did not conduct the project alone. Cosponsors, who provided funding and/or valuable support services, included the Michigan History Division, Michigan Department of State; the Institute of Electrical and Electronics Engineers; the Chippewa County Historical Society; the Edison Sault Electric Company; Lake Superior State College; and the City of Sault Ste. Marie.

T. Allan Comp and Larry Lankton of HAER organized and supervised the summer project. Terry S. Reynolds, Associate Professor at the University of Wisconsin-Madison, served as Supervisory Historian on the resident team; Ronald Wilson assisted as historian; and Charles Poor and Kenneth Savoie were the architectural technicians. John Reinhardt and David Fantaci began the planning study, which was completed in HAER's Washington office by James Vaseff and Charles Leach. HAER photographer Jet Lowe completed photographic documentation on the existing structure and also worked from glass plate negatives to produce superb historic views. A selection of these present and historic photographs are used in this volume, designed by Isabel Hill with the assistance of Jean Yearby.
Foreword

History often repeats itself, according to popular belief, and one aspect of history increasingly proves that saying—the use and economic viability of historic buildings. More and more historically significant but underused or unused buildings are being adapted for uses unrelated to design and thus begin another cycle of being fully used and economically viable. Called adaptive use, it is one of the primary goals and achievements of historic preservation.

The history of the Michigan Lake Superior Power Plant presents a scheme for combining a mammoth electric power plant with an industrial process, to make calcium carbide, within a single building.

When the power plant was built, it was hoped to be the salvation of Sault Ste. Marie, but it was never as successful as hoped. The plant did house for years the carbide manufacturing operation, together with the large power generating capability. Today, however, most of the building sits vacant, although the powerhouse continues to produce enormous amounts of electricity for the Upper Peninsula.

The historical significance of the power plant is firmly established by this comprehensive historical report; however, the Historic American Engineering Record wishes to go beyond its normal documentation efforts, (of preparing historical reports, measured drawings, and large format photographs) and to set the stage for another era of the building's full use. Because of the building's magnitude, its reuse could substantially revitalize Sault Ste. Marie's economy, which has been hard hit in recent years with the departure of several large employers.

Thus, this volume includes not only the history of the Michigan Lake Superior Power Plant, but also a pre-feasibility study for rehabilitating and reusing the power plant. Although the historical documentation of the structure is quite comprehensive, no attempt has been made to present a comprehensive analysis of alternatives for reuse. Rather, it is our hope that the study will serve as a catalyst to convince Sault Ste. Marie and other communities of the validity of including historic preservation goals in community planning and revitalization, and to present possibilities to the building owners, or possible developers, that might ultimately lead to its full use.

Douglas L. Griffin
Present view of powerhouse.
Documentation

Introduction

Somewhat less than a mile below the Soo Locks in Sault Ste. Marie, Michigan, stands the powerhouse of one of the world’s pioneer large-scale hydroelectric plants. Although erected between 1898 and 1902, it still is the longest horizontal-shaft hydroelectric powerhouse in the world. Once it held even more distinctions. On completion it was the world’s largest hydroelectric installation in terms of the volume of water it was designed to utilize (30,000 cubic feet per second, or “second feet”). Its intended output (40,000 hp) would have made it the world’s most powerful low-head hydroelectric facility and placed it second only to Niagara Falls #1 among all hydroelectric plants. Moreover, the powerhouse at the Sault (or Soo) was intended to house an unprecedented number of turbine units (80) and to use an equally unprecedented number of turbine runners (320).

There were other things about the Sault hydro that made it an impressive engineering work. The “mill pond” or reservoir of the powerhouse was Lake Superior. To control and regulate its levels the power company was compelled to install works that could, almost literally, control the flow of water from Lake Superior like a faucet. The powerhouse itself combined the functions of dam, powerhouse, and factory in an unusual design. Above the combination penstock-generator floor, which also contained the “dam” (a series of steel-plate bulkheads), was a second floor, intended to house power customers. This factory floor was over a quarter of a mile long, and above it was a supplementary third floor an eighth of a mile long.

If the unusual size of the Sault Ste. Marie plant and its unusual design features were insufficient to bring the installation national attention, the caliber of the consulting engineers engaged by the power company for the project should have. As Table I indicates, some of the most prominent names in American civil engineering at the turn of the century, including two presidents, five vice presidents, and two secretaries of the American Society of Civil Engineers, were involved in the facility’s design, construction, and repair.

Why, then, has the hydroelectric plant at Sault Ste. Marie been almost forgotten? The primary reason seems to be that the Soo plant, despite its magnitude and the unique design problems it involved, was both an engineering and a financial failure for the first 10 years of its existence. Financially, the plant failed to produce sufficient revenue to cover the interest on the bonds used to finance its construction and quickly went into receivership. Technically, there were serious defects in the foundations of the powerhouse, which prevented the plant from operating at design capacity for more than a decade. The desire of engineers to avoid association with a technical failure and the desire of the owners and investors to avoid bad publicity seem to have combined to relegate the Sault Ste. Marie hydroelectric plant to obscurity.

In addition, the hydroelectric plant did not have the economic benefits expected by its advocates. “Soo” area businessmen had believed for years that if the water power of the region were developed, cheap power would attract a diversified industrial base and transform Sault Ste. Marie into a metropolis rivaling Minneapolis, Detroit, or Chicago. Instead, the hydroelectric plant attracted only a single industry whose effects on the Soo were not all beneficial. Far from rivaling Minneapolis, Chicago, or Detroit, Sault Ste. Marie remained (and remains) a small city with a very limited economic base.

Yet, despite its early problems and the limited benefits it brought, the Sault hydroelectric plant was an engineering achievement of considerable magnitude. Many of the hydroelectric plants constructed in the last decade of the 19th century and the first two decades of the 20th have long since become hopelessly obsolete and have been demolished. The Soo hydro, with its very impressive array of turbines and generators, continues to produce electric power. Today it still supplies around 60% of the electric needs of the eastern third of Michigan’s Upper Peninsula.

False Starts: Water Power at the Soo Until 1894

The sole outlet for Lake Superior, the largest and most northern of the Great Lakes, is the St. Marys River. This wide, 60-mile-long stream links Superior to Lake Huron and separates the Upper Peninsula of Michigan from the province of Ontario. In its course from Superior to Huron the St. Marys descends around 23 feet. Almost 20 feet of this fall is concentrated at a single point—the Rapids of St. Marys at Sault Ste. Marie.

Recognizing the strategic importance of the St. Marys River and its rapids as a means of controlling traffic to and from the Lake Superior basin, the French early established an outpost in the area. In 1668 Father Marquette founded a small Catholic mission on the site of Sault Ste. Marie, Michigan, and the French later erected a fort. But beyond giving the site a name (Sault Ste. Marie, which means Falls of St. Mary), the French occupation (and the British occupation that followed) left little of a permanent nature. When the American government, after some decades of neglect, first established its presence in the region in 1822, the village of Sault Ste. Marie consisted of 15
to 20 buildings occupied by the descendants of the original French settlers, all of whom drew their living from the fur trade.

The village grew very slowly until the discovery of iron ore and copper in the central and western portions of the Upper Peninsula of Michigan around 1830. This increased shipping on the St. Marys and slowly the town's major source of income shifted from fur trading to the movement and accommodation of the people and goods forced to portage around the unnavigable waters of the rapids.1

By 1837 lake traffic was sufficiently heavy for the state of Michigan to contemplate the construction of a ship canal and lock at the Sault. The projected route of the canal, however, crossed a small millrace, which served a sawmill at Fort Brady, the local army post, and the Acting Quartermaster General ordered the fort's commander to prevent destruction of the race. This incident not only prevented the state from beginning work on a canal but foreshadowed later conflicts between navigation and power interests at the rapids.

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Sault Ste. Marie at first profited little from these actions. The income that had been garnered from portaging ships, cargoes, and passengers vanished. The traffic passing through the locks and up or down the St. Marys increased, but since it was no longer compelled to stop for any appreciable period at the Sault, the city had to eke out its livelihood as best it could on what river trade it could attract.

Early Power Plans
While a hindrance to navigation, the rapids at Sault Ste. Marie were a potential boon to industry as a source of power. Since navigation and river commerce had failed to bring much prosperity to Sault Ste. Marie, some of the city's businessmen began to look to industrial development, based on water power, as the key to the city's future. As early as the 1840s some local entrepreneurs had begun to argue that while the "Soo" was not particularly rich in minerals, its rapids, if harnessed, could be used to process the raw materials of the mining districts to the west.

In 1844 two different groups attempted to implement plans for tapping the water power of the St. Marys. Several local businessmen purchased islands in the rapids with the intention of erecting water-powered stamp mills and furnaces. At almost the same time another local merchant, Samuel Whitney, purchased properties for a power canal, which would conduct water 3 miles around the rapids. But capital to back these ventures was apparently lacking, and both quickly died. A village on the fringes of civilization, far from markets, and with a total population of around 500 was unlikely to attract investment capital, especially since, in 1844, the ship canal had not yet been built, nor the St.

Marys deepened to allow free passage of large vessels.

Plans for developing water power at the Sault did not re-emerge for more than three decades. During this period, and especially after the opening of the ship canal and lock in 1855, Sault Ste. Marie grew slowly. By the 1870s vessels passing through the Soo were carrying not only the iron and copper of the Upper Peninsula and Minnesota, but lumber, pulp logs, and grain. Sault Ste. Marie, however, remained a city largely dependent on river traffic for income—a city without a permanent, diversified, industrial base. This situation was regarded with increasing dismay by local merchants and entrepreneurs, who continued to believe that the variety of raw materials passing by on the St. Marys could be processed just as easily at the Sault as further to the east or south.

The St. Marys Falls Water Power Company
H. W. Seymour, a Soo businessman active in Upper Peninsula lumbering operations, was chiefly responsible for reviving, around 1880, plans for developing the Sault's water power. Recognizing that sufficient capital could not be raised locally, Seymour interested a group of Detroit investors, and together they purchased the old Whitney properties. They then hired a Detroit engineer, Colonel Duffield, to make surveys, plans, and estimates for a 3 mile long water power canal. The group also secured authorization for the project from the Michigan legislature in 1883. Act 39 of that year authorized diversion of water from the St. Marys subject to the consent of the Chippewa County Board of Supervisors. Due to insufficient capital, however, Seymour's project also died.

In 1885 a group of local citizens, including Seymour and entrepreneur William Chandler, tried again. They organized the St. Marys Falls Water Power Company in hopes of attracting an industrial base for the Sault by tapping the power of the falls. The authorized capital stock of the new company was $1 million, but they began operations with only $10,000 subscribed. These funds and $50,000 more were quickly exhausted as the company began to purchase land for a 50-foot-wide canal along the route contemplated by Whitney in 1844 and by Seymour and his associates a few years earlier.7

When local funds were exhausted the company asked William Chandler to find outside investors. He interested a group of LaCoste, Wisconsin, businessmen (primarily grain dealers and processors). This group, called the LaCoste syndicate in Sault Ste. Marie, reached an agreement with local interests and assumed control in May 1887. They purchased all properties and rights from the original owners at cost and agreed to spend $50,000 within 12 months and $100,000 within 18 months on canal construction or forfeit the majority of the company's stock to the former owners. The LaCoste group then hired Edward Ruger of Iowa to begin engineering studies and commenced the purchase of property sufficient for a 100-foot-wide canal. They also began buying real estate all over the city and in suburban areas on the presumption that its value would increase when the canal was completed.9

Land speculation was further encouraged by other developments. In 1887 three railroads were approaching Sault Ste. Marie and the International Railroad Bridge linking the town with the Canadian Pacific Railroad across the river was completed. Rising land prices and the preliminary work being carried out by Ruger and his staff created a mood of optimism. Residents grew confident that the com-
bination of the city's location on Great Lakes' transportation routes, the new railroads, and the development of economical water power would, in the near future, create a city comparable to Minneapolis or Chicago. The power company's 1888 prospectus did little to discourage this optimism. It announced plans to begin sale of power in late 1888 or early 1889 and added that a significant portion of the development's planned output had already been applied for by a number of industrial concerns.

The LaCrosse syndicate planned to construct a canal following approximately the old Whitney route. That is, the intake could be located just upstream from the ship canal, and the canal's terminus would be at the Little Rapids, about 2 miles below the main rapids. The canal was to be 100 feet wide by 15 feet deep, carrying sufficient water to develop 18,000 horsepower (hp). At the terminus of the canal would be a maze of head and tailraces. Adjacent to these would be 200 mill sites, each to be served by rail and leased with the power as a single unit. The arrangement of the mill sites on lateral canals was necessary since it was anticipated that all power would be developed and transmitted by traditional direct mechanical means. The whole development was similar in concept to the great Eastern water power centers at Lowell and Lawrence, Massachusetts.

The ambitious project quickly encountered snags. Ruger, after preliminary surveys along the power canal route, found that construction costs would exceed the original $500,000 estimate. Moreover, even though the LaCrosse syndicate had invested almost half a million dollars in the project, they had spent most of the money purchasing real estate for speculative purposes. Construction had not begun but capital was already running low.

Fearing loss of the franchise for lack of construction progress, yet unwilling to put more of their money into the project without some guaranties of success, the LaCrosse group sought modifications in the terms of their original agreement. After long negotiations with the city they agreed to raise an additional $100,000 to be deposited locally, provided the city of Sault Ste. Marie would arrange for the sale of stock to raise a matching amount. Local merchants, seeing the power canal as their one good hope for economic growth, subscribed the city's share of stock by August 1888. Construction began on a full scale that fall, after the city had granted the company a new franchise, which required completion by May of 1890.

By December of 1888, when construction ceased for the winter, work had been initiated along the entire length of the projected canal. Other matters also looked bright. Several industries showed an interest in leasing power. Thus the syndicate in the winter of 1888–1889 decided to widen the canal to 300 feet.

This was an unfortunate decision, for technical problems alone had already escalated construction costs for the smaller canal beyond the means of the company. Ruger had hoped to construct the canal banks with a 1-in-2 slope, assuming that this slope would have been enough natural resistance to sliding and collapse to eliminate the need for specific retaining structures. The hope had proven false. Muck formations and loose soil along much of the projected canal route compelled Ruger to use retaining cribs, timber piles, and, in some places, a timber plank lining to prevent bank collapse and bank and bottom erosion. The increased costs of canal construction occasioned by this problem, coupled with the decision to enlarge the canal, led first to a request (granted by the city) for an extension of the May 1890 time limit set for
the completion of construction, and then to an increasingly desperate search for new investment capital. By September of 1889 the $200,000 raised to finance construction was gone and work stopped. The franchise granted by the city lapsed. Attempts by representatives of the company between 1889 and 1895 to find additional capital failed, partially as a result of the city’s insistence on a large canal (50 feet or wider) and on maintaining some control over decisions respecting the canal. What little hope remained for attracting outside capital disappeared when the depression of 1893 sharply restricted the money supply all over the nation. In 1893, also, the St. Marys Falls Water Power Company defaulted in the payment of the interest on bonds it had issued in 1888, and the three local banks that had provided a trust mortgage to the company foreclosed. Ownership of the canal company’s assets passed to them. The city of Sault Ste. Marie not only of the canal company’s assets passed to

New Hopes: Clergue Comes to the Soo, 1894–1896

Across the St. Marys River in Canada, Sault Ste. Marie’s sister city, Sault Ste. Marie, Ontario, was encountering similar difficulties. In 1877 property adjacent to the rapids there had been secured by two men for the construction of water-powered mills, but lack of capital prevented implementation of plans. This property had been purchased in 1887 by the Ontario Sault Ste. Marie Water, Light and Power Company. It began construction of a power canal in 1889, after obtaining water rights from the Ontario legislative assembly. But this group also ran short of funds. Like the LaCrosse Syndicate on the US side of the river, they appealed to local investors. Hoping to attract an industrial base, Sault Ste. Marie, Ontario, like its American sister, responded. The city invested around a quarter of a million dollars in the project. The canal was completed, but, due to economies taken during construction, the canal walls gave way during the winter of 1894. Sault Ste. Marie, Ontario, was left with an abandoned canal and $263,000 of bonded indebtedness. The failure of water power development companies on both sides of the St. Marys in the early 1890s, followed by the onset of the prolonged depression, which began in 1893, dimmed hopes on both sides of the border.

These hopes were revived, however, in the mid-1890s. Francis H. Clergue, an American entrepreneur, discovered the abandoned canals while passing through the region in 1894 and persuaded a group of American financiers to purchase the abandoned rights-of-way and develop them, creating, in the process, an industrial empire.

Clergue was born and raised in Brewer, Maine. He briefly studied law, but early in his career abandoned the legal profession for the life of an entrepreneur. His early undertakings included an electric light and power station on the Penobscot River, an enlargement of the waterworks of Bangor, Maine, and an electric street railway in the same city. He followed these undertakings with an extensive resort complex at Green Mountain, which included two hotels, a mountain railway, and a steamship line to carry customers to and from the resort. This venture was followed by promotions of a new pulp mill, a banking firm, a company producing fog horns, and options on an iron mine in Nova Scotia. Few of these projects were successful. Most cost Clergue and his backers severely. But, undaunted, Clergue continued his orgy of projects. He was next associated with investments in shipyards, dry docks, and a bank. These also failed. He then traveled to Persia and to Bulgaria on behalf of investors interested in petroleum or railroads. The Persian mission failed (despite lucrative concessions from the Shah) to attract investment capital, but the commission he received from the successful conclusion of negotiations aimed at refinancing the Bulgarian railroads with English capital revived his by then badly depleted financial reserves. He returned to Maine and organized a number of mining ventures, but all were financial failures.

This long series of defeats did not daunt Clergue, for he enjoyed development for its own sake and was incurably optimistic. Nor did it affect his willingness to tackle problems requiring some technical expertise. According to Clergue’s biographer, Alan Sullivan: “He was not a qualified engineer, though he could discourse at length on engineering possibilities; thus he had, in a sense, the courage of ignorance, a strange term to apply to one of his calibre, but this very ignorance nerved him to attempt that which a purely technical man would have hesitated, while his persuasive qualities drew others to follow his ventures.”

In 1894, at the age of 38, Clergue left Maine. His optimism and persuasive qualities had finally been overcome there by his failures, and he had begun to encounter difficulty in attracting capital for his ventures. But his optimistic and confident manner found a receptive ear when he traveled to Philadelphia. There a group of capitalists, either untouched by or largely unfamiliar with his past, employed him to travel to Fort William, Ontario, on Lake Superior, to investigate a potential water
power investment.

On passing through Sault Ste. Marie, Ontario, on the way to Fort William, Clergue was drawn to the rapids. On his way down to the river front he discovered the abandoned canal whose walls had collapsed in 1894. On inquiry he decided there was no reason for him to travel further. The entire outflow of Lake Superior ran past this site; the work was already partially done; and the property owners (the city) were anxious to eradicate their debt and attract industry to the area. Before leaving Ontario, Clergue concluded an agreement with the city. His backers would assume the city's bonded indebtedness in return for all properties and rights relating to the abandoned power canal. He returned to Philadelphia, sold the idea to his backers, and returned before winter as vice president and general manager of the newly incorporated Lake Superior Power Company (LSPC). Within a year he had settled into the remains of a stone powder magazine of the old North-west Fur Company outpost situated on canal property, added an overhanging second story to transform it into a frontier blockhouse, and acquired a pet bear, usually chained in front of his living quarters.4

Clergue was almost pathologically unable to restrict himself to a single project, so it is not at all surprising that he quickly discovered the abandoned power canal on the Michigan side of the border and became interested in it as well. In early February 1895 Clergue had the visiting president of the company, Edward V. Douglas, and the company's two consulting engineers, Bollar and Bogart, inspect not only the newly-purchased Ontario properties, but also the partially completed canal across the river in Michigan.

Bollar and Bogart were well equipped to evaluate the potential of the site from an engineering point of view. Alfred P. Boller (1840–1912), the chief consultant used by Clergue and Douglas for a number of years, had been in private practice since 1874. Widely recognized as one of the foremost American experts in the area of structures and foundations, he had designed a number of important bridges and constructed the foundations for the Statue of Liberty. His associate, John Bogart (1836–1920), had been involved for decades in the construction of bridges, tunnels, and canals in New York. During the 1890s he was in touch with most of the pioneer hydroelectric projects and had spent time in Europe studying hydroelectric developments.5

No offers were immediately tendered, but Clergue and his associates were impressed with the possibilities.6 In May 1895 Clergue, in the name of the Lake Superior Power Company, offered to buy the properties and rights of the Michigan canal from the local banks that held the majority of the property's bonds, provided sufficient additional properties could be secured on reasonable terms to give a 400 foot right-of-way and the necessary city ordinances were passed.7

Clergue's offer revived hopes on the Michigan side that Sault Ste. Marie might yet become a great manufacturing city. Pressure was put on property owners and city officials to make it as easy as possible for Lake Superior Power to secure the necessary properties and rights, especially since the size of the development Clergue seemed to be contemplating was much larger than anything previously considered.8

Meanwhile, Clergue and the Lake Superior Power Company had already begun extensive work on the Canadian side of the river and by 1896 had a hydroelectric plant operating there. Contrary to initial expectations, however, applications for power did not pour into company headquarters.9 This may have been a major disappointment to many investors, but it provided an excuse for a compulsive entrepreneur like Clergue. He broadened the scope of his operations, creating new companies to serve as customers for his hydroelectric plant. He first organized a local water and light company. Then he persuaded company directors to build a pulp mill (the Sault Ste. Marie Pulp and Paper Company) adjacent to the Canadian power canal to tap the timber resources of the Algoma region of Ontario and to organize a dry dock company to serve Great Lakes shipping. When commercial rivals lowered the price of pulp, Clergue designed a machine to extract water from liquid pulp in order to save freight charges, built a machine shop, and a dry pulp mill. Then, needing sulphur for the dry pulp process, Clergue acquired for his company several nickel mines at Sudbury, Ontario, since sulphur was a by-product of nickel smelting.

To control the local utility, the dry pulp mill, and the Canadian hydroelectric plant, as well as the projected Michigan hydroelectric project and his other schemes, Clergue and his backers in January 1897 formed the American Lake Superior Power Company and incorporated it under Connecticut laws. Then Clergue saw another opportunity. A large deposit of iron ore was discovered 150 miles to the north. Clergue bought the claim and began mining iron ore. Developing this resource required additional capital. Thus in June 1898, to attract new capital, the American Lake Superior Power Company was reorganized as the Consolidated Lake Superior Company and chartered under the laws of the Province of Ontario. Capitalized at $20 million, sale of stock in the new company went well and allowed Clergue to further expand his base. He created a railroad to bring iron ore (and tim-
ber) to the Soo; a steel company to transform the iron into a usable product, and a shipping company to transport the product to industrial centers further east.

Clergue’s promotional efforts brought into this growing industrial empire a large number of prominent Eastern businessmen. Some came in spite of their usually better judgment. For example, John Terry of the conservative New York firm of Sloan-Taylor-Terry-Sage later related that he had frequently listened to and turned down schemes as visionary as Clergue’s, but that he had been “so convinced by the force of this man’s magnetism” that he had immediately become “enthusiastic and interested in the enterprise.”

The opening phases of Clergue’s empire building on the Canadian side of the frontier made the delays caused by property negotiations irritating to canal supporters on the Michigan side. But, despite the failure of the committee in charge of securing property options to persuade the owners of certain properties to accept terms, in August of 1895 the Lake Superior Power Company purchase title to the abandoned canal at the bargain price of $68,370.62, the amount of the defunct St. Marys Falls Company’s debt to the bondholders who had foreclosed in 1893. According to the terms of the agreement, new construction was to begin within three months, completion was to be within three years, and the canal was to be at least 60 feet wide by 15 feet deep.

Thus by the end of 1895 the Lake Superior Power Company had possession of a right-of-way 3 miles long, from 150 to 400 feet wide, with 100 acres for mill sites fronting the St. Marys at the Little Rapids. Negotiations for sufficient property for a 400-foot right-of-way along the entire canal route continued through the summer of 1896 but without success, resulting in the decision to reduce the width to 250 feet and make the canal deeper.

Also delaying matters were negotiations between the power company and the city. After the St. Marys Company had failed, the city had reasserted its right to control certain aspects of canal design since the power canal would affect the physical features and functioning of the city. City officials were particularly worried about terms of taxation, property damage during construction, water and sewer lines, and transportation over the canal. But public pressure forced the city council to temper many of the contemplated restrictions and grant a franchise for the operation of the power canal largely on the terms desired by Clergue and his associates in late 1896, though the city did insist that canal construction begin within six months and be completed by July 21, 1898.

**Vacillation and Delay: Planning the Hydroelectric Plant, 1896–1898**

**Early Planning**

In August of 1896, when it appeared certain the city would pass the needed ordinances and that sufficient property could be purchased for a large-scale development, the Lake Superior Power Company transferred a portion of its engineering force from the Ontario to the Michigan side of the St. Marys to assist Hans von Schon, who Clergue had appointed as chief engineer of the new project. This group immediately began abstracting descriptions of the properties, which had been acquired through the purchase of the assets of the St. Marys Falls Water Power Company.

Hans von Schon (1851–1931) was seemingly well qualified for his position. A German immigrant, he had both military and engineering experience. Enrolled by his parents in Prussian military schools from the age of 10, he had first followed a military career. He graduated in 1869 from the Royal Prussian Military Academy in Berlin and during the Franco-Prussian War of 1870–1871 served as a second lieutenant, winning the Iron Cross. Late in 1871, however, he resigned his commission and emigrated to the United States, apparently due to the inability to support himself in the style expected of a German officer and gentleman. But von Schon never lost the military bearing and military views of discipline and method acquired in his youth. A close friend later called him a “soldierly man, firmly planted on his feet, with a voice to be heard above the din of battle.”

His administrative style was described as “Bismarckian, dominant, efficient, and methodical.” And others noted that he had certain “German peculiarities” (i.e. militarism) and could not be trusted with delicate negotiations since he was too blunt and open.

Von Schon’s early years in the United States, perhaps because of these personality traits, were difficult. At times he was forced to support himself by hunting ducks. By the late 1870s, however, he had adjusted and had begun to find regular employment in a variety of technical enterprises. Several of his early engagements were on mining projects in Utah and California. In 1888 he became principal assistant to the chief engineer of coal surveys and operations in Raleigh County, West Virginia, and in April 1889 principal assistant to Lancaster Brothers, Engineers and Contractors, a Southern firm. For them he plotted land subdivisions and town sites, and designed and constructed iron furnaces. In 1890 von Schon set up his own engineering office in Virginia, and for the next few years practiced in the mid-Atlantic states, designing and constructing water power plants, electric street.
railways, and municipal works, acquiring, in the process, experience and skills in a wide variety of areas.

In May of 1893 von Schon had joined the US Army Corps of Engineers. Commissioned as an Assistant Engineer, he was detailed to the Lakes Survey at Detroit, and in July took charge of a topographical survey of the St. Marys River. This brought him to the "Soo" and, apparently, to the notice of Clergue. While engaged in the closing phases of the river survey in 1896 von Schon was contacted by Clerque and persuaded to take charge of the large project he was contemplating for the American side of the St. Marys. Von Schon brought to the job the broad engineering background required for a major hydroelectric project, for his earlier career had provided him with experience in excavation techniques, surveying, hydraulic work, and electrical installation, as well as structural and mechanical design. His military background may also have been considered relevant, for the project would involve the management of several thousand laborers.

Through late 1896 von Schon and his assistant engineers surveyed and staked off the company's properties, took soundings near the intended canal intake, made sample borings along the projected canal route, and made preliminary studies of forebay and turbine designs. While able to review options for such things as turbine plant, forebay location, canal prisms, and so on, von Schon was unable during this period to make permanent, specific design decisions. This was in part because disputes between the Lake Superior Company management and property owners in Sault Ste. Marie over land costs along the projected canal route continued during this period. Unable to convince certain property owners to sell their land for what they believed was a reasonable price, company officials vacillated over just how large they were going to make the Sault hydroplant. At one time or another canals of 150-, 200-, 250-, 300-, 350-, and 400-foot widths were contemplated. Also contributing to von Schon's problems was uncertainty over the nature of the customers the hydroelectric plant would serve. Frustrated by the continuing indecision, in November of 1896, von Schon finally wrote to Boller, the company's general consultant, complaining that he and his staff had "done considerable work which has been entirely superseded by changes in projects due to alterations in general scope and other considerations . . ." 7

The power development that Clergue and his associates were contemplating was significantly different in a number of respects from the older plans of Whitney and the St. Marys Falls Company. The emergence of electrical power transmission between 1890 and 1895 had eliminated the need for locating power users adjacent to the power source and made it possible to develop power at one central powerhouse and distribute it to scattered factory sites. So while the route of the Clergue power canal was to follow the route of the old power canal (Ashmun Bay to Little Rapids) along the abandoned right-of-way, there was to be no mass of mill sites and millraces at Little Rapids. At this point, however, neither was there to be the one central powerhouse that electric power generation made possible. The plan initially contemplated by Clergue and his associates has a hybrid plan. There would be neither 200 power producers, nor one, but 6 or 7. Lateral canals branching from the main or trunk canal would run to the river at intervals of a quarter to a third of a mile, beginning at a point around three-quarters of a mile below the government ship lock. Each of these powerhouses would develop approximately 10,000 hp (probably hydraulic).8 Al-
though it is not completely clear, the company seems to have intended to lease entire powerhouses to large power consumers. Smaller power users would lease the right to install their generators and switchboard equipment adjacent to one or more of the turbines at the remaining company-supervised powerhouses.

What made the multiple-canal, multipowerhouse idea attractive was that at least some of the powerhouses and associated mills would be close to town, avoiding the necessity of building an entirely new town site at the Little Rapids. Also, the branch mills closer to town would go into operation as much as a year before work in the Little Rapids area was finished, thus speeding up return on investment. The plan also had flexibility. Costs could be cut at any time by eliminating one or more of the laterals.

Working with the general idea of a main canal and six or seven lateral canals, von Schon had completed preliminary plans and estimates by February 1897. In March 1897 Clergue and von Schon traveled to Philadelphia to present the report to other officials of the Lake Superior Power Company. Costs for the project were anticipated to be under two million dollars. The project was approved.

Scarcely had von Schon returned to the Soo, however, before the plans had to be altered. Test drillings revealed a large muck formation along the canal’s projected path in the vicinity of the second and third laterals to the river. The engineering staff investigated methods of erecting retaining walls in muck formations and studied the costs of relocating the canal around the muck formation. But the technical problems and additional expenses these options involved apparently led von Schon and Clergue to re-evaluate their original plans. What emerged was a significantly different hydropower development.

The modified plans that von Schon had developed by May of 1897 abandoned the 3-mile-long canal from Ashmun Bay to Little Rapids. The new canal followed the old canal right-of-way only from Ashmun Bay to Kimball Street, a distance of about a mile and a half. At Kimball Street the canal curved northward and a little over a half mile further terminated at the St. Marys River at Tyson Street. A single 40,000 hp (mechanical) powerhouse replaced the half dozen smaller powerhouses originally contemplated.

This modification was acceptable because it did have certain advantages over the multiple-canal plan, especially since electrical power transmission made it possible to locate power consumers some distance from the powerhouse. The new canal route involved less excavation work; it almost completely avoided the hazardous muck formation; and some additional fall was gained since the canal slope would have exceeded the river’s slope over the last mile of the original route. Diversion to the river even closer to the main rapids would have further increased these benefits, but government property and expensive coal dock property eliminated this option.

The muck formation proved to be only one of the technical problems encountered by the power company in 1897. Potentially more serious and more expensive were the effects that the power development could have on Great Lakes’ navigation. In his February 1897 report to company officials von Schon had noted that the volume of water they were considering diverting from the St. Marys (30,000 second feet) would probably, after a few years, permanently lower the levels of Lake Superior by several feet. This, he had pointed out, would not only lower the head of water available at the powerhouse, but would damage lake navigation and embroil the company in disputes with navigation interests.

To more closely study the effects on lake levels of a diversion of 30,000 second feet the company engaged, apparently on von Schon’s recommendation, Alfred Noble (1844–1914), one of the nation’s leading civil engineers. Widely respected as a bridge and hydraulic expert, Noble was a member of both the Nicaraguan Canal Commission and the Deep Waterways Commission. He had extensive Great Lakes experience, for earlier in his career he had served with the Federal Lake Survey and helped design and construct one of the large ship locks at Sault Ste. Marie.

Noble delivered his report to the company in May of 1897. He agreed with von Schon that the contemplated power canal would materially enlarge Lake Superior’s outlet and lower the lake’s levels if uncorrected. He estimated that at high stage, Superior’s depth would be 1.65 feet below its previous level; at low stage it would be 2.1 feet lower. This, Noble observed, “would be detrimental to navigation and is not likely to be permitted.”

Thus, he concluded, the company would have to erect at its own expense some type of remedial works in the bed of the St. Marys to compensate for the contemplated water diversion and to hold Superior at previous levels. Noble reviewed several options—a fixed dike extending into the river above the rapids, submerged weirs in the river bed, and sluice gates. He calculated that the cheapest and simplest solution, a fixed dike or partial dam, could hold back a flow approximately equal to that being taken in through the power canal under mean flow conditions. But, Noble found, it would raise water levels at high flow, and decrease Superior’s levels at low flow. Sluice gates in the stream would offer flexibility in controlling Superior’s levels and avoid these problems, but were rejected because of their high cost.
and liability to ice damage. Submerged weirs placed in front of or beyond spans 6, 7, and 8 of the International Bridge might do. When installed, the weirs would not lower the level of the lake more than 0.19 feet lower than normal low water, and would not raise the lake by more than 0.04 feet at high water. While this did not literally comply with the requirement that regulating works exactly maintain existing flow conditions and levels, and would cost the company additional money, Noble believed it did represent substantial compliance and would prove acceptable to concerned authorities.

By the summer of 1897, then, many elements of the project were approaching the point where design could be completed and frozen. Location of the powerhouse and output of the power development had been fixed and a workable scheme for compensating for the diversion of water from the St. Marys had been worked out. However, the design of specific elements of the mechanical and electrical systems depended heavily on the nature of the diversion of water from the St. Marys had been worked out. However, the design of specific elements of the mechanical and electrical systems depended heavily on the nature of the power plant’s customers, and customers for power in the Soo were proving hard to find.

The assumption that had guided Clergue and the thinking of Sault Ste. Marie’s citizens for a number of years was that the key to industrial growth was cheap power.16 Because water power was often the most economical source of power in the 19th century, and because this power was available at the Sault, they had reasoned that its development would inevitably and automatically attract industry to the region. The postulate on which Sault Ste. Marie based its future was faulty. Besides cheap power, industries need to be near markets for their products and near raw materials for their processes. The earlier Eastern water-power centers and Niagara Falls had cheap power plus the additional advantages of closeness to markets, raw materials, or both. Sault Ste. Marie could develop power at costs considerably below Niagara’s, but geographically isolated away from the main American transportation routes, it was close to neither raw materials (in many cases) nor markets.

Clergue’s response to this predicament at Sault Ste. Marie, Ontario, had been to create an industrial empire based on local raw materials to serve as a customer for the water-power and to establish a means of shipping the goods produced to market. The development of industrial plants, mines, railroads, and steamship lines for the Ontario side of the river, however, left his Lake Superior Company with little investment capital to undertake a similar feat on the Michigan side of the river. This forced Clergue to attempt to find a major power customer before unequivocally committing himself to construction there.17

Clergue, nonetheless, did consider building up some industrial base on the Michigan side to utilize the power of the projected hydroelectric plant. He talked on several occasions of building a gigantic pulp and paper mill at the Michigan Sault, and von Schon at one time designed the powerhouse around this assumption. Nothing ever came of the idea because of U.S. and Canadian restrictions on the import and export of pulp and the over-commitment of the Lake Superior Company north of the border.18

As surveys and preliminary plans were being carried out, Clergue extended his search for other possible power users. In December 1897 he had von Schon investigate the possibility of transforming the Soo into a flour milling center.19 Then in January 1898 von Schon, at Clergue’s request, made inquiries about rolling mills.20 Increasingly, however, emphasis focused on the use of the plant’s power to manufacture calcium carbide, a material produced by an electrothermic reaction. As early as September 1897 von Schon informed the Westinghouse Company that “discussions” were being carried on relating to the operation of a calcium carbide plant, which would require between 10,000 and 20,000 hp.21

The Coming of Carbide

Calcium carbide was a relatively new substance. Tiny amounts had been first prepared only in 1862 by the German chemist Wöhler, and for three decades thereafter the substance had been largely forgotten.22 In 1892 however, Canadian chemist Thomas L. Willson, and James Morehead, ex-Major, Confederate States Army, formed a partnership and began using the excess power of Morehead’s small hydro-electric plant in Spray, North Carolina, to develop a means of producing aluminum superior to the Hall-Héroult process introduced a few years previously. Willson hoped to isolate metallic calcium cheaply and use its high reactivity to reduce aluminum ore. His experiments, involving a small electric furnace and a mixture of slaked lime \(\text{Ca(OH)}_2\) and tar (largely carbon), however, yielded not metallic calcium but a hard, brown, stone-like substance—calcium carbide \(\text{CaC}_2\). When the unwanted results were discarded as waste in a nearby stream Willson noticed that they gave off a pungent smelling vapor that burned with an intense, smokey, yellow flame. The vapor was acetylene, \(\text{C}_2\text{H}_4\). Willson saw its potential as an enricher of the illuminating gas still used for street and home lighting in many American cities and patented his processes for producing both calcium carbide and acetylene from calcium carbide.

Morehead, meanwhile, found financial backers to produce calcium carbide on a commercial scale. Within the next few years sev-
eral carbide plants were organized, five of them in the United States. Most failed due to an assortment of technical and managerial problems. One of the few exceptions was a small, experimental plant, which the People’s Gas, Light & Coke Company of Chicago erected in August 1896 in Sault Ste. Marie, Michigan, a plant which used hydroelectric power transmitted by cable across the St. Marys River from the Lake Superior Company’s plant on the Ontario side.23

One of the reasons for the success of the small, experimental Soo plant was the development of a new carbide furnace. The original furnace of Willson produced the substance intermittently, in batches. It was inefficient because the furnace was alternately turned on and off, and opened and shut, as a finished batch of carbide was removed or a new container of raw materials was inserted.24 The new furnace, developed in late 1897 or early 1898 by William Smith Horry, chief electrical engineer of the Lake Superior Carbide Company, operated continuously. The Horry furnace resembled a large iron bobbin or reel laid on its rims. This reel, about 8 feet in diameter by 3 feet wide, was mounted so it could slowly be rotated on its axle by worm gearing. Detachable iron plates covered much of its outer periphery. Near the top of the reel, penetrating deeply into its recessed rims, was a hopper containing one part burnt, pulverized lime to three parts of ground coke. Inside the hopper were two carbon electrodes, about 6 inches in diameter, placed about 9 inches apart. These electrodes were fed a current of approximately 3,500 amperes at 110 volts (c. 375 kW or 500 hp). When the circuit was closed, the lime-coke mixture was heated to 3500–4000° F in the arc between the electrodes and reacted to produce molten calcium carbide. As the carbide was formed, the electrical resistance of the arc dropped, the worm gearing, which rotated the reel was activated, and this rotation carried the newly formed calcium carbide out of the arc, allowing fresh raw materials in. As the reel rotated away from the hopper, iron plates were placed over its periphery to hold in the still-molten carbide and the raw materials behind it. These plates were removed when they had rotated to the other side of the furnace and the material beneath them had cooled. Segments of carbide cake, about 6 to 9 inches thick, were then taken out of the furnace and the plates left off so that the spool could once again rotate past the hopper and arc. Horry furnaces made about one revolution in 24 hours, and were operated continuously, save for periodic shutdowns for maintenance and repairs.25

Horry’s furnace insured the success of the experimental carbide plant at the Soo and made commercial calcium carbide production profitable on a large scale. Officials of People’s
Gas Company thus decided to expand their production facilities. In conjunction with New York capitalists they bought up Willson's patents and the only other successful American carbide plant (the Acetylene Light, Heat, and Power Company at Niagara Falls). The resulting company they called Union Carbide.26

Because cheap power is absolutely essential to production of calcium carbide (approximately 3750 kWh per ton produced)27 and because Union Carbide had been able to carry on operations successfully on an experimental scale in Sault Ste. Marie, they were interested in Clergue's plans and less worried about the Sault's geographical isolation than most other manufacturing companies would have been. Negotiations between Clergue and Union Carbide began as early as mid-1897, if not before. They reached a successful conclusion on April 2, 1898.

The terms of the contract between the Lake Superior Power Company and Union Carbide were highly favorable to the carbide company and probably reflect Clergue's desperation to find a customer for power on the Michigan side of the St. Marys before irrevocably committing himself to construction on a large scale. Under the terms of the contract the power company agreed to construct a canal of at least 20,000 hp capacity and to deliver 10,000 hp to Union Carbide within two years; 15,000 hp within three years; and 20,000 hp within four years. The power company agreed to deliver this power at the turbine shaft; all generators, switchboard instrumentation, and furnaces were to be furnished by Union Carbide. The power company agreed to furnish rental free space for the generators and, within 30 feet of the generators, space for electric furnaces. In addition, the power company agreed to lease any additional land needed by the carbide company for a nominal sum, to furnish docks and railroad sidings, and to provide free power to the company for the transportation of materials and men and for lighting on the power company's premises (up to a maximum of 500 hp for each 10,000 hp leased). Moreover, the power company agreed not to lease power to any other carbide manufacturer. Costs were set very low: $10 per horsepower per year.28 Costs for power at Niagara Falls at this time were at least 50% higher, at Minneapolis 100% higher.29 The lease was to extend 25 years with Union Carbide having the option of renewing the contract in perpetuity, as well as an option to lease any additional power generated on the same terms and conditions.

The Carbide contract had a significant impact on three phases of the projected power development. It forced von Schon and his staff to significantly alter the plans they had prepared for the powerhouse; it prompted the creation of a subsidiary, American-based corporation to construct and operate the Michigan hydroplant; and it stimulated a new burst of enthusiasm among Sault Ste. Marie citizens.

In early 1897, when Clergue was still considering a pulp mill on the Michigan side of the river, von Schon and his staff had decided to use turbine units of 500 and 670 hp. Half of the power (in 500 hp units) was to be used to directly grind pulp at 150 rpm. The other half (in 670 hp units) was to be used for electrical power generation. The powerhouse was to have three sections. Two wings of one story were to house direct-connected horizontal-shaft turbines and pulp grinders. The ground pulp was to be piped to an adjacent building containing pulp and paper processing machinery. The central part of the powerhouse was to be two stories tall with turbines on the first floor, belt-driven generators on the second.30

Even before the carbide contract, von Schon had altered this design. In late 1897 he had decided to use a uniform 500 hp penstock unit. He had abandoned the two-story central structure for a one-story powerhouse about 85 feet wide by, presumably, about 1,300 to 1,400 feet long. This low-profile structure was to be more than half-submerged by water on the upstream side, where each of eighty penstocks would have four horizontal turbine runners in two draft cases transmitting power through a single shaft to pulp grinders or electric generators on the other side of a bulkhead.31 The design was submitted to and reviewed by the company's general consultants, Boller and Bogart, in December 1897 and approved.32

The decision to lease a large portion of the projected power (20,000 or 40,000 hp) to Union Carbide necessitated substantial alterations to these plans. Because Union Carbide was paying for power at the shaft of the turbine, and not at the point of consumption (the electric furnace) they had apparently insisted that the company provide space for the furnaces not more than 30 feet away from the generators, thus reducing power losses through transmission.

The powerhouse von Schon had been contemplating did not provide sufficient space for carbide furnaces. Several modifications were thus considered. One was to use the basic one-story structure approved by Boller and Bogart in December of 1897, but to increase its width from 85 to 120 feet. The single floor of the powerhouse would then be divided into three sections—each around 1300 feet long. The turbine bay would be 45 feet wide; the generator room (separated from the turbine by an iron bulkhead dam) would be 37.5 feet wide; and the furnace room (separated from the generator room by a partition wall) would
Partial north elevation of the powerhouse as contemplated in October 1897.
Cross section of the powerhouse as contemplated in October 1897.
be around 35 feet wide. This plan, however, would have enormously increased costs. The foundation and tailrace floors, walls, and roofs would have to be extended, as well as the generator floor itself. The number of steel columns required for the structure, the increased volume of masonry needed, and the new partition wall would have significantly increased costs. The other option was to retain the 85-foot width previously contemplated by von Schon, but add a second floor for the Hurry furnaces. This option required less additional masonry and steelwork than a wider one-story structure. Thus the multifloor powerhouse was adopted.33

Union Carbide also briefly persuaded the company to consider a cut-down version of the old multiple-canal idea of 1896. This would have involved the construction of two lateral canals to the river and two powerhouseks, each producing 20,000 hp. One powerhouse would be occupied solely by Union Carbide. But the added expense of the extra canal and powerhouse forced Union Carbide, reluctantly, to accept joint occupation of a single large powerhouse with the power company.34

The Union Carbide contract also led to a financial reorganization of the hydroelectric project. All of the early planning and preliminary design and survey work on the Michigan side of the St. Marys had been carried out directly under the auspices of the Lake Superior Power Company. Lake Superior Power was an American-owned company, but had been organized under Ontario law. In early 1898 when it became clear that agreement with Union Carbide would be reached and construction would soon begin on the Michigan side, Clergue and his associates formed an American subsidiary to carry out the job. This reorganization was in large part prompted by the provisions of Act 39 of the 1883 Michigan legislature. This act, which had authorized (under certain conditions) the diversion of the water from the St. Marys, required that the company making the diversion be incorporated in Michigan.35 The formation of a subsidiary American corporation, however, had other advantages. Lake Superior Power Company could be considered a "foreign" company, since it was chartered in Canada. A subsidiary Michigan corporation was less susceptible to such charges and thus more likely to obtain needed state and federal permits for operation. Moreover, the "parent" Lake Superior Power Company would be protected against financial liability should the Michigan development fail.

In preparation for the reorganization in March 1898, the Lake Superior Power Company transferred its American properties to its president, Edward V. Douglas, as trustee. On June 28, 1898, the Michigan Lake Superior Power Company (MLSPC) was incorporated in Michigan with a capitalization of $500,000. The parent company, Lake Superior Power, received $495,000 of capital stock in the Michigan Company and $5,000 cash in exchange for the properties it deeded to MLSPC. Named as president of the new company was Edward Douglas. Clergue was named vice president and general manager.36

In September the directors of the new company authorized an issue of $3.5 million of 5%, 50-year first mortgage bonds. Of the proceeds, $2.1 million was slated for construction costs; $450,000 for underwriters' commissions; and $300,000 was reserved for contingencies and interest during construction. Lake Superior Power received $550,000 for the transfer to MLSPC of the Union Carbide power contract.37

This may have damaged the financial integrity of the new company. Both the charge for the Union Carbide contract and the commission charge were high. The high charge for the Carbide contract seems to have been a method of obtaining working capital for the parent Lake Superior Power Company; the high commission charge went to Provident Loan & Trust Company, a major stockholder in Lake Superior Power. As a result of this stock and bond manipulation, Clergue and the Philadelphia syndicate retained complete control of MLSPC while making $1.1 million in profits at its expense. If the new company failed, they would lose little since the bondholders had provided the bulk of the cash for the Michigan plant. If the project succeeded the syndicate could pay off the bonds and retain the profits and the company.

The long delays involved in determining the exact size of the power canal, in redesigning the works to avoid the muck formation, and in securing a customer for a significant block of power had been frustrating to local inhabitants. More significantly, these delays had invalidated the franchise granted to the power company by the city in November 1896, since one of its provisions had stipulated that the canal be completed by July 21, 1898. Signing of the carbide contract provoked a new burst of enthusiasm among city officials, so that when the power company asked for a new set of ordinances, they quickly complied. Their optimism over the future of the project and the city is reflected by section 13 of the new ordinances, which required the power company to raise or lower its railroad to pass over or under city streets as soon as the city's population reached 100,000. Sault St. Marie in 1898 had scarcely 10,000 people.
The terms of the new franchise were approximately the same as the earlier one. Basically the company was given the right to build a canal through the city and to construct a railroad adjacent to the south side of the canal. The company was promised special tax benefits, and the city assumed responsibility for constructing and maintaining permanent bridges over the canal when it was completed. In return the company promised to build a canal, which would develop at least 40,000 hp (hydraulic) to inconvenience the public as little as possible during construction; to maintain temporary bridges, sewer lines, and water lines across the canal right-of-way during construction; and to construct bridge abutments for the permanent bridges, which the city would later install. The franchise was perpetual. With passage of these ordinances on October 4, 1898, and with approval of the water diversion by the Chippewa County Board of Supervisors on October 10, 1898, the last obstacles to canal construction had finally been hurdled.

Decisions: Finishing the Design, 1898–1900

With most issues substantially settled by the summer of 1898 von Schon and his staff, after two years of alterations and management indecision and hesitation, were finally able to freeze the design of most of the elements involved in the Sault hydroelectric project. The final design contained a number of unusual features—a powerhouse a quarter of a mile long, almost 320 turbine runners in 80 penstock units, a power canal lined with timber on an unprecedented scale, among others. These features, as well as a number of less unusual elements in the Soo plant were

Table II.

<table>
<thead>
<tr>
<th>Description</th>
<th>Illustration</th>
</tr>
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<tbody>
<tr>
<td>Right-of-way through city limited to around 260 ft. and decision to make the canal prism 20–25 feet deep</td>
<td><img src="flowchart.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Decision to build the plant to develop 40,000 hp (after turbine and generator losses)</td>
<td></td>
</tr>
<tr>
<td>Best power unit 500 hp (2 pulp grinders or 1 Horry furnace)</td>
<td></td>
</tr>
<tr>
<td>Decision to use the power to grind pulp or provide electricity to Horry carbide furnaces</td>
<td></td>
</tr>
<tr>
<td>Flow velocity of 7 to 7.5 ft./second needed in canal</td>
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</tr>
<tr>
<td>With 16 ft. fall available; 80% turbine efficiency; 93% generator efficiency—30,000 second feet of water needed to develop 40,000 hp</td>
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<tr>
<td>40,000 hp 80 375 second feet of water per penstock</td>
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<tr>
<td>Optimum shaft speed of 180 rpm</td>
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</table>
Enlarged forebay required to slow water to c. 2 ft. per second

Timber lining required in earth sections to prevent erosion

Wide intake mouth

Penstock width of 15 ft. to take in necessary volume of water (375 second feet) at velocity of 2 ft. per second

Powerhouse with a width of 1,340 ft. is necessary once the thickness of the penstock partitions and additional penstocks for spillways are added to the (15 x 80 = ) 1,200 ft. of length needed to get the necessary volume of water into the penstock units

To secure discharge of 375 second feet at 180 rpm at 80% efficiency requires 4 horizontal turbines; 33 in. diameter, mounted in tandem

heavily influenced, if not determined, by the following three critical decisions made in 1898 by company management:

1) to accept a 260-foot-wide right-of-way through the city rather than pay inflated prices to secure a 450- to 500-foot right-of-way;

2) to build a plant to develop 40,000 hp after turbine and generator losses were deducted; and

3) to design the plant to power either pulp grinders or Horry carbide furnaces, or both.

The flow chart on the page indicates how a number of the unusual design features of the Soo hydroelectric plant were influenced by these three basic decisions.

The Power Canal

Clergue several times in the early days of the Michigan project had indicated an interest in building a canal 400 feet wide. But the prices demanded by certain property owners proved excessive. The maximum right-of-way that could be obtained at a reasonable price over the entire length of the canal was only 260 feet. This meant, allowing for slopes and embankments, the greatest canal width that could be used was only 200 to 220 feet. This was to affect many elements of the power canal design.

Von Schon's computations indicated that in terms of excavation costs the most economical depth for a canal 200 to 220 feet wide was 22 to 23 feet. This gave the canal a cross section of 4,500 square feet. To develop the desired 40,000 hp at an estimated 16 foot head, after turbine and electrical losses were deducted, required 30,000 second feet of water. And to secure this volume von Schon had to adopt a flow velocity (allowing for frictional losses) for the canal of 7 to 7.5 feet per second (the veloc-
The Michigan Lake Superior Power Company's power canal was designed to pass 30,000 cubic feet per second. In terms of designed flow capacity it was the largest power canal in the world. Because right-of-way limitations restricted the canal's width to around 200 to 220 feet, an extraordinarily high flow velocity (7 to 15 feet per second) was required to pass this water. The high velocity of water in the canal forced the chief engineer, von Schon, to design a special timber lining for the portions of the canal which passed through sand and clay.

Section I of the canal began at the old shoreline of Ashmun Bay (the banks of intake were formed by filling excavated material behind the cribs projecting out into the Bay). At this point the channel had been reduced from 950 to 220 feet in width. Because this 2,700-foot-long section largely passed through solid rock, the anticipated high stream velocity required no special precautions, save in a few locations where the stone was in bad condition or where the natural rock formation fell below the height of the canal banks.

For almost half of its length, however, the canal passed not through rock, but through sand or clay. Here the projected flow velocity would have quickly eroded the sides and bottom of the canal. Von Schon's solution to this dilemma was ingenious. He designated a trapezoidal (later altered to semicircular for part of the route) timber lining to protect the sides and bottom of the canal, a construction considered by one contemporary engineering firm actually developed in the completed canal was 6 to 6.5 feet per second). This was unusually high for a power canal, but unavoidable because of the right-of-way problems and the projected scope of the development. The high flow velocity forced von Schon to take a number of precautions in designing the power canal.

The power canal was divided into five basic sections: Intake; Section I (rock section); Section II (sand section); Section III (clay section); and Forebay. The intake section extended beyond the natural shoreline into Ashmun Bay. It was approximately 2,400 feet long and led water from the St. Marys River into the canal. The canal at the mouth of the intake section was 950 feet wide and gradually narrowed to the 200 feet necessary for the remainder of the canal. This enlarged intake mouth was but one of the features of the canal made necessary by the high flow velocity von Schon had been required to use in the canal prism. The entrance of the intake was near the established navigation channel of the St. Marys, just above the government ship canal. A 200-foot-wide intake with its 7.5 feet per second velocity would have created crosscurrents hazardous to shipping. The wide mouth enabled von Schon to divert water at a velocity of 2 feet per second, slow enough to avoid endangering passing ships.5

The depth of the intake section of the canal was only 20 feet; the soil for the first 1,000 feet of canal was a mixture of sand, clay, and gravel, with an occasional boulder. The sides and bottom of a channel made up of this material would quickly have eroded away under the high velocity of the incoming water, so von Schon designed retaining cribs, built up from 12-inch-square timber, faced with planking and filled with stone, for the sides of the intake.6
Bearing piles spaced about 10 feet apart were to be driven in rows 5 feet apart running across the bottom of the canal and up its 45° slopes or sides. (The space between rows was later changed to 7.5 feet on the bottom.) Sills 12- by 12 inches were to be spiked to these piles. The space between the sills was to be filled with clay puddle, to inhibit leakage, and on top of the sills a 3- by 4-inch timber lining was to be nailed. This lining was to terminate a foot or two below the water line. Several layers of 12- by 12-inch beams laid on top of each other would follow. Behind this bulkhead von Schon planned to slope a clay-filled bank backwards at approximately a 45° angle, and pave it with stone. The water level was to be just above the top of the 12 by 12's. By keeping the timber lining completely underwater von Schon hoped to preserve it indefinitely.

The timber lining used in the earth sections of the canal was intended to serve a dual purpose: it would protect the banks from erosion and would reduce the friction between water and canal. Von Schon estimated that, due to the lining, the amount of head lost to friction in the sand and clay portions of the canal would be less than that lost to friction in the rock sections, even though the former sections were twice as long.

As the canal passed Portage Street, von Schon planned to enlarge it to form a forebay for the powerhouse. The enlargement of the cross-section of the canal would slow the water down in preparation for its entrance into the turbines. Good hydroelectric practice was to drop the velocity of water at the intake to reaction turbines to around 1 to 2 feet per second, since larger velocities caused vibrations, wear on turbine chambers, and disturbances on turbine runners.
Canal Section III during installation of the semielliptical timber lining. Placement of sills on the piles and clay filling between the sills is being carried out in the foreground. Some timber has been placed over the sills on the upper parts of the walls and on the bottom in the background. Courtesy of Edison Sault Electric Company.
Forebay of the powerhouse in May 1902. Construction of the ice rack has begun near the center. The embankment lining has been almost completed. Note that the forebay floor itself was not planked. Courtesy of Edison Sault Electric Company.
also allowed the water to deposit suspended minerals and reduced the pressures that the combination dam/powerhouse at the head of the forebay had to resist. Finally, the enlarged forebay, and the water that stacked up there behind the powerhouse, provided a slight increase in head. The walls of the forebay, like much of the canal, were to be lined, but with unfinished logs; the bottom of the forebay, since no erosion was expected at the lower velocities of flow, was to be left unfinished.

The Turbines
The basic decisions that influenced the size and nature of the power canal also played a major role in fixing turbine and penstock design. For example, the decision to design the plant for pulp grinders and Horrry furnaces fixed the unit output per penstock at 500 hp. This was the rating of the early Horrry furnaces. The standard commercial pulp grinder of the day required about 250 hp, so two could easily be installed on an extended turbine shaft, also making 500 hp a natural power unit. For general hydroelectric power generation, however, the 500 hp unit was not so natural a choice, and in fact before the Union Carbide contract von Schon had considered electrical generating units ranging from 500 to 1000 hp. But after the commitment to carbide production, the basic penstock unit for the entire plant was quickly set at 500 hp.

The anticipated scope of the power development (40,000 hp) and the establishment of the basic penstock unit at 500 hp meant that the powerhouse would require a minimum of 80 penstocks, an unusually large number. The typical powerhouse at the turn of the century had far fewer penstocks, typically on the order of five to ten. Since these penstocks were required to discharge a total of 30,000 second

### Table III
The Power Canal of the Michigan Lake Superior Company

<table>
<thead>
<tr>
<th>section</th>
<th>approximate length (at water surface)</th>
<th>depth</th>
<th>soil conditions</th>
<th>lining</th>
<th>prism shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake</td>
<td>2400'</td>
<td>950 to 200'</td>
<td>20'</td>
<td>sand, gravel, and clay</td>
<td>rock-filled timber cribs on sides; nothing on bottom</td>
</tr>
<tr>
<td>I</td>
<td>2700'</td>
<td>200'</td>
<td>22'</td>
<td>Largely Potsdam sandstone</td>
<td>natural sandstone with some concrete masonry</td>
</tr>
<tr>
<td>II</td>
<td>3000'</td>
<td>216'</td>
<td>23'</td>
<td>largely sand</td>
<td>timber*</td>
</tr>
<tr>
<td>III</td>
<td>3000'</td>
<td>216'</td>
<td>23'</td>
<td>largely clay</td>
<td>timber***</td>
</tr>
<tr>
<td>Forebay</td>
<td>300'</td>
<td>216 to 1350'</td>
<td>23'</td>
<td>largely clay</td>
<td>timber***</td>
</tr>
</tbody>
</table>

* for more than half of Section II the bottom of the canal prism is rock and only the sides are timber-lined
** originally trapezoidal; modified to semi-elliptical in the course of construction
*** originally only the sides were timber-lined (with half logs); the bottom (except for the upper forebay where the canal entered) was left unlined; the bottom was timber-lined in 1903
feet of water, each had to be able to handle 375 second feet (30,000 / 80). A volume of water of this magnitude under the low-head (16 to 18 feet) conditions at Sault Ste. Marie presented von Schon with another serious problem. Pressure turbines, for optimum performance, must rotate at a peripheral speed of around 75% of the theoretical velocity of the water. Under a 16 foot head, the water velocity is rather low (around 30 feet per second). A single large turbine runner operating under that head could have discharged the 375 second feet at high efficiency. But the shaft velocity would have been very low, too low, in fact, for the anticipated uses of the power.

Von Schon had determined that a speed of at least 180 rpm was necessary to effectively operate both pulp grinding machinery and electric generators. For electric generators a higher speed would have been better (200 to 250 rpm), for high-speed generators are more efficient than slow-speed generators and considerably cheaper because they are smaller than low speed units of the same output. To get a higher shaft velocity under the low-head conditions of the Soo would have required very small diameter turbines, which would have had low discharges and a low power output, necessitating the use of a very large number of runners to develop the needed 500 hp per turbine unit. Von Schon’s use of 180 rpm seems, therefore, to have been a compromise between reasonable turbine and reasonable generator costs. A higher speed would have reduced the cost of electric generators, but would have increased the number and hence the cost of turbine runners. A lower speed would have reduced the number of turbine runners needed, but increased generator costs. The compromise speed was acceptable for generators and was, in addition, adequate for pulp grinders driven directly by turbine shafts. Von Schon, of course, did have the option of using a slower turbine shaft speed and driving high-speed generators by gearing or belting instead of directly. But gearing or belting would have resulted in a power loss of around 10%, and apparently von Schon found this unacceptable.

The choice of turbine style (horizontal-shaft), turbine size (around 33 inches) and number of runners per penstock (4) followed naturally from the choice of the 180 rpm shaft speed, the 375 second feet discharge required per penstock, and the desire to directly link generators or pulp grinders to the turbine shafts. To get 180 rpm under a 16 foot head with high efficiency, von Schon had to use a turbine runner 33 inches in diameter. Since turbine runners of this size discharged only 100 second feet of water and generated only 125 hp, he had to place four of these runners in tandem on an extended horizontal shaft in each penstock to secure the desired 500 hp when generator losses were considered.

This particular arrangement was not at all uncommon in turn-of-the-century low-head hydroelectric plants. One of the major reasons horizontal turbines were preferred over vertical-shaft turbines then was because multiple turbine runners could be mounted on a horizontal axe without loss of head, thus securing an increase in power with the same speed as a single unit. What was unique about the Sault Ste. Marie hydroplant was not so much the four-in-tandem arrangement, but the magnitude of the plant—80 penstock units, 320 turbine runners, all in a single powerhouse. No other hydroelectric plant in the world had nearly that number of penstock units or turbine runners.

The turbines in each penstock were arranged in pairs. Each pair was housed in a cast-iron draft case, which discharged into a centrally located, conical draft tube. Each runner had its own pivoted-vane control gate and was keyed onto a steel shaft. The shafts for each pair of turbine runners were bolted together and penetrated, through a stuffing box, the steel plate bulkhead, which blocked water at the downstream end of the penstock and served as the “dam” for the installation.

The width of the penstock where these turbines were situated (and hence the length of the powerhouse) was determined by the velocity of the water in the forebay and the required discharge per turbine unit (375 second feet). For an opening 13 feet high, a width of 15 feet between partition walls was required. Eighty penstocks of that width, allowing for the thickness of the penstock partitions and extra units needed for spillways, required a powerhouse slightly more than a quarter of a mile long. This length, like the number of penstock units and turbine runners the plant was designed to use, was unprecedented. It made the Sault powerhouse the longest in the world.

While the general dimensions of the powerhouse, turbines, and power canal were determined by the factors mentioned in the opening pages of this chapter, the specific design features of the powerhouse were not. Von Schon was free to select the turbine manufacturer he wished, to design the tailraces and the powerhouse foundations, and to fix the architecture and floor space as he desired, with fewer constraints than was the case with power canal design, penstock power unit selection, and penstock size.

Since turbine installation is the heart of a hydroelectric plant, von Schon devoted considerable attention to it. He had early assumed that he could secure an efficiency of 80% from the turbines and had designed and dimensioned the canal prisms and penstock
units based on this assumption. Securing this efficiency, however, proved a more serious problem than von Schon had anticipated. The premier turbine testing facility in the United States in the late 19th century was at Holyoke, Massachusetts. Results from the test flume were frequently used by manufacturers in their advertising. But von Schon, on closer investigation, found that the Holyoke flume was designed to test only vertical-shaft turbines in single-runner units. He was planning a multiple-runner, horizontal-shaft installation. Moreover, von Schon feared that Holyoke tests would not be reliable for estimating turbine performance since Holyoke tests were made under special refined conditions, which tended to give much higher efficiencies than could be realized in practice.21

After extensive negotiations von Schon persuaded Holyoke to modify their facilities to test a pair of horizontal wheels,22 and in the specifications he sent out to turbine manufacturers for bids in late 1898 he asked that the turbines offered give 80% efficiency as determined by tests conducted by the power company at Holyoke.

When bids for the first 40 turbine units were received in April 1899, the results were disappointing. Only three manufacturers bid, and some of the bids did not fully meet specifications. The primary problem was the size of the order. Forty turbine units involved 40 x 4 or 160 runners, an order large enough to tax the facilities of even the largest manufacturer of the day, especially since the specifications had called for delivery by January 1, 1901. Moreover, turbine manufacturers were reluctant to send a pair of wheels to Holyoke and risk not meeting specification efficiency because of the bad publicity, which could result.23

Von Schon revised his specifications in mid-

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### Table IV

<table>
<thead>
<tr>
<th>Plant</th>
<th>Head (ft)</th>
<th>kW</th>
<th>No. of Penstock Units</th>
<th>No. of Turbine Runners</th>
<th>No. of Generators</th>
<th>Powerhouse Dimensions</th>
</tr>
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<tbody>
<tr>
<td>Buchanan, MI</td>
<td>10</td>
<td>1500</td>
<td>10</td>
<td>10</td>
<td>1</td>
<td>273 x 40 ft.</td>
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<tr>
<td>Millinocket, ME</td>
<td>11</td>
<td>3000</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td></td>
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<tr>
<td>Birchum Bend, MA</td>
<td>14</td>
<td>800</td>
<td>2</td>
<td>2</td>
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<td></td>
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<tr>
<td>Garvin’s Falls, NH</td>
<td>28</td>
<td>1300</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Canon Ferry, MT</td>
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<td>7500</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>225 x 50</td>
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<td>2000</td>
<td>4</td>
<td>4</td>
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<td>2</td>
<td></td>
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<tr>
<td>Spier Falls, NY</td>
<td>80</td>
<td>24,000</td>
<td>10</td>
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<td>3000</td>
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<td></td>
<td>140 x 30</td>
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<tr>
<td>St. Maurice River,</td>
<td>125</td>
<td>10,500</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Niagara Falls #1, NY</td>
<td>136</td>
<td>37,500</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td>120 x 100</td>
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<tr>
<td>Niagara Falls #2, NY*</td>
<td>145</td>
<td>41,250</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>496 x 72</td>
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<tr>
<td>Colgate, CA</td>
<td>700</td>
<td>11,250</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>275 x 40</td>
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<tr>
<td>Santa Ana River, CA</td>
<td>728</td>
<td>2250</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>127 x 36</td>
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<tr>
<td>Electra, CA</td>
<td>1450</td>
<td>10,000</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>208 x 40</td>
</tr>
</tbody>
</table>

*completed after the Sault Ste. Marie plant

| Sault Ste. Marie (as designed) | 17 | 32000 | 80 | 320 | 80 | 1368 x 80 |
| Sault Ste. Marie (as operated 1903–1913) | 14 | 10000 | 40 | 160 | 35 | 1368 x 80 |
1899 and secured better results. The contract for the first 40 units was awarded in November 1899 to the Webster, Camp and Lane Machine Company of Akron, Ohio. Webster, Camp and Lane was not a regular turbine manufacturer. In order to deal with a contract of the size contemplated for the Soo they had entered into a special agreement with the J. and W. Jolly Company of Holyoke, a very well-known turbine producer. Jolly was to provide 160 of its Jolly-McCormick turbine runners. Webster, Camp and Lane was to manufacture everything else—draft cases, draft tubes, turbine shafts, bearings, etc.—and install the units. Each turbine set was guaranteed by Webster, Camp and Lane to develop at least 564 hp at a 16 foot head at 180 rpm, with a discharge of 391 second feet, and 80% efficiency. One complete unit of two runners was to be sent to Holyoke for testing to see if this could be achieved. On the results of this test the company conditioned its acceptance of the units. Installation of all 40 units was to be completed within 34 months.

Substructure
Foundations are a key element in hydraulic projects. It is the one area where mistakes are often critical and invariably difficult to correct. Von Schon had decided to place the powerhouse in the shallows of the St. Marys River. In January 1897 eight test borings were made at the site. All eight indicated around 15 feet of silt, sitting on a foot or two of gravel, which overlay a bed of hard clay 20 to 30 feet thick. Under the clay was bedrock. The results of the eight borings were so uniform that von Schon and his assistants made no additional tests and assumed a fairly regular formation over the projected area of the foundation, an assumption which was later to prove erroneous.
The foundation was to be placed 16.5 feet below the surface of the St. Marys, wholly on clay. This meant that the entire site had to be enclosed by a coffer dam for construction. The silt and gravel overlaying the clay would then be excavated, and the site leveled. Once clay was reached and the site leveled, von Schon planned to drive 1,050 hardwood strain piles, each 16 feet long. They would be anchored on top in a concrete foundation by timber grillage.27 Directly over these foundations would be 85 tailraces, enclosed tunnels leading from the turbine discharges to the St. Marys. Eighty of these races would serve sets of turbines; five would be spillways.28 The floors of each race and the base of the walls separating one race from the other would be monolithic concrete, as would the arched roofs over the races. The partition walls (3 feet thick) and the upstream end of the tailraces were to be constructed of pre-moulded concrete blocks.29

The decision to use pre-moulded blocks for the walls was the result of extended deliberation by von Schon and his assistants. Von Schon recognized that pre-moulded blocks would cost more than monolithic, poured concrete. But pre-moulding would allow concrete work to begin while excavation and foundation work on the powerhouse were still under way. In addition, the pre-moulded blocks would have a chance to age before emplacement, so once in place they could be built on immediately. Poured concrete walls would have to set for 20 to 30 days before it was safe to begin loading them. These advantages, plus ease of repair, convinced von Schon to go with the blocks for part of the powerhouse substructure, despite higher costs.30

Since a powerhouse of the size contemplated by von Schon required an immense amount of masonry, von Schon persuaded the company to purchase a testing machine and to allow him to carry out extensive tests of various brands of concrete, concrete aggregates, and methods of mixing concrete.31 The results of these tests were used to insure that the concrete work at the Soo was of very high quality.32

**The Superstructure**

Above the tail pit walls and roofs, which raised the whole structure above the level of the St. Marys, was the superstructure: the penstocks, generator room, and mill floors. These units underwent some modifications between 1898 and completion. In the summer of 1898 von Schon had planned 85 penstocks, 80 for turbines, 5 for spillways. He reduced the five spillways to one before work on the powerhouse began. Each of the 80 penstocks to be used with turbines was equipped with two rectangular discharge tubes with movable gates. These tubes were designed to pass a volume of water equal to the discharge from the turbines, should the latter be shut down. They also served as drains for the penstocks when they were shut off from the forebay for repairs.33

The penstock construction adopted by von Schon contained several novel features. The partitions between the penstock units were of cellular steel I-beam construction. That is, the skeleton of the walls was formed by a number of vertical 12-inch-thick I-beams, which divided the wall into sections or cells that were filled (and the whole wall faced) with concrete. According to von Schon, this was one of the earliest applications of skeletal steel construction to a hydraulic structure.34

For the dam or forward end of the penstock, von Schon's assistant, J. W. Rickey, designed a semicylindrical steel bulkhead in late 1897. This curved bulkhead was built up of double-riveted, one-quarter-inch-thick steel plates. This was a completely new design, and Rickey later patented it. The advantage of this type of "dam" or bulkhead was the elimination of a considerable volume of masonry, since it substituted quarter-inch-thick steel for several feet of monolithic concrete.35

Von Schon's plans for the powerhouse foundations, substructure, and superstructure were reviewed in January of 1899 by Alfred Noble, who had been retained by the company as a general consultant. He generally approved von Schon's plans, making only minor changes.36

The portion of the powerhouse that underwent the most radical design changes between 1898 and completion in 1902 was the portion of the powerhouse above the generator-turbine floor. In the summer of 1898 the one-story structure initially planned was, as noted, abandoned for a two-story structure, with the second floor placed directly over the generator room to house carbide furnaces. The architecture of the revised powerhouse was to be the castellated Norman architecture of the original one-story design.37

Further consultation with Union Carbide engineers, however, eventually forced von Schon to make additional changes. For instance, the second story von Schon had planned for Union Carbide was to have had a ceiling 15 to 20 feet high. But later talks with Union Carbide revealed that the hoppers and the conveyor belts needed to feed Horry furnaces required at least a 30-foot ceiling, exclusive of roof trusses.38 Originally the eastern (Union Carbide) and western (company) parts of the powerhouse were to be identical. This changed matters. Von Schon raised the roof line for the whole powerhouse to accommodate Union Carbide's needs. This provided Union Carbide with a 30-foot ceiling on the east. The company divided its half of the
The Power House of the Michigan Lake Superior Power Company combined the usually separate elements of dam, power house, and factory in one structure. This design permitted direct coupling of the turbines to the generators, avoiding the losses entailed by belting or bearings. It also avoided the power losses inherent in power transmission outside the structure by providing space for customers within the building directly above the generators.
The downstream side of the semicylindrical steel plate bulkheads, which served as the "dam" for the powerhouse. The shafts projecting from the bulkheads linked the turbines to the generators. Courtesy of Edison Sault Electric Company.
building into two floors, one with a 16-foot ceiling, and another with a 12-foot ceiling separated from the first by a hollow tile floor. Thus the western half of the building was built with multiple mill floors, while the eastern half had only one.

The overall architecture of the powerhouse was also altered as a result of these changes. The castellated Norman pattern originally planned was abandoned, and J. C. Teague, a local architect, was asked in early 1899 to submit sketches of possible alternative powerhouse elevations. Teague was informed that there would be no further alterations in the general horizontal dimensions of the powerhouse, that the external walls were to be built with red sandstone being excavated along the canal route, and that each individual unit of machinery was to be given a window. He was also told not to indulge in costly and extravagant features.

Teague submitted seven architectural studies to Clergue and von Schon in April 1899. Both von Schon and Clergue selected a Romanesque design. They felt the plan was well-suited to the material to be used in construction, would adapt itself to economical roof construction, and would shorten the otherwise tediously long sameness of the building and give an impression of power, importance, and stability.

The Teague design accomplished these ends. The “tedious” length of the structure is broken up by three large pavilions, one at either end of the structure and one in the center. These tend to draw the eye upward and away from the structure’s extraordinary length. The roof pavilions were equipped with dormers (since removed), which also helped break up the horizontal elements of the structure and draw attention upwards. The roofs in the two long sections between the pavilions are double-pitched. Their height likewise counterbalanced the great length of the powerhouse. The pavilions opened up some additional overhead space in the center of the building and at the ends. In the western half of the powerhouse, the power company took advantage of this feature and installed additional floors in the western pavilion and their portion of the center pavilion.

There was one other major change in the external arrangement of the powerhouse. Original plans called for the roofs over the two long sections of the powerhouse to be identical. Union Carbide, however, insisted that their furnaces required special ventilating facilities to remove noxious gases, mainly carbon monoxide, and the dust given off by the production process. Von Schon had hoped that these ventilation needs could be met by the addition of a few dormers. But Union Carbide insisted on a ventilator running the full length of their furnace room. Thus the portion of the powerhouse between the eastern and center pavilions had a monitor installed on top of the roof, while the roof of the western or power company’s side of the powerhouse did not.
Inclined cast iron and concrete buttresses added in 1969.

North Elevation

South Elevation

First (Turbine & Generator) Floor

20 30 40 50 60 70 80 90 100

100 200 300 400 500 600 700 800 900

Meters 1 2 3 4 5 6 7 8 9

Plms

50 45 43 40

Firm
Auxiliary Works

Unlike the overall design of the power canal and the powerhouse, the project's auxiliary works—headgates, ice racks, penstock gates, and compensating works—were not completed until far into the construction phase of the project.

Gates to control the entrance of water into a penstock and racks to prevent trash and floating ice from reaching the turbines are standard parts of any hydraulic plant. For an ice and trash rack von Schon originally planned to use conventional methods—iron grillwork placed in front of each turbine bay. But this would have required 1,300 feet of iron grillwork. To cut costs in 1899 he developed an alternative scheme. He designed an iron grill mounted on an A-frame, which was to be placed 200 feet in front of the powerhouse, just where the forebay began to widen. This design required only 300 feet of grillwork. The rack was V-shaped, and had an ice or trash flume mounted on timber trestles leading from the apex of the “V” to penstock 43, which was used as a general spillway.44

Von Schon also worked out a way to cut the cost of penstock gates needed to shut off water flow so the turbines could be repaired or serviced. Originally he had intended each penstock to have a roller gate.45 But in 1899 he replaced the 80 plus roller gates with a single traveling derrick mounted on rails. This derrick was to be used to lower timber frame sections into gate post recesses set in front of each penstock. Thus instead of 81 gates, the power company would need only a single traveling derrick and sufficient timber frame sections to close off a half dozen or more penstocks.46

The headgates for the plant were originally planned for just above the point where the canal began to widen into the forebay and were to be mounted on the Portage Street bridge.47 In 1899 von Schon moved them upstream almost two miles, putting them nearer the intake, where the gates could be closed to drain water from the entire canal, not just from the forebay and turbine chambers.48 Exactly where in the intake area the gates were to be placed long remained in doubt, even after the decision to move them to the intake area had been made. The ultimate location was finally settled only in 1900 as a result of a Clergue scheme that never matured.

In the fall of 1900 Clergue was considering the possibility of extending the railroad he had created on the Canadian side of the river (the Algoma Central Railroad) to connect with the terminal railroad planned by the Michigan Lake Superior Power Company by means of a new international railroad bridge. By locating the new bridge just upstream of the existing Canadian Pacific railroad bridge (completed in 1887), Clergue could erect its approaches on lands his companies already owned. Clergue thus suggested to von Schon that he place the headgates for the canal on a line with the location projected for the new international bridge (which never was built) and give the headgates a base structure substantial enough to double as a railroad bridge across the power canal.49

This settled the location of the headgates. The form that they took—stoney sluice type (vertical lift gates between stone piers)—was also in part determined by Clergue’s scheme.
Headgates (or movable dam) designed for the Michigan Lake Superior Power Company by Ralph Modjeski in 1901.

Von Schon had been seeking a cheap method of controlling water flow in the canal, instead of the rather expensive stoney sluice gates. Clergue, who did not usually intervene too strongly in purely technical matters and was usually on the side of economy, pressed von Schon in May 1901 to adopt the stoney sluice design. He seems to have felt (and rightly so) that the piers for stoney sluice gates could be adapted easily to create a railroad bridge across the canal if it were needed.

The design ultimately adopted for the headgates utilized five broad masonry piers. Four vertical gates 50 feet wide by 25 feet high slid up and down in recesses built into the western or upstream edge of these piers. The tops of the piers were fitted with steel frame towers that supported the gears, shafts, and counterweights used to lift and lower the gates. The extended downstream parts of the piers were connected by a reinforced concrete arch roadway, conditioned for either a rail-road or a highway crossing of the canal. The detailed design of the headgates was carried out by Ralph Modjeski, a close friend of Noble. A prominent consulting engineer operating out of Chicago and at the very beginning of a long and distinguished career, Modjeski used only the best consulting engineers on the projects.

Just about the last element to be designed was the compensating work that the company was compelled to erect in the rapids to avoid damaging navigation on Lake Superior and in the St. Marys. The question of compensating works was considered settled by the company following Noble's report in early 1898—submerged weirs covering spans 7, 8, and 9 of the International Bridge would be sufficient. Shipping interests, however, were concerned about the proposed diversion and apparently brought the power plant to the attention of Lt. Col. G. J. Lydecker, District Chief of the Army Corps of Engineers, in Detroit. On September 10, 1898, Lydecker wrote Brigadier General John M. Wilson, Chief of Engineers, concerning the proposed power development at Sault Ste. Marie, suggesting that its power canal would be a hazard to navigation and that the company was dredging in a navigable water-way without a Corps of Engineers' permit (dredging had begun in the intake area by this time). Lydecker suggested that the Corps secure an injunction or restraining order against the Michigan Lake Superior Power Company.

Wilson, however, referred the matter to Secretary of War, Russell Alger, who ordered an investigation of the matter by a three-man board of the Corps, chaired by Lydecker. This board convened in Sault Ste. Marie in November 1898 to review the power company's plans and hear the complaints of the Lake Carriers Association. The Lake Carriers feared the diversion would lower the levels of Lake Superior, even with compensating works, and believed that loss of even an inch of depth would cost them thousands of dollars.

Before the board met, Clergue and his associates attempted to mollify Lydecker and the Corps of Engineers. Although they had operated under the assumption that the state of Michigan's authorization of diversion (under Act 39 of 1883) was sufficient, the company now submitted a petition for permission to di-
vert water and forwarded for the Corps' inspection an outline of company plans, including Noble's projected compensating works. Clergue also informed Lydecker that he had not realized that the company's dredges had been operating in what was considered to be a navigable part of the river. In effect, the Lake Superior Power Company acknowledged the Corps' jurisdiction over diversion of water from a navigable waterway.

During the Corps' hearing in November 1898 the project's future was further clouded by claims made by William Chandler, part owner of a small hydroelectric plant and several islands situated in the rapids. Chandler claimed, as owner of riverfront property along the rapids, to have ownership of all waterpower that could be developed from the rapids.

The board's report to the Secretary of War was a major blow to the power project. Lydecker's report supported Chandler's claim to the Sault's waterpower as being founded in common law, superior to any rights conferred by the state of Michigan on the power company, and he recommended that before any permission was granted for work to continue, the power company should be required to present clear and unequivocal title to the water it intended to divert (presumably through some settlement with Chandler). The board also rejected the company's plans for compensating works, arguing that since these works would be located on the Canadian side of the river, they would be beyond the Corps' jurisdiction. And, the board charged, the plans made for the compensating works were "largely based on theoretical assumption not fully established by observations." The board also recommended the formation of an international commission, composed of representatives from the United States and Canada, to study and regulate the use of power at the rapids, to establish the boundary line through the rapids, and to determine an equitable division of power. Lydecker urged that no developments using the St. Marys' water be authorized until such an international commission was established.

The report of the Corps of Engineers' board, if accepted by the Secretary of War, would not only have indefinitely delayed completion of a design for the compensating works; it would have killed the entire project. The affair was a terrible shock to the officials of the Lake Superior Power Company. No interference from the Corps had been expected so long as navigation was not interfered with. Chandler's claims were particularly shocking since he had been a promoter and stockholder with the St. Marys Falls Company, had encouraged Clergue to purchase the properties of that company, and had been employed by MLSPC as a negotiator in securing right-of-way from property owners and franchises from the city.

To counteract this disaster Clergue and Douglas wrote directly to the Chief of Engineers and the Secretary of War, and also sent a special emissary to Washington. They argued that except for Islands #1 and #2, claimed by Chandler, the lands under the rapids (and thus the waterpower as well;) were unsurveyed and thereby public, owned by the US government. The company offered to modify the compensating works to satisfy the War Department. And while they still planned to build these works at their own expense on Canadian soil, the company offered to protect the water levels in the lake and river by giving the War Department complete control over the power canal's headgates and the amount of flow allowed into the power canal. Clergue and Douglas pointed out that they had already spent $600,000 on the power project, and planned to spend $3 million more. Halting construction would result in major injury to the commercial interests of Sault Ste. Marie and to the state of Michigan.

In Secretary of War Alger they found a sympathetic ear. Alger was a Michigander and an ex-governor of Michigan. He had been one of the stockholders in the canal company organized by Seymour in the Sault in the 1870s. In addition, there were deep jealousies at this time between officers of the line (the Corps of Engineers) and the bureaus that governed them. As a result of one or more of these factors, or because he was honestly persuaded by the power company's arguments, on March 22, 1899, Alger sent Douglas a letter that advised him that as long as the works did not impair or obstruct navigation, it was not necessary for the Department of War to grant a license or permission to complete the works.

Although full documentation is absent, evidence seems to suggest that after Alger's letter, the Army Corps of Engineers dropped its unconditional opposition to the power project. By the summer of 1899 it was pushing, instead, for the substitution of a series of sluice gates (similar in form to those being planned by the power company for its headgates) for fixed structures (submerged weirs and wing dams) preferred by the MLSPC. Gate-type works would give the Corps the ability to artificially regulate the levels of Lake Superior and thus, to improve navigation conditions. Fixed structures would only have kept conditions as they were.

The power company, at first, opposed this plan. In August 1899, however, following a conference with Corps officials, they agreed to a combination system—part stoney sluice gates, part submerged weirs, with perhaps a temporary wing dam. Noble was asked to
redesign the works accordingly, and in January 1900 the power company retained John Kennedy and George Y. Wisner to report on the probable effects of the modified works. Kennedy was a prominent Canadian engineer, a member of virtually every important royal commission dealing with Canada's waterways and waterpower, and the man who transformed Montreal into one of the world’s leading ports. Wisner, a member of the US Deep Waterways Commission and a consultant on many improvements made to the southern coastline of the United States, was a prominent American hydraulic engineer. In March 1900 they approved Noble’s revised plans. These plans called for four stoney sluice gates to be installed above the ninth span of the International Bridge (each 54 feet 3½ inches wide and 12 feet 11½ inches high), submerged weirs to cover spans 7 and 8, and a fixed wing dam or embankment connecting the stoney sluice gates to the shore and covering the tenth span.

Matters, however, were not allowed to rest. While the Corps was placated by these modifications and the opportunity it offered them to artificially regulate lake levels, the Lake Carriers were not. They appealed to the chairman of the House Rivers and Harbors Committee, who called hearings on the question in February of 1900. The Lake Carriers attempted to push through the committee a resolution barring any diversion of water from the St. Marys. But Clergue and his associates, after exhaustive consultation with the Lake Carriers’ Association, finally convinced them that the incorporation of movable gates in the compensating works would yield a positive benefit to navigation by maintaining higher levels and allowing boats to carry heavier loads without fear of grounding. The results of the negotiations between MLSPC and the Lake Carriers were embodied in the Rivers and Harbors Act passed by Congress on June 13, 1902. In brief, this act authorized diversion of water from the St. Marys under certain conditions. The diversion could not diminish water levels; the compensating works had to be constructed and maintained by the company; the operation of these works would be subject to any future international commission established; and the Secretary of War could impose on the operation of the compensating works any rules or regulations necessary to prevent injury to navigation. The act specifically avoided the question of who owned riparian rights to the rapids.

The specific location of the compensating works, like the ultimate location of the headgates, was determined by Clergue’s scheme for a new international bridge. Before this scheme had emerged, plans had been to locate the compensating work below the existing International Bridge so that the bridge itself would offer some protection from ice during winter. There was also some thought given to locating the works under the bridge, using its piers as part of the design. These ideas were rejected in 1900. Clergue decided to locate the works upstream from the International Bridge and to construct the stoney sluice piers for the compensating works, like those of the headgates, with sufficient strength to support a railroad bridge. The location upstream from the existing bridge meant that a new bridge, if it were ever constructed, could be given approaches entirely on company-held lands.
The Electrical Installation

The one portion of the hydro's design that was out of the hands of the company was the electrical installation in the eastern or Carbide portion of the powerhouse, since the company planned to sell mechanical power at the turbine shaft. Expecting the power company to move forward quickly with the construction of the hydroelectric plant, especially since the contract signed in April 1898 had called for delivery of 10,000 hp within 24 months, Union Carbide acted quickly to finish the electrical design for its half of the powerhouse.

By June of 1898 Union Carbide placed an order with the Walker Company of Cleveland for half of the equipment they contemplated installing. The Walker order called for 20 alternators and 5 exciters. The alternators were standard rotary-field design, intended to operate at 180 rpm and deliver 500 hp with 93% efficiency. Since the plans were to place the carbide furnaces on a floor directly above the generator room, Union Carbide ordered low voltage machines. Contract specifications called for armatures wound so that either 100 or 200 volts could be delivered to the bus bars. Carbide, at this point, was apparently still not irrevocably committed to the location within the powerhouse since the contract also contained a clause that would have required Walker to modify the machines at Union Carbide's request to operate at 1,000 or 2,000 volts. The switchboard panels to accompany the alternators were standard design, 24 inches wide, with the usual switches and meters.73

It was expected that this equipment would occupy about 20 penstock units. Since Union Carbide expected to occupy 40 units eventually, the Walker Company agreed in the contract to furnish a duplicate set of equipment at the same price, under identical terms, within a three-year period, if requested. Electrical World noted that this battery of Walker alternators formed possibly "the largest single order for alternating machinery ever placed."74

The alternators were to be arranged in the generator room in groups of four. Each group of four alternators would have a 100 hp dc exciter placed in the middle and driven by belt from a pulley on one of the turbine shafts, but designed so that it could be driven by either of two shafts. Each generator would have its own switchboard placed on a gallery directly above. The leads from the generators were to be carried from the stationary armature directly up to the switchboard panel. All of the panels were to be connected by massive bus bars, which would carry the low voltage, high amperage (c. 1800 to 2000 ampere) current upstairs to the Horry rotary furnaces. For each set of four generators there would be six Horry furnaces, four in operation at any one time, the other two held in reserve.75

Plans for the electrical installation in the company portion of the powerhouse remained up in the air through 1898 and for several years after, primarily because of uncertainty about who the customer(s) for the company's power would be. It was not until early 1902, when the entire development was nearing completion, that any definite decisions were made on the company's electric power plant.

While some elements of the development were not settled until 1902, plans for the basic elements—power canal, powerhouse location, and the design of both of these—were thought to be finished by the summer of 1898. Specifications were, therefore, drawn up for transmission to contractors for bids, with an anticipated completion date for the project of January 1900.

This date was hopelessly optimistic in view of the magnitude of the development being planned and its location. A brief glance at Table IV indicates just how large the Sault plant was, compared to other turn-of-the-century hydroelectric installations. No previous plant even approached the 30,000 second feet of water the Sault was to use.76 No contemporary hydroelectric plant was built to house nearly as many turbine units or turbine runners or electric generators. The size of the powerhouse itself was unprecedented. And in
terms of designed power output (c. 40,000 hp), there was no other low-head hydroelectric plant of comparable magnitude, and only Niagara Falls #1, among all hydroelectric plants—high, low, or medium head—produced more power. Moreover, the plant was being constructed in a sparsely populated area, far from manufacturing centers and a reliable labor supply.

**Construction: Building the Hydro, 1898–1902**

A concise and easily comprehensible description of the construction of the Sault hydroelectric plant is almost impossible because the work proceeded simultaneously in so many areas. For instance, in late 1901 various contractors or company employees were erecting walls of the intake section; excavating in the rock section and the lower intake section; excavating in the earth section of the power canal; installing piles and timber lining in the earth section; excavating in the forebay and constructing the embankment lining there; working on the powerhouse superstructure; erecting a coffer dam around the compensating works site; working on the substructure at the headgates; and installing turbines. All of this work followed the process of evaluating bids and letting contracts.

Tenders were invited by the power company for the construction of the power canal in April 1898, immediately after the contract with Union Carbide was signed. The bids were opened on July 1, 1898, but the contracts were not concluded for several months, an omen of things to come. Redesign work necessary to accommodate Union Carbide and the renegotiation of the franchise with the city were responsible for this first of many construction delays.

When the contracts were sent out for bids, it was anticipated that the plant would be completed by January 1, 1900. This date was steadily moved back as things began to go wrong. By early 1899 completion was expected no sooner than the summer of 1900. By February of 1900 the date for the opening had been moved back to November 1, 1900. By April of 1900 it was expected in 1901, and by early 1901, it was clear that the hydroelectric plant could not be opened until the following year. In fact, it was not until the fall of 1902, fully two and one-half years behind the original schedule, that the hydroelectric plant was substantially ready for operation.

From the start, construction delays began to build on one another. For instance, the delay in awarding contracts meant that none of the contractors were able to assemble their plants and begin construction before September or October of 1898. This left only a month or two of suitable weather before the winter set construction further behind schedule.

The Sault's long and hard winters were one of the major factors delaying completion of the powerhouse. Working conditions during the winter months were often so intolerable that construction ceased or slowed to a crawl for months at a time. For instance, Hubbell, the company with the contract for dredging the upper intake, usually ceased operations completely for the winter as ice made dredging and other work nearly impossible. Thus, every December or January all dredging and retaining crib construction ceased at the upper intake, not to be renewed until late March or April. As a result Hubbell, who had contracted to complete the upper intake by April of 1901, did not finish the job until November of 1901. In the main part of the canal the chief contractor was the E.D. Smith Company of Philadelphia. The severity of the winters caused it to cease operations for the winter of 1898–1899, and for the winter of 1899–1900 in the rock portion of the canal. This put the work hopelessly behind schedule. Smith, in an effort to regain lost ground, attempted to continue operations through the winters of 1900–1901 and 1901–1902, with some success, but was never able to catch up.

Certain processes simply could not be carried out during the Soo's winters and had to wait for warm weather. For instance, the clay puddle that was to be placed beneath the timber lining in the earth section of the power canal had to be mixed and poured at temperatures above freezing to insure a good seal. Thus work on sealing the timber lining, begun in the spring and summer of 1901, had to cease for the winter of 1901–1902. Work with concrete was also near impossible under freezing conditions, since it would neither set nor season well. Hence the preparation of pre-moulded concrete blocks, the pouring of the monolithic concrete in the foundations and powerhouse substructure, and masonry work generally at the powerhouse site and along the canal usually had to be suspended every winter.

Material and labor shortages also caused construction delays. Sault Ste. Marie's isolation from the country's major population and industrial centers and the magnitude of the project made both supplies and labor difficult to come by. Although von Schon made a Herculean effort to insure the steady flow of supplies, there were serious breakdowns. One of the reasons, besides the severe winter weather, for Hubbell's tardy completion of the intake was a difficulty in securing sufficient timber of the right dimensions for the retaining cribs. Work on the coffer dam at the powerhouse site, and hence the whole construction schedule for the powerhouse itself, was
set back by difficulties in securing timber piles. And when the coffer dam was finally completed and work began on the foundations the contractors had additional problems in securing timber piles of sufficient length.

The geographical isolation of Sault Ste. Marie, the severity of its winters, and the sparse population of the Upper Peninsula made labor an even more serious obstacle. The region simply did not have a sufficient reservoir of cheap seasonal labor to support a large-scale construction project. Thus as early as August 1899 von Schon was running into problems and contacting employment agencies asking for 200 to 300 men immediately, and even more the following spring. In October he wrote the U.S. Assistant Engineer at Duluth that work was “much hampered at this point in concrete work for the want of experienced men.” In October 1901 von Schon reported to Clergue that there were barely enough men to keep excavation going in the forebay area. At about the same time von Schon was trying to secure 400 to 500 men, “making efforts... at many point[s] throughout the country.” The power company at this time was offering employment agencies and labor contractors $1 per head for any laborers they could recruit, plus free transportation to the Soo. Even when successful in luring men to the site, the results were often disappointing. For instance, one contractor brought in 48 head in 1901. Only 5 of the 48 reported on the fifth day of work, and many worked less than a day.

Still other factors created major delays in construction. For instance, the scows that Hubbell used to haul away material dredged up from the intake were dumping their loads near the Canadian shore in 1898 and 1899. Objections from the Canadian government over this practice slowed dredging work for a few weeks in 1899 until the matter was settled. More significant delays were caused by poor organization of the work by the contractors and faulty design decisions by the power company. The faulty organization of construction by the contractors significantly slowed work in the intake and power canal, while at the powerhouse faulty engineering decisions caused problems.

The major contractor who performed best was Hubbell at the intake. Despite completing his contract over 18 months behind schedule, von Schon was largely satisfied with Hubbell’s performance. But even Hubbell was plagued with faulty organization. Von Schon noted that Hubbell had not brought sufficient scows to the Soo, so the dredges often had to cease work while waiting for available scows to return. Von Schon also noted that delays in crib construction caused dredges to have to reprepare crib sites.

The general plan of construction in the rock section of the canal involved the use of channelling machines to block out sections of rock. Drill crews with pneumatic drills followed and drilled holes in the rock for the blasters. Blasters then filled the holes with explosives and touched off the charges. After the rock had been blasted, a steam shovel or locomotive crane loaded it into dump cars running along temporary tracks. Locomotives hauled cars to a dump area and then returned them empty to the canal cut for refilling. In the earth sections of the canal, operating methods were slightly different. Channelling, drilling, and blasting were usually unnecessary, and steam
shovels did most of the excavation. Removal of material involved the same combination of temporary track, dump cars, and locomotives as in the rock sections.18

The E.D. Smith Company, the general contractor for the canal excavation, made several errors, which delayed work. In 1898 and 1899 they brought in only 2 or 3 steam shovels, 4 locomotives, and less than 100 dump cars, a plant clearly insufficient to complete the work on schedule. Von Schon, after vainly pleading with E.D. Smith representatives in the Sault to enlarge this plant, finally urged Douglas, the MLSPC president and a Philadelphian, to use his connections with the contractors, a Philadelphia firm, to bring in more equipment. Possibly under this pressure E.D. Smith slowly increased their plant, adding 3 more steam shovels and additional dump cars. Von Schon was never completely satisfied, but the additions did represent a substantial increase over initial conditions.19

Other problems in organizing construction equipment also delayed the work. Von Schon planned a very methodical excavation in the earth section. Beginning at the lower end of the canal, excavation was to be carried upwards towards the intake, with the timber lining added as cuts were completed to prevent the canal banks from collapse in rain. His program was designed to insure that water would always drain from the canal excavation into the forebay where it could easily and conveniently be pumped into the river.20 But the E.D. Smith Company excavated in a very haphazard, disorganized fashion, making seemingly random cuts in every direction and completely ignoring the threat of bank collapse. Boiler, the power company consultant, observed after touring the construction site on one occasion that the earth section had been "gnawed" all over in "a disjointed sort of way," without methodical excavation.21 The results of this policy were, at times, almost catastrophic. On
June 6, 1899, a large rainstorm caused major bank erosion and washing at several points along the canal route. It flooded the partially excavated channel, and put several steam shovels out of action for over a week. In December of 1899 another rainstorm filled the rock cut to a depth of 16 feet, nearly submerging two steam shovels and delaying work for 10 days. Mushy soil conditions created by poor excavation procedures led to constant problems with bank slides; they also caused the service track to shift under the weight of dump trains, derailing or overturning locomotives, cars, and cranes.

Another problem in E.D. Smith’s construction involved the removal of excavated materials to dump sites. Until March 1900, under the terms of the original contract, E.D. Smith was to haul excavated material to sites designated by the power company. As with excavation equipment, von Schon felt that the E.D. Smith Company had not placed enough locomotives and dump cars in service, and he complained that steam shovels and the locomotive and steam derricks were often forced to suspend work to wait for the return of dump trains. He also complained about the poor organization of dump train traffic and inefficient dumping procedures. To remove this almost constant source of friction the power company finally assumed responsibility for the dump trains in early 1900. But even this did not completely solve problems. Von Schon charged that the steam shovels and cranes overbalanced the dump cars and that the dump trains were delivered to the canal banks, where the company took charge of them, in small lots.

The construction company, it should be noted, was not entirely at fault for the mismanagement of dump trains. The power company’s dump grounds were inadequate on occasions, and some of the designated dumps were located over the muck formation, which caused tracks to sink whenever a load was brought in, causing derailments and lost time.

Some faulty design work also contributed to the delays in completing the power canal. As originally planned, the earth section was to be covered with a timber lining shaped like a trapezoid. The prism was used in the sand section (Section II) of the canal, but two major slides in the clay section (Section III) convinced von Schon in 1900 that a milder slope was necessary there; that the banks of the prism were too steep for soil conditions. Thomas Monro, a hydraulic expert, was called in on Noble’s recommendation to consult with von Schon on the issue. They changed the trapezoidal prism in the clay section to a semieliptical prism by replacing the single slope of the trapezoid with three less steep slopes. The depth and width of the canal in this section were increased slightly to maintain a uniform cross-sectional area. The modification
worked well, but delayed the work.

Thus a wide range of problems slowed construction on the MLSPC power canal. Construction mismanagement, primarily on the part of the contractors, was largely to blame. But severe weather, labor problems, materials shortages, and design flaws all contributed. After getting off to a slow start in the fall of 1898 excavation on the power canal never caught up to schedule. By the fall of 1899 it was clear that the canal could not be completed anywhere near the original deadline of January 1900.30

Work on the powerhouse proceeded while the canal was being dug. Because the foundations of the powerhouse were to be well below the surface of the St. Marys, a coffer dam had to be constructed around the site and the water pumped out before the surface could be dug and leveled, the foundations fixed, and the substructure (tailrace channels and partition walls) erected.

The powerhouse contractors (Mason and Hodge of Louisville, Kentucky) and the power company encountered many of the same difficulties and delays here as in the power canal. A shortage of timber piles delayed completion of the coffer dam; Mason and Hodge excavation equipment was not heavy enough to provide sufficient fill material to keep up with the pile drivers at the coffer dam; and the severe winters hindered masonry work. The most critical delays in powerhouse erection, however, were not due to material shortages, labor shortages, construction equipment mismanagement, or severe weather, but to design error.

During the planning stages of the project, von Schon and his staff made only eight borings at the powerhouse site. As already noted, all of these borings seemed to indicate a fairly regular clay formation beneath the river muck and gravel. But when Mason and Hodge dredges began preliminary excavation on the powerhouse site before the coffer dam was completed, they found that the clay formation was not as regular as anticipated. Between the points where the test borings had been made in 1897 the dredges uncovered pockets and gulleys filled with silt as much as 6 to 13 feet below anticipated foundation levels. The dredging also indicated that the clay bed sloped from east to west, and that it was considerably below the anticipated foundation level on the west end.31 These discoveries forced von Schon to move the powerhouse 100 feet southward in late November 1898, wasting, in effect, almost two and a half months of Mason and Hodge dredging work.

Even after the powerhouse had been moved, the foundation problem was not completely solved. Von Schon had hoped relocation would provide him with a solid clay bed for the foundations. But after completing the coffer dam and excavating to the projected foundation depth, he found that the dip in the clay slope from east to west still left the western end of the foundation several feet above the natural clay bed. Moreover, where a small creek had once entered the river, near the center of the site, a silt seam penetrated well below foundation level.

The silt pockets discovered in the clay and the generally irregular nature of the clay formation compelled von Schon in early 1899 to completely redesign the foundations.32 Original plans were to drive 1,050 hardwood strain piles some 16 feet into the clay formation. These piles were to be anchored in the poured concrete foundation of the powerhouse by
timber grillage. Finding that he could not have a level clay bed for the support of the powerhouse, von Schon attempted to compensate. The silt pockets and seams were dug out and filled with clay. He replaced the 1,050 hardwood piles with 10,080 softwood bearing piles 20 to 30 feet long. These were to be 3 feet apart running the length of the building, 3.5 feet apart across the width, and driven to refusal. In an additional attempt to insure the safety of the foundations, von Schon planned to drive 6-inch-thick sheet piling (built up from 2-inch-thick planks) 8 to 16 feet down around the entire foundation. All of these design changes slowed the work, and the powerhouse was not completed until October 1902—two and one-half years behind schedule.

The plant's chief auxiliary works were also delayed, but for different causes. The movable dam or headgates were late because of the indecision regarding their location, and then, after the location was selected to conform to Clergue's plans for a new international river bridge, because of the E. D. Smith Company's slowness in completing the lower intake. Construction did not even begin until October of 1901.

Similarly, indecisiveness regarding the form and location of the compensating gates delayed their construction. The debate over their form largely resulted from the legal barriers being thrown up by the Corps of Engineers and the Lake Carriers Association, as noted previously. After these matters were settled and the design was more or less completed in mid-1900, further setbacks resulted from the company's inability to decide on a specific location for the works, a matter also finally decided by Clergue's scheme for a new international bridge. Construction on the four primary compensating works began under the direction of George Stickney only in June 1901. 

A conventional construction schedule for the headgates and the compensating gates, as for the powerhouse, would have included the suspension of work over the winter months, since pier foundations and the piers themselves were to be poured concrete. But because of the late start of the work at these sites, this policy was abandoned for expensive, but workable, methods of continuing operations through winter. Shacks were erected over the entire construction site at both the headgates and the compensating works. Inside the shacks coal-fired stoves maintained the temperature at around 40° F even when outside temperatures dropped below -20° F. This permitted concrete work to continue on foundations and piers through the winter of 1901–1902. In the spring of 1902 the shacks were removed and the work rushed to completion. The four stone sluice gates for the compensating works were completed in June of 1902 and the headgates were finished in October of that year. Shortly thereafter, the embankment connecting these gates with the Canadian shore was completed, but the submerged weirs originally planned for part of the river remained unbuilt. Clergue and Douglas, already plagued with severe cost overruns and delays, apparently felt that the works erected were sufficient to allow a diversion of 10,000 second feet and that this diversion was sufficient to provide power to meet immediate contract requirements and other needs. They planned to expand the compen-
Rear of the powerhouse, July 26, 1901. The completed tailraces or tail pits are below the partially completed masonry wall of the generator room. The coffer dam is at the right. Courtesy of Edison Sault Electric Company.
sating works as Union Carbide expanded its plant and as other customers for power were found.38

Turbine installation at the Sault was hampered by quite different problems. The contract signed with Webster, Camp and Lane in 1899 conditioned acceptance of the turbines on their meeting certain power, efficiency and discharge criteria as determined by Holyoke tests of a trial unit that began in March 1900. The runners had previously been tested by J. & W. Jolly in a vertical setting, and on the results of these tests Jolly and Webster, Camp and Lane expected to comply with contract requirements.39 However, the results of the first set of tests on a pair of Jolly-McCormick units situated horizontally and running at 180 rpm fell 13 hp short of the 282 hp required by contract.40

Since von Schon, who had personally traveled to Holyoke to observe these experiments, was needed in the Soo, he had the company retain Gardner S. Williams of Cornell, a well-known American hydraulic engineer, to direct...
additional experiments on modified units at Holyoke. Through 1900, under Williams' direction, tests were carried out and modifications made on the standard Jolly-McCormick runners. The discharge edges of the runners were beveled off, the distance between runners enlarged, the form of discharge case enlarged, the draft tubes modified, and the center bearings altered. Only around December 1900, after von Schon had begun to despair of ever getting the units up to requirements, did a modified set of runners perform at or above specifications. Even then MLSPC's acceptance of the units was held up by a dispute between Williams and the Holyoke engineers over methods used in measuring the flow of water into the test flume. After this was settled in early 1901, however, work proceeded rapidly, and by May 1902 all 40 units originally ordered were in place, a little over a year behind schedule. Two additional units were ordered and installed before December 1902.

The electrical equipment in the Union Carbide portion of the powerhouse and the design of the electrical control apparatus had already been largely settled in 1898, although Westinghouse had assumed the contract original to develop 5,000 hp—3,000 hp in the specifications. By December plans were to use direct current machines for the street railways, but make the bulk of the installation alternating current. In December 1901 the company's newly hired electrical engineer, W. Owen Thomas, was considering the installation of enough dc machines for half of the anticipated dc load, using rotary converters to provide the other half as needed. The alternators that he planned to order were Stanley 400 kW, 30 cycle, 3-phase machines operating at 2,400 volts. The low frequency suggests that Thomas was anticipating that the power would be sold to some type of heavy industry for powering electric motors; the high voltage suggests this power was likely to be transmitted some distance from the plant, probably to industrial sites located on the company's properties near Little Rapids. Contemporary correspondence between Clergue and von Schon confirms this. They were now considering the possibility of installing a steel mill, and, as an alternative, Clergue was considering the possibility of transmitting power to the Lower Peninsula at high voltages.

A final decision on the scope of the power company's electrical installation was made only in February 1903. At a personal conference with Clergue, von Schon was instructed to install electrical equipment for 5,000 hp including a single Westinghouse 375 kW, single-phase, 60-cycle machine that had been ordered in December 1901. The remainder of the equipment was to be purchased from the Stanley Electrical Manufacturing Company and was to be installed in penstocks 33 through 42. The contract with Stanley, signed on February 21, 1902, called for:

1: 130 kW frequency changer
6: 400 kW transformers (probably 260 to 16,500 V)
plus switchboard and test instruments for the above.

It was expected that the power company would eventually place orders for 33 alternators.

Thomas' switchboard design differed considerably from that planned by Union Carbide for their portion of the powerhouse in 1898. Thomas objected, for instance, to placing the switchboard panels directly above individual generators. This, he pointed out, would spread the switchboard over almost an eighth of a mile (and eventually a quarter of a mile) and would make it difficult for one man to operate the plant. Carbide's plans had called for connecting the generators and switchboards to a continuous set of bus bars running the length of the plant. This, Thomas noted, would require bus bars of enormous dimensions and would mean that a short circuit anywhere would shut down the whole plant.

Thomas proposed placing the basic means for controlling all 33 company units within easy sight and reach of a single operator. He planned to divide the switchboard into three sections with 11 generators per section, and to arrange the sections to form three sides of a square. The operator's desk would be in the center of this square. With conventional 2-foot-wide switchboard panels, this still would have meant an enormous area of switchboard paneling. Thomas, however, persuaded Stanley to redesign its instruments so that they would set edgewise (that is, in a vertical rather than a horizontal plane) in panels of about half the standard width. Similar instruments in this array of panels were to be placed in the same horizontal plane so that a glance at the edgewise instruments with their
horizontally situated points would normally give a continuous unbroken band around the operations room and any variations could easily be noted.

To reduce the size of the bus bars and the dangers of short-circuiting, Thomas planned two sets of bus bars, with each feeder and generator having a double-throw switch, so that every generator could be connected to either bar. If one bar shorted out, only half the plant would be shut down. None of the main circuits were to be brought directly to the switchboard as in the earlier designs. All control over the generators was by means of remote, electrically-operated switches. The bus bars acted mainly as load equalizers, with feeders tapping off the bars where the generators tapped in. Since only a small percent of the station output was to flow over the bus bars for any considerable distance, bus bar size could be reduced. Thomas also planned to install pilot solenoid circuits to protect the installation. These oil-immersed switches on a shunt circuit would be held closed by current flowing at normal levels, but would open automatically when overloaded or when no voltage flowed.

Thomas planned to connect the direct current units in parallel with a large chloride storage battery of 144 cells. This battery, rated to maintain a discharge of 500 kW for eight hours, was to help regulate dc output and absorb the excess power produced by the generators. For power transmission outside the plant Thomas called for Stanley water-cooled, oil-immersed transformers that would step up the voltage to around 15,000.

Equipment began to arrive in May 1902. Using a temporary switchboard and a few operative units, Thomas was able to provide electricity for the grand opening in October 1902. By December or January 1903 all ordered

| Table V |
| Primary Contractors Involved in the Construction of the Michigan Lake Superior Power Company Hydroelectric Plant |

E.D. Smith Company  
Philadelphia  

Mason & Hodge  
Frankfort, Kentucky  

H.W. Hubbell & Co.  
West Bay City, Michigan  

T.H. Riddle & Co.  
New Brunswick, New Jersey  

H.E. Talbot & Co.  
Dayton, Ohio  

Frankman Brothers & Morris  
St. Paul, Minnesota  

Dominion Bridge Company  
Montreal  

Charles Brown  
West Superior, Wisconsin  

American Bridge Company  
New York  

Russell Wheel and Foundry Company  
Detroit, Michigan  

Garry Iron & Steel Co.  
Cleveland, Ohio  

Excavation of the rock, earth, and lower intake sections of the canal; canal lining in earth sections; construction of intake coffer dams  

Excavation and embankment work in the forebay; construction of powerhouse coffer dam; excavation and construction of powerhouse foundations; construction of powerhouse  

Dredging of intake area and construction of retaining cribs for walls in that area  

Pile driving for coffer dam at powerhouse and for powerhouse foundations under sub-contract from Mason & Hodge; pre-moulded concrete block construction; pile driving for bridge abutments  

Substructure of headgates and compensating gates; breakwater for compensating gate site  

Timber bulkhead work along the canal; maintenance of temporary bridges and water mains crossing the canal; forebay ice/trash rack foundation; bridge abutments  

Steelwork on headgates and compensating gates  

Construction of machine shop and masonry work along canal bank  

Erection of steelwork in powerhouse  

Trash/ice rack in forebay; stairs in powerhouse; cast iron column bases  

Powerhouse roof
equipment had been installed. The company plant, at this point, consisted of six alternators, three dc generators, plus a rotary converter and belt-driven exciter unit, all connected to a temporary switchboard, which was eventually moved to an elevated platform on the wall directly above the generators. This arrangement, intended to be temporary, was to become semipermanent. It was to be more than 10 years before Thomas' rather innovative ideas for arranging electrical apparatus in a plant the length of the Sault plant were adopted.

As Thomas was working on the power company's electrical plant in 1902, it was anticipated that Union Carbide would order 42 Westinghouse 375 kW, 60-cycle, single-phase, 90-volt alternators, with two Westinghouse 220 volt dc generators as exciters. In 1903, however, when Union Carbide began to place their electrical plant in the powerhouse they installed 19 Westinghouse 90-volt, single-phase alternators; 3 Westinghouse 220-volt, two-phase alternators; and 2 Westinghouse 250-volt dc generators (for exciters). The 220-volt, two-phase machines were placed opposite penstocks 1 through 3, while the 19 single-phase units were placed on penstocks 4 through 22. Each alternator had a control panel placed on the gallery, which ran directly above the line of generators. Union Carbide generators were first placed on furnace load on December 23, 1903, and by January 16, 1904, all of the single-phase units, as well as the two-phase units, were in operation, the latter being used for general lighting and power load.

As one portion of the hydroelectric development after the other was finally completed in the summer and fall of 1902, plans were made for testing the power canal and powerhouse and for the formal opening of the plant. Water was first let into the canal on August 11, 1902, with the coffer dam behind the powerhouse still in place. Water was slowly allowed to rise; no problems were encountered. The coffer dam was then opened behind the powerhouse and the canal and forebay pumped out. Still no problems were detected. Corps of Engineers' officers, appointed by the Secretary of War to inspect the plant before issuance of a permit to divert water, observed the tests and approved the plant for operation. Although the permit was not issued until December 2, 1902, special arrangements were made with the Corps to admit sufficient water into the power canal to develop a head of 15 feet and to operate several token turbine and generator units for the grand opening on October 25, 1902.

The celebration planned by Clergue for the plant's opening was a gala affair, designed as much to attract more investment capital into his enterprises as to celebrate the project's completion. Invitations were sent to all members of the Michigan state legislature; to the governor; to the heads of the state governmental departments; to the US Congressional delegations from Michigan, Minnesota, and Wisconsin; to a large number of prominent American engineers; to leading businessmen from all over the state; and to representatives of the press. In addition, special trains, chartered at the company's expense, brought investors and potential investors from New York, Philadelphia, Chicago, Detroit, Montreal, and Toronto.

The local citizenry began the celebration a day early. On Friday, October 24, 1902, the power company feted the school children of Sault Ste. Marie in the quarter-mile-long second floor of the powerhouse, with 3,000 in attendance. Then, on the morning of the 25th, there was a large civic and military parade. At noon Clergue's sister, Helen, threw a gold and jeweled switch provided by the Stanley Electrical Company, setting two generators into operation, lighting up several strings of arc and incandescent lamps, and setting in motion a streetcar that ran over tracks laid from the powerhouse to the country club. In the afternoon adults of the region were treated to a banquet by the company on the huge factory floor of the powerhouse. Approximately 5,000 attended.

The more notable guests brought into the Sault by Clergue (approximately 400) had an even more elaborate banquet on the evening of the 25th in the local armory, served by waiters brought in from Minneapolis for the occasion. The speeches delivered by Clergue and others at the banquet painted a rosy picture of the future of Sault Ste. Marie. With the powerhouse completed, many felt it was only a matter of time until the Michigan "Soo" became a great industrial center.
The “Carbide” or second floor of the powerhouse looking west, October 24, 1902. This quarter-mile-long floor was filled with tables in preparation for the grand-opening celebrations. Courtesy of Edison Sault Electric Company.
Problems: The Hydroelectric Plant in the Lean Years, 1903–1913

The grand opening of the Sault hydroelectric plant was expected, by local residents at least, to herald a new era of prosperity and industrialization. It did not. Partially this was because the supposition the city had been operating on for decades—that cheap power would inevitably attract industry—was faulty. Equally important were the troubles encountered by the power development. Its impact on the region was weakened by: the financial disintegration of the company that owned the hydroelectric plant (the Michigan Lake Superior Power Company) and its parent company (the Consolidated Lake Superior Company); legal disputes over rights to the waters of the St. Marys; and the discovery of defects in the foundations of the powerhouse.

The Search for Customers

Even while Clergue was prophesying the growth of an industrial base in the American “Soo,” there were problems. The lack of applications for power generated by the Canadian canal had forced Clergue to organize industries to use that power. The Michigan canal was much larger and could cost much more. With most investment capital already committed to his industrial empire on the Canadian side of the river, Clergue resolved to begin construction of the hydroelectric plant on the American side only when a considerable portion of the power was leased. The contract with Union Carbide, signed in April 1898, had fulfilled this condition and signaled the beginning of construction. But Carbide planned to use only 20,000 of the 40,000 anticipated horsepower.

Thus between 1898 and 1903 Clergue continued to solicit customers, especially flour milling interests. He had little success. In June 1899 it did appear that he had found a customer for much of the remaining power. The American Alkali Company signed a contract for 15,000 hp and was to be given the west end of the powerhouse. But before the hydroelectric plant was completed American Alkali became involved in patent disputes, failed to meet certain charges due Consolidated Lake Superior, and in 1902 was forced into receivership. Also interested in the cheap waterpower of the Soo was an electrochemical company that planned to electrolytically extract the silver contained in copper and nickel ores. In 1898 there was talk that this plant would lease up to 10,000 hp, and in 1902 engineers for the prospective company even visited Sault Ste. Marie to select a site for the plant. But sufficient capital was not forthcoming and the plant was never built.

As the powerhouse approached completion in 1902 all prospective power leases, with the exception of the Carbide contract, had fallen through. This led to the decision of 1901–1902 to erect compensating works sufficient only to meet the immediate demands of the Carbide contract. Clergue was thus once again forced to consider duplicating his Canadian accomplishment—organizing industries himself for the American side. In 1901 Clergue had negotiated with various manufacturers of paper for the establishment of a paper mill at the Sault, with MLSPC providing free mill sites and free use of company docks and railways with the power lease, plus pulp at a competitive price. While negotiations with a Milwaukee entrepreneur, J. P. Hummel, over the issue failed, Clergue believed that a paper mill on the American side would round out the company’s pulp operations in a satisfactory manner. He was convinced that as soon as the company undertook erection of a paper mill on the American side “we shall be overwhelmed by applications from the big syndicates for some sort of a combination which will secure for us all the profits we ever asked for.” Once again Clergue persuaded his Eastern backers that a scheme was feasible. In 1902 the Great Lakes Paper Mills Company was capitalized, preliminary work was begun on a plant site, and a contract was signed with the Michigan Lake Superior Power Company. But the anticipated power requirements for the paper mill were small, so much of the power still remained to be leased. Clergue did secure a small experimental contract with the Hatch Smelting Company, but that was all. Neither of these projects matured.

The lack of industries willing to locate at Sault Ste. Marie and lease power pushed Clergue to more drastic remedies. In October 1902 he began to inquire about the possibility of transmitting electrical power to Michigan’s Lower Peninsula, specifically to Grand Rapids or Detroit, and in early 1903 he had estimates prepared to determine the cost of transmitting 25,000 hp to Detroit. These plans caused some consternation in Sault Ste. Marie, since local residents wanted all power to be used locally.

Besides the problem of finding new power customers, the Michigan Lake Superior Power Company was in some trouble over the power already leased to Union Carbide. The contract had been negotiated before construction started, when costs for the project had been estimated at $3 million. The final cost, including auxiliary structures and equipment, was between $6 million and $7 million. Thus the Carbide lease rate, $10 per horsepower per year, was much lower than was needed to provide a respectable return on investment.

The problem of attracting new industries to the Soo in 1902 and 1903, however, proved to
be only the beginning of the hydroelectric plant's problems. In fact it turned out to be no problem at all, because a mixture of financial, legal, and technical difficulties paralyzed the hydroelectric plant for 10 years. Between 1903 and 1913 this mix of problems ensured that the hydroelectric plant would generate no more than 10,000 hp of the 40,000 hp planned, and all of this power was absorbed by Union Carbide. For over a decade there was simply no additional power to lease.

The financial, legal, and technical difficulties that crippled the Sault Ste. Marie plant were complex and interrelated. But since money is the lubricant of industry, the financial dilemma faced by the Michigan development was central and will be considered first.

The Financial Dilemma

Even before the power canal and powerhouse were completed, the Michigan Lake Superior Power Company was deeply in debt and in serious financial trouble. Before the end of 1900, for instance, construction costs were approaching the $2.4 million raised by the sale of first mortgage bonds in 1898. Yet the power canal was less than two-thirds completed and only the powerhouse foundations had been laid. Clergue, who had not been keeping a close eye on expenditures, now wrote von Schon:

I have decided that our expenditures on the American side must be curtailed. We are so far exceeding all estimates which we have furnished to the Board of Directors as to excite their alarm. You will proceed with no further work other than that now under contract in respect to dredging or erecting of wharves at the head of our canal. You will purchase no more materials of any kind without first getting my approval in writing. But there was no escaping a considerable cost overrun. Additional capital to complete the Michigan project was provided by loans from the Consolidated Lake Superior Company's Canadian power company, the Lake Superior Power Company. These loans eventually totaled around $2.17 million. They were consolidated on January 1, 1903, in the form of $2.4 million of second mortgage bonds.

The cost for completing the canal, initially estimated at a shade under $3 million, ran to $6.5 million when costs were tabulated in 1902 and was later raised by subsequent tabulations to almost $7 million. Thus by the time of the grand opening in October 1902 the company owning the hydroelectric plant was in deep financial trouble. It owed $5.9 million on its first and second mortgages, had $1 million of unsecured debts to Consolidated Lake Superior, and owed $300,000 annual interest on its bonds.

In order to pay off these debts the power company had to begin full production immediately, but legal and technical difficulties intervened. Loans from the Consolidated Lake Superior Company had kept the company afloat through construction, and could, conceivably have alleviated, at least in part, some of the technical and legal problems. But late in 1902 the parent company began to have serious financial problems of its own, so additional support for the Michigan plant was not available.

The Consolidated Lake Superior Company had steadily expanded during the period of construction of the Michigan Lake Superior Company hydroelectric plant. From a company capitalized in 1898 at $20 million it had grown by late 1902 to a colossus with a capital of $117 million and an annual budget that at times exceeded that of the province of On-
Table VII
The Consolidated Lake Superior Company in 1903
(Capitalization in Parentheses)

Consolidated Lake Superior Company
($117,000,000)

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Capitalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Superior Land Company</td>
<td>($200,000)</td>
</tr>
<tr>
<td>Tagona Water and Light Company</td>
<td>($200,000)</td>
</tr>
<tr>
<td>Sault Ste. Marie Pulp and Paper Company (Algoma Iron Works)</td>
<td>($2,000,000)</td>
</tr>
<tr>
<td>International Transit Co.</td>
<td>($150,000)</td>
</tr>
<tr>
<td>Trans-St. Marys Traction Co.</td>
<td>($400,000)</td>
</tr>
<tr>
<td>Ontario Hudson Bay and Western Railway Company</td>
<td></td>
</tr>
<tr>
<td>Mantoulin and North Shore Railway Company</td>
<td>($1,000,000)</td>
</tr>
<tr>
<td>Michigan Lake Superior Power Company</td>
<td>($500,000)</td>
</tr>
<tr>
<td>Algoma Commercial Company</td>
<td>($10,000,000)</td>
</tr>
<tr>
<td>Algoma Steel Company Ltd.</td>
<td>($20,000,000)</td>
</tr>
<tr>
<td>Ontario Lake Superior Company</td>
<td>($24,000,000)</td>
</tr>
<tr>
<td>British America Express Company</td>
<td>($100,000)</td>
</tr>
<tr>
<td>Pacific and Atlantic Railway Company</td>
<td></td>
</tr>
<tr>
<td>Algoma Central and Hudson Bay Company</td>
<td>($10,000,000)</td>
</tr>
<tr>
<td>Algoma Central and Hudson Bay Railway Company</td>
<td></td>
</tr>
<tr>
<td>Sault Ste. Marie Terminal Railway Company</td>
<td>($100,000)</td>
</tr>
<tr>
<td>Lake Superior Power Company</td>
<td>($2,000,000)</td>
</tr>
<tr>
<td>Algoma Commercial Company</td>
<td>($10,000,000)</td>
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<td>Algoma Central and Hudson Bay Company</td>
<td>($10,000,000)</td>
</tr>
</tbody>
</table>
The rapid expansion of Consolidated with its steel mill, pulp mill, hydroelectric plants, steamship and railroad lines, created an aura of prosperity in the Canadian Soo. But the prosperity and growth of the company was largely dependent on the continual infusion of investment capital rather than on profits made by its subsidiary companies. Much of the business of the subsidiary companies was, in fact, done with each other. This internal flow of business gave the impression of prosperity and activity, but did not provide good return on investment. The small profits that were made by sales with outside consumers were plowed into new schemes, rather than used to provide working capital for existing operations.19

In early 1902 the Board of Directors of Consolidated Lake Superior began to show concern over a growing shortage of working capital and began to more closely control the subsidiary corporations. Essentially this meant closer control over Clergue’s schemes for further expansion. The plans for a paper mill on the American side of the St. Marys were thus scuttled. By this time, however, the structure of Consolidated and its allied companies had become so diverse and complicated that even the Executive Committee found that it lacked sufficient knowledge of the company’s operations “to enable it to intelligently discharge its duties.” Thus the Board of Directors in mid-1902 ordered the company’s president, Edward V. Douglas, to prepare complete financial statements showing the exact income of each individual company.20

The main reason for the confusion was that even though Consolidated’s main office was in Philadelphia, actual management was carried out by Clergue, whose offices were in Sault Ste. Marie, Ontario. All the central office did was to arrange financing. The bulk of the actual business was conducted far from the scrutiny of the Board of Directors. Douglas was the main link with Clergue. He seemed to have had considerable confidence in Clergue and did little to temper his freewheeling style. And Clergue, while a genius at initiating ventures, tended to give little thought to their operation once they were under way.21 As a result, many of Consolidated’s subsidiary companies were poorly managed and unprofitable.

Douglas’ report to the directors indicated that Consolidated was in grave financial trouble and needed an immediate infusion of $3 million in new capital to stay afloat, even if all new construction stopped. In November 1902 the company began negotiations for a $3 million loan and ordered all construction halted.22 The Michigan Lake Superior powerhouse, almost completed, barely escaped the axe. Despite the rapid fall of Consolidated stock on the stock exchange, a loan was arranged with the Speyer Company of New York for $3.5 million. The terms of the loan were severe. Speyer representatives supervised the use of the money and had the right to replace any or all of the company’s directors with their own nominees. Speyer also had complete control of all Consolidated securities. Douglas and Clergue, who had been primarily responsible for the rapid expansion of Consolidated Lake Superior, lost power during the financial crisis.23 Douglas resigned in the fall of 1902 after reporting the company’s financial plight to the directors. Clergue, under some pressure, resigned in April 1903 from his offices.24

Despite these and other changes, attempts to save the company failed. In September 1903 Speyer, after failing to put the company back on an operational basis, foreclosed on its loan, and one of the loan company’s representatives, Benjamin Fackenthal, was appointed receiver of Consolidated’s properties.25

Because the entire economy of the Canadian Sault was by 1903 dependent on the Clergue empire, the industries he had created were not allowed to disintegrate. Following riots by unpaid employees, the Ontario and Canadian governments stepped in. The provincial government agreed to guarantee an additional loan of $2 million and in other ways facilitate the rehabilitation of Consolidated Lake Superior. The province, however, insisted that the president of the new company be a Canadian. C.D. Warren, President of the Traders Bank of Canada, was selected. In May 1904 the Lake Superior Corporation was established with a capital of $40 million to replace the ill-fated Consolidated Lake Superior Company. Clergue was made a director and adviser to the new company since he had played a major role in negotiations with the provincial government and in the reorganization, but he was never allowed a major role in the new company’s operations, despite remaining in the Soo until 1911.26

The reorganized and refinanced company made arrangements to pay off the Speyer loans and other debts through a new bond issue. The United States Mortgage and Trust Company became trustee for the company’s bonds, with C.D. Warren serving as receiver for the mortgage on the company. Even though this reorganization seemed promising, the Lake Superior Corporation paid no dividends on its $40 million of capital stock and ultimately went into receivership in 1932. Not until 1935, when the weakest elements of the corporation were reorganized into the Algoma Steel Corporation, did Clergue’s industrial empire in the Soo begin to show a profit.27

Probably the weakest element in the Lake Superior Corporation was the Michigan Lake Superior Power Company. The overall condi-
tion of the hydroelectric plant was chaotic. The Michigan Lake Superior Power Company was $7 million in debt; the compensating works in the rapids were sufficient only for a diversion of 10,000 second feet; they could not be expanded without more money and until legal questions involving ownership of the St. Marys rapids were settled; the powerhouse needed repairs and modifications before even the existing generators could operate at full capacity; half of the penstocks still had neither turbines nor generators; Union Carbide was leasing power at a rate far too low for MLSPC to make a profit; and, provided all of these problems could be settled, it was questionable whether new industries to lease electric power could be found.

To make bad matters even worse, the mechanisms necessary to make any major financial or technical decision for the plant had been hopelessly complicated during the financial chaos of 1903. As Consolidated Lake Superior crumbled in 1903, the Michigan Lake Superior Company had defaulted on the interest payments to the first mortgage bondholders. In May 1904 the bondholder, Provident Loan and Trust Company, foreclosed as trustee for the first mortgage bondholders. Thus MLSPC had two managers, each representing different owners. The poor financial condition of the power company made the chance of attracting new investment capital poor; the problems involved in securing approval for expenditures from two different groups made it nearly impossible. The financial dilemma of the Michigan Lake Superior Power Company was further complicated and made almost completely insoluble by disputes over water rights and defects in the powerhouse foundations.

The Foundation Dilemma

Even before the grand opening of October 25, 1902, there were intimations of trouble at the powerhouse. On October 22, during preliminary tests, a slight deflection or bowing of the center of the powerhouse towards the river was detected at a head of only 7 feet. As the head was increased to almost 15 feet during the next few days the deflection increased to 1.25 inches. Water was drained from the canal shortly after the opening ceremony and the building was inspected. Inspectors found a slight crack at the east abutment and a small opening between the forebay wall and the timbers of the forebay apron at the center of the powerhouse. These flaws were repaired and the canal refilled. As the head increased to 16.5 feet, the deflection increased to almost 2 inches in the center. The western part of the building held firm, but the eastern end slid a half inch. The head was lowered to 13.5 feet and daily measurements were taken to detect further sliding towards the river.

Fearing for stability of the structure, von Schon consulted with Noble in late November or early December 1902. Following this conference von Schon acknowledged to Clergue that there was no way to predict the limit of deflection or just how much the building could bow and remain intact. But, he declared, the review he and Noble had made of the steps taken in construction to insure stability against sliding showed a large safety factor. He postulated that the deflection was probably due to the compression of the clay that sustained the pile foundation and should not cause too much concern. To arrest the movement of the east abutment, however, he recommended enlarging the east powerhouse dock. For the central deflection von Schon suggested, if conditions persisted, placing some submerged stone buttresses against the downstream face.

The deflection problem persisted. The deflection by February 7, 1903, had increased to 3 inches at a 16.5 foot head, and the plant had not yet begun to produce power for sale. This already troubled situation worsened when, at about 4 a.m., Sunday morning, February 8, 1903, an ice fisherman on the St. Marys near the powerhouse noticed that the usually crystal-clear water was so muddy that it was impossible to see into it. He reported this to the watchman at the powerhouse, who notified von Schon. Fearing that this phenomenon was caused by water under pressure rushing out of the forebay, under the powerhouse foundations, and churning up silt in the river bottom, von Schon quickly ordered the headgates shut and the power canal drained.

After the water was drained, inspection disclosed no serious damage to the powerhouse itself. But a massive cavern had been washed out from beneath the foundations, a cavern approximately 100 feet long, 120 feet wide, and an average of 10 feet deep. The washout appeared to have begun around penstock 50 where a small creek had once emptied into the river. Although the silt deposited where the creek had cut into the clay had been excavated and the volume refilled with clay, the foundation construction, the work had been incomplete. Some gravel, sand, or silt strata must have remained between the
natural clay bed and the filled area. Von Schon speculated that forebay water, under pressure, had followed this strata, washed it out, and had then begun to erode and wash out the clay puddle and the natural clay bed. The 8-foot-deep row of sheet piling driven around the foundations had been designed to protect the clay against this type of action, but had proven inadequate. 33

To repair the damage, von Schon had a sheet pile coffer dam constructed on the north side of the powerhouse, 2 feet in front of the foundation apron, extending across the washed out area and 100 feet further on either side. He covered these piles with heavy canvas and dumped coarse gravel on both sides. Divers then laid concrete in bags inside the sheet piling. To complete the filling of the 3,-000-cubic-yard chasm under the powerhouse von Schon had 7-inch holes drilled through the floors and foundations over the cavern. Sand and coarse gravel were forced through pipes inserted into these holes under pressure from water pumps until the northern half of the washout was very thoroughly packed. Sheet piles were driven 2 feet in front of the upstream edge of the foundation apron and extended east and west up the entire face of the powerhouse. This portion of the washout was also filled with sand and gravel, which was consolidated by cement grout forced in afterwards. 34

Von Schon's program of repairs was submitted to a consultation board consisting of Noble, Boller, and Samuel Whinery, one of Noble's associates. They visited the site and generally approved of von Schon's plans and actions. They recommended, in addition, that the entire forebay area be planked in a manner similar to the timber section of the canal, and that the 12- by 12-inch sills be connected by iron straps and braces to the masonry of the powerhouse. 35

The total repair program took much longer than anticipated. Von Schon had told Douglas' successor as president of Consolidated Lake Superior, Cornelius Shields, in early February 1903 that repairs would cost around $12,000 and be finished by early April. 36 The additional work recommended by the consultant board increased costs and delayed completion. 37 There were problems in securing planking for the forebay. 38 Construction equipment shipped in by rail could not be used immediately because freight charges could not be paid immediately because of the parent company's financial difficulties. 39 As a result, it was not until August 22, 1903, that the powerhouse resumed operation, and the total cost of repairs was not $12,000, but close to $180,000. 40

The foundation problems at the powerhouse, together with the repair cost overrun and the delays encountered in repair completion, destroyed von Schon's credibility with company officials. He was relieved of his duties on October 1, 1903, when the plant passed into receivership along with the rest of Consolidated Lake Superior. Boller made an attempt to have von Schon retained to direct the hydroplant he had constructed, declaring to Shields:

Mr. von Schon stands very highly among Hydraulic Engineers, is a man of the highest integrity, thoroughly versed in the Science of Hydraulic Technics . . . The care of these Soo hydraulic properties is a tremendous responsibility, and requires the highest technical skill, and conscientious qualities of character . . . You will find no better man in the Country for the custodianship of these properties than von Schon . . . 41

Despite Boller's financial involvement and long connection with the project, Shields demurred. He frankly told Boller that in his opinion von Schon was "not an economical man to handle work" and that he "very much" questioned his judgment. 42

The Sault Ste. Marie hydroelectric plant was the pinnacle of von Schon's career. Never again, after leaving the Soo under a cloud, was he chief engineer on a project of comparable magnitude. Von Schon's career, however, was not destroyed. After leaving the Soo he set up a consulting practice in Detroit, specializing in hydraulics. He directed the construction of small to medium-size hydroelectric plants at several points over the country. He designed and marketed a hydroelectric plant that placed the generator room within the dam, completely submerged by the overflowing water. He designed a water supply system for Highland Park, Michigan, where he made his home from 1904 to 1916. Between January 1913 and October 1914 he edited a short-lived periodical called Water Power Chronicle (later Water Chronicle), and he also published several editions of a work on Hydro-Electric Practice. Von Schon retired from active engineering practice in 1916 and died in 1931. 43

Hope that von Schon's 1903 repairs would solve the powerhouse's problems quickly proved false. As the canal was refilled, measurements were taken for deflection. Even with no water in the forebay the building remained bowed 2½ inches towards the river. As the head was increased the deflection increased. At 13.5 feet the deflection had increased only slightly, to 2% inches. The new chief engineer of the MLSPC, L.H. Davis, an 1892 graduate of Lawrence Scientific School, Harvard, pushed the head up to 14.4 feet through the winter of 1903-1904. In the spring he in-
creased it to 14.6 feet with no appreciable increase in deflection, hoping to push it ultimately to 14.7 feet so that he could secure 500 hp per turbine shaft. By the fall of 1904 he was operating the plant under a 15 foot head, at the cost of a slight increase in deflection. But his success was short-lived.

With the plant operating under 15 foot head on September 7, 1904, a new leak was discovered when muddy water was noticed on the north side of the powerhouse. Fearing that the leak had been caused by the building's deflection, Davis first lowered the head by 6 inches and later by a foot. The leak was not serious when detected, but it was alarming since it was located around penstock 50, the very point where the big 1903 washout was centered. Divers discovered the forebay apron had again separated from the forebay wall by as much as ½ of an inch and that the joints in the forebay planking leaked. They caulked crevices and openings with oakum and spread heavy sail cloth on the planking. By the end of the month the leak disappeared.

Although this leak was repaired without shutting down the plant, it was apparent that the 1903 repairs had solved neither of the major powerhouse problems: leaks and deflection. For the next six years forebay leaks were fairly frequent, and for the next twelve years the company was compelled to restrict its operating head to 14 feet.

Moreover, any slim hope that restricting the head to 14 feet would stop further deflection and forebay leaks was quickly destroyed. Muddy water appeared again on the north side of the building in February 1905, indicating further leaks under the foundations. Divers found some of the canvas strips laid in the forebay the previous year had been displaced. This was corrected and the leak disappeared.

But six months later, in July 1905, a leak of considerable proportions broke out close to the earlier leaks. Caulking forebay plank joints with oakum and covering the smaller crevices with lathe reduced the leak, but did not eliminate it, and on the morning of July 31, water began bubbling up on the north side of the building. New inspection of the forebay revealed cavities beneath the timber lining all across the suspected problem area and large cavities (14 to 21 feet deep) in front of penstocks 49 and 50 and 53 and 54. Drillings and soundings made through the foundation of the powerhouse revealed channels 3 feet deep there. Where the cavities were deepest, 6-12-inch pipes were inserted through holes bored in the forebay planking and a variety of materials—hay, manure, cinders, and gravel—were forced down by means of capped smaller pipes rammed into the larger ones. These actions sealed the leak by the end of August.

Plant operations had scarcely returned to normal when, in late November, a small leak was discovered opposite penstock 54. By the next day water was bubbling up 1 to 2 inches just inside the sheet piling on the north side opposite penstock 51. Cavities were again discovered in the forebay. Filling these with pipe and plunger began almost immediately. By early December, after much hay and gravel had been forced under the forebay planking, the cavities were again plugged and the leakage stopped.

For almost two years there was no further trouble. But on the afternoon of October 15, 1907, muddy water again appeared on the north side of the powerhouse, boiling up at several spots. The head at the plant was lowered and 12-inch filler pipes began forcing material into the leak areas. But, even with the head at only 11 feet, conditions worsened. Divers reported that the planking and timber work of the forebay apron in front of penstock 59 had begun to sag, opening seams through which water was flowing at high speed. Davis ordered the headgates lowered and the canal drained so the powerhouse could be examined and repaired. A pile driver was brought into the forebay to drive new sheet piling in front of the powerhouse foundation apron where the old piling had failed, while the cavities under the forebay planking were again filled with clay. To better seal the forebay Davis added a layer of 2-inch tongue-and-groove planking to the two layers already installed.

The 1907 shutdown lasted around twenty days, and water flowed back into the canal on November 9. As water filled the forebay a small leak was still detectable on the north side of the powerhouse. Holes were bored through the concrete floor of the powerhouse and through the foundations to determine the extent of the cavities between penstocks 54 and 61. Cavities from 6 inches to over 2 feet deep were discovered. Filler pipes 6 inches in diameter were used to fill these spaces. Under the direction of plant superintendent, A.W. Dawson, drilling and filling teams worked night and day. The leak slowed and then stopped on November 20, 1907.

The 1907 repairs held for only two years. Shortly after noon on November 9, 1909, a slight leak was detected opposite penstock 64. The leak rapidly worsened, and in a few hours water was boiling up several inches over an area 8 feet in diameter. Divers found that the filling under the forebay lining had washed out badly between penstocks 52 and 64. Davis again decided to shut the canal down for repairs.

Where the cavities under the forebay planking were worse, they took up the planking and replaced the clay underneath. The forebay apron was removed, the clay beneath it
replaced, and the apron completely reconstructed around the trouble area. After a shutdown of thirteen days, water reentered the canal on November 22.

When the powerhouse resumed operation, the leak persisted. Holes bored through the powerhouse floor and foundations between November 1909 and February 1910 revealed cavities from 1 to 14 feet deep between penstocks 46 and 64. Filler pipes rammed clay into these cavities and reduced the leakage, but did not eliminate it. Davis, meanwhile, was forced to lower the operating head at the plant to 12.5 or 13 feet. In January 1910 a slight crack appeared in the outer wall of the powerhouse between the first and second floors, indicating that the leaks were beginning to undermine its structural integrity.

Yet another shutdown for repairs became imperative.

Because the water levels in Lake Superior were extraordinarily low in the spring of 1910 the Corps of Engineers ordered the Michigan Lake Superior Power Company on April 20, 1910, to cease diverting any water from the St. Marys. This order had been expected, and Davis used this opportunity to undertake repairs. Through late April and May of 1910 extensive remedial work was carried out. In the powerhouse, night-and-day crews resumed the clay ramming, which had been stopped in February. Outside in the forebay, they took up much of the old planking, filled the voids beneath the floor with clay, and placed two new layers of 2-inch planking, separated by tar paper. The forebay apron was refilled and replanked and a deep trench was dug on both sides of the 1903 sheet piling and filled with good clay. The repairs were completed in early June.

Unlike many of the earlier repair jobs on the forebay, the work carried out in 1910 was solid. No leaks developed when water was readmitted to the forebay, and no leaks occurred for some years to come. Davis and his associates recognized, nonetheless, that the repairs they had made were only temporary and that, sooner or later, more expensive corrective measures would have to be taken to make the foundations of the powerhouse waterproof. But the financial resources to make permanent repairs were simply not available in 1910.

The leakage problem could be temporarily corrected. The deflection problem could not. It remained a constant hindrance to operations throughout this period. From 1904 on, standard operating policy at the powerhouse was to keep the operating head at 14 feet in order to avoid further endangering the structure. This
precaution enabled the company to indefinitely postpone corrective measures on the deflection, but at a cost. Turbine units expected to generate 564 hp at the shaft were often barely able to produce 400 hp.56

The Michigan Lake Superior Power Company was of course anxious to remedy the foundation defects at the powerhouse, increase its operating head to 18 feet, and generate power at capacity. But foundation defects are among the hardest to correct, so the problem of how to do this at a price the financially troubled company could afford was a critical one.

Between 1903 and 1916 Michigan Lake Superior Power Company and its successor, the Michigan Northern Power Company, studied the problem intently, calling in more than a half dozen consultants or teams of consultants to study the foundation dilemma. The array of engineering talent that attacked the dual problems of leakage and deflection included some of the most distinguished names in American engineering in the early 20th century.

One of the first to make recommendations, for instance, was Gustav Lindenthal (1850-1935). Lindenthal, born in Moravia and educated in the Austro-Hungarian Empire, had emigrated to America in the mid-1870s. By 1890 he was recognized as one of America’s great bridge designers (the steel arch Hell Gate Bridge in New York is considered his greatest work).57 Since foundation work is key to successful bridge construction, he was a logical consultant. Lindenthal visited Sault Ste. Marie in May 1903, while repairs to the first washout were underway. At the request of the company he studied the powerhouse foundation and underlying soil conditions.

Lindenthal’s report contains the best analysis of the source of the foundation problem. Lindenthal believed that von Schon and “the Consulting Engineer” (Noble) had erred in assuming that the friction between the concrete foundation and the clay and gravel surface on which it rested would contribute to resistance against sliding. Water seeping under the foundations, he felt, had lubricated the contact surfaces between concrete and clay, so there was little friction between them to resist the horizontal force of the water in the forebay. Thus the full force of the water in the forebay had been impressed on the tops of the 10,000 or so bearing piles and had bent them toward the river; the powerhouse was taken with them. Lindenthal felt that von Schon and Noble should have recognized that the contact surface between the clay and the foundations could not be kept dry.58

The deflection had not occurred immediately, Lindenthal believed, because it took some time for water to penetrate the clay puddle used to seal the forebay floor. It had occurred soon after the plant had gone into limited operation because either the vibration of

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**Table VIII**

<table>
<thead>
<tr>
<th>Year</th>
<th>Dates</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1903</td>
<td>February 8 to August 22</td>
<td>Plant shutdown for leak repairs</td>
</tr>
<tr>
<td>1904</td>
<td>September 7 to September 26</td>
<td>Leak, repaired without shutting down plant</td>
</tr>
<tr>
<td>1905</td>
<td>February 6 to February 8</td>
<td>Minor leak, repaired without shutting plant down</td>
</tr>
<tr>
<td></td>
<td>July 19 to August 27</td>
<td>Leak, repaired without shutting plant down</td>
</tr>
<tr>
<td></td>
<td>November 29 to December 4</td>
<td>Leak, repaired without shutting plant down</td>
</tr>
<tr>
<td>1907</td>
<td>October 15 to November 9</td>
<td>Plant shutdown October 19 to November 9 to repair leak, which began on October 15</td>
</tr>
<tr>
<td></td>
<td>November 9 to November 20</td>
<td>Leak recurred when water readmitted after repairs, but slowly decreased as corrective actions taken</td>
</tr>
<tr>
<td>1909</td>
<td>November 9 to November 22</td>
<td>Plant shutdown for leak repairs; a very slight leak was noted when water was readmitted and it slowly increased</td>
</tr>
<tr>
<td></td>
<td>November 28 to December 9</td>
<td>Leak, reduced to a trickle without shutting down plant, but slight leak continued on into 1910</td>
</tr>
<tr>
<td>1910</td>
<td>April 20 to June 9</td>
<td>Plant shutdown for leak repairs; this shutdown coincided with a government-ordered shutdown because of low water levels in Lake Superior</td>
</tr>
<tr>
<td>1926</td>
<td>August 13 to December 26</td>
<td>Plant shutdown for leak repairs</td>
</tr>
</tbody>
</table>

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the turbines had disturbed the clay puddle, permitting water to percolate under the foundations, or, possibly, because the ice that formed in the forebay during the first winter had, due to the shape of the forebay, exerted additional pressure on the powerhouse toward the river.

Lindenthal had two suggestions. To prevent deflection he recommended that a number of inclined iron tubes or piers, filled with concrete, be sunk to bedrock, using compressed air methods, on the north side of the powerhouse. He left the size, number, location, and plans open until information on the exact nature of the underlying material could be determined by borings. To seal the forebay from washout he suggested completely enclosing the foundation with sheet piles driven to bedrock.69

Lindenthal only sketched the repairs he believed were necessary. His ideas were expanded and modified by L.H. Davis, von Schon's replacement as chief engineer. In 1905 Davis proposed placing 40 inclined cast-iron buttresses, 5 to 6 feet in diameter, filled with concrete, at the rear of the powerhouse, one for every other talrace wall. To solve the leakage problem he advocated interlocking steel sheet piling driven to bedrock across the forebay and into the forebay embankment for about 300 feet in front of the powerhouse. Between the sheet piling and the powerhouse Davis suggested removing the 1903 forebay floor. Once this was done additional piles would be driven and these would be capped with 12- by 12-inch sills and a layer of 2-inch planks. A second tier of 12- by 12-inch sills run perpendicular to the powerhouse would follow, and these would be topped with 6-inch groove-and-spline planking. The purpose of the second tier of 12- by 12-inch sills would be to provide drainage channels in the floor around 4 feet wide by 1 foot high, leading through the forebay directly to the forebay wall. At the forebay a watertight floor would form an inclined apron to the penstock chambers. Under the watertight apron a chamber would collect the water from the drainage channels and discharge it into the tail pits through 24-inch-diameter valves if the pressure against the forebay side of the building exceeded that in the tailrace.60

Lindenthal and Davis were but the first of a series of engineers who were consulted about the powerhouse. After the 1904 leaks several other groups of consultants were called in. One of the most notable teams was that of Clemens Herschel and Alexander Pringle. They visited the site with von Schon and Davis around September 1904. Clemens Herschel (1842-1930) was perhaps the best known American hydraulic engineer of his era. One of the designers of the test flume at Holyoke, inventor of the "Venturi meter," Herschel had won major awards from both the Franklin Institute and the American Society of Civil Engineers. He had been on the board of engineers that made recommendations for the turbine installation at Niagara Falls, and was a future president of the A.S.C.E.61 His associate, Alexander Pringle, was less well known, but a respected Canadian hydraulic engineer. Pringle and Herschel sought to remedy the leak and deflection problems with a single construction. They proposed driving two rows of sheet piling in the forebay to bedrock, immediately in front of the powerhouse. The soil between these rows would be excavated and a concrete dam around 25 feet thick built from the bedrock up to the level of the forebay floor. This would eliminate leakage. Steel anchor rods running from the dam into the powerhouse substructure would provide the needed lateral stability.62

John Wilde, chief engineer of the Canadian Soo hydroelectric plant, was also asked for recommendations. Wilde believed that if water could be prevented from penetrating below the powerhouse, both the deflection and the leakage problems would probably disappear. He suggested excavating a trench about 30 feet deep the entire length of the building just a few feet in front of the penstocks. This trench would be refilled with a puddle core of mixed clay and gravel. Cavities already created under the powerhouse would be cured by stock ramming. If making the forebay watertight with this construction did not simultaneously solve the deflection problem, he asserted, it should be considered separately at some later time.63

A third report was developed and delivered in 1905 by Samuel Whinery, with the assistance of Boller and Noble. Whinery (1845-1925), a consulting engineer with headquarters in New York, had participated in the Muscle Shoals Improvement of the Tennessee River between 1878 and 1881 and was later involved in highway construction, water supply engineering, and river improvement at several locations. A former vice president of the A.S.C.E., he was not as well known as Boller, Lindenthal, Noble, or Herschel, but he was well respected within the engineering profession.64

The Whinery-Boller-Noble plan was similar in conception to the attempts made to repair the powerhouse in 1903. That is, the powerhouse was to be reinforced by tying it into a strengthened, leakproof forebay foundation. But the methods proposed in 1905 represented a significant improvement over the steps taken (partially at the recommendation of Boller and Noble) in 1903. Whinery proposed removing the existing plank covering in the forebay and excavating the clay beneath to a...
**Scheme I - Lindenthal, Davis - 1903-4**

- Steel sheet piling and additional timber piles and planking in forebay
- Inclined tunnel buttresses

**Scheme II - Herschel, Pringle - 1904**

- Concrete dam as anchor support and water stop
- Reinforcing steel anchors
- Temporary crib coffer dam
- Concrete dam
- Steel sheet piling
**Scheme III - Wilde - 1905**

- Puddle Clay Water Stop

**Scheme IV - Whinery, Boller, Noble - 1905**

- Additional Timber Piles
- Forebay wall anchored by steel eye bars fastened to piles set in concrete bed
- Sheet piling cut off in Forebay

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100' 150'

1½ Conc Bed

2½ Reinforced Conc Bed over 1½ Crushed Stone Drainage Chamber

Additional Wood Piles Connected by Eye Bars and anchoring the Power House

20 Drain pipes (27)
depth of 3 feet. For a distance of 150 feet back of the powerhouse, new piles, equal in number of those already in the forebay area, would be driven among those already in place. A layer of crushed stone 1.5 feet thick would be placed on the excavated floor, and upon this layer of stone a bed of reinforced concrete 2.5 feet thick would be poured. In this concrete a system of steel eye-bars would be implanted. These would be anchored to the powerhouse substructure through the forebay wall. This, Whinery believed, would have the effect of extending the foundation of the powerhouse and lending additional lateral resistance to the structure. To give further security, particularly against washouts, the layer of concrete was to be carried back into the forebay an additional 100 feet, to a distance of 250 feet from the powerhouse, but at a reduced thickness of 1.5 feet. At the junction of the concrete floor with the powerhouse a flexible, watertight joint was to be constructed, while along the upper edge of the concrete a continuous line of interlocking steel sheet piling was to be driven to bedrock. Any water that penetrated the sheet piling and the concrete lining of the forebay would drain through the stone placed beneath the concrete to the forebay wall and then, through openings placed in that wall, flow harmlessly into the tail pits.

Yet another plan was sketched by the Foundation Company of New York in 1905. This scheme contemplated transforming the forebay (save at the point where the canal entered) into a self-contained, watertight basin. Reinforced concrete, with steel anchorages, was to be poured over the entire forebay from the powerhouse to the forebay embankment walls. To sustain the powerhouse against the thrust of the water, a sloping concrete wall, placed on batter (or inclined) piles, would be built against the forebay embankments opposite the powerhouse. Tie rods leading from steel anchorages embedded in the concrete forebay floor would curve gradually from a horizontal position in the floor to a near-vertical position in the wall. Running across the front of the powerhouse at the forebay wall there would be a continuous steel girder. This would be tied into the reinforced concrete forebay floor. Eyebars from this steel girder would penetrate the forebay wall and be tied into steel grillage embedded in the pit walls about 30 feet from their upstream ends. Sheet piling driven to bedrock where the power canal entered the "bathtub" would prevent seepage beneath the concrete floor.

Of the various schemes of powerhouse repair delivered to the receivers of the company between 1903 and 1905, three seem to have been given very serious consideration: Lindenthal's 1903 scheme as modified by Davis, Herschel and Pringle's 1904 scheme, and the Whinery-Boller-Noble plan. Each of these groups were asked at various times in 1905 and 1906 to deliver critiques on the others' proposals. The David-Lindenthal plan was criticized for being too costly due to the dangerous and unusual character of the pneumatic work it would involve and for continued reliance on timber and clay for waterproofing in the forebay. Herschel and Pringle's dam scheme would have involved an even larger expense and shutting down the plant for an extended period of time. It was feared that the concrete forebay proposed by Whinery and his associates would crack because of the tem-
perature extremes experienced in Sault Ste. Marie. It was also urged that the additional strength provided by this plan was sufficient only for a 17-foot head.

By late 1905 the options seem to have been narrowed to two: the Davis-Lindenthal scheme and the Whinery-Boller-Noble plan. Davis and Whinery met in November 1905 to agree on common data by which they would both work out their computations and estimates. At the conference Whinery and Davis both revised their plans in the light of the other’s criticisms, set standard costs for labor and materials so that their estimates of construction costs could be fairly compared, and agreed on methods for computing the forces that any remedial works would have to withstand. They also agreed to tailor their reinforcement plans so that the powerhouse could withstand up to a 24-foot head.

By early 1906 there seems to have been general agreement that the Davis-Lindenthal scheme was probably the most effective remedy for the powerhouse problem. The only question remaining were those concerning its practicality and cost. A neutral consultant, Howard A. Carson (1842–1931), was asked to review Davis’ proposals. Carson was an experienced hydraulic engineer. He had, for example, supervised construction of the Boston Main Drainage System between 1878 and 1884, inventing in the process the Carson trenching machine, extensively used in the construction of hydraulic systems. During the 1880s and 1890s he had designed sewer systems all over Massachusetts, and from 1894 to 1909 had served as chief engineer of the Boston Transit Commission, designing one of the earliest American subways and the first underwater tunnel for subway service in the country.

Carson consulted with Davis in February or March of 1906. He agreed that the Lindenthal-Davis scheme was practical and that Davis’ estimate of costs ($402,000) was only about $60,000 too low. Boller, who favored the Whinery scheme, remained unconvinced, writing Davis in July 1906 about the pneumatic buttresses:

> It is about as nasty a job as I have ever run across to get those tubes in, establishing the air locks and shield device, under the peculiar conditions, and I have run up against a good many tough propositions in the last forty years.

Nonetheless, the receivers applied to the US Circuit Court of the Western District of Michigan for permission to issue receiver’s certificates for $500,000, the proceeds of which would be used to repair the power plant in conformity with Davis’ plan. By August 1906 the courts had granted permission for the certificates and by September Davis had prepared specifications and sent them to prospective bidders.

The response was disappointing. The J.G. White Company of New York, for example, told co-receiver C.D. Warren in October that “all the work involves a great deal of risk, particularly the compressed air work.” Unforeseen developments, they believed, might add up to 50% of estimated costs. They would consider the job only on a cost-plus-profit basis. In a similar vein the Foundation Company expressed reluctance to bid, noting “the difficulties involved and the uncertainties as to costs.” By January 1907 the bids were in. The lowest was from John Griffith Sons of Chicago for $700,000, well above the amount the receiver’s certificates authorized.

Carson blamed the poor results on the abundance of construction work available and the unusual nature of the project which caused contractors to pad their estimates to cover contingencies. He suggested the company contract to have one buttress installed in order to establish the practicality of the scheme and give some solid idea of costs. The bondholders accepted this advice and instructed Davis to prepare specifications and proposals for bids on a trial buttress in February 1907. Davis did this, but again the response was disappointing. All three companies submitting bids asked for the job on a cost-plus-fixed-fee basis, an option the company found unacceptable. The bondholders briefly considered a plan broached by Davis, which would have had the company install a trial buttress on its own. But the legal and financial problems entangling the company in 1907 (the legal problem is discussed in more detail later) led company officials to drop all plans for repair. Davis had estimated that the plant’s output could be increased from 10,000 to 14,000 hp simply by reinforcing the powerhouse to resist deflection, since this would allow him to operate at 18 instead of 14 feet of head. There was another option. More power could be obtained without making expensive repairs simply by taking more water from the St. Marys. The works erected in 1901–1902 were intended to compensate for a diversion of 10,000 second feet. Extending these works with four additional compensating gates, Davis estimated, would also allow him to increase power output from 10,000 to 14,000 hp. An even greater increase, of course, could have been gained by both increasing the diversion from the St. Marys and installing more turbines and generators. But as early as 1905 Union Carbide had refused to consider installing any more equipment until the powerhouse was repaired, and the power company, due to its financial difficulties, could not afford to buy ad-
ditional turbines and generators on its own.  

In 1907, after the decision was made to abandon plans for powerhouse reinforcement, Davis proposed that the company request permission from the Corps of Engineers to extend the breakwater left in place after completion of the first set of compensating gates in 1901–1902 and to increase the diversion of water. This, he argued, could be done cheaply and could be considered an adequate temporary expedient until the company could afford to erect more permanent works. This project, like the trial buttress project, was seriously considered. Plans for breakwater extension were drawn up late in 1907, and in 1908 petitions were prepared seeking permission from the courts to spend the money necessary for an expansion of the compensating works.

What eventually blocked both options for increasing plan output—foundation repairs and compensating works extension—was partially the financial dilemma of the company. But more important were the serious legal difficulties in which the company had become embroiled.

The Legal Dilemma

What complicated and ultimately killed all efforts to repair the powerhouse, to expand the compensating works, to bring the turbine plant up to full capacity, and to improve the financial status of the MLSPC was a complex legal dispute over ownership of the water flowing over the St. Marys rapids.

In 1881 William Chandler, an early promoter of waterpower development in the Sault, filed a claim in the government land office on the lands that lay between the government ship canal and the rapids, with the intention of building a waterpower plant. He did nothing immediately, but was a major figure in the formation of the St. Marys Falls Water Power Company in 1885. In 1887, however, he organized the Edison Sault Light and Power Company, and in 1888 built a small power canal, powerhouse, and light plant in the rapids to furnish Sault Ste. Marie with electricity. This enterprise soon collapsed, partially due to engineering problems. In 1891 the company mortgaged its assets to Harris T. Dunbar, and together Chandler and Dunbar formed the Chandler-Dunbar Water Power Company to push power development in the rapids. Along with several other businessmen they rebuilt the canal and powerhouse in the rapids and formed the Edison Sault Electric Company, which leased land and water rights from Chandler-Dunbar. In 1892 power generation was resumed, though the plant’s output was small (600 hp).

Chandler’s interest in other hydroelectric power schemes in the Soo continued. In the mid-1890s he was manager of one of the banks that foreclosed on the St. Marys Falls Water Power Company. When Clergue showed an interest in its properties, he was appointed to negotiate their sale. Clergue retained Chandler’s services after the purchase as right-of-way negotiator and public relations man on the American side. At the same time Chandler began making plans for enlarging the output of his small plant in the rapids. These plans were initially not seen as conflicting in any way with Clergue’s development.

In late 1898, however, Chandler wrote to Col. Lydecker, then serving as chairman of the board of Army Corps of Engineers, which was investigating the possible effects of Clergue’s plans on lake levels. In the Lydecker letter Chandler laid claim to all the waters of the rapids by virtue of his ownership of the landed properties fronting on the rapids. This claim, if acknowledged, would have made the diversion of water around the rapids by canal, as the Michigan Lake Superior Power Company was planning, illegal. Chandler’s claim was largely ignored by the Secretary of War when he rejected the findings of Lydecker’s board in early 1899 and gave the power company the right to divert water.

Clergue, however, had sufficient foresight to realize that Chandler’s claims, if pressed, could cause problems, and in April 1900 he had his lawyers study the legality of Chandler’s position.

In 1901, as the powerhouse and power canal approached completion, Chandler began to press his claim more vigorously. Plans for enlarging his powerhouse in the rapids, latent since 1895, were suddenly revived, and Chandler applied to the War Department for permission to extend his works. On September 21, 1901, Chandler completely broke with Clergue, officially informing the Michigan Lake Superior Power Company of his intent to claim all waters flowing over the rapids. He forbade any expansion of the company’s compensating works beyond the international boundary line and any diversion of water from the American side.

Both Chandler’s planned extension of his plant and his claim to all waters on the American side of the frontier were potentially dangerous to the Michigan Lake Superior Power Company. His claim to the waters could prevent the hydroelectric plant from becoming operative without securing a water lease from Chandler. His extension of the plant in the rapids could create a superior competitor, for in April of 1898 von Schon had compiled a report for Clergue which indicated that Chandler could develop waterpower in the rapids at a much lower cost per horsepower than the planned MLSPC development.

Following up on his threats, Chandler filed suit in Chippewa County Court on March 6,
1902, to prevent the diversion of waters into the MLSPC canal, a move that led Clergue to refer to Chandler as a "blackmailer" attempting to "extort blood-money." Chandler was unable to secure an injunction, partially because the US government had given the power company permission to divert and partially because (since the compensating works were on the Canadian side of the border) MLSPC could claim that the 10,000 second feet of water they were planning to divert initially was Canadian water.

Clergue struck back quickly. On March 14, 1902, he asked the War Department to approve another power development in the rapids adjacent to an island (Island #5) that Clergue had purchased at the foot of the rapids in preparation for a possible court fight with Chandler. Clergue probably did not actually plan to build a powerhouse there, but Clergue felt that if the War Department accepted and acted on his petition, it could be considered an acknowledgement that the US government, and not private individuals, held the right to the waterpower of the rapids.

The War Department, faced with two petitions for the erection of works in the rapids, was unwilling to approve either until the legal matter of property ownership and water rights in the rapids was settled in the courts. Chandler's suit against the MLSPC was quickly followed by a countersuit. Since the Michigan Lake Superior Power Company had the right to divert water under a Congressional act of 1902, Clergue decided that it was in his best interest to establish that the water rights belonged to the US government. So, shortly after the grand opening, the Michigan Lake Superior Power Company filed suit in the name of the United States against the Chandler-Dunbar Water Power Company.

Despite these counterattacks, Clergue's position was still precarious. The diversion of water into the Michigan power canal had been authorized under the Rivers and Harbors Act of June 13, 1902. But this act specified that its provisions could not be held to effect any existing riparian or other rights of a person or corporation. And the permit issued to the power company on December 12, 1902, by Secretary of War Elihu Root reiterated this provision.

Ownership of waterpower in the rapids remained in legal limbo during the power plant's first two years of operation. But in January 1905 the US Circuit Court in the case of the "United States vs. the Chandler-Dunbar Water Power Company" found for Chandler-Dunbar. The case was immediately appealed, but in view of the decision the War Department gave Chandler the permit he needed to expand his power plant in the rapids and to divert a larger volume of water for power production, a diversion that could, if repairs were ever made and the compensating works enlarged, definitely affect the amount of water available to the MLSPC plant.

The issue of who owned or should own the water in the rapids, however, was quickly clouded again in 1905 by the entrance of another participant—the International Waterways Commission. Since the St. Marys was an international river, as early as 1895 the creation of an international commission to regulate the use of its waters had been suggested. This recommendation was renewed by Lydecker's board when it met in 1898 and 1899 to review plans for waterpower development in the Sault. The creation of such a commission was authorized by Congress in 1902 in the same Rivers and Harbors Act that authorized the diversion of water into the MLSPC power canal. The Canadian government, however, did not act immediately. But in 1905 Canada finally passed legislative authorization for its half of the new commission, named the International Waterways Commission. One of the first actions of the new commission was to investigate the complicated situation at Sault Ste. Marie. The commission immediately claimed the right to review any future plans for diversion or construction at the rapids and ordered the MLSPC plant to divert no more than 8,500 second feet of water until additional plans for remedial works were submitted and approved. The commission also recommended that their respective governments assume absolute control of all waters and lands necessary to improve and promote navigation in international streams.

The International Waterways Commission's first report was well received by the power company. If its recommendation that the American and Canadian governments retain or secure control of all waters and lands necessary for improvement of navigation was followed, it meant the end of Chandler's rival plant in the rapids. New lock facilities were sorely needed at Sault Ste. Marie, and the obvious direction of expansion was onto lands owned by or claimed by Chandler. Government condemnation of Chandler's lands would eliminate Chandler's suit and allow the power company, if they could raise the necessary capital, to expand the compensating works, divert more water, and generate more power.

But the US government took no immediate action on the IWC recommendation, and in 1907 the power company received another legal setback. The Court of Appeals upheld Chandler's ownership of the lands and waters of the rapids. Although the decision was appealed to the Supreme Court, it was this adverse judgment that led the receivers to abandon plans to either repair the powerhouse or
expand the compensating works.

The legal defeat also convinced the receivers to try to negotiate with Chandler-Dunbar for the right to divert water into the canal. The negotiations lasted for almost a year, but were hampered by the animosity that had developed between the two companies, by uncertainty over the international division of water (would the United States get ½ or ⅔?), and by pending review of the case by the Supreme Court.103

Also forced to negotiate with Chandler-Dunbar by the adverse decision in the Court of Appeals was the Secretary of War. The growth of Great Lakes' shipping by 1907 had put such a severe strain on existing lock facilities at Sault Ste. Marie, that Congress, in the Rivers and Harbors bill of that year, had appropriated $6.2 million for expansion and improvement. The act also instructed the Secretary of War to enter negotiations for the acquisition of land, and, if negotiations failed, to condemn the land (but without an acknowledgement of ownership).104 Thus in 1907 the War Department also began to negotiate with Chandler. Chandler, however, refused to settle without an acknowledgement that he was the legal owner of the land in question. He also demanded a very high price for his lands. In 1908 the War Department's negotiations with Chandler also broke down. The War Department then began to make plans to condemn the lands bordering on the rapids and his claim (under the doctrine of riparian rights) to the waterpower of the rapids.105 This victory was short-lived. The 1909 Rivers and Harbors Act authorized condemnation of all private lands in the rapids and instructed the Secretary of War to lease to private interests (read MLSPC) any water available in excess of the needs of navigation.107 Notice of condemnation was filed on September 27, 1909.108 But due to delays in the preparation of the condemnation suit by government attorneys, hearings on the case did not begin until February 1911.109

Chandler-Dunbar valued its properties at $7 million to $8 million. But the court awarded only $652,312 to the Chandler-Dunbar Company, plus $300,000 to the Edison Sault Electric Company for its plant on the Chandler-Dunbar properties.110 The Chandler-Dunbar company appealed this award to the Supreme Court. This was a mistake. On June 21, 1913, the Supreme Court ruled that the government was condemning the land in the rapids, not its potential as a waterpower site, and reduced the award to Chandler-Dunbar from $652,312 to $65,450.111 This finally ended the dispute over water rights in the rapids once and for all.

The decision by the US government to condemn the lands in the rapids in 1909 (incorporated in the Rivers and Harbors Act of 1909) finally eliminated many of the legal entanglements that had strangled the MLSPC hydroelectric plant almost from the time of its opening. But even this decision did not completely clear matters up. The same Rivers and Harbors Act that brought the rapids under federal control altered the relationship between the MLSPC and the government. These relations had previously been regulated by the Rivers and Harbors Act of 1902, which gave the power company the right to divert water into the canal, free of charge, provided lake levels were not affected. The 1909 act required the power company to enter into a lease agreement with the government. Soon after passage of the act, Brown, one of the co-receivers, inquired of the Chief of Engineers when negotiations could begin for a lease of water and extension of the compensating works. But the Chief of Engineers refused to begin talks until the amount of compensation for the Chandler properties was finally determined by the courts, since this would help set the cost of the water lease.112 Thus, legal questions impaired the Michigan Lake Super Power Company for some years after 1909. Preliminary negotiations for a lease and compensating works expansion began only in 1911, after the lower court had made its award to Chandler and his associates, and the Corps of Engineers took final action only after the final condemnation award was made by the Supreme Court in June, 1913.113

The closely interrelated and entangled problems of finance, law, and engineering at Sault Ste. Marie thus completely crippled the hydroelectric plant for over a decade. Because of these problems the plant's average annual output between 1903 and 1913 was never more than 11,000 hp, or only some 25% of the designed output, and often it was much lower due to plant shutdowns for leak repairs. Operating at only a quarter of design capacity, with most of the output going to Union Carbide at a rate far too low to bring a good return on investment, the Michigan Lake Superior Power Company was unable to generate sufficient income to cover the interest on its bonds, much less begin to retire them. Raising additional capital to correct the foundation defects, install additional turbines (only 42 of 80 units had been placed in 1901-1902), and expand the compensating works proved impossible because of the plant's poor financial con-
diation, the state of the powerhouse’s foundations, and the legal entanglements over water rights. In brief, the Michigan Lake Superior Power Company was caught in a classic bind. To solve these myriad problems it needed investment capital; yet it could not secure the investment capital because of the problems.

Solutions: The Repair and Expansion of the Soo Hydro, 1913–1926

As legal problems began to clear up in 1909, money became the key to the plant’s remaining problems. With sufficient capital, additional turbines and generators could be purchased, the compensating works expanded, the powerhouse repaired. Yet the outlook was bleak. In 1908 the first mortgage bondholders had formed a committee and with co-receiver Clarence Brown had inspected the company’s financial situation in detail. What they found was discouraging. Estimates for completing (but not repairing) the plant had been $1 million in 1905. These estimates had now risen to almost $2 million. Since the initial cost of the powerhouse and canal had been around $7 million, a completed, operative plant would have cost nearly $9 million. It was doubtful the company, as organized, even under full production, could pay off a debt of this magnitude.

Thus the committee representing the first mortgage bondholders in June 1908 decided that a complete reorganization was necessary. Late in 1908 they met with co-receivers Warren and Brown to assess the alternatives, and then decided to foreclose on their mortgage and take control of the company’s assets. This action would remove the Michigan Lake Superior Power Company from the Lake Superior Corporation and reduce the indebtedness by eliminating that corporation’s investment in second mortgage bonds. Lake Superior resisted the move, but the first mortgage bondholders had first lien on the Michigan development’s assets, and Lake Superior could do little to prevent foreclosure. The Canadian company could have paid off the first mortgage, but by the end of 1909 this mortgage had accumulated nearly $1.5 million in interest, so that the total debt was nearly $5 million. The Lake Superior Corporation, struggling to stand on its own, did not have sufficient capital to do this, and probably had very little desire to pour more money into what must have seemed a lost cause.

Hoping to salvage what they could, the Board of Directors of the Lake Superior Corporation began negotiations with the first mortgage bondholders in 1909. In 1910 the Canadian conglomerate agreed to relinquish all interest and control in the Michigan Lake Superior Power Company for only $200,000, rather than fight foreclosure. The resignation of Charles Warren as co-receiver of the Michigan company on March 28, 1911, signaled the end of the Michigan hydroelectric plant’s connections with the huge Canadian industrial complex Clergue had created.

Some organizational changes were required. The Michigan hydroelectric plant had been managed by the Lake Superior Corporation from its main offices in Sault Ste. Marie, Ontario. New offices had to be established on the Michigan side. In early 1910 portions of the boiler room and pumphouse on the west side of the powerhouse were converted into office space. L. H. Davis, chief engineer of the plant since von Schon’s departure, was offered and accepted the post of chief engineer and general manager of the now-independent company, though not without some serious misgivings.

By forcing the Lake Superior Corporation out of the Michigan hydroelectric company in 1910 the first mortgage bondholders significantly reduced the plant’s indebtedness. But a number of problems remained. A lease had to be negotiated with the War Department, which continued to hesitate due to Chandler’s appeal of the initial condemnation settlement. At least $2 million was still needed to complete and repair the plant. A new lease had to be negotiated with Union Carbide if there was to be any hope of profitable operations. Additional power customers had to be found if and when the plant was brought up to capacity.

When the bondholders approached Union Carbide about renegotiating the 1898 contract, the Carbide company refused. Instead it offered to buy out the first mortgage bondholders and assume ownership of the power plant itself. Seeing an opportunity to rid themselves of the plant, the parties worked out a rather complex agreement in 1912 and 1913. The first mortgage bondholders agreed to foreclose on the property as quickly as possible and have it auctioned off subject to the lien of Union Carbide’s contract. At the auction a committee of the first mortgage bondholders would bid the par amount of the mortgage bonds ($3.5 million). A new company organized by Union Carbide would then buy the plant from the first mortgage bondholders with first mortgage bonds from the new company at fifty cents on the dollar of the face value of the old first mortgage bonds (i.e., for $1.75 million). Both the principal and interest on the new bonds would be guaranteed by the Union Carbide Company. In addition, the new power company would pay the $200,000 owed by the Michigan Lake Superior Power Company to the Lake Superior Corporation.

The new power company, called the Michigan Northern Power Company, filed articles
of incorporation with the Chippewa County Clerk on August 6, 1913. The foreclosure sale took place on the steps of the county courthouse on August 26, 1913, with the first mortgage bondholders as the only bidders. They turned the property over to the Michigan Northern Power Company. Backed by the assets of the Union Carbide Corporation the new power company had no difficulty in disposing of $4.5 million in first mortgage bonds. After subtracting the $1.75 million owed the first mortgage bondholders of the old Michigan Lake Superior Power Company, and the $200,000 owed the Lake Superior Corporation, the new company still had $2.55 million for repairs, improvements, expansion of equipment, and erection of additional compensating works.

Equipment Expansion
Even before formal foreclosure proceedings had been filed, Union Carbide had begun to make plans for expanding its plant at the Soo. In April 1913, for example, Union Carbide contracted with Westinghouse for the delivery of 19 new 60-cycle alternators. In August eight new turbine units (32 turbine runners in 16 draft cases) were ordered. The eight new turbine units were ordered from S. Morgan Smith Company and were pre-tested at Holyoke like the original Jolly-McCormick models. They were installed in early 1915 in penstocks 44 through 51. In January of 1916 Michigan Northern ordered 14 more S. Morgan Smith units for penstocks 52 through 65. These units achieved almost 90% efficiency at Holyoke, probably the highest ever recorded for a low-head horizontal turbine at the test flume. In early 1916, 15 Wellman, Seaver, Morgan turbine sets were ordered for penstocks 66 through 80. By April 1917 all units were in place and the turbine installation complete.

Table IX
Turbine Installation at Sault Ste. Marie, 1902 to Present

<table>
<thead>
<tr>
<th>Penstock</th>
<th>Turbine Installation</th>
<th>hp at 16 Head</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Webster, Camp &amp; Lane 33&quot; Specials Spillway (no turbines installed)</td>
<td>600</td>
<td>1901-02 to 1916</td>
</tr>
<tr>
<td>2-42</td>
<td>Webster, Camp &amp; Lanes 33&quot; Specials</td>
<td>600</td>
<td>1901-02 to Present</td>
</tr>
<tr>
<td>43</td>
<td>Spillway (no turbines installed)</td>
<td></td>
<td>1901-02 to Present</td>
</tr>
<tr>
<td>44-51</td>
<td>S. Morgan Smith 33&quot; Specials</td>
<td>675</td>
<td>1915 to Present</td>
</tr>
<tr>
<td>52-65</td>
<td>S. Morgan Smith 33&quot; Specials</td>
<td>725</td>
<td>1916 to Present</td>
</tr>
<tr>
<td>66-80</td>
<td>Wellman, Seaver, Morgan 34&quot; Specials</td>
<td>750</td>
<td>1916-17 to Present</td>
</tr>
<tr>
<td>81</td>
<td>Spillway (no turbines installed)</td>
<td></td>
<td>1916-17 to Present</td>
</tr>
</tbody>
</table>

Note: There were four turbine runners per penstock, arranged in pairs. Each pair was housed in a cast-iron draft case. The shafts for each pair of turbine runners were bolted together.

There were some changes from von Schon's original plans. He had intended to have 80 turbine units. Michigan Northern had only 78. Penstocks 1 and 81 were used as emergency spillways, in addition to the regular spillway at penstock 43, the only penstock von Schon had intended to use for that purpose. This change did not reduce the power capacity of the plant below the 40,000 hp von Schon had designed it for, since the 1915 and 1916 turbine sets were significantly more powerful than the 1901-1902 models.

As the turbine equipment at the powerhouse was being brought up to full capacity, so was the generator equipment. While 19 new 60-cycle Westinghouse alternators were ordered, delivered, and partially installed in 1913 and 1914, the bulk of the expansion occurred, as in the case of the turbines, in 1916 and 1917. In January 1916 Union Carbide ordered 50 new 25-cycle alternators and two dc exciting units from General Electric. Westinghouse in February 1916 was asked to rebuild 19 of the original single-phase, 90-volt, 60-cycle alternators to three-phase, 440-volt, 25-cycle operation. At the same time Michigan Northern contracted with Westinghouse for installation of all switchboard equipment for the enlarged electrical plant. Both General Electric and Westinghouse did most of the installation work on their contracts in late 1916 and early 1917. By February 1917 all work was completed and the plant, at last, was equipped to generate power at design capacity.

The new generator layout had some unu-
sual features. All 25 cycle generators were grouped at the eastern three-quarters of the plant; the much smaller number of 60-cycle machines were mainly at the extreme western end. From penstock unit 62 through 73, however, both 25- and 60-cycle alternators were placed on the same shaft. Which of the alternators was placed on load depended on whether Union Carbide needed more 25-cycle or more 60-cycle power. Also, when the power of the 60-cycle units at penstocks 74 through 80 was not needed, they were used to drive the 60-cycle machines on shafts 62 through 73 as motors, thus increasing the power input to the 25-cycle alternators on those shafts. The Stanley dc generators used for streetcar service were placed on extended shafts under a similar arrangement at penstocks 46 through 48, the dc exciters at 41 and 45.

The switchboard arrangement at the reconstructed plant was, in some ways, similar to that proposed by Thomas in 1902. In order for the plant to be conveniently controlled, the switchboards were made unusually narrow. A control panel for a typical generator in the early 20th century was as much as 24 inches wide; those designed by Westinghouse especially for the Soo plant were 9 inches wide. A panel of this width was made possible by mounting the rheostats, which controlled the direct current fed to the field coils of the alternators, and the oil switches, which put generators on line or took them off, at convenient points on the extension of the switchboard gallery. Remote electrical (solenoid) switches were used to operate the accessories. Four sets of the bus bars were installed; two for the east end of the plant and two for the west end. Thus each generator could feed into one of two bus bars. A short circuit in any single bus bar would only shut down a portion of
### Table X
The Generator Installation at Sault Ste. Marie, 1903 to Present
Generator Plant, 1903–1916

<table>
<thead>
<tr>
<th>Penstock</th>
<th>Date Installed</th>
<th>Maker</th>
<th>ac/dc</th>
<th>kW/kVa</th>
<th>Phase</th>
<th>Freq.</th>
<th>Volt.</th>
<th># Units</th>
<th>Extended</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1903</td>
<td>Westinghouse</td>
<td>ac</td>
<td>375</td>
<td>2</td>
<td>60</td>
<td>220</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2–3</td>
<td>1903</td>
<td>Westinghouse</td>
<td>ac</td>
<td>375</td>
<td>1 or 2</td>
<td>60</td>
<td>220?</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4–22</td>
<td>1903</td>
<td>Westinghouse</td>
<td>ac</td>
<td>375</td>
<td>1</td>
<td>60</td>
<td>90</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>1903</td>
<td>Westinghouse</td>
<td>dc</td>
<td>375</td>
<td></td>
<td></td>
<td>250</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>23–24</td>
<td>1903,1913*</td>
<td>Westinghouse</td>
<td>ac</td>
<td>375</td>
<td>1</td>
<td>60</td>
<td>90</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>25–32</td>
<td>1913</td>
<td>Westinghouse</td>
<td>ac</td>
<td>600</td>
<td>3</td>
<td>60</td>
<td>4000</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>33–37</td>
<td>1903</td>
<td>Stanley</td>
<td>dc</td>
<td>600</td>
<td>3</td>
<td>60</td>
<td>2400</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>38–41</td>
<td>1913</td>
<td>Westinghouse</td>
<td>ac</td>
<td>600</td>
<td>3</td>
<td>60</td>
<td>4000</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>38–39</td>
<td>1903,1913*</td>
<td>Stanley</td>
<td>dc</td>
<td>400</td>
<td></td>
<td></td>
<td>600</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>1903,1913*</td>
<td>Stanley</td>
<td>dc</td>
<td>400</td>
<td></td>
<td></td>
<td>600</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>1903,1915*</td>
<td>Westinghouse</td>
<td>dc</td>
<td>375</td>
<td></td>
<td></td>
<td>250</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>45–51</td>
<td>1915</td>
<td>Westinghouse</td>
<td>ac</td>
<td>600</td>
<td>3</td>
<td>60</td>
<td>4000</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

*installed 1903, placed in this location in year indicated.
The plant also contained a 147hp/100kW motor-generator and a 30/60 cycle frequency changer.

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Generator Plant, 1916–1963

<table>
<thead>
<tr>
<th>Penstock</th>
<th>Date Installed</th>
<th>Maker</th>
<th>ac/dc</th>
<th>kW/kVa</th>
<th>Phase</th>
<th>Freq.</th>
<th>Volt.</th>
<th>Units</th>
<th>Extended</th>
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</thead>
<tbody>
<tr>
<td>2–20</td>
<td>1916–17</td>
<td>Westinghouse (rebuilt '03 units)</td>
<td>ac</td>
<td>750</td>
<td>3</td>
<td>25</td>
<td>4400</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>21–41</td>
<td>1916–17</td>
<td>General Electric</td>
<td>ac</td>
<td>600</td>
<td>3</td>
<td>25</td>
<td>4400</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>1903,1916*</td>
<td>Westinghouse</td>
<td>dc</td>
<td>375</td>
<td></td>
<td></td>
<td>250</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>1903,1916*</td>
<td>Westinghouse</td>
<td>dc</td>
<td>375</td>
<td></td>
<td></td>
<td>250</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>44</td>
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<td>General Electric</td>
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<td>220</td>
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<td>General Electric</td>
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<td>220</td>
<td>1</td>
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<tr>
<td>45–73</td>
<td>1916–17</td>
<td>General Electric</td>
<td>ac</td>
<td>600</td>
<td>3</td>
<td>25</td>
<td>4400</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>46–48</td>
<td>1903,1916*</td>
<td>Stanley</td>
<td>dc</td>
<td>400</td>
<td></td>
<td></td>
<td>600</td>
<td>3**</td>
<td></td>
</tr>
<tr>
<td>52–73</td>
<td>1913,1916*</td>
<td>Westinghouse</td>
<td>ac</td>
<td>600</td>
<td>3</td>
<td>60</td>
<td>4000</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>74–80</td>
<td>1915,1917*</td>
<td>Westinghouse</td>
<td>ac</td>
<td>600</td>
<td>3</td>
<td>60</td>
<td>4000</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

*first date is date equipment first installed; second date is year placed in this location
**the Stanley dc generators were scrapped around 1930
Generator Plant, 1963 to the Present

<table>
<thead>
<tr>
<th>Penstock</th>
<th>Date Installed</th>
<th>Maker</th>
<th>ac/dc</th>
<th>kW/KVa</th>
<th>Phase</th>
<th>Freq.</th>
<th>Volt.</th>
<th># Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-40*</td>
<td>1963</td>
<td>Electrical Prod.</td>
<td>ac</td>
<td>650</td>
<td>3</td>
<td>60</td>
<td>4400</td>
<td>39</td>
</tr>
<tr>
<td>41</td>
<td>1916**</td>
<td>General Elec.</td>
<td>ac</td>
<td>600</td>
<td></td>
<td></td>
<td>4400</td>
<td>1</td>
</tr>
<tr>
<td>41</td>
<td>1916</td>
<td>Westinghouse</td>
<td>dc</td>
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*Electrical Products generators on Westinghouse base (penstocks 2-23) or General Electric base (penstocks 21-40, 46-61) **: inoperative, field windings removed
# unit 70, extended shaft moved to main shaft position, no extended shaft unit today
## units 75, 78, 79, 80 rewound by Electrical Products for 4400 volts in 1964
the plant. All of these features—the use of remote switches to control the rheostats and circuit breakers, the very narrow switchboards for one man control, and the use of multiple bus bars—were elements in Thomas' original switchboard design.

Manufacture of the narrow switchboards caused some trouble. When Davis visited Pittsburgh to inspect the first shipment, he found the front of the panels in good shape, but in the rear the wiring and exciter bus bars were too crowded, even dangerous. Westinghouse engineers acknowledged the faulty workmanship:

... fully realizing that the shop work was not up to the usual standard, which is accounted for by the fact that this is an unusual board of special design with extraordinary space limits, to which the workmen were not accustomed ... 

Davis described the workmanship of the panels after the earlier defects had been corrected as "beyond our expectation" and congratulated Westinghouse on the neatness of the job. The manager of the switchboard department of Westinghouse, Stremer, considered publicizing the switchboard arrangement at the Soo. Writing to plant superintendent Dawson in late 1917 he stated:

I feel that your installation at the Soo represents such a novel and exceptionally arranged switchboard equipment that the Westinghouse Company would very much like to prepare an article descriptive of the plant ... 

Stremer even paid a visit to the Soo to secure information and photographs for a description that was to appear in *Electrical World*. The description was never published, perhaps because the power company tended to shy from publicity and Union Carbide was reluctant to release any technical information about the carbide manufacturing process. 

At approximately the same time the additional turbines and generators and the new switchboard were being installed, Union Carbide made massive changes in their furnace arrangements. The rows of Horry rotary furnaces were replaced by large tapping furnaces, which consumed 10,000 to 20,000 hp apiece and absorbed almost all of the expanded generating capacity of the plant. One of these furnaces was originally installed on the second floor of the powerhouse, another was placed in a separate furnace building constructed on the grounds east of the powerhouse around 1916. Eventually, the second floor of the powerhouse was used for cooling and storage purposes only.

Expanding the turbine, generator, and furnace plant in the powerhouse would have been a useless extravagance unless additional water to drive this equipment was diverted from the St. Marys. Davis had estimated in 1905 that the water being diverted (around 10,000 second feet) was sufficient to drive only about 25 penstocks at full capacity. 

### Compensating Works Expansion

Union Carbide's purchase of the hydroelectric plant at Sault Ste. Marie in 1913 through the Michigan Northern Power Company coincided rather closely with the conclusion of legal problems in the rapids. In mid-1913 the Supreme Court made the final determination on the award to be given the Chandler-Dunbar waterpower company. Also in mid-1913 the negotiations over the terms of a water lease with the government, underway since 1911, were brought to a successful conclusion.

Under the terms of the 33-year lease, the power company was allowed to continuously divert 25,000 second feet of water (designated as "primary water"), with a possible increase of 5,000 second feet ("secondary water"), if it were available. The cost of the water was set at $2.50 per second foot per year for the "primary water"; $1.00 per second foot for "secondary water." The power company was to build the compensating and remedial works necessary for this diversion according to plans furnished by the company and approved by the War Department. On completion the compensating works were to become property of the United States, with the cost of the works to be paid back to the power company out of the water rentals. The company also pledged to repair and strengthen the powerhouse and forebay.

The terms of this lease were subject to approval by the International Joint Commission, an international body created by treaty with Canada in 1909 and successor to the earlier International Waterways Commission. Both the terms of the proposed lease and the power company's plans for expanding the compensating works were submitted to this body in the summer of 1913, almost immediately after the Supreme Court's final decision in the Chandler awards case.

The power company was able to submit plans for expanded compensating works so quickly because it had had plans for such expansion under study for some years. For example, when it appeared in 1909 and 1910 that the government would soon take control of the rapids, the Michigan Lake Superior Power Company had retained Noble and Woodard to report on the effects of a wing dam on Lake Superior water levels. Shortly after, Noble and Woodard were asked to draw up plans for remedial works that would allow a diversion of 30,000 second feet. These plans had only to be updated and modified to
take into account government modifications in the rapids (the old Chandler-Dunbar dike was removed in 1911) before submission.

Initial plans called for six additional sluice-type gates plus a long dike. In late 1913 and early 1914 negotiations were conducted with Canadian engineers on the proposed works.

Several Canadian engineers objected to the company's plans. The Canadians feared that if, at some point, both the Michigan and Canadian power canals had to be shut down simultaneously, the 10 gates (four existing plus six proposed) would not be able to discharge a sufficient quantity of water and the level of Lake Superior would be raised. They wanted Michigan Northern to erect 15 additional compensating gates (for a total of 19) to avoid this.

In February 1914, Davis, the company's consultants Noble and Woodard, and the Army's District Engineer, Mason Patrick, met with nine Canadian engineers to iron out their differences. A compromise was worked out. The number of compensating gates was increased from 10 to 16, with the Canadians agreeing to construct four immediately adjacent to the existing four. Michigan Northern agreed to construct the other eight plus the dike needed to link the works to US government lands and completely close off the rapids.

The International Joint Commission held a public meeting at Detroit on March 9, 1914, to consider Michigan Northern's application for diversion. But the issue was not in doubt since Canadian and American engineers had reached an acceptable compromise. The Commission report, issued May 26, 1914, approved the lease signed between Michigan Northern and the US government, and gave permission for increased diversion as additional regulatory works were constructed. Two days later the water lease with the government was finalized.

In order not to obstruct the flow through the rapids more than absolutely necessary the eight American compensating gates were built four at a time. The procedures used in their construction were substantially the same as followed in 1901–1902. Coffer dams were built, towed into place, and sunk around the location. The water was pumped out, and the work on the substructure started. Work began in September 1914 on the first four new gates (numbers 13 thru 16), and the last four American gates were completed by July 1916. The four new Canadian gates (numbers 5 through 8) were completed by December 1915.
By 1919 the entire channel of the St. Marys River had been closed off by dikes, locks, power plants, or compensating gates, with the exception of a short gap above span 5 of the foundation problems the area beneath the sill was excavated deeper than planned and a concrete cut-off wall was poured. The sill was then extended in order to give the gates a broader base, so that the water pressure exerted against the gates would be distributed over a wider area.\textsuperscript{30}

Preparing to close off the last remaining open section of the St. Marys River at Sault Ste. Marie—the completion of the dike joining the compensating gates to the U.S. government headrace in August 1921. Courtesy of Edison Sault Electric Company.

International Bridge between the government power canal dike and the abutment of compensating gate 16. Work was postponed on this portion of the works because the existing structures were more than sufficient for the waters being diverted. In the summer of 1921 the last remaining section of open channel in the St. Marys at Sault Ste. Marie was closed by a dike (enlarged in 1922) leading from the compensating works to the dike of the head race of the government powerhouse (the old

View of all 16 compensating gates from the American end, c.1919–1920. At this point a small section of the St. Marys River was still open since the dike connecting gate 16 (the one closest to the viewer) and the government hydroelectric plant headrace (barely visible in the lower right-hand corner) was erected only in 1921. Courtesy of Edison Sault Electric Company.

8) were completed only in December 1918.

The form of the new compensating gates was almost identical to that of the 1901–1902 gates.\textsuperscript{29} The dimensions of the vertical gates and the masonry piers were the same. The only major changes were in the width of the sills. The eight gates on the Canadian side of the border, including the four original gates, had sills approximately 40 feet wide. The sills of the eight American gates are much wider, around 52 feet. During foundation excavation it was discovered that the rock under the location of the American gates was badly undermined by a mud seam. To avoid possible foundation problems the area beneath the sill was excavated deeper than planned and a concrete cut-off wall was poured. The sill was then extended in order to give the gates a broader base, so that the water pressure exerted against the gates would be distributed over a wider area.\textsuperscript{30}
While Michigan Northern did not complete all of the promised works until 1922, the Corps of Engineers gave the company permission to increase flow to 17,500 second feet in September 1914 and to 21,500 second feet in December of the same year. This was increased to 25,000 second feet in early 1916. The plant was pushed to full design capacity (30,000 second feet) only in July 1917, after the long-delayed repairs to the powerhouse were completed.

Powerhouse Repair
Within months of Union Carbide’s purchase of the powerhouse there were indications that comprehensive powerhouse repairs were once again under consideration. No definite moves were made, however, until April of 1915. Then two more consultants—R.D. Johnson and Silas Woodard—were asked to make additional studies of the powerhouse and methods of remedying its deflection and leakage problems.

Johnson delivered his report to the company in July 1915. He proposed paving the forebay out to 130 feet in front of the powerhouse with 1.5-foot-thick reinforced concrete. This paving was to be supported on 5,000 inclined piles driven to bedrock and tied into the powerhouse at the tailrace walls by steel rods. In front of this forebay floor a reinforced concrete dam, 5 feet thick, was to be constructed between steel sheet piles to keep water from under the forebay floor. Under the concrete, several layers of graded gravel were to carry any leakage that did occur to a drainage and inspection chamber formed at the point where the concrete forebay floor met the powerhouse. The water collected in this chamber was to be discharged through the end spillways.
Woodard, a prominent consulting engineer long associated with Alfred Noble and specializing in hydraulics and foundations, delivered his report to Michigan Northern in September 1915. He examined and criticized all the previous plans for powerhouse repairs and offered two plans of his own. One of his reinforcement schemes, similar in concept to von Schon's recommendation in 1903, contemplated the installation of concrete buttresses at the rear of the powerhouse. There were to be 38 of them, 6 feet thick, 48- to 60-feet long, anchored to bedrock, and connected by a smaller buttress to the north powerhouse wall. One would be placed at every other tail pit wall; all would be sunk pneumatically. The forebay leak was to be eliminated by driving a row of steel sheet piling to bedrock 3 feet in front of the powerhouse. The material between the sheet piling and the powerhouse was to be excavated to a depth of around 15 feet and the cavity filled with concrete.

Another option outlined by Woodard involved the use of 18-inch-diameter cast-iron batter (inclined) piles driven to bedrock at a 45° angle by hydraulic jacks through holes made in the tailrace floors. Woodard's plans called for 6 of these piles arranged in pairs in each of the 81 penstocks. After the piles had been forced to bedrock and filled with concrete, a steel I-beam was to be placed across the top of each pair, extending across the tail pit and under the tailrace walls on each side. After the I-beam was placed, the floors and walls would be restored to their previous dimensions by concrete filling. In this scheme, as in Woodard's masonry buttress scheme, steel sheet piling and a concrete apron were to eliminate the leak problems.

Woodard's report was studied at some length by Davis, who had been retained by Michigan Northern as chief engineer and gen-

![Diagram](image-url)
eral manager of the hydroelectric plant, as well as by other company officials. They decided to give his cast-iron batter piles a try. The plan adopted differed slightly from that originally outlined. Instead of six batter piles driven beneath the floor of every tail pit, there were to be two rows of five piles on either side of every other tail pit wall.38

By early April 1916 one of the tail pits (no. 73) had been drained and by late April holes had been cut in the floor and driving had begun. The contractor, the Underpinning and Foundation Company of New York, had problems from the start. The first pile hit one of the existing timber foundation piles. It was eventually driven eight feet, but attempts to drive it further failed. A second pile was driven in early May. It struck hard pan at about 3 feet above bedrock and could not be driven further. Davis and Woodard, after consultation, decided that the batter pile method might not work, would definitely be very expensive, and should be abandoned.39

Failure of the batter pile scheme led to a revival of the Davis-Lindenthal inclined cylindrical buttress plan. The Foundation Company of New York agreed in mid-1916 to install 40 cast-iron buttresses at the rear of the powerhouse on a cost-plus-fee basis. They estimated the cost of the work at around $25,000.40

The plans worked out by the Foundation Company differed somewhat from Davis' earlier proposals. Davis had contemplated cutting out the bottom portion of every other tailrace wall near its northern end and removing a portion of the foundation so that the iron cylinders would butt directly against the powerhouse. To avoid having to work at close quarters in a coffered-off tail pit, and to avoid having to destroy and then repair a large amount of masonry, the Foundation Company worked out a different system, in conjunction with Davis. The top of the inclined buttresses would not butt directly on existing walls. Instead the top of the buttress would rise just above the outer edge of the existing powerhouse foundation. The tail pit walls would then be extended to the end of the foundation apron. These extended walls would transmit stresses from the powerhouse to the buttresses. The buttresses, being anchored in bedrock, would resist the stresses and hold the building stable. To resist the tendency of an inclined buttress to move upward when horizontal pressure was exerted against it, a gravel-filled, reinforced-concrete arch bridge, 18 feet wide, was to be run from extended wall to extended wall across the entire rear of the powerhouse.41

One of the big advantages of the modified plan, beyond ease of construction, was that it did not require shutting down any of the turbines for more than a few hours. A turbine had to be shut down only when the Foundation Company, operating from a floating plant, was setting and securing with timber piles and struts the cylinders from which the buttresses were driven.

A cylinder was first set in place on the concrete foundation apron, which extended beyond the existing tail pit walls of the powerhouse. On the top end of the cylinder, once it was secured in position by piers and struts, an air lock was mounted. At the lower end of the cylinder was an inverted "y." One leg of the inverted "y" was a cylinder that rested on the foundation apron; the other was a cylinder that was cut off on a horizontal plane at the level of the river bed.

The latter cylinder was 5 foot, 8 inches in diameter and within it a 'shield' 7 feet long and 5 feet 7.5 inches in diameter was assembled. As this 'shield' was driven down into the river bottom by jacks, the 1-foot, 9.5-inch-with Davis. The top of the inclined buttresses were assembled. Every time the shield was driven 1 foot, 9.5 inches into the river bed, another segment was added to the buttress. Excavation in front of the shield, jacking forward the shield, and erection of the cast-iron buttress segments continued until the shield reached solid rock. After penetrating bedrock for a distance of 6 to 12 feet a chamber was belled out beyond the shield with drills and small charges of dynamite. Then the shield and the buttress were filled with concrete. The inverted "y" cylinder and air lock were removed from the upper end of the buttress and moved on to another location. A wooden coffer dam, which served as the form for pouring the concrete for extending the pit walls out to meet the buttresses, was then erected. The water was pumped out of the form and the concrete tailrace wall extensions were poured. After adjacent buttresses had been completed and the tailrace wall extensions poured, a reinforced concrete arch bridge was run from pier to pier. These operations occurred in front of every other tail pit wall.

The contract for buttress construction was signed with the Foundation Company on June 5, 1916. The company quickly moved a large floating plant to Sault Ste. Marie, including equipment to drive 10 buttresses simultaneously. Work got off to a slow start. This was not surprising since the type of construction contemplated was, in the words of the Engineering Record, "a combination of caisson, tunnel and cofferdam methods unique in the history of American contracting."42 The first buttress took 43 days to complete. But as the construction crews gained experience things speeded up. By late summer buttresses were being driven in an average of 24 days. Because Union Carbide was in need of maxi-

85
Cylinder used in erecting the inclined buttresses for powerhouse reinforcement in 1916. An air lock was placed on top; the lower portion of the vertical element rested on the powerhouse foundation apron. The inclined cylinder jutting off the right contained the shield used to begin the erection of the segmented inclined cast-iron buttresses. Courtesy of Edison Sault Electric Company.
Extension of the tailrace walls, April 28, 1917. The timber work in the foreground was used as combination coffer dam and form for pouring the concrete tailrace wall extensions. In the background along the powerhouse several completed wall extensions can be dimly seen. Courtesy of Edison Sault Electric Company.
mum power (perhaps because of the demand for acetylene produced by the war in Europe) work was carried on night and day, and in October, to further accelerate construction, bonuses were offered for faster work. The last tunnel was concreted on December 29, 1916. By August 21, 1917, the last arch had been concreted and gravel loading the entire bridge had commenced. With completion of the loading bridge in September 1917, reinforcement of the powerhouse against sliding was accomplished. The fears of structural failure, which had kept the plant operating at only a 14 foot head for almost 15 years, were gone.

Forebay leak repair, the remaining problem area, was not included in the mass of reconstruction and plant improvement work undertaken in the first five years of Michigan Northern's tenure at the powerhouse. The 1910 repairs were holding up and Union Carbide, in the midst of heavy war-time demand for its product, was reluctant to shut down operations to permanently repair the forebay. Some other improvements, however, were made to the plant. The canal bank had collapsed at several points along the power canal. These sections were excavated and repaired. The headgates were equipped with electric motors, which were enclosed in small box-like houses.
North side of powerhouse, August 29, 1917, after the last arch connecting the extended tailrace walls had been poured. To add more weight to the bridge, gravel was placed over the arches. Courtesy of Edison Sault Electric Company.
Table XI
Average Annual Output in Horsepower and Kilowatt Hours of the Michigan Lake Superior Power Company Hydroelectric Plant (after 1913 the Michigan Northern Power Company Hydroelectric Plant), from 1903 through 1935

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Units Operative</th>
<th>Average Annual Output in Horsepower</th>
<th>Total Station Output in Millions of kWhs</th>
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NOTE: All figures approximate
The interlocking steel sheet piling, which was driven to bedrock in the fall of 1926 just in front of the powerhouse to eliminate the leakage problem. The piles and sills for a portion of the forebay floor and for the new forebay apron are also visible. Just behind the steel sheet piling is the timber sheet piling driven in 1903 in an unsuccessful attempt to eliminate the leakage. Courtesy of Edison Sault Electric Company.

debri (35,000 tons were removed), and bulges and breaks in the canal walls repaired.50

The 1926 repairs were successful. Since that date the powerhouse has never been shut down due to structural instability or foundation washout. Since 1926 few changes have been made to the basic configuration and arrangement of the powerhouse and its canal. The intake was modified when the government decided in the 1940s to extend the southwest pier leading up the St. Marys Falls Canal.51 The dormers were removed from the east and west pavilion roofs in the 1950s. Also the trash rack was removed from the forebay in the early 1970s; it was less necessary since the St. Marys was no longer in use to float pulp wood.

An engineering firm that reviewed the condition of the hydroelectric plant in 1962 found the powerhouse foundations in stable condition and the exterior masonry walls of the powerhouse “surprisingly free of cracks and other signs of settlement or deterioration due to age.” It pronounced the hydroelectric plant “in remarkably good condition.”52 Not only does the hydroelectric plant at Sault Ste. Marie remain in remarkably good condition, it is, despite its age, still an impressive engineering work. As the president of the James Leffel Company noted with some surprise in 1971, it has the “most impressive line-up, of greater length and number of horizontal units, than we have ever encountered in one location heretofore.”53

Epilogue: Sault Ste. Marie and the Hydroelectric Plant

By the turn of the century Sault Ste. Marie had pinned all of its hopes of becoming a major industrial center on the gigantic hydroelectric plant that Clergue and the Michigan Lake Superior Power Company were constructing on the banks of the St. Marys River. This plant was billed as a dangerous rival to Niagara Falls, a development with the potential of drawing industry away from that important center.1 A local newspaper in 1899 asserted that when the plant was operative “the old Soo will be transformed into a new Soo, one of the most important cities in the west.”2 Even outsiders did little to dampen local optimism. For instance, Secretary of War Alger on a visit to the area in 1899 declared that the power plant would “revolutionize” business in the northwest and would, in time, make the Soo one of the biggest manufacturing cities in the union.3

But waterpower alone was insufficient to at-
tract most industries, as Clergue had discovered in the Canadian Soo. Despite widespread publicity, the power company was not flooded with applications for power and Clergue's extensive efforts to attract industries (with the exception of Union Carbide) all but completely failed. Thus, as we have seen, he was forced by 1902 and 1903 to begin making discreet plans for exporting some of the power, via high-voltage electric power transmission, to industrial centers far to the south. But the erroneous belief that powerhouse alone would attract industry and transform Soo into an industrial metropolis died with difficulty. Local papers found it hard to believe that Clergue was having to consider transmitting power out of the Soo and labelled rumors of these plans "hot air."4

The morass of technical, financial, and legal problems, which paralyzed the power plant beginning in 1903, dimmed local hopes of attracting additional industry to the area. But the public's attitude towards the power company was at first one of sympathy, encouragement, and support. This did not last long. Because the high hopes so long raised by promoters largely went unfulfilled, the community's sympathy, encouragement, and support soon changed to impatience, frustration, bitterness, and complaint. Typical of the changing public attitude towards the power company is a 1905 editorial:

There has been for some time talk among the people of the Soo that we are not getting our dues from the Michigan Lake Superior Power Company in the completion of the canal and in the fulfillment of certain pledges and promises made by that company. The people would not like it to appear that they are dissatisfied but they feel that the building of the canal has imposed burdens upon them which are hard to bear and they would like some encouragement from the company to help them bear the burdens. We understand that the company has been up against it in many ways—but they have directed their energies toward developing the interests in the Canadian Soo while the enterprise on this side of the river is in status quo, not a cent having been expended here in some years.5

Public opinion in the Soo had originally supported Clergue and the Consolidated Lake Superior Company against Chandler's claims. This, too, changed as the dream of the Soo becoming an industrial center languished. When, in 1905, Chandler began making plans for a large power development in the rapids and the US Circuit Court upheld his claims, many local businessmen decided that the court's decision was a mandate for Michigan Lake Superior to acknowledge Chandler's claims and reach a settlement with him, so that both powerhouse projects could be fully developed. The expectation, of course, was that Sault Ste. Marie could then begin to enjoy the long-delayed rewards of industrialization.

The impatience and frustration of local businessmen took concrete form when, in 1905, the Sault Ste. Marie Chamber of Commerce began agitating for the repeal of the specific tax law. This law, passed by the Michigan legislature in 1899 at the request of the city as part of its agreement with Clergue, allowed the hydroelectric plant to pay a special tax of $5,000 per year in lieu of normal property taxes, which would have been $75,000.6 The campaign for repeal of the specific tax was seen by local businessmen not only as a way of relieving their tax burdens, but as a lever to force the power company to repair the hydroelectric plant and come to a settlement with Chandler over water rights. Relations between the city and the power company thus became a major local political issue between 1905 and 1909.

To a certain extent the city had reason to complain. Sault Ste. Marie had contributed over $100,000 to the St. Marys Falls Company. This investment had been lost when Clergue bought all rights and properties of that company from its bondholders. The city had spent $100,000 to erect bridges over the power canal. The hydroelectric plant had also forced the city to spend $150,000 to change the site of its pumping station; $40,000 to modify the sewer system; and $20,000 to alter streets, alleys, sidewalks, and water pipes. And the specific tax provision was costing the city $70,000 in revenue every year. These costs and the basic inconvenience of the power canal (it had made the central part of the city an island) had at first seemed acceptable, since it was believed that the costs would be more than covered by the influx of new industries and the creation of a larger and more stable tax base. But the hydroelectric plant had attracted only Union Carbide, and even Union Carbide was able to operate at only half of promised capacity. In addition, people in the American Soo were somewhat jealous and resentful of the much larger industrial base that Clergue had erected on the Canadian side of the river, feeling that some of the investment capital should have gone into repairing and expanding the American hydroelectric plant.7

The power company responded to these charges by pointing out that the Consolidated Lake Superior Company had already spent millions of dollars in purchasing properties and in building the power plant. More money could not be put into it until legal matters
were cleared up. "There is not a company on the face of the earth that would accept our water power plant, powerhouse and all as a gift subject to the present encumbrances," the company noted. The power company also pointed out that it did pay, beyond the $5,000 specific tax, an additional $5,000 on lands not included in the specific tax legislation and that their $30,000 annual payroll was a major benefit to the city.8

The growing antagonism between the power company and the city is probably best explained by the enormous gap that existed between the inflated hopes and expectations built up prior to 1902 and the depressing reality of the post-1902 period. This antagonism culminated in the repeal of the specific tax provision in 1909. A gesture of frustration and impatience more than anything else, this action had been taken there was little else the city could do.

In the spring of 1913 when the negotiations between the bondholders of the Michigan Lake Superior Power Company and Union Carbide were reported, the reaction of local newspapers was enthusiastic, but with serious reservations. Generally, Soo residents seemed pleased that an end to the financial and technical difficulties of the hydroelectric plant was in sight. But Union Carbide's role in the negotiations was described as "a feature that has been feared by Soo business interests for the past ten years."9 It was feared because the local business community did not want all of the power of a revitalized hydroelectric plant to be absorbed by the one industry they already had—Union Carbide. They wanted Union Carbide to be restricted to the 20,000 hp committed to them under the 1898 contract. They hoped that the other 20,000 hp would be reserved to attract less power-intensive and more labor-intensive industries, each utilizing a small- to medium-size block of power. Responding to these hopes B.F. Price, vice president and general manager of Union Carbide, announced that Union Carbide only wanted to bring its operations in Sault Ste. Marie up to full capacity, i.e., 20,000 hp, and that the company's policy would be to try to attract small users of power for the remaining output.10

Price's statement was deceptive; the fears of the Soo's business leaders were well-founded. A memo from L.H. Davis, retained as chief engineer and general manager of the hydroelectric plant after Michigan Northern Power Company assumed ownership, to E.F. Price of Union Carbide in November 1913 indicates that plans were to sell no power to any customer other than the carbide company, except those already being supplied.11 The contract between the Michigan Northern Company and Union Carbide, signed on December 10, 1913, formalized these plans. Michigan Northern committed 35,000 hp to Union Carbide at all times. Since the remaining 5,000 to 7,000 hp capacity of the plant was power available only part of the time (low water levels and winter icing often dropped output to around 35,000 hp), there was little to attract other industries.12

During World War I, when the increased demand for calcium carbide began to press heavily on existing production facilities, Union Carbide expanded its plant at Sault Ste. Marie and absorbed all of the hydroelectric plant's output. Although this made the Union Carbide plant at Sault Ste. Marie the largest single producer of calcium carbide in America,13 it ended any possibility of the hydroelectric plant attracting new industry to the Sault Ste. Marie area.

Several other industries besides Union Car-
bide moved into the Soo early in the 20th century, most notably the Cadillac-Soo Lumber Company (incorporated in 1923) and the Northwestern Leather Company (incorporated in 1898). But they were lured by the area’s timber resources (tannin, used in the treatment of leather, is extracted from oak bark), not by its hydroelectric power. And they were small companies. Even with Union Carbide they were incapable of transforming Sault Ste. Marie into the industrial metropolis predicted by over-confident prophets at the turn of the century. The city grew, but very slowly. In 1900 its population was around 10,500. By 1950 it had reached only 18,000.

The hydroelectric plant and the adjacent carbide manufacturing facilities were responsible for much of what growth there was, and did make a substantial contribution to the area’s economy. In 1945, for instance, Union Carbide and the associated Michigan Northern Power Company employed around 25% of the work force of Sault Ste. Marie; they paid 37.58% of the city budget and 31.37% of the combined city and county taxes. But this contribution was somewhat offset by other considerations. Carbide production was a dirty process. Black, powdery dust from the Union Carbide plant coated every house in the vicinity and carbide wastes accumulated in big piles on the eastern edge of town.

Moreover, failure of the hydroelectric plant to attract a diversified industrial base left the Soo heavily dependent on only a few industries. Union Carbide was clearly one of the most important of these and by mid-century its future had become clouded. Originally the output of the Sault Ste. Marie Union Carbide plant had been shipped all over the country. But by the 1950s, because of the relative isolation of Sault Ste. Marie and the high cost of transporting materials to and from the Soo, the plant was unable to compete with newer plants further south along the main east-west American rail and road networks. The Sault Ste. Marie plant was able to continue making a profit despite this primarily because, by this time, 85 to 90% of its output was being absorbed by one customer—DuPont at Montague, Michigan. Montague was relatively close to the Soo and carbide could be shipped to Montague in bulk using lake freighters. In 1961, however, DuPont announced that it intended to manufacture its own acetylene, extracting it from natural gas instead of calcium carbide. Faced with the loss of the customer, which absorbed the bulk of the output of the Sault plant, Union Carbide decided to close its works at Sault Ste. Marie.

Union Carbide approached the Edison Sault Electric Company in early 1962 about purchasing the old hydroelectric plant. Edison Sault, a local utility that since 1911 had been largely limited to leasing and distributing power from the government powerhouse in the rapids, was interested. After some negotiations, an agreement was reached. Edison Sault took over the hydroelectric plant in May 1963 and subsequently invested over a million dollars in converting it to deliver 60-cycle current for domestic consumption.

Union Carbide’s closure was just one of a series of blows that struck the Soo around 1960. The Cadillac-Soo Lumber Company and the Northwestern Tanning Company, two other major employers, also went out of business about the same time. The effect of these actions is reflected in population statistics. In 1950 Sault Ste. Marie had a population of around 18,000. By 1975 the population had dropped to around 13,700. In many respects Sault Ste. Marie in the 1970s was in the same position as Sault Ste. Marie in the 1870s—a city without a strong economic or industrial base, whose economy was heavily dependent upon highly seasonal transient traffic. In the 1870s the traffic came from lake freighters passing through the locks; in the 1970s it came largely from tourists stopping in Sault Ste. Marie for a few hours to watch lake freighters pass through the locks.
Additional Use of the Powerhouse

The Soo powerhouse failed to turn the city into a major industrial metropolis, yet Sault Ste. Marie has potential for continued small-scale growth. Situated along the Soo locks, the city offers both visitor and resident an unparalleled opportunity for observing large lake and oceangoing vessels. The waterfront below the locks is generally attractive, and has not been preempted by industrial use. Directly south of its Canadian sister city, Sault Ste. Marie, Ontario, the Soo offers an international crossing point, the only one between Port Huron, Michigan, 350 miles to the southeast, and Grand Portage, Minnesota, 590 miles to the northwest. The international bridge across the St. Marys River is the northern terminus of I-75, which passes through Detroit, and has its southern terminus in Tampa/St. Petersburg, Florida. Fortunately, the city has not ignored the river, as have so many industrial cities, but has recognized the potential for enhancing its waterfront.

Sault Ste. Marie is a city of 15,800 people. Throughout its history, migration has played a large role in its population. During the 1960s, the city suffered a stagnant economy. Many of the residents left to find employment elsewhere, resulting in a population of mostly elderly citizens. After 1970 outmigration in Sault Ste. Marie reversed and the area began to experience a population increase. From 1970 to 1975, net immigration accounted for almost half of the population increase in Chippewa County, home of Sault Ste. Marie. Some of this growth can be attributed to older people retiring to the Soo. The Kincheloe Air Force Base closed in 1977 causing a dramatic change in the area's economy and population. This closing brought an estimated 8 percent decline in the city and a 25 percent decline in Chippewa County.
Market Analysis

Although the powerhouse continues to generate hydroelectricity, the upper floors, once intended for industrial use, lie vacant. The summer team determined potential markets for industrial, retail, residential, and tourist-related uses in Sault Ste. Marie, and suggested ways the upper floors of the powerhouse might be used, and ways the city might capitalize on its historic resources.

Introduction

Sault Ste. Marie is divided geographically into two sections by the power canal. The oldest part of the city lies between the St. Marys River and the canal, and is familiarly known as the “city island.” It is here that the downtown section is located, centered on Ashum and Portage streets, about six blocks west of the powerhouse. Portage is the first continuous east-west street south of the river. Most of the tourist facilities line this street. Ashum Street, perpendicular to Portage, and in the center of city island, is one of the few streets bridging the canal to the remainder of the city, and serves as the main local shopping street. The remainder of the city, to the south of the power canal, contains newer residential districts, as well as a new shopping mall. Historic Fort Brady is also in this section of Sault Ste. Marie and houses Lake Superior State College.

In addition to the powerhouse, there are many other historic structures on the city island. The downtown is filled with Victorian commercial structures that lend an air of grace and importance to the city. Second Empire style Chippewa County Courthouse constructed of red sandstone stands next to the downtown; the classical revival Federal building and the Renaissance revival Corps of Engineers buildings overlook the river through broad landscapes. Fort Brady, established in 1825, has several historic structures from various periods; Mariner Park, adjacent to the berth of the old lake freighter Valley Camp (now a maritime museum), and near the powerhouse, has three historic buildings, which have been moved there. These buildings commemorate the early history of Sault Ste. Marie, and the city hopes to move additional historic structures there in the future.

Sault Ste. Marie faces a number of problems: it lacks an industry and its retail core needs bolstering; it has an increasing population of elderly citizens; and it has high unemployment. The city is dealing with these problems and possible solutions are discussed below. The potential reuse of the Sault Ste. Marie Powerhouse and its function in revitalizing the Soo are examined.

Industry in the Soo Area

During the 1950s and 1960s many industries like Union Carbide that had settled in Sault Ste. Marie moved away. Being too far north, Sault Ste. Marie’s location posed real problems for industries in their ability to compete with those farther south. Transportation problems and the increasing obsolescence of older plants caused many firms to relocate or to close permanently. Between 1955 and 1970 seven businesses, which once employed 2,458 persons, ceased operation. Today five major industries in the area employ only about 400 people.

This loss of industry left the Soo area heavily dependent upon public employment, particularly within defense-related agencies. In 1970, federal, state, and local government agencies employed 3,000 persons, or 43.5% of the total wage and salary employment in Chippewa County. To overcome this dependence, local government officials have sought to attract new industries to the Soo.

Since the early 1960s, they have had some success in their efforts. A 64-acre industrial park established in 1962 features a 17-acre free-trade zone and an incubator building. The incubator building, owned by the city, enables industries to begin operations with low rents and no taxes. Aside from two vacant areas, the industrial park is fully used; however, these industries are small, and none employ more than 15 persons.

When the Kincheloe Air Force Base closed, the city relocated its municipal airport to that site. The new airport did not require the entire abandoned base, so some 36 buildings remain, offering 560,000 square feet of usable space. The 600 acres occupied by the former airport facility are also available for reuse. The city has developed an Airport Reuse Plan, which calls for multiple use of the site. Eighty-five acres on the site have been set aside for light industry.

Consequently, the city/county area has available about 700,000 square feet of industrial space, but only 115,000 square feet is currently being devoted to manufacturing. Moreover, it is doubtful the area could draw manufacturing that would fill space six times that which is presently used.

The Soo’s most successful industries involve manufacture of small and/or lightweight durable goods, such as precision machine components. The Edison-Sault powerhouse should be kept in mind as a site for one or more of these kinds of industry. The area has many unskilled or semi-skilled persons, so wages are low and unions are virtually nonexistent.

The former airport and airbase both have utilities and are both accessible to I-75. The powerhouse, on the other hand, is not convenient to gas lines or sewage disposal, and is not convenient to I-75. An industry that
needed large amounts of either electricity or water or that used water transportation would find the powerhouse a useful location. But for industries that show a potential for growth in Sault Ste. Marie, the powerhouse is not as appealing as the other two sites.

Retail Business
Two Upper Peninsula cities, Marquette and Escanaba, offer the major competition to the Soo. But Sault Ste. Marie dominates the trade in the eastern Upper Peninsula, and accounts for 52% of all sales there. Ashmun Street between the power canal and the St. Marys River remains the major marketing area for Sault Ste. Marie, since the new shopping mall has not had an impact on downtown shopping. The downtown has been beset by some retail outlets closing, but this is due to the population decline and not to competition.

The city is currently involved in a long-range program to revitalize downtown. Six economic programs have been identified, which will help to improve the retail sector of the Soo. These are 1) to expand area industry; 2) to exchange duty-free goods between the two Soo cities; 3) to organize downtown merchants, landowners, and investors; 4) to maximize interrelationships between tourism and the downtown; 5) to use existing educational mechanisms to help meet needs of merchants; and 6) to help merchants reinvest capital.

Retail demand, the present use of space, and the way retail goods are merchandized are important to the Soo and to the reuse potential of the powerhouse. If crowds came to shop in Sault Ste. Marie, chances of using the powerhouse would be considerable, but this is not expected. Moreover, because the city is involved in upgrading and revitalizing the downtown area, and because the powerhouse is remote from the central downtown, using it as a retail space is not recommended. However, it is feasible for some convenience retail establishments to be located in the powerhouse if their operation is secondary to the main use of the building.

Housing
Little hope exists for developing a vigorous housing market in the Soo area for the near future. Houses vacated by middle- and upper-income people have been marketed at prices well below those of the 1975-1976 period, allowing lower-income persons to move into better housing. Therefore, the upper-income housing stock is not becoming vacant; instead an overall improvement in the quality of occupied housing stock has shown up in housing inventories since the 1970 census. About 26% of this stock, or 1,200 homes, need repair and have been targeted for renovation and rehabilitation; 60 percent (750) of the persons in the 1,200 homes need some form of financial assistance to do the renovation work.

The city has identified a need for rental units for elderly persons who require public assistance. The Housing Assistance Plan suggests that some of the 1,400 vacated standard dwellings units on the Kincheloe Air Force Base be designated as a senior citizen center. However, the base is 20 miles from Sault Ste. Marie, and it offers few services. A location with ready access to downtown Soo would be preferable.

The powerhouse offers such a location. Rental units for elderly persons could be provided through the use of the Department of Housing and Urban Development’s Section 8 money. Units in the powerhouse would overlook splendid views of the St. Marys River, and would offer easy access to downtown and to recreation spots along the river.

Tourism and Visitor Potential
The Sault Ste. Marie waterfront attracts many summer visitors. During the 1970s the locks attracted between 700,800 and 1 million visitors. However, these figures are misleading because tourists often did not remain in the Soo area for more than a few hours, and thus the amount of money spent is far less than such a large volume suggests.

Much of the waterfront in Sault Ste. Marie has been developed for recreational and tourist use, with the Soo locks as the major attraction. The Corps of Engineers and the city have developed a park area along the south side of the locks with a viewing stand, flower gardens, benches, a fountain, and walkways. A chain-link fence separates the park area from the lock area. The Renaissance revival Corps of Engineers buildings and Ojibway Hotel lend an air of dignity to the site. Fine late-Victorian houses also overlook the water at this point.

The lock operations are slow but exciting. The Corps operates four locks, and the volume of ship traffic (nearly 100 million tons annually) is high enough that at times three vessels may be locking through at once.

Tourist retail and service facilities are situated along Portage Avenue near the viewing stand. The Ojibway Hotel’s cocktail lounge and dining room afford fine views of the locks and the passing ships. However, the remainder of the tourist facilities simply exploit visitors with garish signs and displays that attempt to capture as many tourist dollars as possible. Immediately east of the locks the waterfront is not accessible to the public, but aside from this area, tourist attractions line the waterfront between the locks and the power-

President Reagan has recommended that the HUD Section 8 Program be eliminated. The proposal is awaiting legislative action.
house. The handsome classical revival Federal building (now unused) occupies a prominent block between Park Place (Water Street) and Portage Avenue overlooking the river.

A local group, “Le Sault Ste. Marie Historical Sites, Incorporated,” is gradually restoring a Great Lakes freighter as a museum of shipping on the Great Lakes. The S.S. Valley Camp is anchored in a slip about 100 yards west of the powerhouse.

To the west of the S.S. Valley Camp the city is completing Mariner’s Park where important historic homes from Sault Ste. Marie will be displayed. The park will also have a band shell, space for both active and passive recreation, and a boardwalk. Two other historic ships occupying a slip just west of Mariner’s Park will soon be renovated. One of these may be turned into a floating restaurant.

The powerhouse could serve as an important link in developing a continuous chain of water-related, historical, recreational, and human interest sites between the Soo locks, ¾ mile west, and an historic brewery building, ½ mile to the east. To accomplish this, access around or through the powerhouse must be provided. The city should turn its 15-acre tract east of the powerhouse into usable public space. The Coast Guard should be approached regarding public access to its land. The Coast Guard could create displays describing its work and the use of the icebreakers moored there. With a number of changes and with the development of appropriate information, Sault Ste. Marie could give tourists a unique historical and recreational experience.

Whether Sault Ste. Marie takes advantage of its waterfront potential, the powerhouse can still make use of some travellers’ demands, such as providing hotel space, convention facilities, long-term vacation rentals, and historic interpretation.

Hotel Space
In 1975 Chippewa County had 1,932 seasonal and year-round rooms for rent, with half of these open only seasonally. At a time of energy shortages (tourism was off 10–15 percent in the Upper Peninsula in 1979), it might at first appear foolish to recommend increasing hotel space. However, tourism in Sault Ste. Marie is highly seasonal, with an average of 30–50% of the year-round rooms occupied during the winter. Aside from tourism, business people and convention delegates come to the Soo at a relatively constant pace throughout the year. Generally these people demand first-class accommodations, but the current number of year-round, first-class rooms in Sault Ste. Marie is insufficient for this demand. About 265 year-round first-class rooms would meet business and convention needs, but Sault Ste. Marie only has 165 such rooms. Therefore, assuming that a 75 percent occupancy rate would be marketable, at least 100 new quality hotel or motel rooms are needed.

Convention Business
Attracting convention trade to Sault Ste. Marie is limited because of location, but there is a potential to expand that market for specialized types of conventions. A study conducted by the Michigan Department of Commerce concluded that it would be difficult to attract regional, national, or international associations. State associations, which are generally smaller and which have several meetings throughout the year, represent a greater convention potential. Data on the past activity of state associations show that Sault Ste. Marie competes with three other northern Michigan communities for approximately 90 conventions per year. Based on the competition, Sault Ste. Marie should be able to attract 15–20 state conventions per year. Using 4 days as the standard length of a convention, 17 conventions would mean the space would be used nearly 70 days or 20 percent of the year. Coordinating the use of the facilities with the needs of the Lake Superior State College would help to insure use during the winter season when the college is in session.

Because of its proximity to its sister city in Ontario, Sault Ste. Marie has much more to offer in a cosmopolitan atmosphere than do other locations in northern Michigan. Quality shopping, entertainment, and dining can all be found in the Ontario city. In addition, Ontario offers a culture and goods that are somewhat different from that available in the United States. Conference planners could capitalize on this unique location.

Long-Term Vacation Accommodations
Spending a 2-week or a month vacation in a cottage in Michigan has long been popular. Michigan attracts more people desiring seasonal accommodations than do surrounding states and provinces. With energy shortages and high fuel prices, the demand for such accommodations grows. People find it less expensive to settle in one place for an entire vacation than to move around a great deal.

An analysis of the existing market for seasonal homes shows that over the past 20 years the stock of units has been decreasing. At the same time, at least within the past 5–10 years, the demand has been increasing. People in the seasonal home market (both renter and owner) are looking for modern facilities and access to such amenities as shopping and entertainment.

The location of the powerhouse offers a spectacular site for this type of accommodation. The views of river traffic, of Sault Ste. Marie, Ontario, and of the St. Marys River are dramatic. Fishing along the tailraces of the
powerhouse is popular. A portion of the city-owned land to the east could be developed as a marina. As was mentioned previously, quality shopping and entertainment are provided by Sault Ste. Marie, Ontario. Access to wilderness or scenic areas in both Michigan and Ontario are within easy access of Sault St. Marie. Apartments could be developed in the powerhouse, which would adequately meet the needs of long-term vacationers. The market analysis indicates that approximately 150 units are presently marketable in Chippewa County.

Historical Interpretation

The Soo locks is one of Michigan’s major attractions, second only to Greenfield Village outside of Detroit. A survey of the visitors at Soo locks has shown that of all visitor activities, 23 percent involve visiting historic sites. Of the people interviewed, 59 percent placed visiting historic sites as their primary activity.

The powerhouse is one of several historic buildings in Sault Ste. Marie. The Corps of Engineers’ structures, the old Federal building, and the brewery building, among others, add to this treasury. Little has yet been done to capitalize on these potential attractions.

Downtown Sault Ste. Marie has Victorian commercial structures, many of which are still intact or nearly intact. The second site for Fort Brady, now occupied by the Lake Superior State College, has several important historic buildings.

Developing and interpreting downtown’s historic nature would help to build the now tenuous connection between the major local shopping street (Ashmun) and the major tourist street (Portage). Using the waterfront as a historic walk might attract tourists who come to the locks for longer stays, which would help to improve the economy of Sault Ste. Marie.

Recommendations

Because of the nature of the industrial and retail markets in Sault Ste. Marie, recommendations for the powerhouse are based on a combination of uses that involve housing for the elderly, vacation apartments, and hotel and convention space. These uses relate to the strongest markets in the Soo area. Elderly housing units can be constructed in the west pavilion, that portion of the building closest to the downtown. About 44-53 units could be constructed here. Aside from placing the elderly residents close to the downtown, the use of this particular space, which is architecturally distinct, would give the tenants a sense of identity.

The convention center should be located in the east pavilion of the building, where it will be close to the largest suitable parking area. About 15,000 square feet of convention space is recommended, which could be used as one open area, or divided into separate meeting and display facilities. A major lobby entrance to the hotel in the central portion of the building could also be located here.

The hotel and vacation apartments use the central portion of the building for identity where they can take advantage of vertical organization through three floors as well as the possibility of shared facilities as they may change from season to season. Since the east side of the building is the most logical place for parking, a motor entrance to the hotel could be placed using imaginative design. A conveyor belt could carry luggage to the lobby. An elevator could be used to bring guests to the main floor, and a glassed-in passage along the river side of the building with shops located along the south side of the aisle could lead to the lobby.

Retail facilities should be provided in the building to meet some of the convenience shopping needs of hotel guests, vacationers, and elderly residents. These would include grocery, drug, gift, and apparel stores. Certain passages around or through the powerhouse could be used in the historic interpretation of Sault Ste. Marie and are needed to provide the continuous passageway for tourists along the waterfront.

Architectural Treatment

The Romanesque style powerhouse was built of Pottsdam sandstone quarried from the power canal excavation. It is 1,340 feet long and 80 feet wide. To appreciate the scale of this building, compare it to the Empire State Building, which is 1,250 feet high. The facade is symmetrical with a 180-foot central pavilion flanked on each side by six, 65-foot bays articulated with pilasters ending with 120-foot-wide pavilions.

The structural system is riveted steel frame and masonry bearing walls on a concrete foundation integral with the turbine penstocks. All of this rests on a 3-foot grid of timber piles. Although symmetrical in exterior appearance, the flanking wings have different structural bay sizes. On the west side, three rows of columns, 18 feet by 6 inches apart, have 16-foot bays running its length. The east side, which housed the carbide Horry furnaces, has the center row of columns removed, making a central bay of 37 feet and runs the 22-foot length of the wing with 22-foot-long bays.
For adaptive use, three suitable floors lie above the turbine level of the powerplant. The first “mill floor” (also called the carbide floor) runs the entire length of the building. This floor is constructed of reinforced concrete and has a live-load capacity of 300 pounds per square foot. The second mill floor, 16 feet above the first, spans only the west side, is structural clay tile on a steel frame, and has a live-load capacity of 150 pounds per square foot. The only columns on this floor are in the central and end pavilions, leaving an open space measuring 460 feet by 75 feet. The overhead height of this floor is 12 feet by 10 inches to the bottom cord of the modified Fink roof truss. In the west and central pavilion is a small third floor.

The first mill floor has approximately 87,000 square feet, the second mill floor 48,000, and the third floor 13,500 square feet, totaling 148,500 square feet. Only 15,000 square feet on the second floor are presently in use. Above the east side of the first mill floor is an open space distributed only by horizontal bracing at the second-floor level. If more floor space were needed, this plane of wind bracing could be replaced with a reinforced concrete floor yielding another 39,000 square feet of floor space and keeping the structural integrity of the building.

Fifteen percent of the exterior surface of the building is glazed. The large amount of window area presents good opportunities for reuse and yet presents problems regarding energy conservation. On the positive side, the windows offer natural light and ventilation throughout the structure. The summers in northern Michigan are temperate, and cross-ventilation from the windows would adequately cool the building. On the other hand, the single glazed steel casement windows lose a considerable amount of heat from air infiltration, conduction, and convection.

Weatherization and Heating
Historically, heating was not a problem in the powerhouse while the Horry furnaces used by Union Carbide generated heat from 81 turbines/generator bays rose through the building. Now the Horry furnaces are gone, but 78 bays are still used for power generation. If the powerhouse were to be inhabited in its reuse, it would need insulation in the roof and weatherization of the windows. Glazing with ½-inch double insulating glass, and an emissivity coating of 0.05 would have an R factor of 2.6 and would reduce heat loss at windows by 83 percent. About 9-12 inches of insulation would be needed in the roof for an R factor of 27-38. Unused spaces should be isolated as nonheated areas. The attic space with its roof trusses may best be sealed off from the warmer areas if it is not used. This would substantially reduce the volume of space to be heated.

Regardless of the type of heating system, the tall ceiling clearances allow ample space for air ducts, pipes, and electrical conduits serving any part of the building.

Access and Circulation
The open structural system, with subsequent open space, lends flexibility in planning space in the powerhouse. There are several existing elevator openings and the floors can easily be penetrated to accommodate fire stairs and elevators.

There are some distinct access limitations to the powerhouse. It is a structure one-quarter mile long with a door at each end. Three circulation layouts are possible in the powerhouse: 1) central double-loaded corridor, 2) twin perimeter corridors, and 3) exterior circulation on the “loading” dock, an 18-foot-wide promenade on the north side. Because there are distinct advantages and disadvantages with each system, the adaptive use proposals use all these systems in concert rather than depending entirely on one.
Notes

Introduction

4. I have been unable to find an explicit claim in the literature indicating that the ‘Soo’ hydro had more penstock units and turbine runners than any existing hydropower. But an extensive search of contemporary literature on water power failed to uncover a hydroelectric plant even approaching the number of penstocks and turbine runners in use at the Sault Ste. Marie plant.

False Starts: Water Power at the Soo Until 1894

2. There are a number of works that deal with the history of the ship canal at Sault Ste. Marie, among them the two works mentioned above and Otto Fowle, Sault Ste. Marie and Its Great Waterway (New York and London, 1925); Charles Moore, ed., The Saint Marys Falls Ship Canal (Detroit, 1907); and Isaac De Young, “Beyond the Moon,” A History of the St. Marys Falls Canals and Environs (Sault Ste. Marie, Michigan, n.d.), a pamphlet.
5. Ibid.
7. Sault News-Record, October 24, 1902.
10. Bayliss, River of Destiny, pp. 190–192, discusses the boom of 1887. See also Sault Democrat, July 8, 1887, for the belief that waterpower development would transform Sault Ste. Marie into a new Minneapolis.
drawing collection.


*A abbreviations such as vf, Jf, OCF, GL, PL, etc. indicate collections of documents in the Edison Sault Electric Company archives. For an interpretation of the abbreviations see the bibliography.

**New Hopes: Clergue Comes to the Soo, 1894–1896**


2. The basic sources for biographical information on Clergue were Donald Eldon, “The Career of Francis H. Clergue,” *Explorations in Entrepreneurial History*, v. 3 (1950–51) pp. 254–268, and Alan Sullivan, *Francis H. Clergue*, unpublished 200-page manuscript. The Sullivan manuscript was furnished by Michael Bliss of the University of Toronto. It is a rather uncritical account of Clergue's career with no documentation. Sullivan published a novel based on Clergue's career, without referring to Clergue by name—*The Rapids* (Toronto, 1922).

3. Sullivan, *Clergue*, p. 34.

9. Francis H. Clergue, “An Instance of Industrial Evolution in Northern Ontario, Dominion of Canada; an Address Delivered at a General Meeting of the Board of Trade of the City of Toronto, April 2nd, 1900” (pamphlet).

104
Vacillation and Delay: Planning the Hydroelectric Plant, 1896–1898

1. For activities in the first months of work on the “Soo” hydroelectric plant the Work Diary is the best source of information. See also von Schon to Clergue, November 2, 1896 (GL, 1, 75–80); von Schon to Clergue, September 8, 1896 (GL, 1, 5–11); and von Schon to Boiler, October 3, 1896 (GL, 1, 31).


3. “Memoir of von Schon,” p. 1342. The author of the eulogy was Francis C. Shenehon, who had been in the Corps of Engineers with von Schon in the mid-1890s and described himself as a close family friend.

4. Ibid.

5. Boiler to Shields, September 21, 1904 (Mf 24090). Von Schon’s arbitrary military manner of running the project caused some resentment among employees. There is an unsigned letter from an employee to Cornelius Shields (Clergue’s successor as general manager) dated August 8, 1903, which states: “Do as I teel (sic) you right or wrong, that is Mr. Von Shon’s (sic) style.” Another letter in the same file dated July 17, 1903, also unsigned, mentions the “contempt that a certain class of our Citizens are held in by that Noble Duke Chief (sic) Von Schon” (Mf 24030).


9. Clergue to W.P. Douglas, February 19, 1897 (GL, 1, 490). W.P. Douglas was the company’s secretary.

10. Evidence of this first appears in the Work Diary, which on March 29 and 30, 1897, begins to refer to an “amended map of Canal Sections III and IV” and on April 1, 1897, to the relocation of these sections. The diary further indicates that one of the assistant engineers on
April 5, 1897, began to investigate retaining walls. References to relocation were frequent through the diary in April. See also the report of Barnes (one of the assistant engineers) on retaining wall possibilities, April 6, 1897 (Reports, A, 39–52) and the report on “Re-Location of Canal Sections III and IV,” undated (Reports, A, 76–80).

13. Soo Democrat, April 20, 1899, quoting a letter from E.V. Douglas to F.J. Firth, President of the Lake Carriers’ Association of February 21, 1899. Von Schon’s February 1897 report could not be located despite an extensive search.
16. Francis Clergue, “An Instance of Industrial Evolution in Northern Ontario, Dominion of Canada; an address Delivered at a General Meeting of the Board of Trade of the City of Toronto, April 2nd, 1900” (pamphlet, copy available at Lake Superior State College Library, Sault Ste. Marie, Michigan), and Sault Ste. Marie News, August 10, 1895, provide examples of this thinking.
17. Soo Democrat, April 14, 1898.
21. von Schon to Westinghouse, November 1, 1897 (GL, 4, 55); see also von Schon to General Electric Co., September 14, 1897 (GL, 3, 359–360).
22. For the early history of acetylene and calcium carbide see Vivian B. Lewis, Acetylene (Westminster and New York, 1910), pp. 1–62.
26. For the early history of Union Carbide see Haynes, *American Chemical Industry*, v. 6, pp. 430-432.


29. For the cost of power at Niagara Falls see J.N. Pring, *Some Electro-Chemical Centres* (Manchester, 1908) p. 5; for the cost of power at Minneapolis see *Soo Democrat*, July 8, 1887.

30. von Schon to S. Morgan Smith Co., May 10, 1897 (GL, 2, 332-333); von Schon to Dayton Globe Iron Works Co., May 17, 1897 (GL, 2, 364-365). Von Schon had also inquired about turbines to develop 700 hp (speed immaterial) and 550 hp (at 150 rpm) a little earlier (von Schon to Dayton Globe Iron Works, April 29, 1897 [GL, 2, 272-273]).

31. “Discussion of stability of 500 h.p. unit Penstock Installation against Sliding,” by J.W. Rickey (one of von Schon’s assistant engineers), October 7, 1897 (*Reports*, A, 176-181); Rickey to von Schon, October 14, 1897 (*Reports*, A, 182-185); Rickey to von Schon, October 16, 1897 (*Reports*, A, 201-205) all suggest that a 500 hp penstock unit had been adopted by the fall of 1897. For the design of the powerhouse see the original inked drawings dated October 15, 1897, and numbered 231 and 232 in the Edison Sault drawing collection, Folder 5, Pocket 3. The design is also outlined in von Schon to General Electric, October 15, 1897 (GL, 4, 3) and von Schon to Westinghouse Electric, October 15, 1897 (GL, 4, 2).

32. von Schon to Douglas, November 21, 1897 (GL, 4, 124-126); von Schon to Clergue, December 13, 1897 (GL, 4, 300); *Work Diary*, December 20, 1897, and following.


34. von Schon to Clergue, April 21, 1898 (GL, 5, 480-481); von Schon to Clergue, April 30, 1898 (GL, 6, 37); von Schon to Clergue, April 30, 1898 (*Reports*, B, 130-132); Clergue to Knapp, April 21, 1898 (GL, 5, 481).


Decision: Finishing the Design, 1898-1900


3. von Schon, General Report, p. 3; Jones to Davis, August 23, 1918 (vf 218–52).

4. As explained in the 1904 General Report von Schon conservatively assumed a 16-foot head. There were no reliable hydraulic formulas available for a canal the magnitude of that contemplated at the Soo, according to von Schon. But he believed that there was a “strong probability” that the effective head would be above 16 feet, and perhaps might reach 17 or 18 feet (von Schon, General Report, p. 38). He was correct. The average head at the plant today is between 17 and 18 feet.


15. For example, von Schon to General Electric Co., October 15, 1897 (GL, 4, 3).


17. von Schon to Clergue, January 25, 1902 (PL, 6, 60–61).


21. von Schon to E.A. Fuertes, October 26, 1898 (GL, 8, 900–901); von Schon to Rickey, October 3, 1898 (GL, 7, 426); “Turbines at the ‘Soo’,” p. 1.

22. von Schon to E.V. Douglas, November 15, 1898 (GL, 8, 228–230); von Schon to Douglas, November 23, 1898 (GL, 8, 296–298); and Reports, B, 152–158.

23. von Schon to E.V. Douglas, March 27, 1899 (PL, 1, 152–154).
30. Rickey to von Schon, October 16, 1897 (Reports, A, 219–224); von Schon to Clergue, November 30, 1899 (PL, 3, 12–14); Tudor to von Schon, January 21, 1899 (Reports, B, 236–239).
32. The results of von Schon’s tests are summarized in a letter published in the Transactions of the American Society of Civil Engineers, v. 42 (1899), pp. 135–141. See also von Schon to Clergue, September 27, 1899 (Reports, 1, 384—391), and W.W. Dann to von Schon, April 1, 1899 (Reports, 1, 141–156). W.W. Dann was one of von Schon’s assistant engineers.
33. von Schon, General Report, p. 27. The penstocks had to be able to discharge water when the turbines were not in operation because of War Department regulations that required the diversion of a constant volume of water from the St. Marys River.
35. von Schon, Hydroelectric Practice, pp. 257, 260; Rickey to Davis, November 15, 1906 (vf 222.7–43); Rickey to von Schon, October 16, 1897 (Reports, A, 201–205).
38. Blueprint #297 from Union Carbide Company, Chicago, Ill., dated September 6, 1898, in Folder 5, Pocket 3, of Edison Sault Electric Company drawing collection.
39. The reasons for this particular arrangement on the company’s side of the powerhouse is indicated in a letter from von Schon to Clergue, April 8, 1899 (PL, 1, 213). Clergue still had plans for putting in a paper mill. The first floor (generator room) was to have pulp grinders; the second floor (carbide floor) was to have wet machines; and the upper two floors (another was added when pavilions were incorporated into the architecture of the powerhouse) would be available for paper making machinery.
40. J.T. Teague to von Schon, April 3, 1899 (Reports, 1, 119–127).
41. von Schon to E.V. Douglas, April 3, 1899 (PL, 1, 206–207).
42. von Schon to E.V. Douglas, April 28, 1899 (PL, 1, 267–270); B.F. Price to von Schon, May 3, 1900 (PL, 3, 395); von Schon to E.V. Douglas, May 13, 1902 (PL, 6, 229).
43. J.W. Rickey to von Schon, October 18, 1897 (Reports, A, 196–200); also the original inked


45. See note 43.


48. C.H. Hollingsworth to von Schon, June 1, 1899 (Reports, 1, 223–224); “Construction History Report,” MS #1, p. 3 (OCf, von Schon Reports).

49. Clergue to von Schon, October 27, 1900 (VP, 29–30); Clergue to von Schon, November 14, 1900 (VP, 61).

50. von Schon to Noble, October 4, 1900 (GL, 13, 463–464); von Schon to Noble, January 22, 1901 (GL, 14, 433); von Schon to Noble, February 1, 1901 (GL, 15, 6).

51. von Schon to Noble, May 24, 1901 (GL, 15, 473).

52. von Schon, General Report, pp. 25–25a; also the original inked drawing, number 1226, November 6, 1901, in Folder 2, Pocket 1, Edison Sault Electric Company drawing collection.

53. For biographical data on Modjeski see “Memoir of Ralph Modjeski,” American Society of Civil Engineers, Transactions, v. 106 (1941) pp. 1624–1628. Modjeski was later retained as MLSPC’s inspector of steel work.


Construction: Building the Hydro, 1898–1902

1. The progress of construction can be followed through the weekly and monthly progress reports submitted by von Schon. They are scattered through the General Letter Books, the Presidential Letter Books, and the surviving volumes of Reports, set 1. For the progress of work in specific areas the extent “Construction History Reports” are good.

2. von Schon to E.D. Smith Co., July 19, 1898 (GL, 6, 479); Soo Democrat, August 11, 1898.
5. Soo Democrat, February 1, 1900.
6. von Schon to Clergue, April 20, 1900 (PL, 3, 355-356).
7. von Schon to Clergue, May 21, 1901 (PL, 5, 80-81); von Schon to Clergue, May 24, 1901 (PL, 5, 93-95).
10. von Schon to Clergue, March 30, 1900 (PL, 3, 317–319); von Schon to Messrs. Coolidge Fuel & Supply Co., May 7, 1900 (GL, 8, 160). The dispute between von Schon and Mason and Hodge over the piles is reviewed by O.B. Holley in a letter to O.M. Jones, June 5, 1941 (Ff 11; Jf 7.11).
11. “The Sault Power Canal,” *Scientific American*, v. 82 (1900), p. 329, reported 1,500 men working on the project; *Sault Ste. Marie News*, February 3, 1900, noted that a force of between 2,000 and 3,000 men would be used in the coming year.
13. von Schon to C. Coleman, October 19, 1899 (GL, 10, 403).
16. von Schon to Owen Bowers, October 23, 1901 (GL, 17, 223); von Schon to Owen Bowers, November 14, 1901 (GL, 17, 365). See also von Schon to G.M. Gardner, November 26, 1901 (GL, 17, 441).
17. “Construction History Report,” MS #1, p. 93.
19. von Schon to Clergue, December 1, 1898 (GL, 8, 363–366); von Schon to Douglas, December 10, 1898 (GL, 8, 441–442); Clergue to E.D. Smith Co., October 12, 1900 (GL, 13, 490); von Schon to E.D. Smith Co., September 21, 1901 (PL, 5, 315–318). For details on the E.D. Smith Co. plant at Sault Ste. Marie see “Construction History Report,” MS #1, p. 59. Von Schon also did not approve of the type of equipment used by Smith. The soil in the sand and clay sections of the canal was naturally rather soft. What von Schon felt was needed there was a large plant made up of small units—small steam shovels, small cranes, light narrow-gauge rails, small locomotives, and dump cars. Instead the Smith plant in the earth section was substantially the same type as that used in the rock section where heavy equipment was appropriate [von Schon to Clergue, “Recommendations,” October 5, 1899 (Reports, 1, 412)].
20. von Schon to Clergue, October 5, 1899 (“Survey of One Year’s Construction Progress”, *Reports*, 1, 400–401); von Schon to Clergue, June 6, 1899 (PL, 1, 451–455); von Schon to E.V. Douglas, August 5, 1899 (Reports, 1, 317–319).
21. Boiler to Clergue, October 12, 1898 (Reports, 1, 437–439); von Schon to Clergue, June 6, 1899 (PL, 1, 453–454).
22. *Soo Democrat*, June 8, 1899.
24. von Schon to Clergue, December 1, 1898 (GL, 8, 363–367); Report of W.W. Dann to von
26. von Schon to Clergue, October 1, 1900 (PL, 4, 149–151).
27. von Schon to E.V. Douglas, November 25, 1898 (GL, 8, 316); Report of C.G. Tudor for September 1899 (*Reports*, 1, 430); ? to von Schon, August 15, 1900 (GL, 13, 177).
29. Clergue to von Schon, October 11, 1900 (VP, 17); von Schon to Thomas Munro, October 15, 1900 (GL, 13, 26); von Schon to Clergue, February 4, 1901 (PL, 4, 390); Clergue to E.V. Douglas, November 6, 1900 (VP, 43–45). Munro’s report is included with the last item.
31. von Schon to Clergue, June 3, 1899 (PL, 1, 444–448); von Schon to Douglas, November 25, 1898 (GL, 8, 310).
32. W.W. Dann to von Schon, January 7, 1899 (*Reports*, B, 280–282). See also the other assistant engineers’ reports on pp. 283–293.
33. Albert S. Crane to von Schon (August 1900), reprinted in a letter from O.B. Holley to O.M. Jones, June 5, 1941 (Jf 7.11; Ff 11); see also von Schon, *General Report*, pp. 8–9.
34. See note 10 above.
40. von Schon to Clergue, March 15, 1900 (PL, 3, 274).
42. A description of these changes can be found in the report of Williams cited in note 39 above, pp. 6–10.
43. von Schon to Holyoke Water Power Company, January 11, 1901 (GL, 14, 368); A.F. Sickman to von Schon, January 12, 1901 (GL, 14, 447), for examples.
44. von Schon to W.S. Horry, October 3, 1901 (GL, 17, 91). Von Schon had written to the James Leffel Co. earlier (September 17, 1901 in GL, 16, 486–487) noting that the company planned to install 40 units (20,000 hp), half ac, half dc.
45. For data on the electrical installation planned by MLSPC see W. Owen Thomas to Geo. E.
Fostar, December 13, 1901 (GL, 18, 26); Thomas to Crocker-Wheeler Co., December 20, 1901
(GL, 18, 68); and Contracts, 239–251.

46. On the steel plant see Clergue to von Schon, June 23, 1902 (VP, 412) and Clergue to von
Schon, June 25, 1902 (VP, 425–426). On long distance power transmission see von Schon to
Clergue, October 8, 1902 (PL, 6, 494–495); von Schon to Clergue, October 17, 1902 (PL, 7,
13); von Schon to Clergue, November 29, 1902 (PL, 7, 102); von Schon to Clergue, February
27, 1903 (PL, 7, 225); von Schon to C.S. Chesney, September 24, 1902 (GL, 21, 118–119);
Clergue to E.W. Cottrell, October 10, 1902 (VP, 500–501); Clergue to J.P. Hughart, October
10, 1902 (VP, 504–505); and Clergue to von Schon, February 16, 1903 (VP, 591).

47. von Schon to Clergue, February 14, 1902 (PL, 6, 89–90).


52. For example, the control panels for the generators were placed directly above the genera-
tors instead of adjacent to one another as Thomas had planned (vf 116a–14, blueprint dated
April 28, 1913). Whether these panels were the very narrow type that Thomas had asked
the Stanley Company to prepare for the Sault plant could not be determined from surviving
records.


54. O.B. Holley to L.H. Davis, May 17, 1941 (Jf 14.0).

55. Record of Switchboard Output, January 1906.


57. Davis to B.F. Fackenthal, December 24, 1903 (vf 17–4); Davis to J.S. Fackenthal, January 15,
1904 (vf 17–10). Davis was von Schon’s successor as chief engineer of the power company.
Also Record of Switchboard Output, December 1903 and January 1904.

58. Descriptions of the “Soo” hydroelectric plant as completed in 1902 can be found in: von
Schon, General Report on Plant of Michigan Lake Superior Power Co., July 1904, 63 pp. (OCf,
Von Schon Reports); “New Water Plant at Sault Ste. Marie, Mich.,” The Engineer (USA), v.
are, however, a number of errors of detail in all of these.


60. The grand opening celebrations are described briefly in von Schon, “Power from Lake Su-
perior,” pp. 346, 349. The best source is Sault Ste. Marie Daily News-Record, October 25 and
October 27, 1902.
Problems: The Hydroelectric Plant in the Lean Years, 1903–1913

3. History of Consolidated, p. 35.
5. B.J. Clergue to von Schon, July 30, 1902 (VP, 452).
8. Clergue to E.V. Douglas, December 14, 1901 (VP, 298).
11. For instance, Clergue to B.W. Cottrell, October 10, 1902 (VP, 500) and Clergue to Geo. B. Goodwin, October 29, 1902 (VP, 519).
12. Clergue to von Schon, February 16, 1903 (VP, 591).
15. Clergue to von Schon, October 5, 1900 (VP, 9).
17. Ibid., and “Analysis of Real Estate & Franchise, June 30th 1904” (vf 28–4).
19. Ibid., p. 21.
20. Ibid., p. 78.
22. Ibid., p. 78.
23. Ibid., pp. 79–82.
24. Ibid., p. 86.
25. Ibid., p. 92.
27. Ibid., p. 264.
30. von Schon to Clergue, December 6, 1902 (PL, 7, 117–118).
33. von Schon to Boller, April 3, 1903 (GL, 22, 209–213); Boller, Whinery, and Noble to von
34. von Schon to Boller, April 3, 1903 (GL, 22, 209–213); Boller, Whinery, and Noble to von Schon, April 25, 1903 (vf 222.2.5–1); von Schon, General Report, pp. 16–17.

35. Boller, Whinery, and Noble to von Schon, April 25, 1903 (vf 222.2.5–1).

36. Shields to Boller, October 8, 1904 (Mf 24090), citing a report of February 13, 1903, which could not be located.

37. von Schon to Shields, April 14, 1903 (PL, 7, 245–246), estimated completion of repairs would cost $50,000 more. How much had been spent up to this point is not mentioned.

38. von Schon to W. Coyne, June 13, 1903 (PL, 7, 320).

39. von Schon to Shields, May 13, 1902 (PL, 7, 282); von Schon to Shields, July 17, 1903 (PL, 7, 376–377).

40. Shields to Boller, October 8, 1904 (Mf 24090).

41. Boller to Shields, September 21, 1904 (Mf 24090). Boller had invested heavily in the project and was thus personally concerned with its outcome.

42. Shields to Boller, October 8, 1904 (Mf 24090). Von Schon left MLSPC with ill feelings. There was a dispute between von Schon and the company over unpaid salary, the mortgage of the house von Schon was living in, and certain company documents held by von Schon. See Mf 24084 for correspondence on these matters.

43. “Memoir of von Schon,” pp. 1,541–1,542, and scattered passages in his Hydro-electric Practice.

44. Davis to J.S. Fackenthal, April 16, 1904 (Mf 24068); Davis to B.F. Fackenthal, October 10, 1903 (vf 222.4–2).

45. Davis to J.S. Fackenthal, September 22, 1904 (vf 129.1–3).

46. [?] to B.F. Fackenthal, September 7, 1904 (vf129.1–1); [?] to B.F. Fackenthal, September 8, 1904 (vf. 129.1–2); Davis to J.S Fackenthal, September 22, 1904 (vf. 129.1–3); Davis to Shields, October 4, 1904 (vf129.1–4).

47. Davis to Whinery, September 3, 1905 (vf 129.2–1); Davis to Sawyer, February 8, 1905 (vf 129.2–3).

48. Dawson to Davis, March 4, 1910 (vf 129.4–18.5) describes the type of equipment used for ramming clay in 1910. The filler pipes used in 1905 were probably similar in principle, but with force provided by hand rather than by very large weights. For a description of the 1905 leak and the repairs see Dawson to Davis, September 1, 1905 (Ef 45); Davis to Whinery, September 3, 1905 (vf 129.2–1).

49. Dawson to Davis, December 8, 1905 (Ef 45).

50. Davis to J.S. Wynn, October 18, 1907 (vf 129.3–2); Davis to Warren, October 23, 1907 (vf 129.2–12); Davis to Brown, March 13, 1908 (vf 129.3–37); Dawson to Wynn, November 17, 1907 (vf 129.3–32).

51. Dawson to Wynn, November 17, 1907 (vf129.3–32); see also Ef 45.

52. Davis to Franz, November 11, 1909 (vf 129.4–16); Davis to Franz, November 23, 1909 (vf 129.4–16); see also Ef 45.
53. Dawson to Davis, March 4, 1910 (vf 129.4–18.5) for a description of the clay ramming equipment used. Dawson to Davis, March 3, 1910 (vf 129.4–18); photo of crack, January 11, 1910 (vf 129.4–16.5); and Ef 45 for other material on the leak and repairs. Also Davis to Brown, May 7, 1910 (Mf 27 8).

54. Davis to Franz, December 27, 1909 (Mf 27 8); Franz to T.J. Kennedy, February 18, 1910 (Mf 27 8); Davis to Franz, April 22, 1910 (Mf 27 8). The Soo Businessmen's Association had petitioned the War Department for an allowance of enough water for one turbine (to power the street railway), and the company had gone along with this move even though it had already made the decision to shut down the plant completely (Franz to J.F. Taylor, March 2, 1910 [Mf27 8]). Apparently the company was trying to keep up the appearance of being public spirited, hoping that the petition would be turned down by the War Department and that they would look good for working with the city.

55. Ef 45.

56. Davis to Fackenthal, January 15, 1904 (vf 17–10); Davis to Sawyer, December 28, 1906 (vf 222.1–15); also Record of Switchboard Output. All of these indicate that the average output per turbine was on the order of 350 to 360 hp.


60. Davis to Sawyer, January 4, 1905 (vf 222.2.7–4).


62. Herschel and Pringle to the Lake Superior Corporation on Engineers Commission to Examine the Michigan-Soo Water Power (sic), October 1, 1904 (vf 222.2.10–3) and Herschel and Pringle to Engineers Commission etc., November 1, 1904 (vf 222.2.10–4). See also vf 222.2.3–6 and 222.2.3–8 for other copies of the Herschel and Pringle preliminary and final reports.

63. Wilde to W.N. Sawyer, February 16, 1905 (vf 222.2.10–10; also v222.2.4–1).


65. Preliminary Report on Strengthening the Foundation of the Power House of the Michigan Lake Superior Power Company, Sault Ste. Marie, Michigan," Whinery to Boller, September 1905 (vf 222.2.5–16); Whinery to Boller, December 14, 1905 (vf 222.2.5–24); Whinery to Boller, November 28, 1905 (vf 222.2.5–20). Originally Whinery was to work on a report on the powerhouse problems with Herschel and Pringle. Herschel, however, refused to work.
with Whinery on the grounds that he had participated with Boller and Noble in investigating the repairs made in 1903 and had concurred in their conclusion that those repairs would make the structure secure. This, Herschel felt, would prejudice Whinery in working with him and Pringle in seeking an alternative solution. Correspondence on this matter includes: C.D. Warren to Shields, September 12, 1904 (Mf 24088); C. Orvis to Herschel, Whinery, and Pringle, September 12, 1904 (Mf 24088); Herschel and Pringle to Whinery, September 21, 1904 (Mf 24088); Shields to Orvis, telegram, September 14, 1904 (Mf 24088).


67. Herschel and Pringle to Orvis, February 18, 1905 (vf 222.2.10–7); Davis to Warren, March 21, 1905 (vf 222.2.10–9); Davis to Sawyer, September 23, 1905 (vf 222.2.10–17); Whinery to Boller, November 8, 1905 (vf 222.2.10–20).

68. Davis to Sawyer, December 9, 1905 (vf 222.2.10–22).


70. Carson to Warren, February 23, 1906 (Mf 24112); Davis to Warren and Brown, February 16, 1907 (vf 222.7.1–5).

71. Boller to Davis, July 5, 1906 (vf 222.2.10–30).

72. Davis to Sawyer, September 9, 1906 (vf 222.7–4).

73. F.H. Reed to Warren, October 19, 1906 (vf 222.7–15); J.G. White & Co. to Warren, October 10, 1906 (Mf 24112).

74. Boller to Warren, December 14, 1906 (vf 222.7.4–3).

75. Davis to Wynn, January 23, 1907 (vs 222.2.10–37).

76. Carson to Warren and Brown, February 6, 1907 (vf 222.2.6–1).

77. Davis to Wynn, March 22, 1907 (vf 222.2.10–40).

78. Davis to C.R. Perry, June 1, 1907 (vf 222.6–46).


80. Davis to N.W. Rowell, February 13, 1907 (vf 165.0.3–2).

81. Ibid.

82. Ibid.

83. Ibid. and Davis to Wynn, October 3, 1907 (vf 165.0.3–22).

84. Davis to Shaw, November 23, 1907 (vf 165.0.3–28); Rowell to Davis, telegram, December 2, 1907 (vf 165.0.3–31).

85. Franz to Davis, October 12, 1908 (vf 165.0.3–66); Rowell to Brown, October 26, 1908 (vf 165.0.3–67).


94. *Reports*, 1, 20–35.


102. “International Waterways Commission Rules and Regulations” (vf 13–26); *Soo Times*, May 12, 1906 (vf 1–204).


104. “Rivers and Harbors Act, March 2, 1907 (Public No. 168)” (vf 1–23). The Frye amendment to this act authorized the Secretary of War to enter negotiations for the acquisition of Chandler’s claims and if negotiations failed to condemn the land while denying that any such action was acknowledgment of Chandler’s ownership.


112. Davis to W.C. Franz, August 12, 1909 (vf 17–219); Brown to Rowell, April 21, 1909 (vf...
113. "Application of Clarence M. Brown, Receiver of the Michigan Lake Superior Power Company, for approval of proposed lease with the United States . . .," Jun 27, 1913, p. 9 (vf 165.3.2-1), notes that the application was made on or about September 25, 1911. This document reviews the course of those negotiations and the final settlement.

Solutions: The Repair and Expansion of the Soo Hydro, 1913–1926

2. Electrical World, June 20, 1908 (vf 27–1).
5. “Agreement Between the First Mortgage Bondholders and the Lake Superior Corporation” (vf 28–7).
10. O.B. Holley to Davis, May 24, 1941 (Jf 14.0).
11. Ibid., and Davis to Trump Manuf. Co., May 22, 1913 (vf 162.6–1).
13. This was also due to the fact that the plant developed a higher head than the 16 feet von Schon had relied on in making his early calculations. In the 1904 General Report von Schon noted that there were no reliable hydraulic slope formulas for a canal of the dimensions contemplated at Sault Ste. Marie and that, therefore, his assumption of 16 feet was conservative. “There is a strong probability,” he noted, “that the effective head will be in excess of 16 feet, it may be 17 or even 18 . . .” (p. 38). The average head at the powerhouse after all repairs were made was 17 to 18 feet.
14. Holley to Davis, May 24, 1941 (Jf 14.0).
15. Dawson to Davis, October 18, 1913 (vf 169a–218).
17. Dawson to Davis, December 5, 1917 (vf 155-226.5).
18. E.F. Price to Davis, June 8, 1915 (vf 147-44): “We do not like to give publicity on voltage, phase and frequency of our power and generally do not like publicity of this kind.” This was in response to a proposed Westinghouse circular.
19. Davis to Warren, February 13, 1905, telegram (vf 165.0.2-11).
20. “Application of Clarence Brown to the International Joint Commission, June 27, 1913” (vf 165.3.2-1)
21. Davis to Franz, May 15, 1909 (vf 165.2.1-1).
22. Davis to Noble and Woodard, September 12, 1910 (vf 165.2.2-97); “Study of Elevations of Lake Superior Under Efflux Conditions of 1899 and 1900,” by Noble and Woodard, December 9, 1910 (vf 165.2.2-182).
23. Davis to Noble and Woodard, April 24, 1913 (vf 165.3.1-16); “Application of Clarence M. Brown, Receiver . . .,” June 27, 1913 (vf 165.3.2-1); see also the map in vf 165.3.1-19.5.
24. Davis to Noble and Woodard, October 11, 1913 (vf 165.2.2-363); J.L. Allison to Thomas Gibson, October 6, 1913 (vf 165.2.2-374); Davis to Noble and Woodard, December 4, 1913 (vf 165.2.2-376).
25. Noble and Woodard to Davis, December 8, 1913 (vf 162.2.2-378), for calculations on the probability of both canals being closed and high water occurring simultaneously. For the negotiations with the Canadian engineers see Davis to B.F. Price, February 24, 1914 (vf 165.2.2-406); Mason Patrick to Davis, March 12, 1914 (vf 165.3.14-8); Davis to Sabin, May 1, 1914 (vf 165.3.14-29).
30. Davis to Patrick, June 28, 1915 (vf 165.4–239).
31. E.M. Markham to Michigan Northern Power Company, February 11, 1920 (vf 165.6.1–19); Jones to Markham, July 16, 1920 (vf 165.6.3–40); Markham to Michigan Northern Power Company, August 5, 1920 (vf 165.6.3–46); Jones to Davis, September 26, 1921 (vf 165.6.4–34). These deal with construction of the dike. See vf 165.6.5 for material on the enlargement of the dike in 1922.
32. Patrick to Michigan Northern Power Company, September 5, 1914 (vf 132–7); Davis to Patrick, December 8, 1914 (vf 132–21); Patrick to Davis, December 2, 1914 (vf 132–20).

35. R.D. Johnson to Davis, July 10, 1915 (vf 222.2.9-19).


38. Davis to Jones, February 23, 1916 (vf 222.8.2-7); Davis to Price, February 23, 1916 (vf 222.8.2-8).

39. Davis to Price, April 28, 1916, telegram (vf 222.8.2-49); Davis to Woodard, May 3, 1916, telegram (vf 222.8.2-53); Davis to E.F. Price, May 9, 1916, telegram (vf 222.8.2-64); Davis to E.F. Price, May 10, 1916 (vf 222.8.2-70).

40. Foundation Company Contact, June 5, 1910 (Mf 49 51); F. Remington to Davis, May 24, 1916 (vf 222.8.4-10); Davis to W.J. Knapp, May 23, 1918 (vf 222.8.4-149).

41. Davis to Woodard, June 12, 1916 (vf 222.8.3-25); Doty to Davis, June 8, 1916 (vf 222.8.3-24).


45. Davis to Woodard, August 22, 1917 (vf 222.8.7-107).

46. [?] to Davis, August 11, 1916 (vf 221-6 to 221-8); F.W. Welgate to Davis, October 23, 1916 (vf 221-32); Davis to E.F. Price, October 17, 1917 (vf 221-101); Davis to E.F. Price, August 9, 1916 (vf 221-4).

47. Davis to Knapp, February 5, 1918 (vf 194.3-153).

48. See documents in vf 46.

49. Dawson to S. Morgan Smith Co., January 29, 1915 (Misc.f 110) and other correspondence in the same file.

50. The bulk of available information on the 1926 repairs is in Ef 45; see also Sault Ste. Marie Evening News, August 16, 1926; November 18, 1926; and December 20, 1926. Additional information can be gained from blueprint no. 1085r, Folder 6, Pocket 1, Edison Sault drawing collection.

51. O.B. Holley to Jones, August 26, 1943 (Jf 6.2); Jones to Holley, March 20, 1945 (Jf 6.2); Jones to L.H. Davis, March 20, 1945 (Jf 6.2).


Epilogue: Sault Ste. Marie and the Hydroelectric Plant

1. *Soo Democrat*, June 8, 1899.
3. *Soo Democrat*, July 6, 1899. The *Engineer* also declared in 1902 that waterpower would transform the wilderness around the "Soo" rapids into "a teeming industrial center" (*The Calcium Carbide Industry as a Factor in Water Power Development*, *The Engineer* [USA], v. 39 [1902] p. 561).
7. For antipower company feelings see: Democratic political leaflet, 1906 (Mf 24112); Chippewa County Grange political leaflet, February 8, 1908 (Mf 24112); J.S. Wynn to N.W. Rowell, March 5, 1907 (Mf 24112).
8. The company's response to criticism was a circular titled: "What About This Much talked of Specific Tax Proposition?" (Mf 24112).
10. *Sault Evening News*, April 11, 1913; *Soo Times*, April 12, 1913.
11. Davis to E.F. Price, November 4, 1913 (vf 17–?).
Bibliography

I. Archival Materials

A. Letter Books and Report Books

*Cloud Letter Book*, 1 volume. Letters of F.W. Cloud, August 1, 1916, to February 17, 1919. Cloud was the assistant to the general manager of the Michigan Northern Power Company.

*Contracts*, 1 volume. Handwritten copies of various contracts, c. 1896 to c. 1905. Specifications are not included with the contracts and only certain contracts are copied. Coverage is by no means complete.

*Davis Letter Book*, 1 volume. Letters of L.H. Davis, February 14 to October 16, 1905. This volume contains only a few letters. Most of Davis’ correspondence is found in the *General Letter Books*, series 2. Why these few occur bound separately is not clear. Davis was von Schon’s successor as chief engineer at the powerhouse.

*General Letter Books (GL)*, series 1, 22 volumes. Letters of H. von Schon, August 16, 1896, to September 20, 1903. Von Schon was chief engineer of the hydroelectric plant during construction.

*General Letter Books (GL)*, series 2, 25 volumes. Letters of von Schon’s successors as chief engineer, primarily L.H. Davis and Owen M. Jones. Many of these letters are duplicated in the vertical files.

*Moore Letter Book*, 1 volume. Letters of Charles Moore, April 3, 1903, to December 29, 1903. Moore was an assistant to Cornelius Shields, President of the Consolidated Lake Superior Company.


*Presidential Letters (PL)*, 7 volumes. Letters of von Schon to the president and vice-president of the Michigan Lake Superior Power Company, February 8, 1899, to October 2, 1903. Some of these letters also appear in the *General Letter Books*.


*Record of Switchboard Output*, 4 volumes. Stored in the vault in the hydroelectric plant, these cover the years 1903–1913.

*Reports*, 5 volumes. Reports by von Schon and his assistant engineers between c. 1897 and c. 1903. These fall into two sets:

- **Set 1**: 3 volumes numbered 1, 3, and 5 on the spine. These cover the following periods—volume 1 (March 16 to December 18, 1897), volume 3 (January 10 to September 1, 1901), volume 5 (June 13 to December 11, 1902). The intervening volumes are missing. Much of the content of these volumes is duplicated in the *General Letter Books*.

- **Set 2**: 2 volumes which we have arbitrarily designated as volumes A and B. These are not the missing volumes in Set 1. Volume A covers the period January 17, 1898, to January 27, 1899. The label on the front of this volume reads “Specifications,” but the volume has only one set of specifications. The bulk of the volume contains reports by von Schon and his assistant engineers. Volume B has reports dating from
between June 6 and December 1, 1899.

*Sault Ste. Marie Board of Supervisors and Common Council Proceedings and Ordinances (P & O)*, 1 volume. Proceedings and ordinances relating to the power canal, April 21, 1886, to October 18, 1901.

*Vice Presidential Letter Book* (VP), 1 volume. Labeled “A.” Letters of F. Clergue, vice-president and general manager (later president) of the Michigan Lake Superior Power Company. These letters date between August 31, 1900, and April 8, 1903.

*Work Diary*, 2 volumes. Daily diary of activities at the power canal for the years 1896 and 1897. Sketches of the activities of each of the company’s employees during the planning stages of the project.

**B. Vertical Files**

Daily Report Files (DRf), 3 drawers. Filed chronologically, covering the period c. 1904 to c. 1922.

Edison Sault Electric Company Current Files (Ef). These are kept in the new company offices. Only a few selected files were used, furnished at the request of the research team by Elgin Nixon.

Sam Finlay’s File (Ff), 1 drawer. Correspondence dealing mainly with technical matters, filed by subject, dating from around 1940.

General Correspondence File (GCf), 1 drawer. Material filed alphabetically and covering primarily the period 1903 to c. 1920.

Horizontal Drawers, 9 drawers. Used mainly to file graphs, but including a number of miscellaneous reports from 1900 on.


O.M. Jones File (Jf), 3 boxes. Material filed by subject. Most of the material dates from the period 1930–1950. O.M. Jones was successively engineer, general manager, and vice-president of Michigan Northern Power Company.

Main Vertical Files (vf), 19 drawers. Some 70% of the vertical files in the Edison Sault Archives relating to the pre-Edison Sault ownership period (before 1963) belong to this set. Materials are filed by subject. There is a card file, which indexes the files, but it has been scrambled up.

Manager’s Office, Correspondence from, file (Mf), 1 drawer. Primarily correspondence of and with the general manager of the Michigan Lake Superior Power Company in the period c. 1904 to c. 1910.

Miscellaneous Vertical Files (Misc.f), 2 drawers. These are labeled “Miscellaneous.” The contents of these drawers are arranged in no discernable order. Most of the material is correspondence with equipment companies dating from the period c. 1910 to c. 1925, but with some letters as late as 1950.

Old Correspondence File (OCf), 1 drawer. Correspondence from the period 1898 to c. 1902, including von Schon’s *General Report* of 1904.
C. Works in the Vertical Files of Sufficient Length to List Separately

"Agreement Between the First Mortgage Bondholders and the Lake Superior Corporation, 1910" (vf 28-7).

"Application of Clarence M. Brown, Receiver of the Michigan Lake Superior Power Company; for Approval of Proposed Lease with the United States, and of Diversion of Water, Construction of Compensating Works, and Plans Therefore, and all Acts Authorized in Said Lease, to the International Joint Commission, June 27, 1913" (vf 165.3.2-1).


"Discussion of the Situation at Sault Saint Marie, Michigan; submitted to The Rivers and Harbors' Committee of Congress on Behalf of the Receivers of the Michigan Lake Superior Power Company, 1908" (vf 1-130).

"Further Statement by Michigan Northern Power Company in regard to the Power Situation at Sault Ste. Marie, Michigan, September 12, 1941" (Jf, Box 1).


"Statement by Michigan Northern Power Company in regards to plans for reconstruction of power facilities at Sault Ste. Marie by the War Department, for the hearing ... March 3, 1941 at the Office of the Board [of Engineers for Rivers and Harbors]" (Jf, Box 1).

Schon, H.A.E.C. von. "Construction History Report," MS #1: Movable Dam History; Balance of Intake History; Canal Section I, II, and III; MS #2: Revetment Construction, Section II and III; Bridge Abutments (OCl, von Schon Reports). These are handwritten notes outlining the history of construction. Many pages in the two surviving notebooks are blank; in fact only a small portion of either notebook has been used. These were apparently to form a part of a longer report. There is some evidence that they were typed up, but the comprehensive "Construction History" covering all aspects of the hydroelectric project could not be found.


"Sixth Report of the First Mortgage Bondholders Committee—Plan of Reorganization, April 10, 1913" (vf 27-0).

Woodard, Silas H. "Report on Reinforcement of Power House at Sault Ste. Marie, Mich. made for Michigan Northern Power Co., September 10, 1915" (vf 222.2.8-29). Woodard's comprehensive report on powerhouse repairs gives not only his recommendations, but, in a series of appendices, reprints the reports of Lindenthal; Davis; Herschel and Pringle; Wilde; Whinery, Boller, and Noble; and summarizes the Foundation Company's scheme.
II. Published Materials

A. Books
Haynes, Williams (ed.). *American Chemical Industry*, v. 6 (The Chemical Companies), Toronto, etc.: D. van Nostrand, 1954.

B. Articles—Technical
*American Manufacturer*

*American Society of Civil Engineers, Transactions*
The ASCE Transactions were used extensively to locate biographical information on engineers involved in the project.

*Cassier’s Magazine*
Central Station

*Electrical World and Engineer*

*The Engineer (USA)*

*Engineering and Mining Journal*

*Engineering News*

*Engineering Record*

*Iron Age*

*Mining Reporter*

*Railway and Engineering Review*

*Scientific American*

*Water (Power) Chronicle*
III. NEWSPAPERS

*Sault News-Record*, daily, published 1901 to 1903.
*Soo Democrat*, weekly, published 1883? to 1900? (before 1890 published under the names of *Sault Ste. Marie Democrat*, *Sault Democrat*, or *Chippewa County Democrat*).
*Soo Times*, daily (all quotations and citations from the *Times* were taken from clippings from that paper found in the vertical files of the Edison Sault archives).
IV. UNPUBLISHED MATERIALS (other than those in the Edison Sault Archives)

Clergue, Francis H. “An Instance of Industrial Evolution in Northern Ontario, Dominion of Canada; an Address Delivered at a General Meeting of the Board of Trade of the City of Toronto, April 2nd, 1900” (available at the Lake Superior State College Library, Sault Ste. Marie, Michigan).


Sullivan, Alan. Francis Hector Clergue, typewritten copy, undated, 200-page manuscript, furnished by Michael Bliss of the University of Toronto; no footnotes; no bibliography (copy available at the Lake Superior State College Library, Sault Ste. Marie, Michigan).


V. Photographic Materials

The Edison Sault Electric Company owns a collection of approximately 1,000 8- by 10-inch glass plate negatives. About half of these date from 1898 to 1903; the other half date from 1903 to 1927.
As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities to protect and conserve our land and water, energy and minerals, fish and wildlife, parks and recreation areas, and to insure the wise use of all these resources. The Department also has major responsibility for American Indian reservation communities and for people who live in island territories under US administration.