Manitoba Hydro

Grand Rapids Generating Station

Grand Rapids Generating Station, located on the Saskatchewan River about 400 kilometres (km) by air northwestward of Winnipeg, has a capacity of approximately 472 megawatts (MW). It is the first hydroelectric generating station built by Manitoba Hydro in northern Manitoba to produce electricity for the provincial power system. Power planners had to look for other water resources to produce electricity after the Winnipeg River had been fully developed.

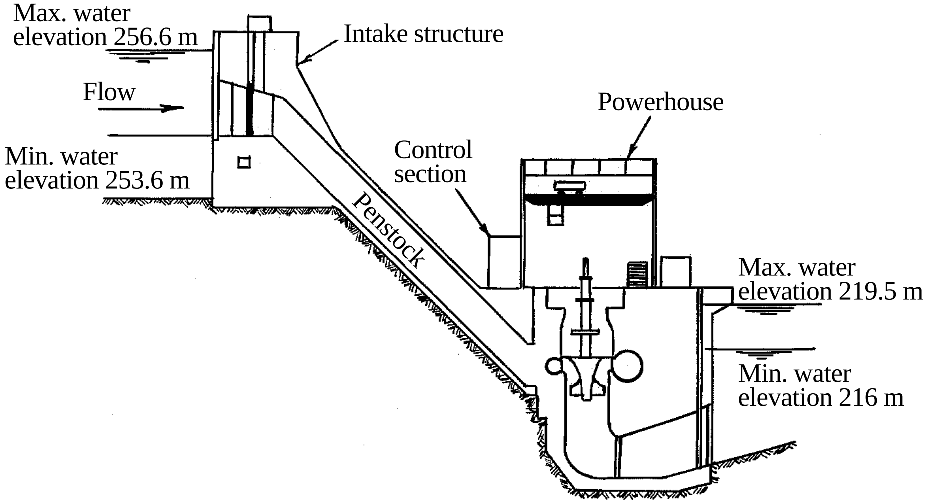
Construction of Grand Rapids Generating Station began in January 1960 and it was fully operational by November 1968. The first three turbine generators (called units) were running by 1965, and the final unit by 1968. Turbines with vertical variable pitch blades turn the four generators, that each have a capacity of approximately 120 MW. The turbine hub and blade assemblies, also known as turbine runners, are 6.44 metres (m) in diameter. At the time the generating station was completed, the giant turbines and generators were the largest of their kind ever built in North America.

Grand Rapids is Manitoba Hydro's only generating station on the Saskatchewan River. As well as producing electricity, it is also the controlling station for the entire provincial power system. The units operate on load frequency control — meaning they respond to every change in the demand for electricity to keep the frequency constant on the system. The frequency is the number of cycles an alternating current (AC) passes through per second. For Manitoba Hydro and other North American utilities, the standard frequency is 60 cycles per second, or 60 hertz.

Upgrades improve efficiency

After 30 years of faithful service, during 1995 to 2000 the units at Grand Rapids received major overhauls, and the turbine runners were replaced. These upgrades are expected to make the units more efficient and will increase their megawatt output by approximately 10 per cent. Also during the upgrades, a new computerized unit control and monitoring system was installed to control the generating station more effectively. The system allows control room operators to monitor the units by computers.

In addition, new designs at the generating station incorporated many features that will reduce impacts on the local environment. For example, each unit will be capable of running in either generation mode or in synchronous condenser mode. Generation mode provides power to



This cross-section of Grand Rapids Generating Station shows the relationship between the intake structure and the powerhouse structure. All other Manitoba Hydro generating stations are built with the intake structure adjacent to the powerhouse.

the transmission system. Synchronous condenser mode provides voltage support for the transmission lines that supply power to the northern part of the province. In synchronous condenser mode, no water runs through the units, allowing Grand Rapids to hold water in reserve for future use. While in this mode, the water intake gates are closed, an air pressure system depresses water below the runner, and the units spin as a motor to stabilize the electric current.

Grouting program and dykes

The area around Grand Rapids is predominately limestone which formed 400 million years ago, a very porous material consisting of calcium carbonate, dolomite, and magnesium carbonate. It was left behind from the subtropical seas of that time.

The forming of this material was not a continuous process, as can be seen in the layers that comprise limestone. Each successive bed is separated usually by a layer of shale material. Each layer represents a period of uninterrupted formations, while the shale material represents a break in the process.

Because of the layering, it was a challenge to build a dyke system to contain water for the Grand Rapids Generating Station's forebay. Due to numerous crevices and separations in the limestone, it was necessary to form an underground seal, or grout curtain, beneath the dyke area that would eventually enclose the reservoir. Without the grout — a thin fluid mortar used for filling intervening spaces, chinks, or crevices — water would seep out beneath these dykes.

First, 5-cm-wide holes were drilled to various depths at 1.5-m intervals in the limestone. Grout was forced under pressure into the horizontal and vertical fractures and crevices to a depth of 61 m. In this way, 25.7 km of dyke plus 6.4 km of high ground were placed upon a solid 61-m deep concrete wall.

Of the 200 000 tonnes of cement required to build the Grand Rapids' project, slightly more than half was used in the grouting program — one of the largest such programs ever attempted in the world.

Grand Rapids' dykes contain water to be used to generate electricity in the powerhouse. Two of six major dykes were built adjacent to the water intake structure while one dyke contains the spillway structure, which spills excess water when large amounts flow in the Saskatchewan River and are not needed to generate power.

All of the dykes were built of local materials. Those adjacent to the spillway and intake structure were constructed of rock excavated from the intake channel construction site, and others were made of homogeneous fills.

A layer of riprap, or large rock, along the water's edge was placed to protect the dykes from wave action. Recently, granite rocks were added to give extra protection.

The falls and forebay

Grand Rapids was a natural spot to build a generating station on the Saskatchewan River because of a series of natural waterfalls between Cedar Lake and Lake Winnipeg that formed a total drop of 35.6 m. The greatest number of falls, with a total drop of 22.9 m, occurred along one 5.8-km stretch of rapids. With the overall total drop plus the height of the concrete intake structure, Grand Rapids would achieve a maximum operating head, or waterfall, or 36.6 m to operate four units.

To ensure a continuous supply of water, a large reservoir was created in Cedar Lake. Its water level was raised 3.5 m, making it cover an area of nearly 3 500 km^2.

The intake, spillway and powerhouse structures

Grand Rapids' spillway structure is not adjacent to the powerhouse, as it is at most other Manitoba Hydro generating stations. The spillway is situated at the old river channel, and is about 5 km away from the intake and powerhouse structures. The spillway allows water in the forebay to be discharged down the old river channel, rather than at the powerhouse tailrace channel.

The spill way is a concrete structure approximately 116 m long and 21.4 m high, and has four gates that are operated by electric hoists. The gates, which can open to spill excess water in order to prevent it from damaging the dykes around the forebay, are equipped with heaters that prevent them from freezing up during winter months.

Grand Rapids' other unusual feature is the intake concrete structure. From the intake, four penstocks — huge round pipes approximately 8.9 m in diameter — lead downwards at an angle of 22° to the turbine runners. Water flows through the 69-m-long penstocks to turn the turbines that produce electricity. Each penstock has two gates. The penstocks are embedded in concrete except for special joints, which allow the penstocks to expand or contract. The concrete intake structure is reinforced by rockfill on the downstream side.

Major overhauls at Grand Rapids Generating Station, such as replacing the turbine runners, helped increase the output of electricity by about 10 per cent.

The transmission system

In order to send the power produced at Grand Rapids to customers, it is transported via a transmission system. Before it travels down five transmission lines, transformers outside the powerhouse step up the voltage from 13.8 kilovolts (kV) to 230 kV for transmission.

Two 400-km transmission lines head south to the Dorsey Converter Station near Winnipeg. One line goes to Ponton, about 173 km north from Grand Rapids. One line goes northwestward to the Overflowing River terminal station, about 70 km from The Pas, where power is distributed to the northwest side of the province. The fifth line goes southwestward to Dauphin, about 300 km.

The Saskatchewan River

The fourth largest river in Canada, the Saskatchewan River derives its name from the Cree Indian word Kisiskatchewan meaning swift current. The river's origin lies in the eastern Rocky Mountains in Alberta, and travels almost 1 940 km to enter Lake Winnipeg at Grand Rapids, draining an area of about 340 000 km^2.

A wildly turbulent rapids once flowed in the final 6.4-km stretch of the Saskatchewan River. It was known as Grand Rapids. The Town of Grand Rapids was named after it, as well as the Generating Station. However, the town was originally known as Fort Bourbon, which was the first of many trading posts established along the river. Le Chevalier de la Verendrye, son of the famous explorer Pierre de la Verendrye, built Fort Bourbon at the discovery of the Saskatchewan River in 1741.

For many years, the Town of Grand Rapids was the gateway to the vast northwestern region — part of a water highway plied first by York boats from York Factory and Upper Fort Garry, then by lake and river steamers. Explorers, fur traders, missionaries, and settlers all portaged the difficult rapids as they journeyed up the Saskatchewan River.

In 1877, HBC built a tramway to move horse-drawn cargo cars from the mouth of the Saskatchewan River to the navigable part of the river. The Grand Rapids' tramway was the first railway built in western Canada. In the late 1800s, larger and faster river steamers replaced York boats.

It was, in fact, the development of the railways that ended the Saskatchewan River's importance as a transportation route into the Prairies.

Archeological studies at Grand Rapids

As the construction project began, it became apparent that some of the historic and prehistoric remains discovered at the site needed preserving. An archeological study was established in early 1961 that resulted in a collaboration between the provincial government's Department of Mines and Natural Resources and the University of Manitoba's Department of Anthropology. Thirty-nine individual sites were marked for study around the area that would eventually become the forebay.

The artifacts uncovered were representative of the surrounding area, and revealed an interesting history of the various peoples who had lived there during earlier times.

The Easterville townsite

The provincial government and Manitoba Hydro cooperated in developing programs to assist people adversely affected by the Grand Rapids Generating Station project. One was the establishment of the new community of Easterville on the southern shore of Cedar Lake. The community is located approximately 40 km westward of Grand Rapids and about 60 km from provincial highway #6. Easterville was named after Donald Easter, Chief of the Chemawawin Band at the time.

The residents of Easterville formerly lived on or near the Chemawawin Reserve, located 50 km away (by water) in an area that was required for the generating stations forebay. Manitoba Hydro was responsible for developing the new townsite and its related environment, and paid the costs of the services, studies, and relocation programs involved.

At Easterville, the families were provided with two to four-bedroom, all electric homes, built to the standards established by the Department of Indian Affairs. Water wells were drilled and a wharf for commercial fishing was constructed. The new community was also provided with schools, a church, and a fish warehouse.

On November 14, 1990, a settlement agreement was reached between Manitoba Hydro and the Chemawawin-Easterville community. Under its terms, the utility paid the community $13.7 million to resolve any outstanding claims for adverse effects related to its relocation and the generating station project.

Grand Rapids Generation Station facts

Construction began	January 1960
Construction completed	November 1968
Cost	$117 million (1968 dollars)
Capacity	472 MW
Average annual generation	1 540 kW·h
Waterfall drop	36.6 m
Powerhouse length	152 m
Intake gates	8 measuring 4.9 m by 11 m
Number of turbine generators (units)	4 (each turns at 112.5 rpm)
First and final units in service	1965 and 1968
Production of units	120 MW each
Units' discharge capacity	1 500 m^3/s
Forebay area	3 500 km^2
Forebay's maximum water level	256.6 m
Spillway with 4 gates	Length: 116 m — each gate measures 12.2 m by 13 m
Spillway's discharge capacity	3 936 m^3/s of water
Transmission lines (all 3-phase)	Two 230-kV to Winnipeg One 230-kV to Thompson One 230-kV to Overflowing River (The Pas) One 230-kV to Dauphin

Major contractors

General contract	Grand Rapids Constructors (a consortium comprised of Northern Construction Co. and J.W. Stewart Ltd., Vancouver; Peter Kiewit Sons Company of Canada Ltd., Toronto; Al Johnson Construction Co. of Canada Ltd., Windsor; Perini Quebec Inc., Montreal)
Turbines	English Electric (three) Canadian Allis Chalmers (one)
Generators	Canadian General Electric

The fish hatchery

In the early 1970s, the Department of Mines, Resources and Environmental Management, built a $1.125 million fish hatchery at Grand Rapids. This hatchery incorporated the temporary facilities that had been installed in the townsite shortly after the generating station began operating. The hatchery incubates walleye, whitefish, and trout eggs for commercial and sports fishing throughout the province.

Manitoba Hydro remains committed to providing funds for the operation of the hatchery, a project that benefits the province.

Conservation measures were an integral part of building the generating station. Manitoba Hydro, through agreements with both provincial and federal agencies, undertook to bear the major costs of environmental studies of the area as well as for any steps taken to minimize adverse environmental effects identified by the studies.

Our immediate concern was for the commercial fishing industry on Cedar Lake, but statistics collected since the generating station was completed indicate that fish numbers have improved since the lake's level was raised.

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