

Canadian Consulting Engineering Awards 2012  
Submission Category – Buildings

## Churchill Northern Studies Centre



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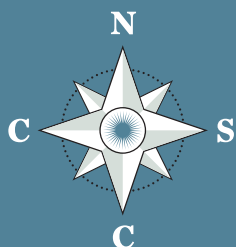


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# Project Highlights



Churchill Northern Studies Centre

## Churchill Northern Studies Centre

### Project Highlights

In the summer of 2011, the Churchill Northern Studies Centre (CNSC) moved into their new 27,800 ft<sup>2</sup> facility. The building is designed for 88 visiting scientists and 12 staff working year-round on sub-arctic scientific research and education. Facilities include large and small dry laboratories, two classrooms, a gift shop, an observation dome, a library, herbarium, and study collections of various animal species. The Centre also has vehicles, a helicopter landing pad, a garage, and comprehensive logistical support for remote field camps. The new Churchill Northern Studies Centre's innovative features and technologies include heat recovery in a difficult climate, intelligent building controls, an energy-efficient kitchen with best-in-class range hood ventilation and energy-efficient appliances, and waterless composting toilets to deal with a lack of municipal services.

The site is remote and exposed with only shrubby tundra vegetation and thin gravelly soils over shallow bedrock. There are no piped municipal services for water, sewer, or gas, and no prospect for any in the future. The remote location also makes regular maintenance an issue – systems must be reliable and simple. There is also no local fire service or on-site hydrant.

Cold, windy conditions of -40°C and 140 km/h winds are the norm. Less access to sunlight was also a consideration from a daylighting perspective. The building envelope is designed to be air-tight and well-insulated with R-40 freezer panel construction and low-e, argon-filled, triple-glazed windows. The whole structure is raised above grade for snow drift control, thus providing a convenient space for building ventilation openings, under the building, protected from snow entry and minimizing mechanical elements on the striking building facades.

Laboratory areas had to be provided for wet/dry and clean/dirty research activities. Some samples must be archived in a room with controlled temperature and humidity, and some experiments also need controlled temperature and humidity, especially in the summer during the peak field research activity. Activities generating noxious fumes have to be conducted in fume hoods, which have to be operated in as energy-efficient manner as possible, i.e., controlled exhaust and makeup ventilation, while maintaining good indoor air quality (IAQ) in the lab.

The four, main building ventilation systems have ventilation heat recovery (where incoming, fresh air is pre-heated by outgoing, stale air)—a challenging accomplishment in an environment where heat recovery ventilators (HRVs) are very vulnerable to freezing. The main ventilation system is an innovative reversing flow heat exchanger made in Manitoba and features 85% heat recovery efficiency and no requirement for defrost. The other HRVs, serving the dining room and kitchen, labs, and composting toilets, rely on electric pre-heaters to keep them out of defrost mode and optimize their heat recovery performance. The reversing-flow heat exchanger supplies up to 1175 L/s of ventilation, depending on demand, and does not require any preheat.

Building controls are designed for reduced operating costs, while still being relatively simple and easy to operate. The basic approach is to turn equipment off when not in use. For example, ventilation is supplied by multiple, dedicated units which slow down or stop when any individual unit is not needed. Local controls include occupancy sensors,

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CO<sub>2</sub> sensors, timers, and variable motor speed drives. The project team can access the building automation system for monitoring and trouble-shooting via the internet when they are off-site.

A commercial kitchen serving three meals a day to 100 people can be extremely energy intensive, due to large amounts of cooktop ventilation, hot water use, and appliance energy. The best-in-class range hood ventilation at the CNSC is low-flow and variable speed, responding to the amount of cooking and providing only the amount of exhaust and makeup air required. Solar wall panels pre-heat the large volume of fresh air for the kitchen and cafeteria, supplemented by a dedicated energy recovery ventilator which even recovers heat from the dishwasher exhaust. Energy intensive appliances such as the dishwasher were selected for best-available water and energy efficiency.

Waste heat from the computer room can be circulated to the underfloor plenum for heating, rather than being directly exhausted or air conditioned, and refrigeration compressor waste heat is also recirculated for space heating.

Lighting fixtures are high efficiency, without over-lighting spaces. The average building-wide lighting power density is a mere 7.7 W/m<sup>2</sup>, which is 30% below ASHRAE 90.1-2007 levels for an office/lab/dormitory building using the building area method.

The old facility had to truck water 20 km from town, then truck back the sewage. Every effort was made to decrease this considerable cost of carbon emissions and money. The most significant measure is two large composting systems serving waterless toilets and urinals. Wastewater is treated on-site to tertiary quality by two 5,000 litre biofiltration vessels indoors and two area bed sand dispersal fields outdoors, made of manufactured sand and woodchip-and-sand layers. The permitted daily design flow is 8,000 L and design flow is only 68 L/person, compared to the metered 100+ L/person last year in the old building.

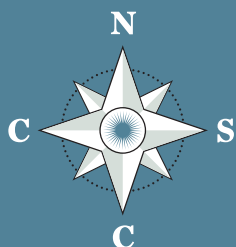
An innovative ventilation system using a heat recovery ventilator provides continuous exhaust from the composter, with the toilets themselves acting as the exhaust fans for the washrooms. The system is water-and-energy efficient, keeps the washrooms odour-free, and thanks to a healthy population of red wriggler worms, automatic moistening system, compost tea removal, and the aerobic decomposition process, requires very little maintenance.

Lake water is pumped 2 km to the site in summer and treated with settling, simple cartridge filters and UV to drinking water quality. Two 13,000-litre tanks can store drinking water trucked from town in winter when the lake is frozen. Untreated lake water is distributed through separate non-potable water piping to flush-type toilets, hose bibs and drain trap primers to reduce the need for drinking water, and also to utilize greywater recycled from lavatory and shower wastewater. Drainwater heat exchangers recover heat from the showers and lavatories to preheat domestic hot water.

It is hoped that the combination of ambitious water conservation and on-site treatment will be a model of sustainability for other developments in remote communities. The technologies showcased at the CNSC are scalable to larger facilities.



# Full Project Description

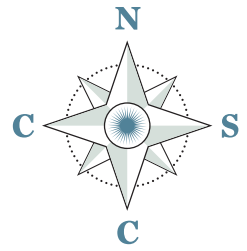


Churchill Northern Studies Centre



### Project Summary

**F**ounded in 1976, the Churchill Northern Studies Centre (CNSC) is an independent, non-profit research and education facility located approximately 25 km east of the town of Churchill, Manitoba. It provides accommodations, meals, equipment rentals, and logistical support to scientific researchers working on a diverse range of topics of interest to northern science. In addition to research, the CNSC facilitates educational programs ranging from general interest courses for the visiting public, to university courses for students.



**The CNSC moved into its new \$19 million, 27,800 ft<sup>2</sup> facility** in the summer of 2011, on the former site of the National Research Council of Canada's rocket research and testing range. The building was designed to accommodate 88 visiting scientists and 12 full-time, year-round staff. The objective behind creating and moving to a new facility was to lower utility and operating costs by creating a high-performance building that showcases green building design, while meeting the unique needs of a remote research building in a harsh northern climate. The new facility includes four laboratories, two classrooms, a gift shop, an observation dome, a library, and herbarium. The CNSC also has a helicopter landing pad and garage for housing vehicles, and for providing logistical support for remote field camps.

Prairie Architects Inc. was the architect on the project, and Enermodal Engineering (Enermodal), a member of MMM Group Limited, provided the mechanical and electrical design. Integrated Design Inc. provided the project management, and Crozier Kilgour & Partners Inc. provided structural engineering on the project. Together, the companies assisted the CNSC in creating a northern Manitoba facility that fulfilled the organization's goals and pushed the traditional design envelope.



### Complexity of Project

**T**he CNSC is ideally situated along the Hudson Bay seacoast, at the intersection of three major biomes: marine, northern boreal forest, and tundra. This diversity of biomes creates a tremendous range of plants, birds, mammals, and human cultures.

The remote location of the facility, harsh climate, and difficult site conditions, presented a variety of challenges to the design team even before considering the building functional requirements. Remote, and exposed with only shrubby tundra vegetation and thin gravelly soils over shallow bedrock, the site has no piped municipal services for water, sewer, or gas and no prospect for gaining these services in the future. A 1 km power line connects to Manitoba Hydro's electrical service, but is frequently interrupted by winter weather. As a result of the above challenges, a high degree of reliability and independence were required for water, wastewater, heat, and power.



**The building itself was designed to be air-tight** and well-insulated with R-40 structural insulated panel construction and low-e, argon-filled, triple-glazed windows. The whole structure is raised above grade for snow drift control, thus providing a convenient space underneath for building ventilation openings, protected from snow. This feature also minimized the need for any mechanical elements on the striking building facade. Laboratory areas had to be provided for wet/dry and clean/dirty research activities, taking into consideration that some soil and plant samples need to be dried for extended periods of time, and the issue of moisture and smell had to be addressed. Other samples must be archived in a room with controlled temperature and humidity, and some experiments need the same conditions, especially in the summer where there is peak field research activity. Actions generating noxious fumes have to be contained to ensure good indoor air quality in the lab.



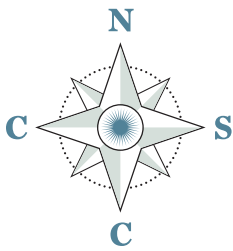
Other challenges in the design and construction of the building included the need for multiple water tanks to supply drinking water and fire protection. These tanks weigh close to 20 tonnes, and could not be structurally supported by the above-grade structure. As a result, space had to be renovated in the adjacent existing building to accommodate the tanks on a slab on the grade floor, running the connecting pipes through a buried pipe trench with protection from frost and groundwater.

Additional challenges were that the recreation rooms used for entertainment and exercise had to be acoustically isolated from the bedrooms down the hall, and the waterless toilets had to be located on the second floor in order to provide space below for the large composting chambers.



## Technology

Beyond meeting the complex needs of the building and site, the Churchill Northern Studies Centre wanted the design team to create a building that reflects the organization's environmental stewardship, which dovetails with its research and mission. The building was also intended to act as a precedent for the Manitoba building industry, demonstrating what is possible with solid engineering design, green building design practices, and leading-edge technology. Some innovative mechanical and electrical features used in the design and construction of the facility include heat recovery, intelligent building controls, and waterless composting toilets to deal with the lack of municipal services.



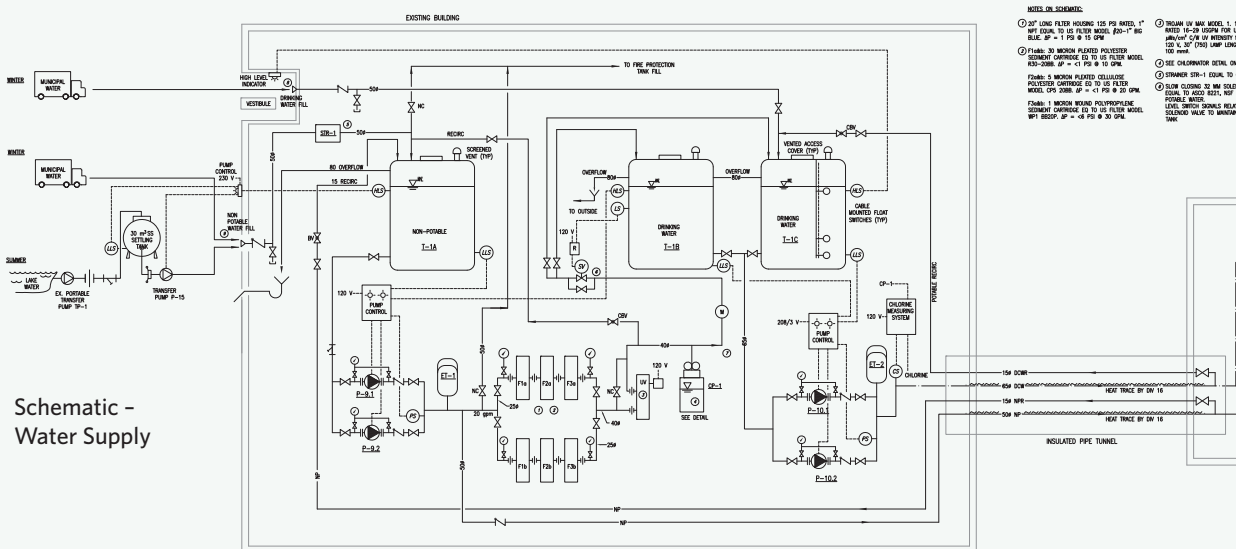
## Heating and Ventilation

The four main building ventilation systems have heat recovery, which is a challenging accomplishment in an environment where heat recovery ventilators (HRVs) are vulnerable to freezing. The main ventilation system is an innovative reversing flow heat exchanger; featuring 85% heat recovery efficiency and no requirement for defrost. This system supplies up to 1,175 l/s of ventilation (depending on demand), and does not require any defrost preheat. The other HRVs, serving the dining room and kitchen, labs, and composting toilets, rely on electric pre-heaters to keep them out of defrost mode and optimize their heat recovery performance.

Various heating and ventilation technologies in the building reduce operating costs; for example, almost all have heat recovery individual ventilation units that stop or slow down when they sense they are not needed. Local controls for these units include occupancy sensors, CO<sub>2</sub> sensors, timers, and variable motor speed drives. The project team can access the building automation system for monitoring and trouble-shooting via the internet when they are off-site.

Due to cooktop ventilation, hot water use, and appliances, a commercial kitchen can be extremely energy intensive. Enermodal selected best-in-class range hood ventilation, which is low-flow and variable speed (responding to the amount of cooking that is being done), and provides only the amount of exhaust and makeup air required. Solar wall panels pre-heat the large volume of fresh air for the kitchen and cafeteria, supplemented by a dedicated energy recovery ventilator, which utilizes the heat from dishwasher exhaust. Appliances that provided the best water and energy efficiency were selected for the kitchen, and two oversized grease interceptors were installed in the basement wastewater treatment room, where they provided heat to the room, while cooling and improving grease separation.



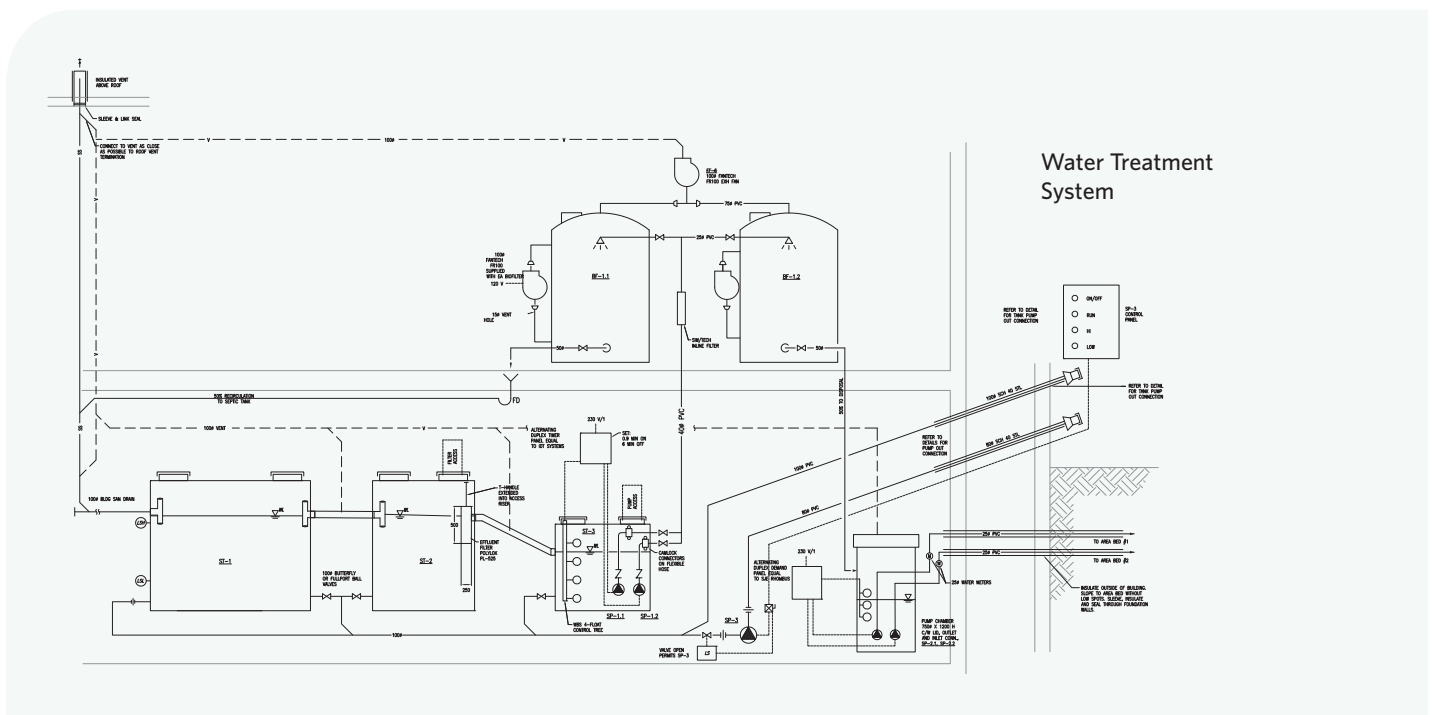


Wasted heat from the computer room was designed to circulate to the underfloor plenum for heating, and refrigeration compressor waste heat is also recirculated for space heating. All other areas have individual thermostats controlling electric baseboard heat.

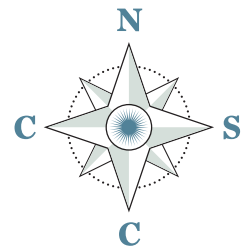
In laboratory areas, exhaust hoods and fans were installed to address the smell and moisture of soil and plant samples, and a split system air conditioner provides rooms with controlled temperature and humidity for research and storage. Low airflow variable air volume (VAV) hoods with a dedicated VAV makeup air unit efficiently contain fumes that are generated by experiments.

## Water and Wastewater

The old facility had to truck water 20 km from town, which then trucked back the sewage. Enermodal addressed these considerable costs and carbon emissions by using two large composting systems on-site, serving waterless toilets and urinals. An innovative system using a heat recovery ventilator provides continuous exhaust from the composter, and the toilets themselves act as exhaust fans for the washrooms. This system is water and energy efficient and keeps the washrooms odour-free. Thanks to a healthy population of red wiggler worms, an automatic moistening system, and compost tea removal, the aerobic decomposition process requires very little maintenance. Composted solids are typically removed every few years.

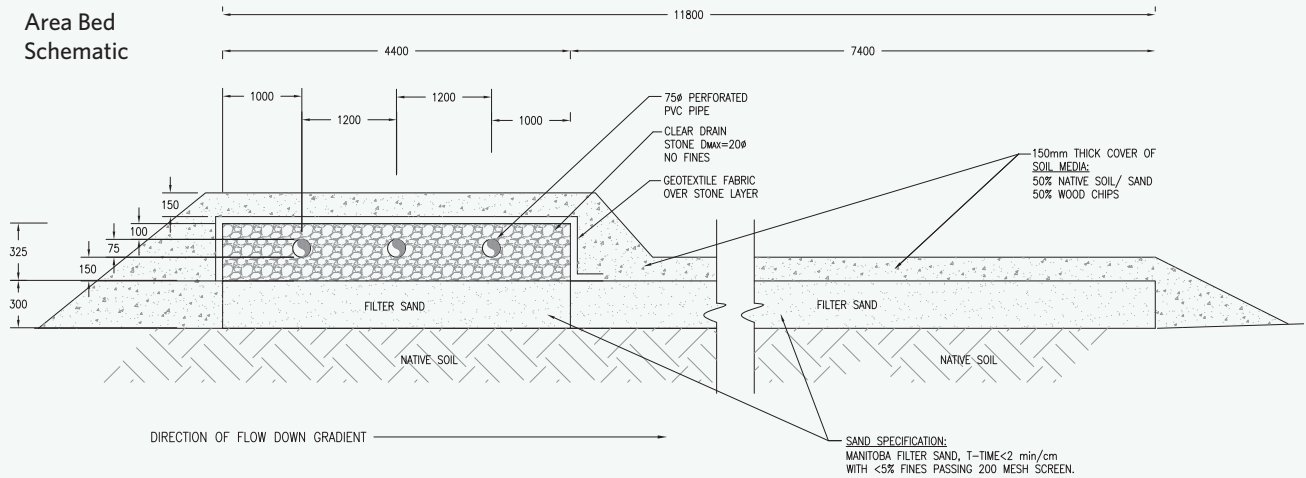


Wastewater is treated to tertiary quality by two 5,000 L biofiltration vessels indoors, and two area bed dispersal fields outdoors, made of manufactured sand and woodchip-and-sand layers. The primary treatment septic tanks in the basement double as holding tanks with 32,000 L capacity, and truck pump-out connections for when conditions may be too cold for on-site disposal. The permitted daily design flow is 8,000 L and expected use is less than 68 L/person, compared to the metered 100+ L/person last year in the previous building.



Lake water is pumped 1 km to the site in summer and treated with settling, simple cartridge filters, and UV to drinking water quality. Two 13,000 L tanks can also store drinking water trucked from town in winter when the lake is frozen. Untreated lake water is distributed through separate non-potable water piping to flush-type toilets, hose bibs and drain trap primers to reduce the need for drinking water and also to utilize greywater recycled from lavatory and shower use. Drain water heat exchangers recover heat from the showers and lavatories to preheat domestic hot water. These water conservation measures significantly reduce the volume of water and wastewater in the facility.

## Area Bed Schematic



## Electrical

Lighting fixtures in the new facility are high efficiency, and the design avoids over-lighting spaces. The majority of the fixtures are suspended in the offices, labs, dorm rooms, cafeteria, and ground floor corridors to take advantage of the high ceilings and to utilize the white drywall and painted metal deck ceiling to reflect the light throughout the space.

The adjacent service building also accommodates a 400 kW emergency generator to power the facility for emergency purposes and utilizes a large auxiliary diesel tank for extended power outages and closed roads.

The dormitory rooms contain a single overhead direct/indirect fluorescent fixture for general lighting, and each bunk bed (four in each room), has a directional, wall-mounted LED light which can be turned on and off without disturbing other roommates. The rooftop Aurora Borealis viewing dome was outfitted with LED way-finding lights (like emergency exit lights in an aircraft cabin), with a switch to allow users to turn off non-essential exterior lighting. Exterior lighting is wall-mounted metal halide fixtures with low temperature start ballasts, which are controlled from a central relay panel with daylight sensing, astronomical time control and an auxiliary override from the viewing dome.



There are many social, economic, and environmental benefits from the Churchill Northern Studies Centre project. The CNSC provides employment in a remote area for a specialized group of experts. The occupants benefit from the superior indoor conditions and air quality, while the scientific community and general public will benefit from the unique research that is conducted through this facility, made possible by the innovative program and operation of the facility.

**Social,  
Economic and  
Environmental  
Impact**

Acting as a precedent for the Manitoba building industry, the Churchill Northern Studies Centre demonstrates what is possible with solid engineering design, green building design principles and leading-edge technology. It is anticipated that the combination of ambitious water conservation and on-site treatment techniques for this building will serve as a model of sustainability for future developments in remote communities, especially as the technologies showcased at the CNSC are scalable to larger facilities. Enermodal is sharing the lessons learned from this project through industry seminars and by authoring articles. Recently, the company gave a presentation at the Ontario Onsite Water Association's 2010 conference in London on this project, and was also featured in an article in Water Next, a Canadian water-efficiency magazine.



## Fulfilling the Owner's Requirements

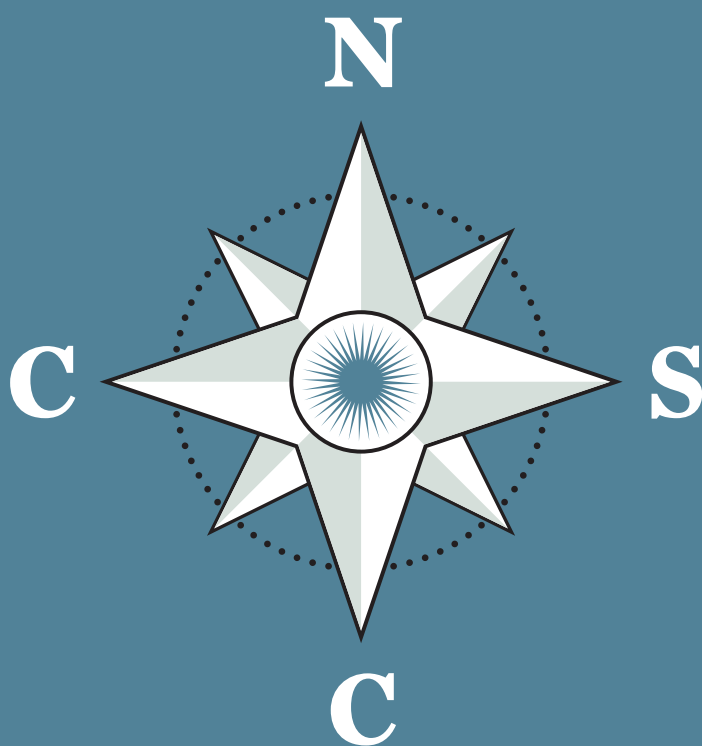
The Churchill Northern Studies Centre is a private, non-profit scientific foundation operating in Canada's harsh sub-arctic climate. Minimizing building costs and expenses, conserving energy, producing an attractive and productive work environment, and the ability to move into the building by fall of 2011, were top priorities for the organization on this project.

Enermodal's design contributed to meeting these objectives by creating a building that is cost-effective to operate, and reduces utility costs for the CNSC. On-site and off-site operations utilize modern systems and controls which allow for a more economical and sustainable building. The daylighting, indoor air quality, and ventilation systems will ensure that staff and visitors are more comfortable and productive in their new environments. Constant communications between Enermodal and the owner was effective in identifying project challenges and opportunities for innovation, and ensured that both parties were well informed of any potential delays or increases in cost. As a result, the building was completed and ready for move-in on schedule in June 2011 and costs were kept under control, with the project delivered close to budget.



**T**he Churchill Northern Studies Centre was a challenging design project in a remote and northern climate, with inconsistent electrical service, and no municipal services. Enermodal worked with other consultants on the project to provide innovative, sustainable, and technologically advanced design, which can be applied to a variety of building types in northern locations. The current building meets the needs of the occupants for a modern building with the associated amenities and services, while providing significant energy and water savings for the owner and environment.

## Conclusion



Churchill Northern Studies Centre