# Challenges, Risks and Successes
# in the Construction of the
# Lake St. Martin Emergency Channel

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## Abstract

The magnitude of flooding in Manitoba in the spring and summer of 2011 brought an unprecedented challenge to the Province of Manitoba. Using the criteria of feasibility, utility and constructability, several options for managing the flood levels were considered. After some analyses, the construction of the Lake St. Martin Emergency Outlet Channel was chosen as the best option.

The requirement to complete construction of the channel prior to winter freeze-up represented a major challenge. With the decision to build being made on July 22nd, only four months were left to complete the final design, contract awards, mobilization, and construction by November 1st. In addition, construction was constrained by project location which was accessible only by boat, barge or helicopter, and was flooded at the time of construction.

Once the magnitude of the job (2 million cubic meters of material) and the timelines had been set, the next task was to estimate the type and amount of heavy equipment required to complete the required excavation on schedule. Almost simultaneously, potential contractors had to be selected based on their recent performance and equipment capability.

It was decided that Manitoba would assume the majority of the risk for the project in order to negotiate the best financial rates possible for this time-sensitive and complex project. Provincial representatives met with contractors to negotiate contracts and set rates encompassing as much of the equipment and construction scenarios that could be anticipated. It was also the intent of contract negotiations to maximize local aboriginal involvement in the project.

The contractors, MIT and AECOM worked as a team to plan construction and oversee the work. This effort resulted in a project completed on time, well under budget, and with an impressive safety record that was seen as an integral part of the successful flood fighting effort in Manitoba.

**Background**

Widespread record flooding was seen across much of southern Manitoba in 2011, resulting in unprecedented high inflows into Lake Manitoba especially through the Portage Diversion and Waterhen River. Outflows from Lake Manitoba travel downstream through the Fairford River to Lake Pineimuta and Lake St. Martin, then through the Dauphin River to Lake Winnipeg. The major watershed components of the Dauphin River Watershed are illustrated in Figure 1.

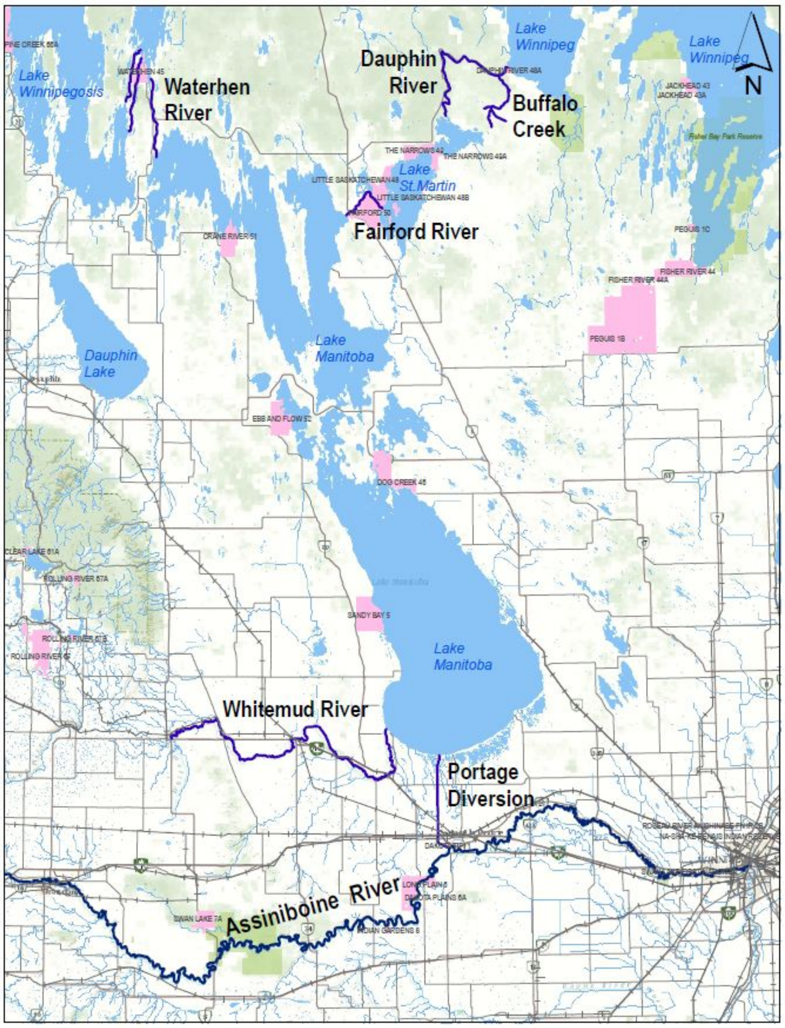


**Figure 1: Major Components of Dauphin River Watershed**

The prolonged high flows overwhelmed the capacity of the existing regulatory system. As a result, Lake Manitoba crested at 817.3 (249.1m), approximately five feet higher than the upper end of the desirable regulatory range of 810.5 to 812.5 ft (247.0 – 247.7 m). Flooding on Lake Manitoba caused significant damage to hundreds of properties around the lake, particularly during a storm in late May when winds reached over 62 mph (100 km/h), wind set-up raised the lake up to 5 ft (1.5 m), and waves as high as 7 ft (2.1 m) were reported in some places. Preliminary analysis indicated that the cumulative impact of high water from all systems flowing into Lake Manitoba combined with the major wind storm in May approached the range of a 1 in 2000 year event on the lake.

Due to the high Lake Manitoba levels, the flow through the Fairford River Water Control Structure (FRWCS) reached a record 22,000 cfs (623 cms) in 2011. The Fairford River flows into Lake St. Martin, where the peak level reached 805.5 feet (245.55 m), were almost 3 feet (0.9 m) higher than the historic peak of 1955 and well above the desirable operating range of 798 ft to 800 ft (243.2 m to 243.8 m). This flooding on Lake St. Martin prompted the need for emergency construction of dikes up to 8 ft (2.4 m) high with a top elevation of 809 ft (246.6m) above sea level.

Road access was severely limited to several communities and requiring widespread long-term evacuation from the four First Nations around Lake St. Martin. On both shores of Lake St. Martin and Lake Manitoba, approximately 2,000 people were evacuated. The extremely high water levels on these lakes were expected to continue for an extended duration, leaving communities, homes, cottages and farms at high risk of further damage from flooding, wind and waves. The spring 2012 break-up of lake ice at such elevated water levels also had the potential to cause devastating damage to properties around the lakes. Without emergency action, spring runoff would have caused another rise in water levels and further extend the duration of flooding.

**Analysis of Overall Design Options for Lowering Lake St. Martin and Lake Manitoba**

The Province commissioned AECOM and KGS to urgently explore options to bring the levels of Lake St. Martin and Lake Manitoba down to the desirable range on an emergency basis. Manitoba sought a broad review of any potential options to achieve this objective in a timely and cost-effective manner, with minimal impact on other areas of the province.

AECOM and KGS assembled a team of some 30 senior engineers and technical specialists, including hydraulic and geotechnical experts to evaluate the Province's requirement. In cooperation with Manitoba Infrastructure and Transportation and then Department of Water Stewardship, significant resources were devoted to assessing the viability of several different emergency channels and other options that would lower the levels on the lakes as quickly as possible. The options examined are shown on Figure 2.

On July 22, 2011, Manitoba accepted the recommended option, which was to begin immediate work on construction of a 5,000 cfs capacity emergency outlet channel from Lake St. Martin to Buffalo Lake and Creek, en route to Lake Winnipeg to address the hydraulic flow restrictions out of Lake St. Martin and to accommodate additional Lake Manitoba outflows over the winter. The channel alignment is shown on Figure 3.

The construction challenges were significant. At the onset, there had only been a preliminary exploration of the proposed route. The channel site was located on the "wrong side" of Lake St. Martin with no road access. Even exploratory access was limited until a shipping channel was excavated through hundreds of meters of flooded trees and muskeg. The site remained only accessible by barge, boat or helicopter throughout the project. In addition, the site was known to have flooding far inland and a surface layer of saturated peat underlain by a layer of hard basil till. Flooding persisted throughout the project, which required constant adjustment of design, personnel and logistical support to meet extremely tight deadlines and contractor capabilities.

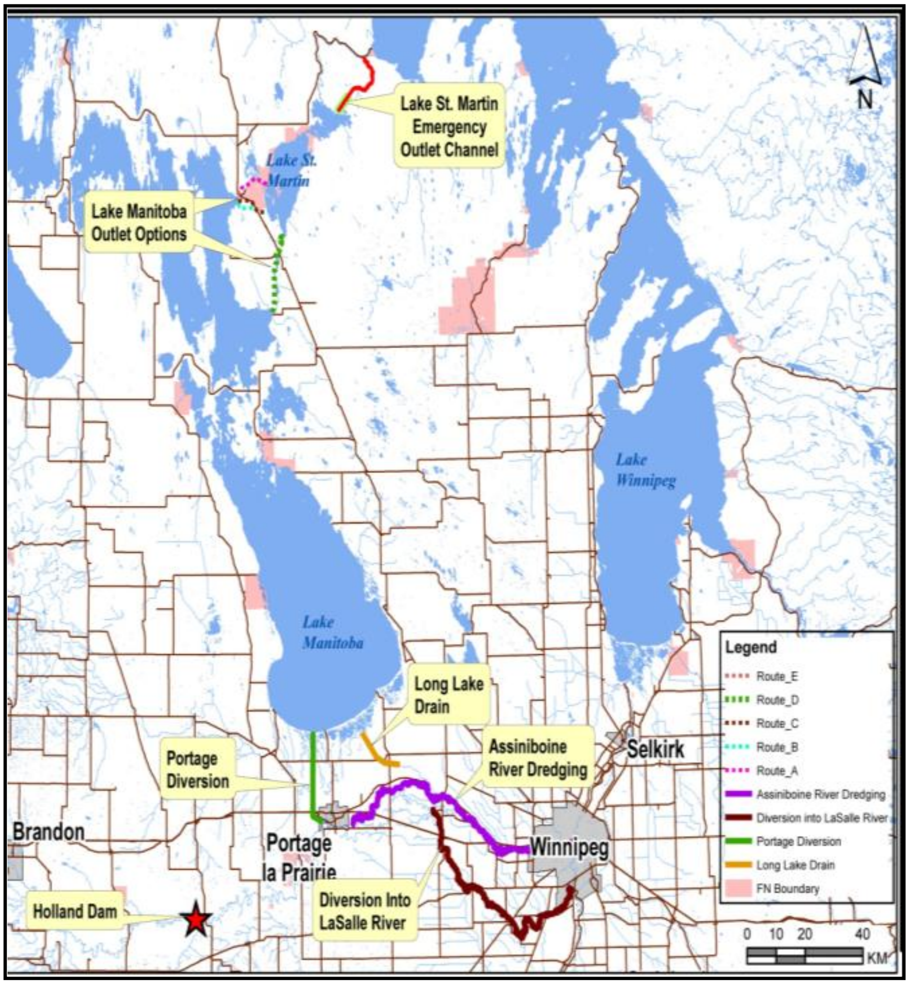


**Figure 2 – Options Analyzed**

Over and above these site limitations, the construction of this 6.2 km long, 60 meter base width channel required close to 2 million $m^3$ of excavation before winter prevented even water access. This required several measures to be taken simultaneously including the immediate mobilization of contractors; the completion of exploration works and the final modeling and design of the channel and associated works.

## Site Reconnaissance

Reconnaissance of Lake St. Martin North East shore began in mid-June with government and consultant personnel flying over the site to consider drainage route possibilities. Aerial photos taken June 17, 2011 showed the extent of flooding in the forest and fens. Contractors familiar with this type of construction also flew over the area and suggested a route on higher ground would be most feasible from a constructability perspective. Site exploration commenced in mid-June, with boat access to shore proving difficult due to flooded forest regions. An initial beach head was then established in the vicinity of the construction site in late June followed by labourers with hand tools clearing a path for boat access to dry land for equipment off-loading.

Consultants from AECOM and KGS, assisted by labourers from the local first nations, set out in early July searching for high ground on which to propose construction of the first six (6) kilometres of drain north east of Lake St. Martin. Visual search from helicopters and ground teams probing through peat attempted to identify alternate drainage routes. Alignments that followed lower ground were ultimately ruled out by engineers and construction advisors as these are too difficult to construct with the high water conditions. This left Route "L" Reach 1 as the preferred route.

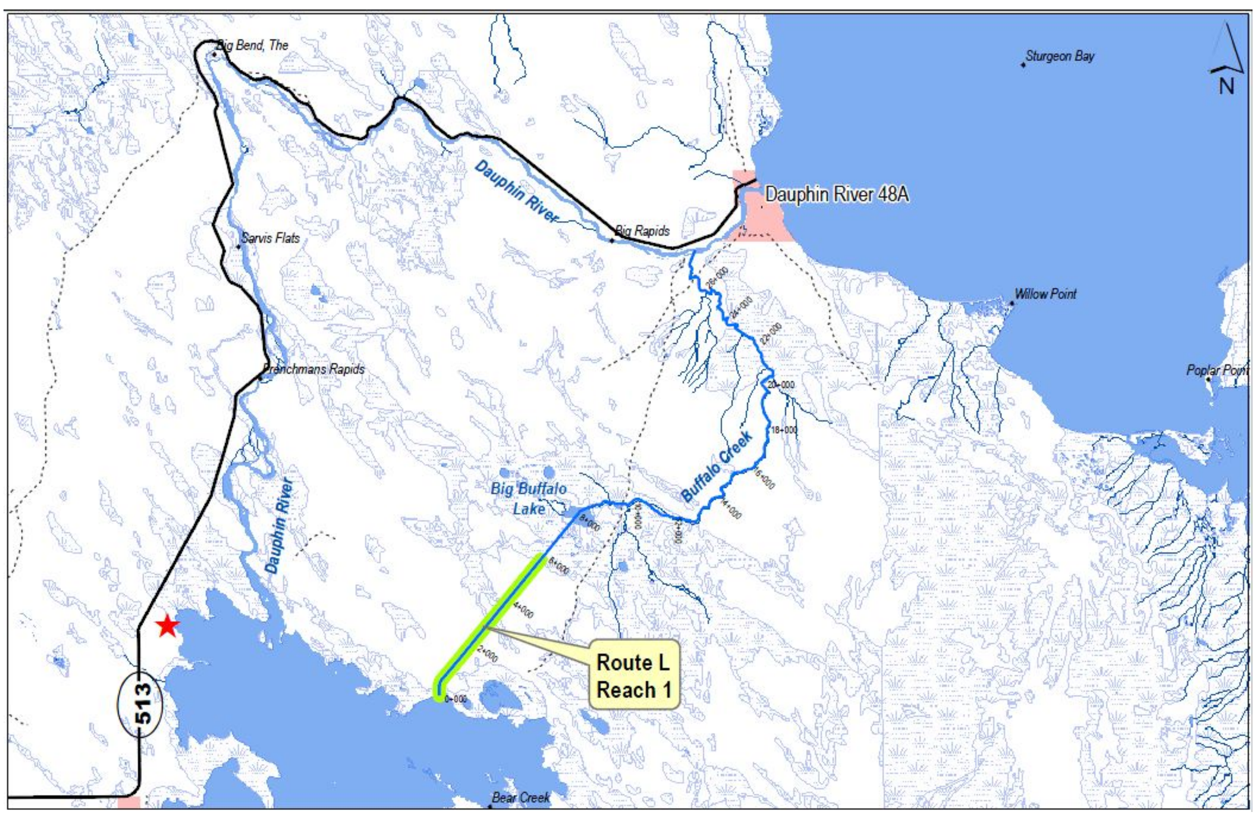


**Figure 3 – Lake St. Martin Emergency Outlet Channel**

Line clearing crews were deployed to cut narrow paths to facilitate GPS alignment survey. This led to the collection of topographic data necessary to estimate earthwork quantities and support engineering estimates of total construction cost. Additional line cutting crews cleared helicopter access pads, while surveyors installed local control points as temporary benchmarks at helipad locations.

Geoseismic exploration teams were deployed to identify the underlying geology to support drain route selection by quantifying layers of overburden peat versus till and bedrock. Geoseismic data and initial engineering judgment confirmed that no bedrock was located within the depth of anticipated excavation on the higher ridges on Route "L". Earth work quantities were refined, level of effort predicted and the route alignment details selected.

**Figure 4 – Attempting to Cut Access Channel**

**Figure 5 – Survey Crew Setting Alignment**

### Mobilization and Pre-Construction

Mobilization and pre-construction activities took place from June 28 to August 14, or 48 days. This was a remarkably short period considering that contractors were busy with other flood fighting activities and contract negotiations were still on-going. The principal activities during this phase included:

- establishing construction camps near Benson's Big Rock Camp;
- construction of boat and barge landing at Benson's Big Rock and at the construction site;
- equipment and materials mobilization at construction site;
- construction of access roads at proposed lateral limits; and
- clearing of bush within the 300 m-wide construction footprint.

Prior to the formal construction contracts, these activities were primarily performed by Hugh Munro Construction under contract to AECOM.

**Figure 6 – Access Channel Construction Using Barge Mounted Excavator**

### Construction

*Contract Delivery Issues and Options*

Once a decision was made on the need to build an emergency outlet, senior government staff met with construction industry representatives and toured the likely site for the channel. At the time, the site was completely inundated with water and survey crews had just recently been mobilized to the site to collect elevations and other site information. As the location was flooded, aerial inspection had to suffice for field review. Although this did not allow for a thorough review, it fairly provided an indication of the task at hand. Discussions were held with the industry on possible options, timelines, equipment availability, and likely production rates. In addition, project considerations and objectives were discussed with senior provincial executives to decide on the best possible contract and project outcomes that would help determine the tender process for the works needed.

Some of the considerations and objectives included:

- Commencing construction as soon as practical
- Targeting project completion by November 1, 2011
- Minimizing the environmental impact
- Reducing risk to the contractor to ensure the best price possible
- Ensuring suitable contractor compensation for a difficult project
- Maximizing aboriginal involvement
- Reducing risk to the province
- Ensuring the safety of all involved
- Contingency planning
- Transparency in the contracting process
- Developing strong working partnership between contractors, engineering service providers, and MIT
- Minimizing overall project cost
- Minimizing disruption to manpower (contractors, project management staff) deployment for other flood mitigation works

Reviewing the site, developing contract options based on the above criteria and receiving approval to proceed were accomplished within one week.

*<u>Contract Negotiations</u>*

After a review of all construction companies that had previously worked for MIT, the decision was reached to negotiate with three companies to be hired on a sole source basis for the project. All three companies had a strong working relationship with MIT, had equipment and manpower available immediately that would not require them to leave other ongoing flood mitigation work, and had performed well with other urgent work earlier in the spring as well as on previous provincial projects.

On August 15, 2011, MIT, as Prime Contractor, entered into contracts with:

- Hugh Munro Construction Limited (HMC). Based in Winnipeg, HMC is a large contractor that was already onsite, assisting the engineering service providers with access to the project site.
- Sigfusson Northern Limited (SNL). SNL is the largest earth moving contractor in Manitoba with headquarters in the Interlake region (Lundar), the general area of the project

- Tri-Line Construction (TLC). Based in Arborg, TLC is a medium sized construction company that had performed well in other flood fighting activities and had knowledge of the construction area.

Contract details included:

- Each of the three contracts ranged from $10 million to $20 million with no bonding required.
- A set hourly rate for all equipment based on the Manitoba Heavy Construction Association (MHCA) guidelines
- Any specialized equipment that did not have a rate in the MHCA guidelines would be negotiated prior to arriving on site.
- All three contractors would be treated as equally as practical
- MIT would act as the prime contractor and be responsible for the overall safety of the project, including the provision of an onsite medical unit.
- MIT would contract for helicopter service for emergency evacuations and transport of personnel to and from the site when weather conditions did not allow for transport by boat, the only other means of getting to the project
- MIT would pay for the cost to set up and take down camps at a hourly rate
- MIT would pay a negotiated price for daily boat transportation to and from the construction site.
- MIT would pay for all barge and tugboat costs at negotiated rates once a decision was made on the type and size of all watercraft. Contractors would arrange for the fuel supply for their equipment with the fuel costs included in the hourly rates.
- Lodging and meals for workers were paid at a set daily rate
- Standby would not be paid, with the exception being when weather would not allow employees to travel to the work site. A rate would be paid for all staff remaining in camp during these periods.
- Determination of hours paid for equipment would be based on actual hours operated, not when the employees begins to be transported to the site

**Figure 7 – Barge Channel and Drainage Development**

In addition to the three main contractors, other Sub-contractors and companies involved in the construction works included:

- Buus Construction Ltd. (Subcontractor to HMC) - excavators, tug boats, barges;
- Canadian Dewatering Ltd. (Subcontractor to HMC) - dewatering pumps, supply and operation;
- CEDA Environmental Fluid Solutions - inlet dredging;
- Titan Environmental - supply and installation of turbidity curtain around inlet;
- Taiga Air Services Ltd. - helicopter Services (Short-Term Contract);
- Custom Helicopters Ltd. - helicopter Services (Short-Term Contract);
- Yellowhead Helicopters Ltd. - helicopter Services (Long-Term Contract);
- Manitoba Conservation - operation of Amphibex machines for barge channel maintenance;
- Rainy Lake Tugboat - tug boat and barge; and
- Criti-Care - paramedic services.

In total, the project had over 150 pieces of light and heavy equipment on site, requiring 3 construction camps, 3 tugboats, 4 barges, 10 support boats, 2 helicopters, 2 field offices and over 130 construction, AECOM and MIT staff.

*Monthly Project Progress*

*August Progress*

The primary focus in August was bush clearing, peat excavation and removal, establishing access roads and dewatering. Excavation of the channel (till excavation) commenced on August 30$^{th}$.

Initially, work progress was difficult to gauge quantitatively, due in part to the contract being based on equipment hours, as opposed to being a typical Unit Price Contract. Without the need to measure volume for the purposes of progress payments, it was difficult to determine the volume of peat and till excavated to estimate percentage completion of the channel. This was not a major concern in August, when activities had just begun. However, the need for a reasonable estimation of progress became more pressing in September.

**Figure 8 - Barging Field Office to Site**

August saw the first major influx of earth moving equipment to the construction site, increasing from 10 to 43 units including 19 dozers, 17 excavators and 7 rock trucks.

The main concern for August was the ability to meet the November 1st deadline to open the channel, due to the slow pace of equipment mobilization and construction operations. At the end of August, there was very little progress on channel excavation and most construction efforts were focused on site preparation including: clearing, dewatering and peat excavation.

Near the end of the month, a decision was made in the field to reduce the width of the cleared right-of-way (ROW) by half, from 300m to 150 m due to concern with production rates. The new channel centerline was shifted 75 m to the east and the former channel centerline became the western ROW limit and the east ROW limit remained where it had been designed. At this time, the channel dimensions remained the same with a 60m wide channel bottom with 3:1 side slopes.

This decision had ramifications on the design of the spoil pile. The original 300m ROW had adequate room to contain the large spoil pile that would result from the channel excavation. With the reduced dimensions, bush clearing to accommodate the spoil pile would have to be done on an “as-needed” basis.

The issue of excavated peat material placement also arose as a result of reducing the ROW dimensions. Contractors wanted to deposit peat material into the access road ditches. However, peat has generally poor geotechnical strength and the contractors were advised that peat was not to be deposited in the road ditches as this location was critical for spoil pile and embankment strength and performance.

*September Progress*

As in August, progress was difficult to quantify initially. A suggestion was made to survey the excavated parts of the channel and perform volume calculations to determine progress. As this processed proved too onerous and labour intensive, the site inspectors resorted to estimating progress throughout the site by recording the estimated cut remaining at various stations. This information was entered into a spreadsheet of estimated daily cumulative progress. The method did not provide the level of accuracy as one would have with surveyed cross-sections, but it was considered adequate given the conditions and constraints of the project.

**Figure 9 - Progress by September 9**

The construction of the channel intensified in September with the major efforts focused on clearing the remaining bush, peat excavation and removal and excavation of till material. At the start of the month, it was estimated just over 50% of the bush clearing was complete. This figure was due in large part to the decision to reduce the cleared right-of-way to 150 m width. By month's end, bush clearing was nearing completion, at approximately 86%.

With an estimation procedure in place to record the volume of peat excavated, progress was measured to indicate that excavation and removal was approximately 78% complete by the September 30$^{th}$.

Excavation of till material had only begun at the very end of the August and initial progress was slow, partially due to the difficulty of digging the hard basil till. Near the end of the month it was estimated only 14% of the required till excavation was complete. There was concern this method of estimating the till excavation understated the true results and the method was subsequently refined to provide a more accurate picture of the progress. However, regardless of the estimation, with only just over a month remaining until November 1, there was concern the deadline could not be met. A decision was therefore made to construct the channel to 75% of the original design, with the west half of the channel to be constructed to its full base width (30 m) and full depth, while the eastern half would be constructed to half the base width (15 m) and full depth.

By the end of the month, till excavation was estimated to be approximately 35% complete. Both the reduction in channel dimension as well as the more detailed progress notes by inspectors and more accurate calculations of excavated volumes contribute to this apparent jump in productivity.

The amount of earth moving equipment nearly doubled in September, reaching 82 units from the 43 units at the end of August. The equipment roster was comprised as follows:

- dozers increased from 19 units to 38 units, including larger equipment; nine (9) Caterpillar D8s and one (1) Caterpillar D9
- excavators increased from 17 to 24, including one (1) Caterpillar 385 unit
- rock trucks increased from 7 to 20, the peak number of trucks for the project

Rain hindered construction progress on a few occasions, but generally, good weather predominated in September. High winds and unsafe boating conditions on Lake St. Martin affected transport of personnel on a few days and personnel had to be ferried back to camp by helicopter. With the hours of daylight becoming shorter, there were concerns about boating in the dark. Arrangements were then made mid-month to obtain and deploy channel marker buoys from the Coast Guard to reduce the risk of collision.

A major setback in barging operations occurred in mid-month when the tugboat operators from one of the subcontractors left site. The issue was resolved when the Siggy Oliver, a tugboat owned and operated by the Government of Manitoba arrived, near the end of the month.

*October Progress*

In October, the contractors made the best progress. The weather was near perfect, site drainage had been established and the contractors had developed efficient means of moving overburden and till. By mid-month it was evident the objective of having the ¾ channel complete by November 1 would be achieved. The total number of earth moving equipment at the channel construction site peaked at 90 units in October and demobilization started on October 26$^{th}$.

**Figure 10 - Channel Progress by October 2**

**Figure 11- Channel nearing Completion - October 25**

In October, the majority of the emergency channel components were completed. The bush clearing work was complete by October 8th and the construction effort focused mainly on excavating till material and constructing the channel slopes and berms. Average peat removal progress was approximately 8,100 $m^3$ per day and peat excavation and removal was complete by the 20th.

At the start of October, till excavation was approximately 35% complete. Progress was steady for the first two weeks of the month averaging about 22,320 $m^3$ per day. Excavation rates increased to 31,620 $m^3$ as the deadline approached. By October 31, 2011, excavation of the channel was complete.

The main construction obstacle during October was the slow pace of dredging operations; in particular, the productivity of the specialized dredging machine operated by CEDA Environmental Fluid Solutions (CEDA).The dredging equipment arrived on October 6 on three trailers; the main central portion and two sconces. Once the dredge was in the water, it took an additional three days before mobilization was completed. The dredging operations began on October 12th, but it was slowed by weeds and rocks. The discharge contained very little excavated material. A week later, CEDA informed the project team they expected to complete only 30% of the inlet excavation by the November 1st deadline. It was evident that additional and alternative methods of dredging were needed if the deadline was to be reached.

Excavators on barges and a floating excavator completed the dredging operations. The excavators would pull themselves to the area to be dredged, dig out the lake bottom and deposit it in the barge. When full, they would pull themselves to shore, where they would unload before returning for another load.

October saw the construction methodology of the channel being well established and, apart from the issue with the inlet dredging, there were no major alterations to the channel design or construction methods.

*November Progress*

The main focus for November was opening the outlet channel by excavating the “South Access Road” (or south dike - opening of channel), continued dredging of the inlet, and equipment demobilization.

Excavation of the south dike, which separated Lake St. Martin from the channel, was initiated around noon on November 1st using six (6) excavators along the length of the dike. The excavation started from the west end working eastward. The western most excavator cut into the dike and the material was pitched back to the successive excavators behind. Excavation of the dike continued the following day, but was suspended due to an incident where one of the tugs and a barge were swept into the channel by strong cross-channel currents.

**Figure 12 - Construction Equipment on Site**

**Figure 13 –Channel Opening November 1, 2011**

At this point the dike excavation was 50% complete. When a new barge channel, positioned away from the strong forebay currents was constructed, excavation work was able to resume on November 13 and continued until November 19, when weather conditions no longer allowed safe passage across the lake. Mean daily air temperatures had dropped to -15 $^{o}$C by this time with lake ice close to 100mm thick, which refroze immediately after the passage of a tug.

In the end, there were eight (8) barge-loads of equipment remaining on site. Majority of this equipment loads was removed by winter road later in the winter.

**Success Factors**

As indicated, both the design and project field conditions and requirements were unknown at the time of the contract negotiations. With so many unknowns, it would have been very difficult for a contractor to provide a unit or lump sum price, especially with the extremely tight timelines and probability of weather having a huge effect on productivity. The intent of the contracts was to take as much risk as possible away from the contractors which then allowed them to agree on lower overall prices. Excellent, cooperation, strong management and oversight, and favourable weather contributed to the huge success of this project.

*Direct negotiation*. Although MIT believes strongly in open tendering with the award going to the lowest qualified contractor, in emergencies such as this, direct negotiation with contractors is certainly preferable. Since there is a direct relationship between risk and cost, high-risk projects for contractors must come with the opportunity of high rewards; otherwise, contractors would not undertake the work. Minimizing contractor risk on this project was the single biggest factor in reducing overall contract prices. A lump sum contract for this work would have likely cost the province double or triple what was ultimately paid for this work. This is some $40 million to $70 million savings for the Province.

*Hourly work*. With all the work undertaken on an hourly basis, the design work was able to proceed while work was ongoing. This allowed MIT and their consultants to find cost-saving and timing-saving options, with the main one being reducing the width of the channel from a 60 meter bottom to 45 meters.

*Manitoba as prime contractor*. Manitoba decided to retain the role of prime contractor and be responsible for the project's overall safety program. MIT would normally have the main contractor take on this role, but with all of the risk of having three large contractors in one short work location with many unknowns; it would have taken a substantial cost for one of them to assume the role. MIT set up the safety program and was able to work with the contractors and consultants to have an amazingly safe and issue free project.

*Open communication and close coordination*. Another positive aspect of the contract administration was regular meetings between the contractors, MIT and consultant. This allowed issues to be addressed in a timely manner and reduced the number of cost items to be negotiated at the end of the project.

**Lessons Learned**

There were a few items related to the contract and contract administration that, in hindsight, could have been improved had it not been for the tight timelines.

The intent was to have unit or hourly rates decided for all specialized equipment before the equipment was brought to the site. However, with such a fast-paced project with a very small number of MIT and consultant staff overseeing a project that was changing constantly at the start of the project, there was not time for this to occur. Once the equipment was on site working, with the very tight timelines of the project, MIT was not in the best bargaining position to determine rates.

Also, although all three contractors indicated during the contract negotiation stage that they would immediately mobilize all available equipment to the site, one of the three contractors, due primarily to other priorities, did not mobilize as quickly or with as much equipment as envisioned. Fortunately, the other two contractors were able to bring more resources to the project to make up for this. In hindsight, the contracts could have been negotiated to specifically identify a minimum amount of equipment that would be mobilized immediately.

Another item that could have been specifically included in the contracts was the cost to transport employees to the work site each day. As it was unknown how this would be accomplished, it was left to each contractor to determine the best way to transport their employees. Each contractor procured their own large boats and then negotiated for their use. Although the costs were fairly high for this, the large boats proved to be very useful as no days were lost to being unable to get the crews across the lake to work. This both enabled the work to proceed, kept the employees gainfully employed, as well as minimized standby costs.

The contract was also silent on demobilization of equipment at the end of the project. It would have been preferable to state exactly what costs would and would not be covered to demobilize under different scenarios. The vast majority of the equipment was removed by barge back to the mainland once it was no longer required. However, a small amount of equipment was still at the site when the lake froze over and halted any further barging. This equipment needed to be walked out once a winter road was in place.


**Figure 14 - Final Day of Barge Operations – November 19, 2011**