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Bull Arm Fabrication Site Dry Dock in Mosquito Cove, Newfoundland

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ABSTRACT

The Bull Arm Fabrication Site is a world class facility built in Mosquito Cove, Newfoundland and Labrador in the 1990's as a construction site for the first Gravity Based Structure based oil production platform on Canada's Grand Banks known as Hibernia. This huge multimillion dollar facility boasts: on site pipe and rebar fabrication, concrete batch plants, large module construction halls, and many other permanent facilities.

Noticeably, one of the critical facilities seemingly missing is a functional and reusable dry dock. Each large project requiring such a facility must, at the project owner's expense, create their own functional dry dock facility within Mosquito Cove. To date, the favoured solutions for the two largest mega projects constructed at Bull Arm has been a geotechnical solution with placed aggregate forming a bund wall or dyke around the cove and dewatering by pumping water out via crane emplaced temporary pumps. Is this current functional solution the best available?

As of 2008 Nalcor Energy, the provincial utility and energy crown corporation, has been granted control of the facility and has touted a focus of continuous and concentrated work at the facility with little or no downtime

The following paper will discuss the advantages of a temporary geotechnical solution with project descriptions of recent uses of this method. A focus on practicality, environmental issues, and possible upcoming projects will be discussed.

1 INTRODUCTION

Bull Arm Fabrication Site is located on the west side of Trinity Bay and near the isthmus of the Avalon Peninsula in the Canadian Province of Newfoundland and Labrador, Canada. The site itself is located in a cove known as Great mosquito Cove. The nearest settlements in the area are the village of Sunnyside, about 4 km from the site and the town of Clarenville about 35km along the Trans-Canada Highway. The Capital of Newfoundland and Labrador is about 165 km east.[1]

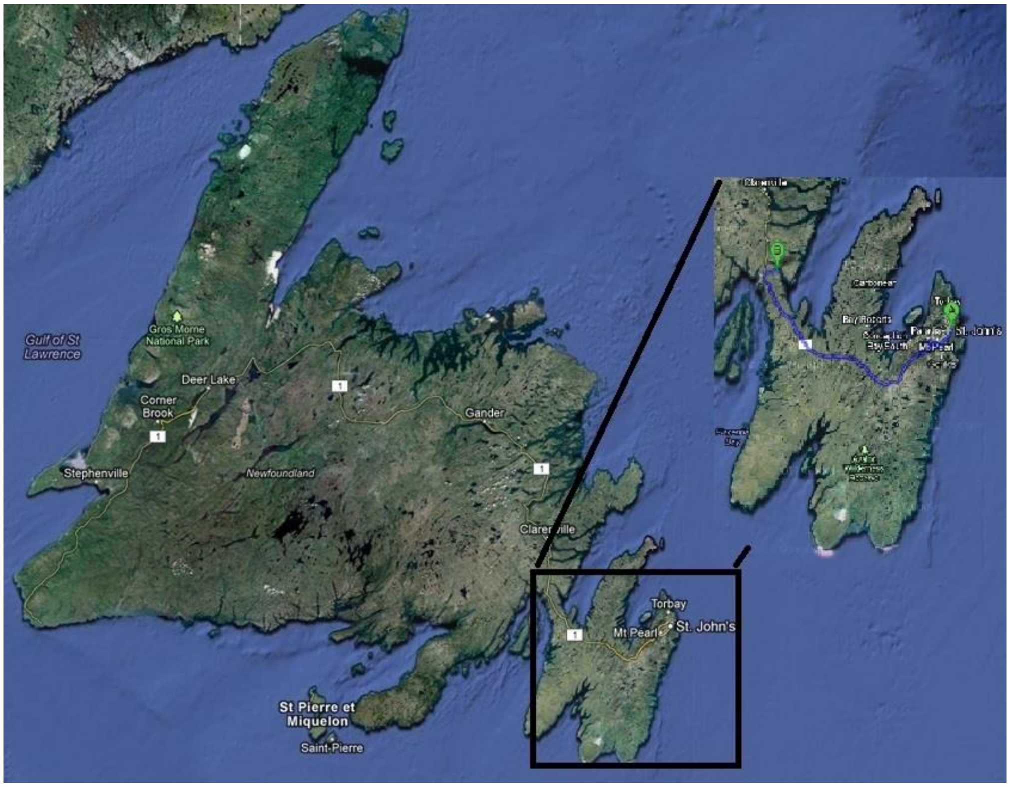

Figure 1 – Bull Arm Fabrication Site Location

The site was originally constructed in October 1990 for North America's first gravity base structure (GBS) oil production platform known as Hibernia. [2]

This site was originally chosen as the home for a large fabrication yard by virtue of its sufficiently sheltered nature and the shoreline being extremely steep in places. This combined with very deep near shore water up to 200m allowed there to be both dry dock and onshore construction coupled with deep water site construction within a few minute ferry ride or floating bridge connection away. [3]

Bull Arm has seen many large projects. The stars in the portfolio are the large GBS megaprojects Hibernia and Hebron, however, many other projects such as significant work related to the fabrication, hook-up, and commissioning of the Terra Nova FPSO project, oil rig refits and maintenance such as the recent Henry Goodrich refit, and assorted other work has been completed at site to date.[4]

As Bull Arm's ownership is now in the hands of Nalcor Energy, Newfoundland and Labrador's crown energy corporation it is of vital importance to maximize cost and workload for the benefit of the general public.

Figure 2 – Bull Arm Fabrication Site

Since the construction of the site there have been long periods of lull with no work and the site in a mothballed state. [5] It has been called into question if the lack of a functional dry dock may have hampered interest in the site as a base for large projects. To date at Bull Arm we have seen geotechnical solutions involving dumping aggregate directly into the water and dewatering by temporary client procured pumps that are placed and removed as required from scratch with each project in Great Mosquito Cove. This is a critical design decision that will be discussed at depth.

2 HIBERNIA - BULL ARM DESIGN AND INITIAL CONSTRUCTION

Hibernia is a gravity base oil production platform that was the original purpose for Bull Arm's construction. The Hibernia platform has three separate components: Topsides, Gravity Base Structure (GBS), and Offshore Loading System (OLS).

The completed platform was towed to the Hibernia oil field and positioned on the ocean floor in June of 1997 and began producing oil on November 17, 1997. The platform stands 224 metres high, which is half the height of New York's Empire State Building (449 metres) and 33 metres taller than the Calgary Tower (191 metres). [2]

Bull Arm site was originally in a totally undeveloped area with only small fishing villages in the environs. All structures, shops, and infrastructure such as roads, sewer, water, electrical power, and telecommunications with capabilities to service a multibillion dollar construction project had to be completed totally from the ground up. In October of 1990 the start of a rough road straight off the Trans-Canada Highway into Great Mosquito Cove was began.

The date of start of construction is of critical note. Due to the demanding nature of the Hibernia project, the entire fabrication yard had to be not only designed, but also constructed, in a mere 18 months. The history of the politics and human factors surrounding the Hibernia project is perhaps more critical in understanding some of the initial design considerations than even the hairiest of technical details. [3]

2.1 History of the Hibernia Project

One of the first steps in bringing Hibernia into production was the naming of a Federal Environmental Assessment Review Office Panel in March 1985.

On 18 July 1988, the federal government announced the details of an agreement reached with the four-company consortium to develop the Hibernia field. Through much political wrangling, interest free loans, tax breaks, and various other corporate incentives the project received a green light and was set to go ahead in September of 1990, a period of almost 2 years. The original cost was estimated to be $5.2 billion with an additional $3.3 billion required for production-related spending.

Figure 3 – Hibernia Platform Preparing to Leave Bull Arm

Prior to the go ahead of actual project work, one of the four members of the consortium, Gulf Canada Resources Ltd., put up for sale half of its 25% interest in the project. Then, in February 1992, it withdrew from the project altogether. The consortium was then made up of Mobil Oil, Petro-Canada, and Chevron Canada. Mobil was contributing $1.1 billion, Petro-Canada $1 billion, Chevron $879 million, and the federal government's contribution was $1 billion. Gulf's promised $1 billion had, of course, been withdrawn. So far, the consortium had spent $450 million.

Both federal and provincial governments had tried to ease this crisis by agreeing to cover the costs of the partners for 75% of the project expenses beyond 15 May 1992 if a replacement for Gulf could not be found and the project had to be put on hold. In the end, Murphy Oil of El Dorado, Arkansas, would take 6.5%, with various other members of the consortium increasing their holdings and the Government of Canada taking on a portion of the projects ownership.

The first concrete pour for the base slab of the gravity base structure began in April 1993. Design changes and slow construction hampered and delayed the schedule. The original cost estimate of the gravity base of $1.2 billion also rose by 30%.

In 1994, Petro-Canada announced that a huge cost overrun of over a billion dollars accompanying schedule overruns of half a year was announced. The hammer fell and NODECO (Newfoundland Offshore Development Constructors) the original notoriously inefficient and staff strapped contractor was replaced by Norwegian Contractors, a consortium that had been overseeing NODECO since the fall of 1993. In the end $5.4 billion had been spent on the project with final mating and tow out of the structure form Bull Arm occurring in 1997.

Production of 125,000 barrels a day was originally slated to start in 1992 and last for 18 years. In fact, Hibernia oil destined for the U.S. market finally began flowing in November 1997. [6]

2.2 Original Dry Dock Design

The major component of dry dock construction is the berm, dam, or more accurately bund wall, to block water from Greater Mosquito cove and form the dock itself. With a green field site presented to the Hibernia site engineering team there were many options presented before them.

The initial thoughts of the NODECO engineers was a cheap and effective sheet pile wall solution. However, given the soil conditions present in the cove this was thought to not be a fully feasible solution. At or near the seafloor throughout the area is displayed bedrock of a poor to good condition. This would not enable effective driving of sheet piles and prevent sufficient watertight sealing and structural support at the bottom of any proposed structure. [7]

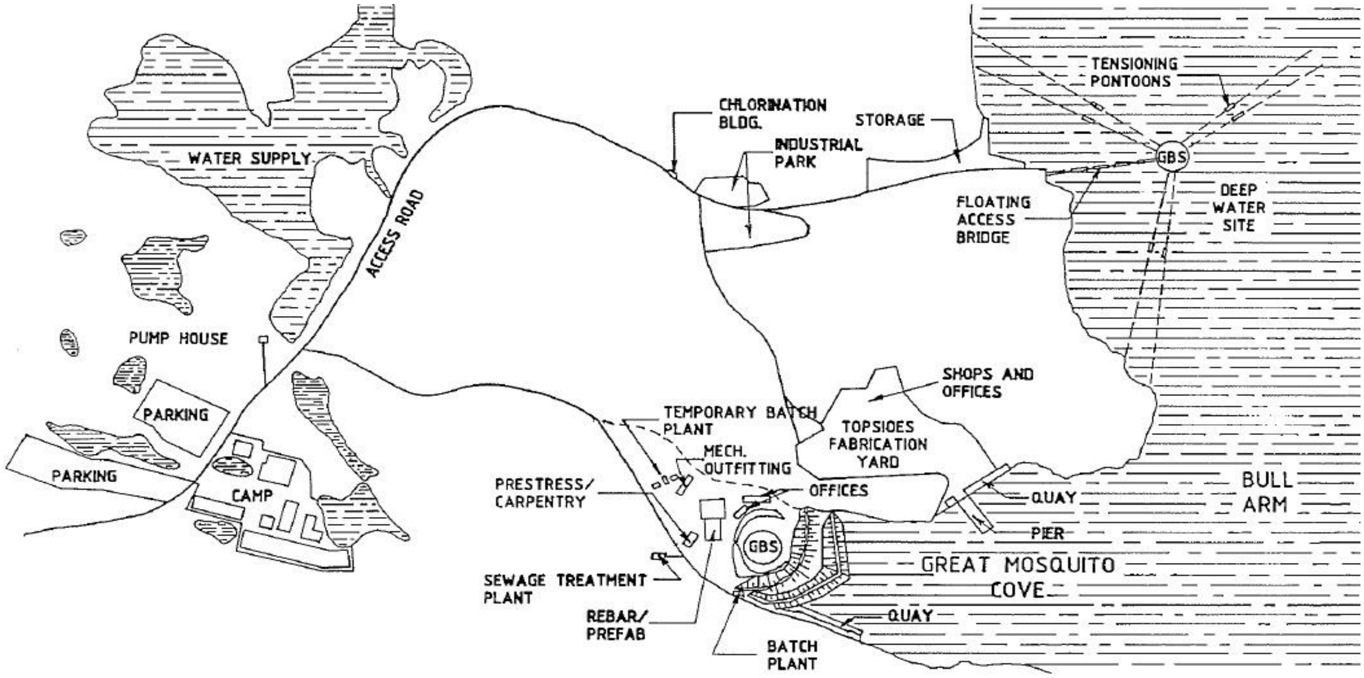

Figure 4 – Bull Arm Design Plan

With a pile based solution passed over, design engineers settled on another locally known and reliable solution, the glacial till core earthen dyke.

In the province of Newfoundland the earthen dyke was previously used extensively for many hydroelectric projects. The real gem of these hydro projects was the massive Churchill Falls hydro development in Labrador. 88 dykes were created with a total berm length of over 64 km with construction finishing in 1971. This construction experience combined with a period of time having elapsed between their creation to the date of Bull Arm's construction to give valuable maintenance and life cycle experience. [8]

Figure 5 – Hibernia Berm Construction

The original concept called for a crushed rock berm with an impervious till layer placed on the seaward side by direct dumping of till material off the top of the rock berm. A small filter layer of a gap graded material was to be placed between these two layers to prevent till layers from migrating into the larger structural rock berm. Also chosen was the route over which the structure would follow. It was critical to maintain an plan area where not only there would be enough space for required equipment to build the GBS structure but to allow its removal. The inside of the dry dock was to provide 30 m of working area as well as a channel exit of 130 m. It is of interesting historical note that these design decisions were completed by NODECO engineers before a consultant was hired to completed detailed design of the dam. The driving factor in all these decisions were not based on physical constraints but upon expediency and ease of not only construction but also removal of the semi completed Hibernia GBS form the dry dock structure to be floated to a deeper water construction site part way through its construction cycle. [7]

In 1990 Acres International Ltd. was hired to complete the structural design of the structure. Complex analysis, for the time, consisting of stability and seepage analysis using state of the art computer software was completed. Despite an estimated 2 year lifetime for the dry dock, the catastrophic consequences of a failure required a return of 100 years was chosen for wind and wave loads with a factor of safety of 1.3 used throughout. It was determined that a standard slope of 1.5:1 Horizontal:Vertical was required to provide sufficient support and provide the safety factor required.

As construction began and completion occurred rapidly it was found that an insufficient slope was being reached. A horizontal to vertical slope of about 1.3:1 was created from direct dumping of aggregate from berm top. After much rapid discussion with design consultants and NODECO engineers the economical solution of the placing of an additional berm at the downstream toe of the original structure using more rock fill material was decided upon. [3, 7]

3 HEBRON – BULL ARM'S SECOND GBS

Despite the growing pains of Bull Arm's creation and Hibernia's difficult construction process it was successfully completed and has become a success story for the province of Newfoundland and Labrador. Hibernia has shown that it is possible to successfully develop oil resources on the grand banks.

Figure 6 – Grand Banks Oil Developments

Following Hibernia is the Hebron project. Currently in construction as of the writing of this paper, it will be a similar development to Hibernia but modernized using state of the art computer aided structural and process design with the latest in material and construction science. It will be constructed again at Bull Arm beginning in 2012 with a similar construction process being planned for the platform requiring the creation of a dry dock once again.

3.1 Hebron Dry Dock Design

Given the success and speed at which the Hibernia projects dry dock was completed it was to be used as a model for the Hebron project. Detailed bathymetry was already known and serious geotechnical investigations were already completed. By taking the Hibernia design and optimizing it for routing, material, ease of construction and removal, and water tightness the proven and effective earthen dyke solution was again used.

Importantly, while Hibernia success may be used as a baseline, very different approaches to certain design elements (including right of way and safety concerns) as well as the platform being designed for different water height results in different elevations of water height being required. This results in rock removal being required in the dry dock bottom as well as a higher clearance for the dry dock.

The Hebron project bund wall will be constructed of two types of engineered fill with two zones, a central zone of ¾” minus material followed by an external sheath of 4” minus rockfill material. Placed on the seaward side of the structure will be rip rap armour stone to protect the structure. The approximate length of the structure is 253 linear meters with a design volume of aggregate of about 189 200 m3 (Inclusive of both ¾” and 4” minus aggregates). 5000 m3 of armour stone will be placed.

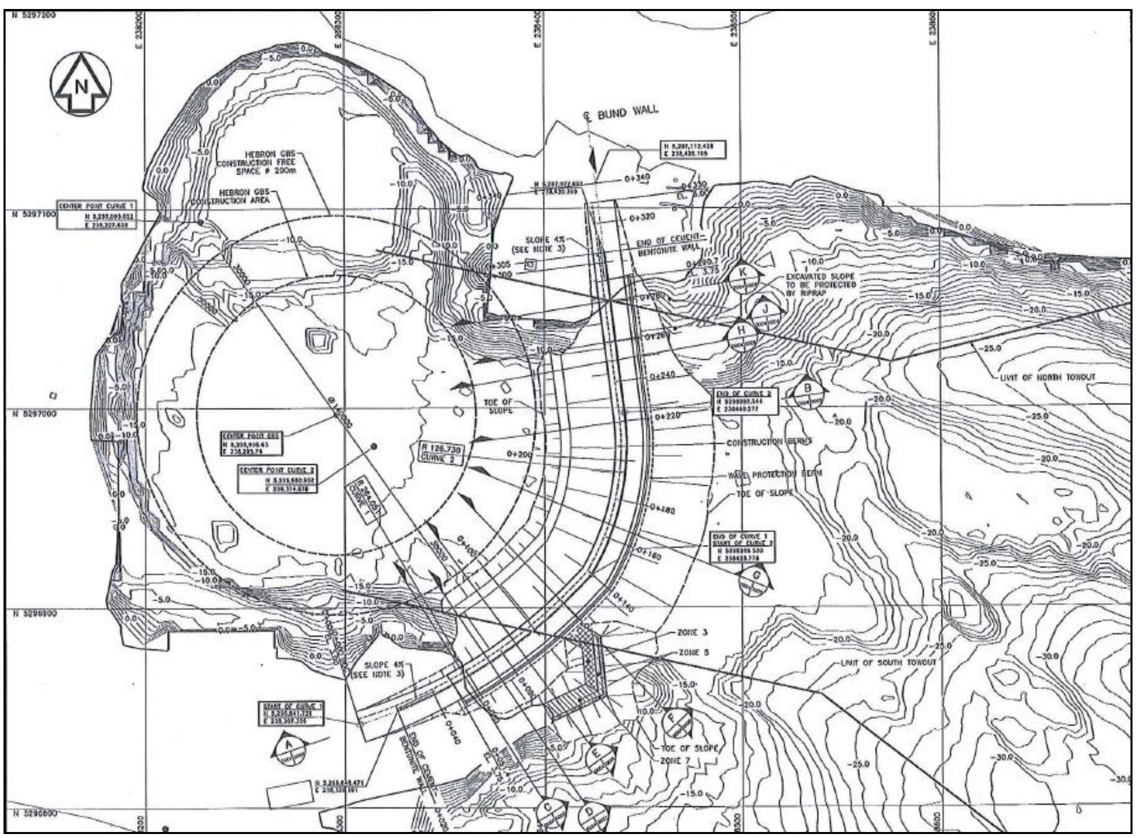

Figure 7 – Detailed Bull Arm Drydock Bathymetry and Hebron Bund Wall

The basic construction sequence followed in bund wall construction will be as follows:

1. Aggregate Material Received via Ship and Stockpiled – The optimal solution for material supply for construction was determined to be a source on Newfoundland's west coast. The material was then shipped to site on a series of bulk carriers and offloaded directly to the site of GBS construction.

2. Bulk Pushing of Aggregate – Once material has all been received the basic structure of the Bund Wall was created by pushing the material into the water with a tracked bulldozer. Alternating lifts of 4" and ¾" material was deposited creating the basic structure with a ¾" minus core and rockfill exterior.

3. Vibroflotation – Following completion of the bulk structure of the Bund Wall, the material is then compacted. Vibroflotation is an in situ compaction method very similar to the concept behind a concrete vibrator. A large probe (known as a Vibroflot) penetrates the material using vibration and high pressure water jets to desired depth. Powerful vibration induces horizontal action in soil particles around the probe and causes the soil particles to be rearranged into a denser configuration. As the ¾" central fill section of the wall is the main functional waterproof section, where an impermeable slurry wall will be constructed, all compaction will take place in this central core unit.

As illustrated above we have a rapid aggregate placement by land based standard construction equipment with a minimal gravel cross section. In situ compaction of aggregate along with a new type semi solid concrete slurry wall for water fastness is used. This semi solid concrete wall is watertight and forms a locking seal with the sea floor, however, due to its soft setting concrete it is easily removed by traditional earth moving equipment.

This approach has been pioneered at the Diavik Diamond Mine operated by Rio Tinto Ltd. in the North Slave Lake region of the Northwest Territories. While the design has been proven, the construction of the structure was also undertaken by experienced crews and proven arctic hardened equipment used on the same project increasing productivity and lessening required rework.

4 CONCLUSION

After examining the two major projects requiring a dry dock at the Bull Arm Fabrication Site we can make a very strong case for the advantage of a temporary geotechnical solution for a fabrication yard of this type and size by examining a few critical factors.

The variable nature of project scope given a yard of this size that is designed to focus megaprojects is large. They are one off designs of vast size and scope. With the variable nature of offshore developments on the grand banks given various water heights we have a variable structure size. A simple, rapid, reliable, and relatively cheap solution that doesn't limit project scope is critical.

The facility is made to accommodate such projects and shoe horns in other work as available. The danger of creating a limiting permanent solution could increase the cost of upcoming large projects or even the possible construction of such a project like Hebron. The risk of driving away future large projects may not be worth the risk of increased small work capacity with other purpose designed yards available in the province by private corporations such as the Peter Kiewit and Sons Ltd. shipyard in the nearby Marystown area.

In conclusion, a rapid, easy, and reliable solution that allows projects of any scope to fit in a yard designed for mega projects is optimal solution and recommended for Nalcor's Bull Arm Fabrication Site.

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