Should Canada Continue Drilling for Oil and Gas Under the Great Lakes?

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Introduction

The Great Lakes are Canada's greatest natural resource that represents the largest freshwater system in the world and contains 18 % of the World's fresh surface water

(Clark and Dutzik, 2002). The Great Lakes consist of a chain of five major lakes: Superior, Huron, Erie, Ontario, and Michigan shared by the United States and Canada. This system covers an area of 94,000 sq miles and contains 22.8 quadrillion liters of water (EPA). More than 40 million people closely depend on this unique region (Krantzberg and de Boer, 2006).

For years, Canada has overcome challenges associated with protection and restoration that has led to significant improvements. The Great Lakes Water Quality Agreement between the United States (US) and Canada has played a vital role in the protection of the region, however the Lakes still require stabilization and restoration (Lee and Muldoon, 2005).

A key issue in oil and gas exploration under the Great Lakes has raised the problem of protection and restoration of the lakes' area. In the past, the US and Canada have tapped into some of the oil and gas source rocks that are present beneath Lakes Michigan, Huron, Erie, Ontario and throughout much of the Great Lakes Basin. Oil and gas production under the bed of the Great Lakes currently occurs in the Canadian portion of Lake Erie via offshore vertical drilling and onshore directional drilling. In 2005, the US imposed a permanent ban on oil and gas exploration under the Lakes, and the ban was part of the Energy Policy Act signed by President George W. Bush (USACE, 2005).

According to the regulation, any oil or gas exploration enterprise undertaken by any of the US states or Canadian provinces will have to be limited by their political and geographical boundaries (USACE, 2005). On the other hand, any decision by any one of the states or provinces in question has potential ramifications for the entire Great Lakes area, and thus this issue has more of a binational character. Therefore, in order for

Ontario to evaluate its decision to ban oil and gas development under the Lakes, it is important to understand the reasons for the US moratorium on such activities in their portion of the Basin.

1.0 Resources of the Great Lakes Basin

The Great Lakes region is located in the eastern part of North America and borders eight states (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin) and one province (Ontario) (GLIN "Great Lakes"). Currently, oil and gas exploration occurs only within the province of Ontario in Lake Erie, which is the fourth largest and shallowest of the Great Lakes (USACE, 2005; GLIN, "Lake Erie"). The northern shore is bordered by the province of Ontario, while the southern shore is shared by the states of Michigan, Ohio, Pennsylvania and New York. Detroit River connects Lake St. Clair to Lake Erie while the Niagara River connects Lake Erie to Lake Ontario (ILEC).

The US side of Lake Erie is densely populated with the large metropolitan areas such as Detroit, Toledo, Cleveland, and Buffalo that are established at or adjacent to major rivers (USACE, 2005). However, there is only one city in the Ontario's portion of the Lake with a population of over 300,000, which is the city of Windsor (MNR, "Lake Erie"; Statistics Canada, "Community Profile"). Lake Erie is also known for its abundant fish catch, which is much greater compared to the rest of the Great Lakes and represents 80% of Ontario's commercial fishery (Krantzberg and de Boer, 2006)

The Great Lakes water provides a variety of benefits such as public water supply, agricultural irrigation, industry, energy production, commerce and recreation. The Great Lakes contain roughly 5,472 cubic miles (22,810 cubic km) of fresh water. Currently,

most of the drinking water for the inhabitants of the Great Lakes basin comes directly from the Lakes. The Great Lakes water is also widely used in manufacturing, chemical production, paper production, mining, mineral extraction and power production. The province of Ontario consumes approximately 24% of the total water withdrawn from the lakes (GLC, 2006).

Table 1. Daily Water Withdrawals In 2004 Within The Great Lakes Basin (GLC, 2006)

Category	Withdrawals (BL/d)			
	Great Lakes Surface Water	Other Surface Water	Groundwater	Total
Public Supply	11.88	4.31	2.08	18.28
Domestic Supply	0.15	0.16	1.41	1.73
Irrigation	0.03	0.60	1.10	1.73
Livestock	0.04	0.05	0.43	0.53
Industrial	14.45	1.73	0.65	16.84
Fossil Fuel Power	52.31	6.44	0.02	58.77
Nuclear Power	57.74	0.00	0.00	57.74
Hydroelectric Power	1632.81	1,430.03	0.00	3062,84
Other	0.00	0.95	0.00	0.96
Total	1769.42	1444.29	5,833.31	3219.40

The Great Lakes support a number of recreational activities including boating, sport diving, swimming and fishing. It was estimated that 250 million people visit the region annually, attracted by its parks and recreational areas. The number of hunters who visit the Great Lakes Basin is estimated to be 5.5 million. Also, recreational boating is a large industry in the region that contributes $9 billion annually to the Basin economy and provides 125,000 jobs. Recreational fishing is estimated at a value of $ 7.5 billion on both sides of the Great Lakes. In 2000, it was estimated that 469,128 anglers fished on the Great Lakes in Ontario (Krantzberg and de Boer, 2006). All of the communities located on the Lakes have at least one marina. The cruise ship industry that was established in 1997 has increased to 14,000 travelers per year (USACE, 2005). The beaches of the

region provide important recreational services for local residents and visitors (Krantzberg and de Boer, 2006). A summary of quantified economic attributes of the Great Lakes resources is given in Table 2.

Table 2. Summary Of Quantified Economic Attributes Of Great Lakes Resources (Sources: Krantzerg and de Boer, 2005; GLC)

Sector	Value per annual (except where noted)	Where value is counted	
Commercial fishing	$35 million	Landed value of fish only (before processing	Ontario, Canada
	$91.4 million including indirect sales, employment income and taxes +1136 persons years of work	Direct and indirect sales	
Aquaculture	$23-24 million	Landed value of fish only	Ontario, Canada
	$65 million + 500 person years of work	Total value added to the economy	Ontario, Canada
Transportation	$2.5-3 billion +17/18,000 person years of work	Value added to provincial GDP through activities generated by transport industry	Great Lakes and St. Laurence region
Sport fishing	$7.5 billion	Value of total industry including money spent on trips, boats, travel, tourism, etc.	Canada and US
	$500 million	Direct spending on trip only, no secondary effects	Ontario, Canada
Recreational Boating	$2.2 billion	Value to the overall economy	Canada (interpolated from US values)
Beaches	$200-$250 million	As valued by beach-goers in terms of what they would be willing to spend and what they do spend to recreate at the beach	Ontario (interpolated from US values)
Wetlands and biodiversity	$70 billion	Includes value of nutrient cycling, flood control, climate control, soil productivity. Forest health, genetic vigour,	Canada (unable to separate values by provincial lines-inextricably linked)

		pollination and natural pest control	
Water supply	1769.42 BL/d	Great Lakes surface water withdrawal for public, domestic, irrigation, livestock, industrial and electricity and other uses	

The Great Lakes are a natural treasure that supports more than 40 million residents and even greater number of visitors. All of the above activities and natural resources can be affected by irrational resource exploitation, and thus careful planning and management must be implemented.

2.0 Oil and Gas Industries in the Great Lakes Region

2.1 Origin and History of Oil and Natural Gas in Ontario

Approximately 300 million to 545 million years ago, shallow seas covered the area now known as southern Ontario. During this period, Ontario was located 20 to 35 degree south of the equator which created a suitable environment for growth of a prolific collection of marine life. The organic material from these marine inhabitants settled to the sea bottom and was deeply buried and exposed to temperature and pressure impacts that eventually led to their transformation into oil and natural gas. The sediments enclosing them lithified into sedimentary rocks (MNR, “Crude Oil”).

All crude oil and natural gas produced in the province is found in sedimentary basins formed by sedimentary rocks. Four such basins are found in Ontario: Michigan, Appalachian, Moose River, and Hudson Bay Basins. The sedimentary rocks in southern

Ontario are tilted towards the Michigan Basin to the west and the Appalachian Basin to the south (MNR, “Crude Oil”).

Crude oil and natural gas have been discovered in a total of over 300 separate “pools” or formations of sedimentary rock that contain oil or natural gas, either along or in combination with each other or water. Most of these pools are located in southern Ontario in several different formations of bedrock at depths ranging from 100 to over 1100 metres below the surface (MNR, “Crude Oil”).

The first commercial oil production in North America began in Ontario in 1858, and natural gas production started later in 1889. The area became very attractive for oil and gas development since the produced wells had the initial flow of 2,000 to 5,000 barrels per day (MNR, “Crude Oil”; Clayton Research, 2001). The cumulative production of oil in Ontario since 1863 (the first year for which data is available) was almost 14 million cubic meters. Natural gas production totalled for almost 36 billion cubic meters in 2006 (MNR, “Crude Oil”). Figures 1 to 2 represent the dynamic of oil and gas production in Ontario.

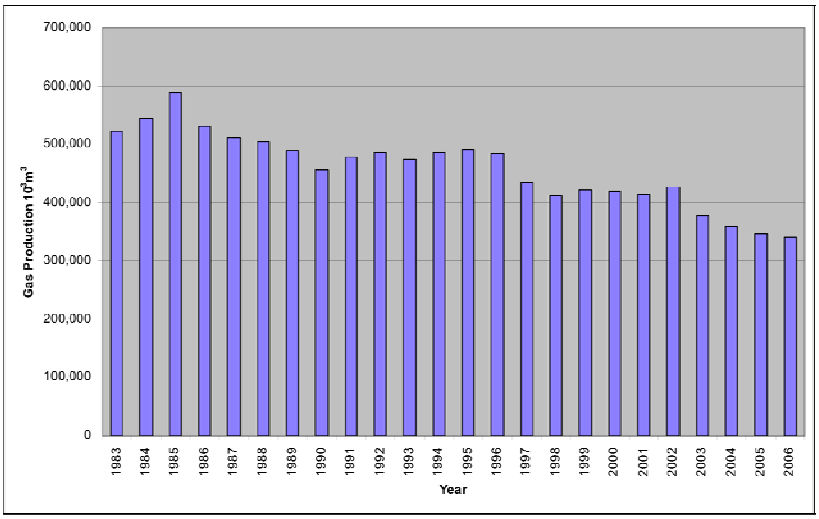

Figure 1. Historical Overview Of Ontario's Annual Gas Production (Source: Oil, Gas and Salt Resources Library, 2007: 37)

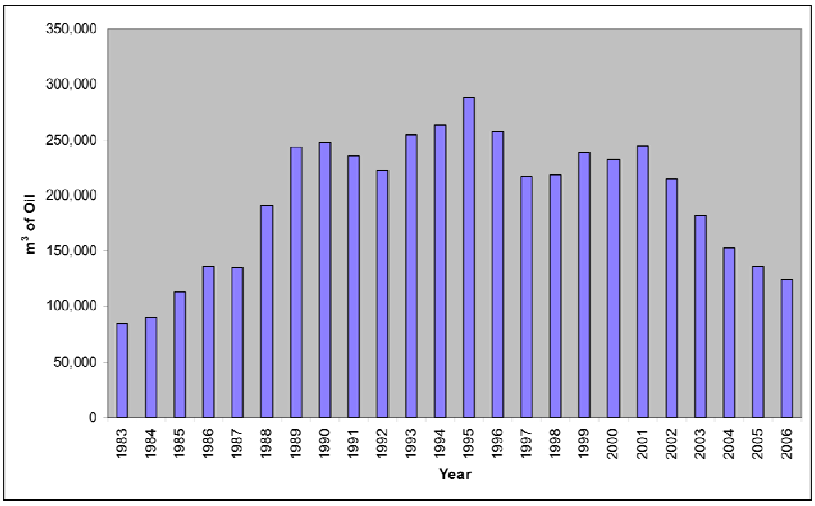

Figure 2. Historical overview of Ontario's annual oil production (Source: Oil, Gas and Salt Resources Library, 2007: 30)

The province's gas production strongly depends on Lake Erie's reservoirs as it is shown in the Figure 3. The natural gas production under the bed of Lake Erie started in 1913, and the cumulative production had totalled for 12 billion cubic meters in 2006 (Oil, Gas and Salt Resources Library, 2007). It is estimated that more than 50,000 wells have been drilled in Ontario, and approximately 2200 of them have been drilled under Lake Erie (MNR, "Crude Oil"; Ostrowski, 2008).

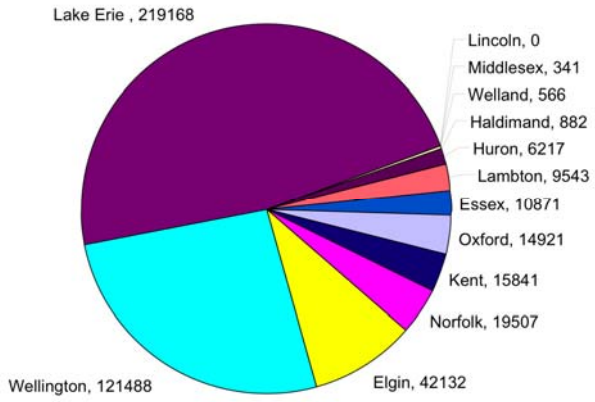

Figure 3. Natural Gas Production By County (10^3 m^3) In 2006 (Source: Oil, Gas and Salt Resources Library, 2007: 36).

2.2 Industry Overview

The remaining provincial potential of crude oil was estimated to be 31 million cubic meters, and approximately 24.7 million cubic meters of these resources are located on Crown Lands under Lake Erie, Lake Huron, Lake St. Clair and Lake Ontario. The remaining potential (undiscovered) resources of natural gas are approximately 36 billion cubic meters, which almost equals the amount that has already been produced by the end of 2006. Most of the remaining natural gas (26.2 billion cubic meters) lies under Lake Erie, Lake Ontario, Lake St. Clair and Lake Huron (Table 3, Appendix A) (MNR, Crude Oil”).

Table 3: Remaining Potential Oil And Natural Gas Reserves In Ontario (Source: MNR, "Crude Oil")

Sedimentary Rock Basin	Mineral Rights Ownership		Surface Area km^2	Potential Recoverable Reserves		Cumulative Production to 1999		Remaining Potential Reserves	
				Oil in 10^6m^3	Gas in 10^9m^3	Oil in 10^6m^3	Gas in 10^9m^3	Oil in 10^6m^3	Gas in 10^9m^3
Hudson-James Bay Lowlands	Crown Land		249,500	0	0	0	0	0	0
Eastern Ontario	Freehold		10,818	0	0	0	0	0	0
Southwestern Ontario	Freehold		66,199	19	38	12.4	17.0	6.6	21.0
	Crown Land	Lake Erie	12,745	12	37.3	0.1	16.2	12.1	21.0
		Lake Ontario	9,807	0.3	0.5	0	0	0.3	0.5
		Lake St. Clair	684	1	0.5	0	0	1.0	0.5
		Lake Huron	28,7330	11	4.2	0	0	11.3	4.2
Total:			128,986	43.3	80.5	12.5	33.2	31.3	47.2

In 2006, Ontario's petroleum industries operated 1,045 active oil wells, 1275 active natural gas wells, and 158 wells which produced both oil and natural gas (MNR, "Crude Oil"). Lake Erie accommodated 513 of the offshore gas wells and 18 horizontal wells that produced both oil and natural gas from Crown Lands. The total number of wells drilled in Ontario in 2006 was 94 ,and 25 of them were drilled under Lake Erie for gas (Oil, Gas and Salt Resources Library, 2007). On average, 100 new oil and gas wells are drilled in Southern Ontario annually, and the same number of wells is plugged every year (MNR, "Crude Oil"). To compare, according to Canadian Association of Petroleum Producers, 21,210 wells were drilled in Canada in 2007 (CAPP, "Industry Facts").

Drilling activity in Ontario increased in 2006 when compared to the previous year. Nevertheless, the volume of the produced oil and gas has the overall tendency to

decline including the provincial hydrocarbon production in Lake Erie as it is shown on the Figures below (Carter, “Crown Revenue”, 2008).

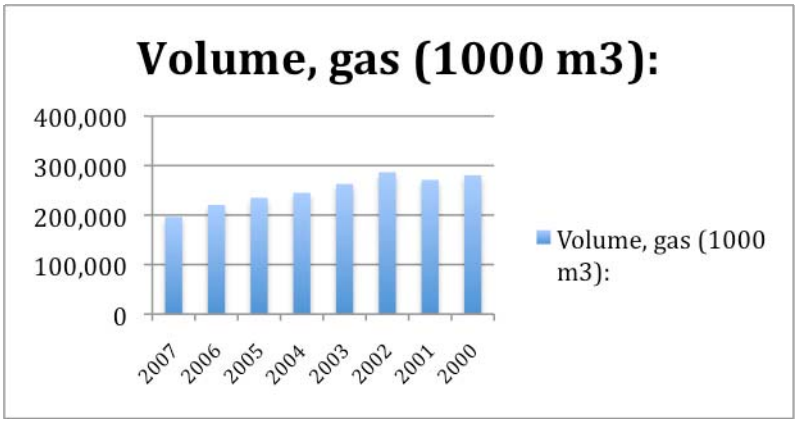

Figure 4: Overall Trend Of Natural Gas Production In Lake Erie (Source: Carter, “Crown Revenue”, 2008)

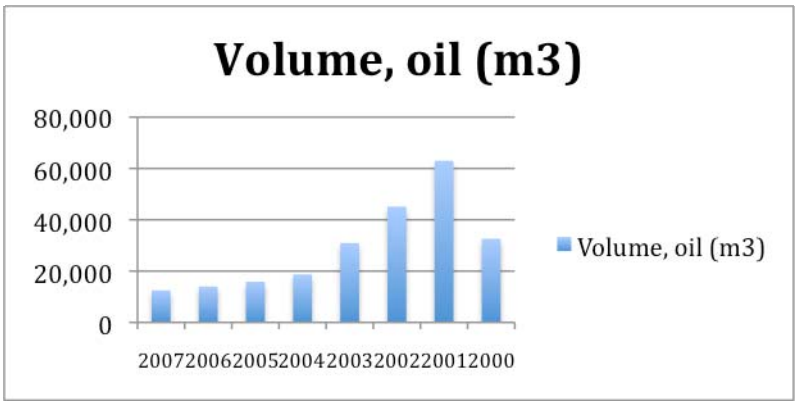

Figure 5: Overall Trend Of Crude Oil Production In Lake Erie (Source: Carter, “Crown Revenue”, 2008)

The decline is explained by the reduction in drilling activities due to the inability of new production to replace production from current wells that are on the brink of depletion (Oil, Gas and Salt Resources Library, 2007: 8). The production of oil may increase if the existing policy on oil exploration that does not allow offshore drilling is changed (Carter, 2008).

The next important oil and gas industry activity is storage, and Ontario possesses the largest storage capacity in the country. Natural gas storage capacity is about 6 billion cubic metres, which is 60% of the total storage capacity in Canada. The storage capacity for liquefied petroleum products is about 3.5 million cubic metres (Clayton Research, 2001: 1).

2.3 Consumption

The province consumes approximately 564,000 barrels (0.09 million cubic meters) of oil daily and 2.4 billion cubic feet (70 million cubic meters) of natural gas per day (CAPP, “Industry Facts”). All of Ontario's crude oil and natural gas production is consumed within Ontario, and the shortage of gas is covered by supplies from Saskatchewan, Alberta and British Columbia (MNR, “Crude Oil”; MEI, “Oil and Gas”). Great Lake production of crude oil accounts for only approximately 1% of the province’s annual domestic consumption, while production of natural gas accounts for 2% of the natural gas consumed in Ontario. About 125,000 cubic meters of crude oil with the value of $57 million was produced in Ontario in 2006. This was estimated to be enough to provide fuel for 27,000 cars and 2200 transport vehicles annually. In 2003, approximately 340 million cubic meters of natural gas with a value of $98 million was produced in Ontario, and it was estimated to be sufficient to heat 150,000 homes annually (MNR, “Crude Oil”). In short, Ontario possesses some hydrocarbons deposits, however the resources are small.

2.4 Oil and Gas Industry Economy

The Ontario oil and gas industry spent almost $70 million on locating and developing new wells (16 for oil and 105 for natural gas) in 2006. Industrial revenue from crude oil and gas was $200 million in 2006 (CAPP, "Industry Facts").

The net worth for the oil and natural gas production from Crown Lands in Ontario totaled almost $61.4 million in 2007. The volumes of gas and oil produced were 196 million cubic metres and 12 thousands cubic metres, respectively (See Table 4 for details) (Carter, "Crown Revenue", 2008).

Table 4: Crown Revenue From Oil And Gas Exploration (Source: Carter, "Crown Revenue", 2008):

	2007	2006	2005	2004	2003	2002	2001	2000
Annual rent, $:	975,067	952,773	1,020,458	1,069,687	1,076,147	1,125,250	1,221,343	1,464,267
Admin. Fees, $:	3,800	7,700	3,300	7,000	8,922	9,600	22,000	20,604
Royalty, gas, $:	6,341,778	7,907,047	11,423,534	8,729,874	9,750,318	6,235,238	6,509,214	6,841,023
Royalty, oil, $:	768,929	787,953	795,009	838,048	1,252,580	1,483,146	1,887,086	1,017,475
Total Royalty, $:	7,110,706	8,695,000	12,218,543	9,567,923	11,002,898	7,718,384	8,396,300	7,858,497
Volume, gas (1000 m^3):	196,267	220,434	235,020	244,953	262,970	286,623	271,050	280,365
Volume, oil (m^3)	12,511	13,963	15,828	18,715	30,926	45,141	62,981	32,600
Value, gas, $:	55,274,109	64,256,791	91,401,796	65,043,400	78,139,445	57,717,163	65,043,400	68,727,665
Value, oil, $:	6,081,813	6,273,878	6,287,969	6,642,128	10,018,597	11,863,637	13,660,387	9,325,151
Bonus bids, $:	239,510	191,156	45,932	0	322,790	72,762	280,883	148,937

The sources of revenue from oil and gas industry in the Great Lakes area are bonus bids, annual rent, administration fees, and royalty. In 2007, all of these sources represented $8 million dollars revenue, which is extremely small relative to the overall provincial revenue that totalled $50 billion in the same year (Carter, "Crown Revenue"; Statistics Canada, "Local Government Revenue"). As indicated in Table 4, the Crown revenue from oil and gas exploration under the Lakes has an overall tendency to decline.

Direct employment in the oil and gas industry is relatively small and accounts for about 1 in every 4,000 jobs in Canada. In Southwestern Ontario, this ratio is

approximately 1 in every 800 jobs. The jobs in the oil and gas industry are relatively well-paid jobs since the average income among employees of those industries is the highest of all sectors of the economy. Consequently, these jobs provide higher tax revenue for the government. The high wages are explained by the high productivity due to the high investment in capital and technology (Clayton Research, 2001: 16).

A diverse variety of stakeholders is involved in the oil and gas industry in the province, with producers being the most directly involved. There were 92 companies involved in oil and gas exploration, development, production, and storage (MNR, "Crude Oil"). The next group of stakeholders consists of drilling contractors, companies supplying oil field services and supplies, geologists, geophysicists, petroleum engineers, companies involved in land leasing and assembly, land use planning firms, and companies providing financial, legal, and accounting services. It is estimated that more than 175 companies specialize in this field of oil, gas and salt resources industry. The other group of stakeholders includes landowners, government, consumers, utilities, industry/trade associations, educational facilities and related museums.

There are several companies that possess promising deposits in Lake Erie, however only Talisman Energy provides well development in the region because they have the necessary equipment for offshore drilling (Carter, 2008).

3.0 Oil and Gas Exploration and Drilling Technology

Based on the regulations, Ontario allows offshore drilling only for gas exploration (Carter, 2008). When a promising formation is identified by a seismic survey, an exploratory well is drilled to determine the geological and geophysical properties of the rock formation (USACE, 2005: 6-7).

A brief description of the oil and gas exploration and drilling technology is provided by the USACE. Well-logging is the practice of making detailed tests during or after the drilling process. The collected data is used to choose the correct drilling equipment, materials and supplies. The rotary drill rig uses a derrick, hosting system, which is a steel tower with a mechanism that supports, raises, and lowers the steel pipe and relevant equipments. The whole operational activities depend on the power supply, which is usually generated from diesel engines running along or combined with an electrical power supply. The purpose of this rotary system is to cut the well bore with the drill bit that is located on the first drillpipe (the diameter of well bore can be up to 50 cm). A circulating system cools the drill bit using drilling mud and fluids pumped into the well bore. The mud usually circulates through the hollow drillpipe and exits the pipe through the holes or nozzles on the drillpipe and returns to the surface through the space between the drill pipe and well bore wall. Drilling fluid or "mud" is used not only to cool the bit, but also to lubricate and stabilize the system. Additionally the mud reduces the chance of a cave-in by carrying away the drilling cuttings and plastering the bore wall. Cuttings are separated from mud by screens and hydro cyclones, and then discharged. The mud can be reused or discharged if it becomes too viscous.

Casing is formed by a series of metal pipes cemented near the bottom of the well, and its purpose is to strengthen the walls of the hole. Another function of casing is to prevent fluids and gas from seeping in or entering into the rock formation (USACE, 2005: 5-23).

The Ministry of Environment Guideline B-6 for Evaluating Construction Activities Impacting on Water Resources Legislative Authority states that the

environmental impact of this type of exploration is minimal if all rules are followed (MOE, 1995: 65-66).

Drilling cuttings and mud discharged during drilling operation is released into the lake water where they settle to the bottom of the lake and are deemed to have “minimal environmental impact” on water quality. The expected impact on benthos from these cuttings and mud is “minor and localized”, and accumulation of these substances on the bottom is “not significant” (MOE, 1995: 66). Offshore discharge is the least expensive and uncomplicated measure of waste disposal, however when compared to other options of waste management, it is less environmentally friendly (CAPP, 2001).

The wellhead on the lake bottom connects the producing well to the pipelines and to the shore (MOE, 1995: 65). High-pressure natural gas pipelines lie on the lake bottom with wellheads standing 1.5 metres above the lakebed [23].

Produced water is water that is generated with petroleum hydrocarbons (liquid and gas). Crude oil and gas are brought to the surface as a mixture of different fluid components (gas, oil, water, fluids added during well-developing activities, and many other) also known as produced water. During the process of separation, oil is recovered from produced water, and then the produced water can be reused or injected underground. Occasionally the produced water can also be used for agricultural purposes. The produced water is also used during the process of extraction as an assistive component to help force oil to the well (this process is called enhanced oil recovery). With the depletion of the reservoir, the amount of produced water is increasing (USACE, 2005). Produced water is usually saline and Ontario does not allow the discharge of saline waters into the Great Lakes. However, the gas production in Lake Erie applies the

lake water as drilling fluids that can be discharged into the lake if the drilling fluids are not considered to be brine (Clark and Dutzik, 2002: 32).

There are over 1,000 miles of pipelines under the Canadian site of Lake Erie that transfer natural gas to the surface for further processing (Clark and Dutzik, 2002: 29). Most of the pipelines are concentrated in the northeast portion of the lake [23]. The construction of pipelines requires the approval of Ontario Energy Board or National Energy Board. The MNR and the Department of Fisheries provide the relevant information on pipeline development in the "Fisheries-Related Information Requirements for Pipeline Water Crossing". The environmental concerns associated with pipelines are erosion and sedimentation processes (MOE 1995, 69-70).

Oil exploration under the Great Lakes refers to the on-shore drilling. The on-shore seismological survey is based on the same principals as the offshore exploration. Directional or horizontal drilling refers to the drilling of curved wells to reach promising formations. The directional drilling is considered to be an environmentally sound manner of oil development in the area of Great Lakes since the platform is located on land and the drilling does not occur in water. Horizontal drilling begins with a traditional vertical well that is then angled under a formation to allow oil and gas extraction. This type of drilling is used to access formations that are extended over a large area and allows development of multiple reservoirs from a single platform. In general, the processes of on-shore and off-shore oil and gas development are similar (USACE, 2005: 5-23).

After the oil or gas reaches the wellhead, it flows along flowlines to the separation and storage equipment. The processing of natural gas includes separation of gas from impurities through conditioning processes by boiling off water and gaseous impurities.

The oil is usually accompanied by associated gas and water constituents (USACE, 2005: 5-23).

After the accessible resources are extracted from the well and further exploitation is deemed uneconomical, the well requires to be plugged and abandoned (USACE, 2005: 22. Plugging refers to the cementation that prevents fluids from migrating or seeping into the surface water (MOE, 1995: 66). After plugging, the casing and production platform are cut (USACE, 2005: 22).

4.0 Oil and Gas spills

Canadian Great Lakes spills data can be obtained from the Integrated Division database, which is the result of a consolidation between the Ministry of the Environment (MOE) and Environment Canada (EC), and the database has been used since 2003. Formerly the spills data were sent by the Ministry of Environment to Environment Canada, and therefore there was a difference in the data collected before 2002 and after. Currently, the data is divided by lakes and volumes of spills and is categorized according to the substances spilled rather than incident-based. Land-based spills are reported to the province, while the vessel-based spills are reported to the Pollution Prevention Officer. The combination of the data from MOE, EC, and Canadian Costal Guard can results in double-counting because if the vessel spill is significant, it is then resent and recorded in province (IJC, 2006: 29).

The government of Canada does not publish comprehensive data on spills even on their official website. The comprehensive data is only available from reports published by Environment Canada from 1984-1995 and the provincial report by Spills Action Center in 1995 (Table 5). The IJC managed to combine the information in the “Report on Spills

on the Great Lakes Basin" published in 2006. These data regarding Great Lakes and substances spilled from Canadian sources are given in Figures 6,7, and 8 below (IJC, 2006: 29).

Table 5. Oil Spills In The Canadian Site Of The Great Lakes 1990-1995 (Source: Clark and Dutzik, 2002: 40)

Year	Source	Lake Superior	Lake Huron	St. Clair river	Detroit River	Lake Erie	Lake Ontario	St. Lawrence River
1990	Crude							
1990	Gasoline/Jet Fuel	1	2	2	2	1	6	3
1990	Light Petroleum Oils	5	8	12	4	8	26	
1990	Heavy Petroleum Oils	1		12	1	9	14	
1990	Other Petroleum Oils	1	2	9	6	7	29	4
1990	Non-Petroleum Oils	1		2			2	
1990	Total	9	12	37	13	25	77	7
1990	Crude			1				
1991	Gasoline/Jet Fuel		3	3			8	2
1991	Light Petroleum Oils	2	6	12	2	7	45	3
1991	Heavy Petroleum Oils	2	5	5	1	4	13	
1991	Other Petroleum Oils	1		8	2	1	15	
1991	Non-Petroleum Oils							
1991	Total	5	14	29	5	12	81	5
1992	Petroleum oils (total)	5	20	1	4	11	47	13
1993	Petroleum oils (total)	6	24	12	5	9	43	12
1994	Petroleum oils (total)	2	18	9	5	14	37	6
1995	Petroleum oils (total)		14	11	4	12	37	8

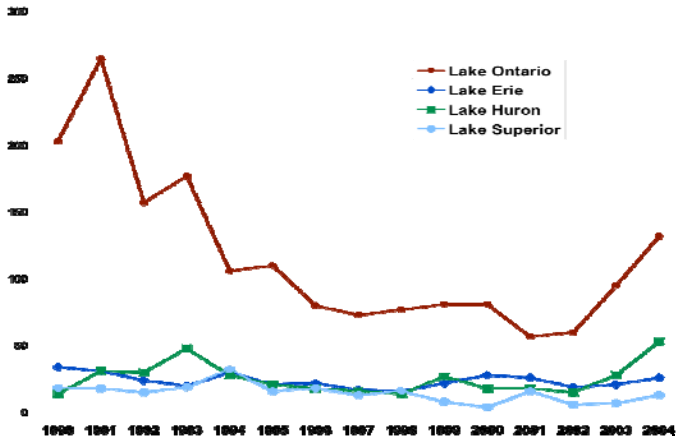

Figure 6. Canadian Great Lakes Spill Incidents, By Lake 1990-2004 (Source: IJC, 2006: 33)

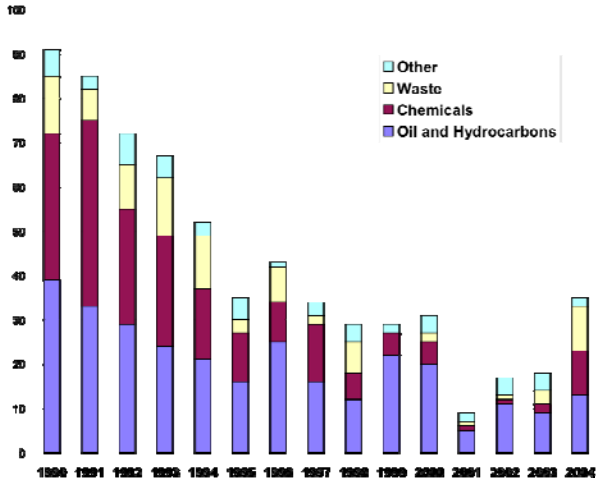

Figure 7. Canadian Spills To The Great Lakes And Connecting Channels By Category Of Substance, 1990-2004 (Source: IJC, 2006: 36)

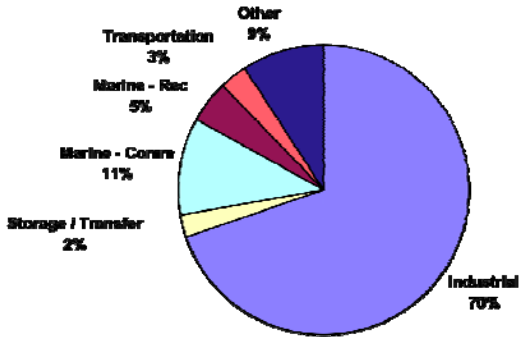

Figure 8. Source Of Canadian Spills To The Great Lakes, 1990-2004 (Source: IJC, 2006: 38)

Ontario's approach to the spills prevention was strongly criticized by the Industrial Pollution Action Team (IPAT) in the report for OME in 2004 including a critique for being inadequate, outdated, not transparent, and ineffective (IJC, 2006: 52).

According to the US Army of Corps, there were 3 oil spills incidents and only one of them was directly attributed to the drilling activities on the Canadian site of Lake Erie since 1959, and resulted in the release of 210 gallons of fuel oil from the drilling rig to the Lake Erie. On the other hand, oil releases from subsurface formations into overlying waters during Canadian drilling or production operations in the Great Lakes have not been reported. In Michigan there have not been spills attributed to the directional drilling (USACE, 2005: 25). However, there were 51 drilling related gas spills between 1997 and 2001 as it is shown in the Table 6 (Clark and Dutzik, 2002: 30-31).

Table 6. Natural Gas Leaks In Lake Erie (Clark and Dutzik, 2002: 31)

SUBJECT	DATE	NUMBER	SUBJECT	DATE	NUMBER
Gas Well Leak	26-Oct-01	C 2727	Gas Well Leak	20-Sep-99	C 2658
Gas Well Leak	24-Oct-01	C 2708	Gas Well Leak	22-Aug-99	C 2380
Gas Well Leak	11-Sep-01	C 2402	Gas Well Leak	15-Aug-99	C 2280
Gas Well Leak	10-Sep-01	C 2393	Gas Well Leak	26-Jun-99	C 1606
Gas Well Leak	15-Aug-01	C 2084	Gas Well Leak	5-Nov-98	C 3052
Gas Well Leak	11-Aug-01	C 2083	Gas Well Leak	29-Oct-98	C 2990
Gas Well Leak	25-Jul-01	C 1813	Gas Well Leak	11-Oct-98	C 2791
Gas Well Leak	13-Jul-01	C 1644	Gas Well Leak	21-Aug-98	C 2433
Gas Well Leak	13-Jul-01	C 1648	Gas Well Leak	2-Aug-98	C 2030
Gas Well Leak	24-Jun-01	C 1386	Gas Well Leak	16-Jul-98	C 1804
Gas Well Leak	16-May-01	C 871	Gas Well Leak	9-Jun-98	C 1269
Gas Well Leak	14-May-01	C 838	Gas Well Leak	22-Apr-98	C 596
Gas Well Leak	11-May-01	C 815	Gas Well Leak	5-Jan-98	C 12
Gas Well Leak	28-Mar-01	C 223	Gas Well Leak	1-Sep-97	C 2593
Gas Well Leak	26-Mar-01	C 181	Gas Well Leak	1-Sep-97	C 2594
Gas Well Leak	14-Dec-00	C 3366	Gas Well Leak	3-Aug-97	C 2201
Gas Leak	31-Oct-00	C 2931	Gas Well Leak	27-Jun-97	C 1688
Gas Leak	31-Oct-00	C 2932	Gas Well Leak	27-Jun-97	C 1687
Natural Gas Leak	26-Aug-00	C 2350	Gas Well Leak	3-Jun-97	C 1279
Gas Well Plugging Operation	12-Aug-00	C 2242	Gas Well Leak	28-May-97	C 1204
Natural Gas Leak	24-May-00	C 1034	Gas Well Leak	26-May-97	C 1179
Natural Gas Leak	13-Apr-00	C 380	Gas Well Leak	24-May-97	C 1157
Gas Well Leak	13-Apr-00	C 495	Gas Well Leak	18-May-97	C 1061
Gas Well Leak	13-Mar-00	C 204	Gas Well Leak	2-May-97	C 753
Gas Leak Reported	24-Jan-00	C 75	Gas Well Leak	23-Apr-97	C 585
Gas Well Leak	20-Jan-00	C 1415			

Oil spills resulting from tanker accidents usually account for the largest volume, however other types of spills such as spills from pipelines, storage tanks, loading accidents and others are more common (ITOPF). 87% of overall petroleum spills accident occurs due to the corrosion in pipeline (45%) and production field (42%) (Clark and Dutzik, 2002: 32)

5.0 Federal and Provincial Regulations and Legislations in Oil and Gas Industry in Canada.

5.1 The Oil, Gas and Salt Resources Act

The Oil, Gas and Salt Resources Act authorizes the Ministry of Natural Resources to regulate petroleum resources. The activities that are regulated by the MNR includes

exploration, drilling and production of oil and natural gas, mining methods, underground storage of hydrocarbons, and disposal of oilfield fluids in Ontario.

Ontario regulation 245/97 regarding Exploration, Drilling and Production that accompanies the OGSRA coordinates the aspects of oil and gas operational activities. The OGSRA and its regulations serve to ensure that the operational activities of the petroleum industry do not pose a hazard to public safety or natural environment (MNR, "Oil, Gas and Salt resource Act").

5.2 Provincial Operating Standards

The Provincial Operating Standards are designed to regulate activities normally encountered in oil, gas and salt resource industries. However, the requirements for abnormal or emerging conditions are not specifically provided. It is expected that all work performed within the scope of these standards will satisfy the safety standards. The changes in the standards may occur from time to time to reflect new knowledge or technology (MNR, "The Provincial Operating Standards").

5.3 Ontario Regulation 263/02

The Regulation accompanies the Mining Act and provides authority to issue exploration licences, production, and storage leases for oil and gas in Crown Land in Ontario. Most of the remaining undiscovered resources of crude oil and natural gas lie on Crown Lands under the 1.2 million hectare portion of Lake Erie. This area is subdivided into areas known as "blocks", and each block is further subdivided into "tracts" lettered A to Y. Each tract is approximately 255 hectares as shown in Figure A6 in Appendix.

Regulation and provincial policy prohibit offshore drilling for oil, however oil can be produced by directional or horizontal well drilling. A well that encounters oil in offshore location must be plugged and the licence for the well's exploration must be surrendered (MNR, "Mineral Right on Crown Land").

6.0 Canada's Existing Environmental Protection Policies with Regard to Oil and Gas Development

6.1 Clean Water Act

In July 2007 the Clean Water Act and five other regulations came into effect in Ontario. The purpose of the act is to ensure that municipalities, conservation authorities, property owners, farmers, industry, community groups, and the public communities are able to protect their municipal drinking water supplies through developing collaborative, locally driven, science-based protection plans. The regulations under the Clean Water Act include the Source Protection Areas and Regions, Source Protection Committees, Terms of Reference, Time Limits, and Miscellaneous Regulations (MOE, "Safe Clean Water").

6.2 Canada's Fisheries Act

Under the federal Fishery Act, the harmful alteration, disruption or destruction of fish habitat is prohibited without prior authorization, and no person may pollute water frequented by fish (Section 35 and 36). The act also applies to works and undertakings on areas that are not normally under the water such as shorelines, riverbanks, seasonally inundated flood plains and privately owned land. The purpose of the act is to manage and protect Canada's fisheries and resources as well as supporting habitat. Fisheries and Oceans Canada has constitutional responsibility to enforce the act with the help of federal, provincial, and territorial government agencies (Fisheries Act).

6.3 Great Lakes Policies and Agreements

The Great Lakes and St. Lawrence region is protected under several agreements signed by the federal, provincial and state governments:

- The Canada-United States Great Lakes Water Quality Agreement
- The Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem
- The Great Lakes Charter
- The Great Lakes-St. Lawrence River Basin Sustainable Water Resources

The US and Canada signed the Great Lakes Water Quality Agreement (GLWQA) in 1972 to protect the physical, chemical and biological integrity of the Great Lakes (Krantzberg, 2006). Under the Annex 8, the GLWQA discussed the principles, as well as programs and measures, to prevent discharges of oil and other substances into the Great Lakes system from drill rigs, pipelines, wells, and other onshore or offshore facilities (Environment Canada). In the IJC Biennial Report (IJC 2002), the discharges from onshore and offshore facilities, including offshore and directional drilling were discussed under the section entitled "further matter of importance". The section gave the overview of jurisdictional policies and noted that the International Association of Great Lakes and St. Lawrence Mayors and The Chippewa Ottawa Resources Authority have opposed any oil drilling activities to exploit oil deposits under the Great Lakes. However, the Twelfth Biennial Report (IJC 2004) and the Thirteenth Biennial Report (IJC 2006) did not mention any issues concerning drilling in the Great Lakes (IJC, "Biennial Reports").

7.0 The US Regulation for Oil and Natural Gas Drilling

In 2002, drilling in the US side of the Great Lakes was banned for a 2-year period under the Energy and Water Development Appropriations Act, which was approved on

November 12, 2001. According to Section 503 of the bill, “during the fiscal years 2002 and 2003, no Federal or State permit or lease shall be issued for new oil and gas slant, directional, or offshore drilling in or under one or more of the Great Lakes.” Section 503 also authorized the US Army of Corps to conduct a study on the “known and potential environmental effects of oil and gas drilling in the Great Lakes” that was completed in 2005. The moratorium on drilling was subsequently extended through 2005 in the Omnibus Appropriations Act of 2003, and extended again through 2007 by the Omnibus Appropriations Act of 2005. Eventually in August 2005, the US President proposed the Energy Policy Act which included Section 386, that prohibits the issue of Federal or State permits or leases for new oil and gas slant, directional, or offshore drilling in or under the Great Lakes (USACE, 2005: 40)

The Submerged Lands Act of 1953 gave each of the eight states bordering the Great Lakes title to and ownership of the lands beneath navigable waters within the Great Lakes within their respective boundaries. Therefore, the states can use, lease, or sell the rights to their portion of the Great Lakes bottomlands within states jurisdictions. However, the public trust doctrine directs that the states are expected to protect the public’s interest in waters and submerged bottomlands of the Great Lakes since the health and well-being of the residents of the Great Lakes region depend on this freshwater source. Most states have implemented regulations related to the technical act of drilling of oil and gas wells, environmental protection, abandonment of wells, and emergency response (USACE, 2005: 41).

In 1985, the eight states bordering the Great Lakes signed “A Statement of Principle Against Oil Drilling in the Great Lakes”. Under this statement the states agreed

to ban oil drilling in the waters of the Great Lakes. However, that document was not specifically addressed to directional drilling or drilling for natural gas (USACE, 2005: 42). In the meantime Canada was practicing these methods of resource production.

In 2005, Michigan was the only state in the United States that had leased directionally drilled wells under the Great Lakes. At that time, there were 7 wells on the Michigan portion of the Great Lakes (one in Lake Huron and six in Lake Michigan) (Price, 2005). The other Great Lakes states either did not permit drilling or did not have the oil and gas resources beneath the Lakes or required conditions. Some states started reconsidering the issue, since the principles did not specifically apply for directional drilling for oil and offshore drilling for gas (USACE, 2005: 42)

The process of banning drilling under the Lakes started in 1997. There was a possibility for 30 new wells drilled under the Michigan portion of the Great Lakes (Belluck, 2001). The program gave rise to public disapproval that led to imposing a temporary ban on the drilling by the US Congress. Consequently, the Michigan House and Senate voted for prohibition at the state level (US House of Representatives) and Governor John Engler, imposed a temporary moratorium on new drilling which expired in 2001 (Clark and Dutzik, 2002: 8).

In July 2001, The New York Times published that seven existent wells in the Michigan's portion of the Great Lakes produced enough energy to heat 19,000 homes and run 2,200 cars each year. Moreover, oil and gas companies paid $17 million to the State, which then used the money to buy and maintain parks. On the other hand, some stakeholders believe that these benefits are minimal compared to the potential risk even though the horizontal drilling virtually expels the possibility of spills (Belluck, 2001).

In 2002, the Michigan Senate approved a permanent ban on Great Lakes drilling. The provision of the previous agreement to reopen development in case of energy emergency was abandoned. Michigan Governor John Engler refused to sign the legislation insisting that the legislation was policy driven rather than science driven. Engler stated that the ban would reduce future revenues that would otherwise be available for Michigan environmental protection. Moreover, the legislation contradicted the national goal of achieving energy independency. The Governor noted that the ban on directional drilling instituted by the Federal government was in fact a case of Congressional interference in state powers. The states constitution allows law to take effect if it was neither signed nor vetoed within 14 days. Therefore, the permanent ban was imposed automatically because the ban was neither signed nor vetoed by the government within this period (USACE, 2005: 42-43).

In July, 2003, Ohio Governor Bob Taft signed an Executive Order that prohibited gas and oil drilling in Lake Erie until the end of his term in 2006. In March 2005, Ohio Representative Chris Redfern introduced a bill to permanently ban the taking or removal of oil and natural gas beneath Lake Erie, where the ban was an amendment to the House Bill 119 (USACE 2005: 43). One of the measures used by opposition was report "Dirty Drilling" by Michigan Interest Public Research Group. In the Report, the Group points to Canadian experience in directional drilling for oil where it is said that the practice had led to 83 oil spills. The research group omitted the fact that these spills were not attributed to spills from directional drilling (Clark and Dutzik, 2002: 30). Subsequently, the misleading data were published in efficient media sources such as the Detroit News (Price, 2005). Even though Tom Stewart, the executive vice president of the Ohio Oil

and Gas Association, stated that the risk possibility was small and that 2,000 wells drilled in the Canadian site of Lake Erie did not cause severe environmental damage (Wright, 2003), the drilling for oil and gas was banned nevertheless in Ohio (USACE, 2005).

In New York, the assemblyman Sam Hoyt proposed an act to amend the Environmental Conservation Law to create a statutory ban that would prohibit oil or natural gas drilling operations or pipelines on or beneath the lands under the waters of Lakes Ontario and Erie, the connecting bays and harbors of such lakes, the connecting waterways of such lakes, or along their shorelines. Wisconsin instituted a statutory ban on drilling operations for the exploration or production of oil or gas beneath the Great Lakes or adjusted bays and harbors (USACE, 2005).

Finally in August 2005, the US President signed into law the Energy Policy Act (USACE, 2005). The Energy Policy Act included large subsidies for oil, coal, nuclear, and natural gas industries and weakened environmental protection (Grunwald and Eilperin, 2005) and imposed permanent ban on the oil and gas exploration under the Lakes (USACE, 2005).

8.0 Political Context

The issue of putting pressure on Canada to ban drilling for oil and gas has resurfaced during the US campaign against drilling on Great Lakes (Great Lakes Directory). International Joint Commission could have been involved in the process since the IJC prevents and resolves disputes between the US and Canada when the parties ask the IJC to resolve a dispute (IJC, “Who We Are”). The attitude toward oil and gas exploration is not shared between the two countries. The US has banned not only onshore

and offshore drilling for oil but also drilling for gas under the lakes, while Canada practices offshore and onshore drilling for gas and onshore drilling for oil under the Great Lakes (Price, 2005). The Commission controls projects affecting the transboundary waters and works for the protection of the environment and the implementation of the GLWQA. IJC must alert the provincial and federal governments about consequences of oil and gas exploration under the Lakes since it may give rise to bilateral disputes (IJC, "Who We Are"). The Canadian Federal Government could influence Ontario through Canada/Ontario Agreement that supports the Great Lakes Water Quality Agreement (Lee and Muldoon, 2005).

The US and Canadian practices has shown that the resource development in the region has not led to the severe adverse environmental contamination. Studies have shown that the risk factor is minor. The federal ban on oil and gas drilling in the area in question has encroached upon the sovereign rights of the individual states. Therefore, the process seems to be completely policy driven rather than with real regard for environmental protection. Compared to the states' practices, Ontario possesses well-established businesses with notable monetary, technological, and labour resources involved in the industry. Also, the resources underneath Lake Erie play an indispensible role in the provincial oil and gas industry. Furthermore, the area of the Canadian part of Lake Erie is more suitable for oil and gas drilling under the Lake because the region is less populated and the roads and pipelines network are already in place.

It is worth mentioning that Ontario plans to dramatically increase its natural gas consumption as part of its new energy policy. According to the Integrated Power System

Plan (IPSP) proposed by the OPA, 25% of future Ontario energy will be generated by the provincial gas or oil firing stations (OPA). Crude oil and natural gas prices have risen dramatically over the past years and according to NYMEX, the price will slowly increase in the future.

The constantly growing prices have led to the situation where US politicians are currently discussing lifting the ban on oil and gas resource development under the bed of the Lakes. In 2007 Tim Walberg, a Michigan Republican Congressman, suggested to reopen the issue and to start drilling in the region (Great Lakes For All, 2007), while President Bush has called the Congress to reconsider the current policy to lift the ban on off-shore oil and gas reserves (Harding, 2008).

Some politicians seem to be primarily concerned with their public image of being environmentally friendly rather than practical considerations. Other politicians believe that the ban on directional drilling was a bad policy and was aimed to reap short term political benefit and neglected long term benefits such as job provision and energy independency of the Great Lakes Basin states (Harding, 2008).

9.0 Policy Proposal

Even though the US has imposed a permanent ban on oil and gas exploration in the Lakes, Canada should continue drilling for oil and gas. Several studies indicate that the risk for environmental contamination is minor; while the industry which strongly depends on the Lake Erie oil exploration already exists, and the ban can lead to adverse economical consequences since not only the jobs of hundreds people depend on the

industry, but the industry also contributes to the economy diversification and helps to cover provincial energy needs.

In 1997, Governor John Engler requested that the Michigan Environmental Science Board (MESB) conduct an evaluation, and the panel concluded that there is little to no risk of contamination to the Great Lakes bottom or waters through releases directly above the bottom-hole portion of directionally drilled wells. However, they also indicated that there is a small risk of contamination at the wellhead (USACE, 2005: 200). The final Programmatic Environmental Impact Statement (PEIS) for the development of Lake Erie natural gas resources studied four accident scenarios for offshore gas development. The postulated accidents that could produce these releases were: (1) loss of well control, (2) rig or barge capsizing, (3) gas-line breakage, and (4) glycol-line breakage. According to this study, releases of petroleum-related hydrocarbons, raw natural gas, and polyethylene glycol could occur during accidents. However, the report concluded that occurrence of these accidents would be highly unlikely. Furthermore, the potential health risk associated with accidental release of di- or triethylene glycols, would not exceed the primary drinking water standards (USACE, 2005: 200). Additionally, the Ministry of Environment reported that “no significant accumulation on the bottom would be anticipated in the shallow water energy regime of Lake Erie. Impacts on the benthos should be minor and localized” (MOE, 1995: 66).

All the resources extracted by Ontario are utilized within the province, and even if they are not major sources of income for the province, they still contribute notably to cover provincial energy needs. The data also shows that the industry is already in decline, so that enforcing the ban seems superfluous.

Several concerns have become apparent while researching this topic. The spill management system is inadequate. The spills report must be comprehensive to sufficiently represent the spill source and spill quantity, and the report has to be easy to track. First of all, the availability of comprehensive information will allow direct identification of the source and means of discharge. Accordingly this will lead to more efficient measures for the analysis of the common patterns of drilling discharges and will help develop effective tools to the prevention of environmental contamination in the future. Moreover, the spills report must be transparent to the public to encourage public participation.

The second concern is the pipeline and underwater construction. Pipeline construction requires physical alteration of the lakebeds that can disturb the habitats of the Basin's flora and fauna. The practice of pipeline development must be confined to the areas less sensitive to the construction processes, to specific times and seasons, and include remediation measures and constant monitoring activities to avoid spills of oil or gas. The measure will also allow identifying the effects of different construction technologies and mitigation measures on the lakebed biota (Dempsey David, Gannon John, 2006).

The life-cycle approach should be implemented in oil and gas drilling waste management. Currently, the choice of drilling fluids depends on the producer (Carter, 2008). There are three main types of the muds that are used for drilling: Oil-Based Muds (OBM), Water-Based Muds (WBM) and Synthetic-Based Muds (SBM). The OBMs are associated with extensive environmental concerns and requires special permission to use. The SBM is preferable compared to WBM since they allow reduction of drilling time and

solid waste generation thus reducing the environmental impact. The solid removal efficiency of the SBM is higher than that of the WBM, and therefore the process requires less drilling fluids and generates less waste (CAPP, 2001; Hinds, 2005). It is reasonable to require special permission to use not only OBM, but WBM to decrease any negative influence of drilling operations on the marine environment.

The offshore cuttings discharge is the most common practice in the oil and gas exploration business. Another option is cuttings re-injection, which involves pumping fluids and seawater-diluted cuttings into an underground formation. Practical experience with CRI on floating facilities is small, however it is less complicated in shallow waters such as waters of Lake Erie. There is also the possibility of onshore drilling waste utilization, however this operation requires extensive use of support vessels (CAPP, 2001). The recommendation is for the requirement for special permission for offshore cutting discharge.

The oil and gas well and pipeline construction should take into consideration the cumulative effect on marine and land environment. There are other constructions anticipated in the future such as wind turbine development, more water pipeline construction and new well and pipeline development. The recommendation is to consider the cumulative effect of underwater constructions in environmental assessment, which is currently, is not considered (Hanna, 2005).

After the oil is recovered from produced water, the produced water can be reused or injected underground. Occasionally, the produced water can be used for agricultural purposes. However, the most environmental-friendly option of produced water management is waste minimization. There are several ways to reduce the volume of

produced water: mechanical blocking devices (packers, plugs, cement), water shut-off chemicals (polymer gels, microbial products, lignosulfonate), and water management without bringing it to surface (dual completion wells, downhole oil/water Separators, downhole gas/water separators, subsea separation). Thus, the switch to the wise produced water management allows for the decrease in the environmental impact on Great Lakes' ecosystem (Hinds, 2005).

Drilling operations typically produce some air emissions, due to the process reliance on diesel engines. Pollutants from these sources include nitrogen oxides, particulates, ozone, and carbon monoxide. Therefore it is recommended to exchange the diesel engines for gas engines, which is a more environmentally friendly option (Environmental Studies Research Funds, 2004). This measure will also decrease the risk of oil product spills into the water.

Conclusion

Generally, because the processing of oil and gas is usually associated with significant environmental contamination, it is not surprising, that the process of oil and gas exploration in the vulnerable region of the Great Lakes provoked significant opposition from US residents (USACE, 2005). More interestingly, the oil and gas development in the region is prone to political manipulations in the American politics where being or appearing more environmentally friendly can significantly change the election outcome. However, authoritative researches done in the US indicated that the possibility of risk of contamination is little to non-existent. Canada has been drilling for oil and gas under the Lake since 1913; oil and gas extraction from under the Great Lakes

in Ontario is a mature business with significant labour, advanced technology, and financial resources involved. The business is currently in decline, and therefore a ban in Canada may be superfluous and harm the existing industry. However, still there is still room for improvement regarding the field of spills, construction, and development organization for better industry performance. All these improvements will prevent the social and political disputes regarding this subject and mitigate the environmental risk and impact.

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