ALBERTA DEPARTMENT OF ENERGY

OIL SANDS PRODUCTION PROFILE

2002-2010

Christopher Holly
Martin Mader, EIT
Jesse Toor

Government of Alberta

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Branch Head
Research and Technology Branch
Alberta Department of Energy
9945 – 108 Street
Edmonton, Alberta Canada
T5K 2G6

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INTRODUCTION

Canada is endowed with significant crude oil resources, in the order of two trillion barrels of oil in place. Although these oil deposits are some of the most challenging in the world to develop, innovative research and production technologies have enabled them to move from resources to proven reserves. Canada is a net exporter of oil and is consistently the top supplier of oil imports to the United States[1]. On its own, Alberta is responsible for approximately 71.2 percent of Canada's oil exports to the United States[2,3] (see *Appendix II-vi*). 60 percent is from the Oil Sands region using a combination of surface mining and in situ production methods[4] .

The purpose of this report is to provide a detailed overview of oil production volumes from the Oil Sands region based on production information submitted to the Ministry of Energy[5]. Specifically, this report will provide an analysis of production volumes based on (1) region, and (2) production technology as defined by the Alberta Department of Energy.

METHODOLOGY

For each given annual reporting period (calendar year - see *Appendix I*), production data was collected by project and converted to barrels of bitumen per day (*bpd*) using standard conversion calculations. If projects were joint ventures, the production was split amongst the operators based on the percentage of ownership (at year end) - the total oil production for the year is provided in *Appendix I*, along with operators' shares of ownership. For each project, area or region was identified as well as owner and production technology (see *Production Technologies*).

For accounting purposes, projects utilizing Primary/Enhanced oil recovery (EOR) production technologies which were smaller than 4000 bpd, belonging to the same company, and in the same area, were combined into one daily production value with the project list provided in *Appendix I-x*. This was done because there is approximately a 2:1 ratio of Primary/EOR projects to the other three production technologies (see *Production Technologies*) projects combined. The Primary/EOR projects are also typically smaller per project than thermal projects because of the nature of the deposits and the subsequent production technologies. Thermal (CSS or SAGD) projects with less than 4000 bpd production remain separate in order to perform growth analyses on these production technologies. The production totals for experimental, conventional, and freehold projects are combined due to their smaller production volumes compared to the majority of Oil Sands projects.

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1 http://www.eia.gov/dnav/pet/pet_move_wimpc_s1_w.htm

2 http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/sttstc/crdlndptrlmprdct/2010/ttlcrdlxprtdstntn2010.xls

3 http://www.ercb.ca/docs/products/STs/st3/2010/Oil_2010.xls

4 http://www.centreforenergy.com/FactsStats/Statistics.asp?Template=5,2

5 http://www.finance.alberta.ca/publications/budget/budget2012/energy.pdf - The Ministry consists of the Department of Energy and the Alberta Petroleum Marketing Commission. It also includes the Energy Resources Conservation Board (ERCB) and Alberta Utilities Commission (AUC), which are provincial agencies exercising independent adjudicative functions for which the Minister is responsible. The ERCB regulates the safe, responsible, and efficient development of Alberta's energy resources: oil, natural gas, oil sands, coal, and pipelines. The AUC regulates the utilities sector, natural gas and electricity markets to protect social, economic and environmental interests of Alberta where competitive market forces do not.

The main objective of the Oil Sands Production Profile (OSPP) was to identify the growth trend in different production technologies over the past 9 years and how these technologies have been applied to different Oil Sands areas. The total production values given in this profile are reflective of ERCB/EUB data with the exclusion of experimental, conventional, and freehold Oil Sands projects. Growth trends (linear or exponential) were measured and verified (≥ 0.95 confidence) using R-squared regression analysis (see Appendix II).

OIL SANDS AREAS

There are three main Oil Sands areas:

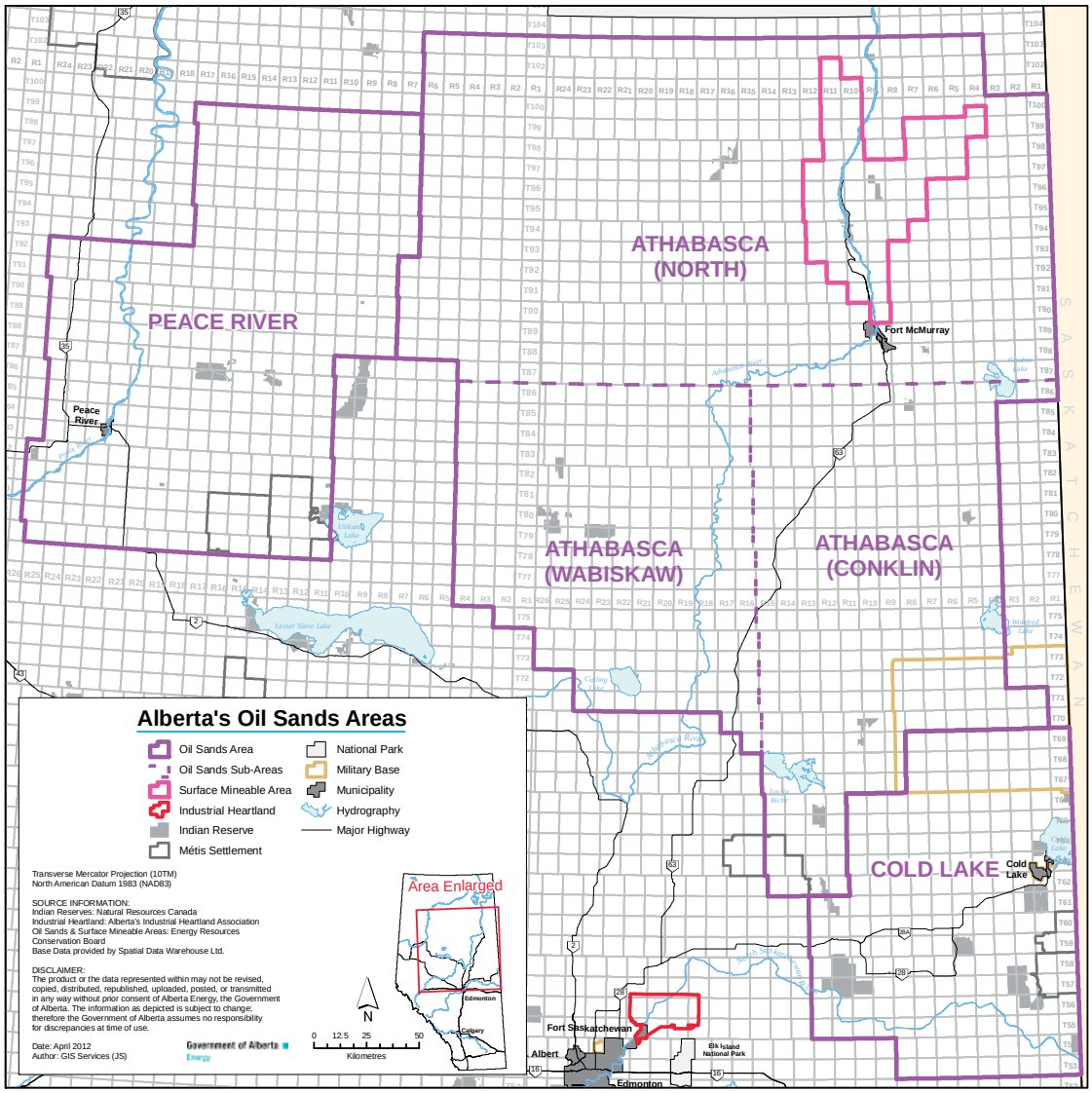
1. Athabasca
2. Cold Lake
3. Peace River

To identify with greater clarity where growth is occurring, the Athabasca Oil Sands Area (AOSA) is divided into three sub-areas:

1. Athabasca (North) – The AOSA, North of Township 86 (known hereafter as "Athabasca North")
2. Athabasca (Wabiskaw) – The AOSA, from Township 86 South, from Range 16 West (known hereafter as "Wabiskaw").
3. Athabasca (Conklin) – The AOSA, from Township 86 South, East of Range 16 (known hereafter as "Conklin").

The map in Figure 1-i shows the locations of these areas. The crude oil characteristics vary significantly among these areas, as shown in Figure 1-ii.

FIGURE 1:
i) OIL SANDS AREAS



ii) SELECT PHYSICAL CHARACTERISTICS OF OIL SANDS AREAS

AREA	RESERVOIR DEPTH (m)		API
	MINING (to top of pay)	IN-SITU	
ATHABASCA NORTH	0-80	80-275	6-10
WABISKAW	N/A	300-550	Up to 18
CONKLIN	N/A	150-475	8-12
COLD LAKE	N/A	375-525	10-13
PEACE RIVER	N/A	525-800	6-16

The combined effect of reservoir characteristics (depth, pressure, permeability, continuity, pay thickness, viscosity, API and others) and technological research have translated into the application and selection of different production technologies.

PRODUCTION TECHNOLOGIES

Four technologies were outlined as the main production technologies currently used in the Oil Sands areas and are as follows:

Primary/Enhanced Oil Recovery

Primary recovery from a reservoir is typically the first method of producing oil from a given reservoir. It uses energy which is already in the reservoir, such as gravity, or pressure drive (also known as waterdrive/gasdrive), to displace oil and drive it to surface facilities. EOR is typically any technology for producing oil after primary production is no longer economically viable. Waterflooding, gas injection, and polymer/chemical flooding are all examples of EOR. In some cases, these EOR production technologies are applied at the start of production, rather than being used as the secondary or tertiary recovery mechanism, in order to increase the ultimate recovery of oil from the reservoir.

Cyclic Steam Stimulation

Cyclic steam stimulation (CSS), or huff and puff as it is sometimes called, is a thermal production technology in which one well is used to both inject steam and produce oil. Steam is injected at pressures high enough that the area surrounding the wellbore fractures, allowing steam to access and heat new areas of the reservoir. After weeks or months, the steam injection is completed; a few days are allowed for the steam to condense and then the production of oil and water begins. Production initially occurs due to increased reservoir pressures; later cycles require artificial lift technologies to produce the remaining oil during the production cycle. The cycle then starts over after the oil production rates become too small. This technology is as also applied in the heavy oil fields in California.

Steam Assisted Gravity Drainage

Steam assisted gravity drainage (SAGD) is a thermal production technology which utilizes two horizontal wells, known as a well pair, one to inject steam below reservoir fracture pressures, and the other to produce water and oil. The top horizontal well injects steam over a period of months to heat the reservoir evenly, creating a steam chamber. The oil from the chamber drains to the lower production well to allow for production initially through pressure drive, and then by artificial lift or gas lift. The steam injection and oil production happen continuously and simultaneously once production starts. This technology has a high ultimate recovery of oil from the reservoir relative to other in situ production technologies.

Mining

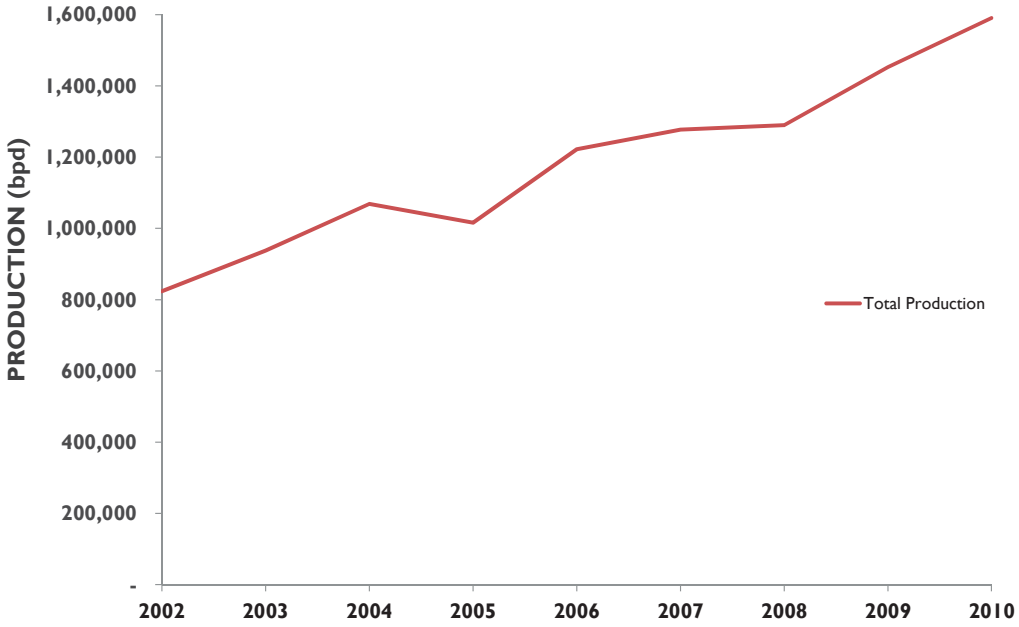
Truck and shovel technology is used to move sand impregnated with bitumen from the mining area to an extraction facility. The bitumen is then treated to remove the sand, mineral fines and other impurities in processes which vary among producers. Once the extraction process is completed, the bitumen is ready for refining or upgrading, depending on the company's chosen configuration.

DATA & ANALYSIS

Annual Oil Sands Production

Oil sands production was calculated on an annual basis for 2002-2010 production years (see *Methodology and Appendix I*) and is presented in Figure 2.

FIGURE 2:
I) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS



ii) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS

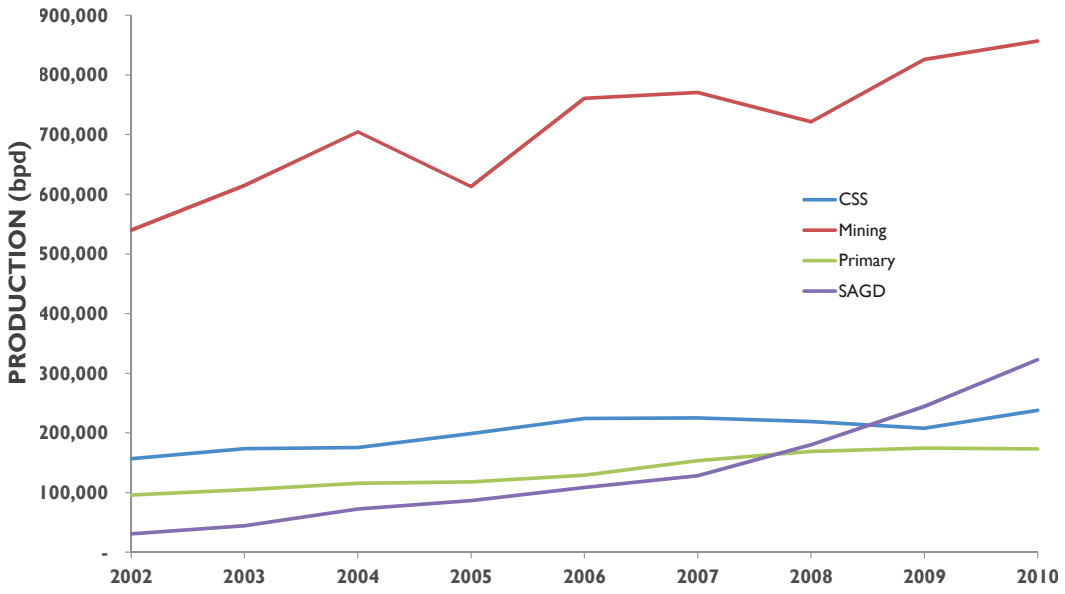
	2002	2003	2004	2005	2006	2007	2008	2009	2010
BBL/DAY	823,418	937,637	1,068,476	1,016,021	1,222,393	1,277,561	1,289,900	1,452,718	1,590,467

This chart shows growth in total crude production for the Oil Sands region. Average annual growth was determined to be 85,228 bpd with an 8.6% Compounded Annual Growth Rate (CAGR) (see *Appendix II* for sample calculation). Figure 2-i graphically illustrates the linear growth (R-squared=0.96, Appendix II-i) over the past 9 years of commercial operations.

Annual Oil Sands Production by Technology

To emphasize the growth of separate technologies over the past 9 years, annual production was further analyzed based on the four commercial production technologies, 1) Primary/EOR, 2) CSS, 3) SAGD, and 4) Mining (as described in *Methodology and Appendix* I). Figure 3-i and 3-ii shows production by the various technologies.

FIGURE 3:
i) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS BY TECHNOLOGY



ii) ANNUAL CRUDE OIL PRODUCTION (BPD) FROM OIL SANDS BY TECHNOLOGY

	2002	2003	2004	2005	2006	2007	2008	2009	2010
CSS	156,899	173,667	175,535	198,860	224,277	225,218	219,029	207,947	237,892
MINING	539,888	614,562	704,777	612,751	760,839	770,835	721,491	825,842	856,876
PRIMARY	96,037	104,839	115,537	117,970	128,878	153,296	169,131	174,423	173,145
SAGD	30,594	44,569	72,627	86,440	108,398	128,212	180,248	244,507	322,644
TOTAL	823,418	937,637	1,068,476	1,016,021	1,222,393	1,277,561	1,289,900	1,452,718	1,590,467

iii) CRUDE OIL GROWTH RATES FROM OIL SANDS BY TECHNOLOGY

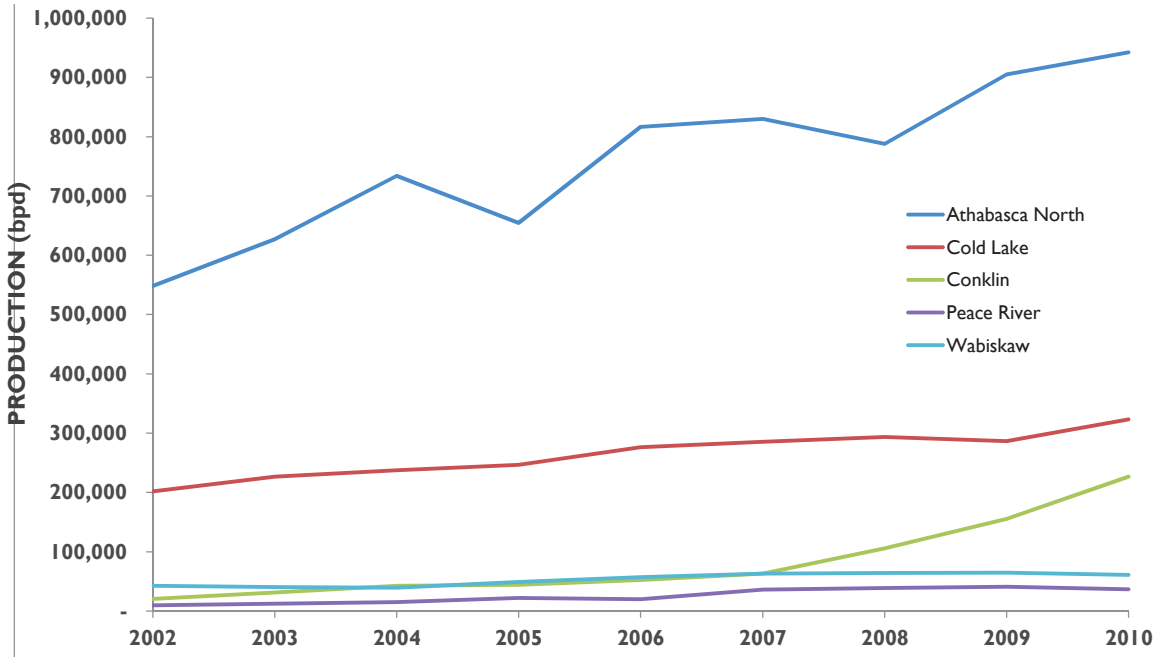
	GROWTH (BPD/YEAR)	COMPOUNDED ANNUAL GROWTH (CAGR)
CSS	8,999	5.3%
MINING	35,221	5.9%
PRIMARY	8,568	7.6%
SAGD	32,450	34.2%

Separating production technologies allowed for calculation of the individual growth rates (CAGR) of the technologies, and showed the corresponding trends. Growth rates can be seen in Figure 3-iii. CAGR for CSS (5.3%), Mining (5.9%) and Primary (7.6%), exhibited growth rates (Appendix II-i) similar to total annual crude production (8.5%) (Figure 2-i and 2-ii), while SAGD production exhibited exponential growth (R-squared=0.99, *Appendix II-iv)* with a significantly greater CAGR (34.2%) than all other production technologies.

Annual Oil Sands Production by Area

Production trends were also examined within the distinct Oil Sands areas (see Oil Sands Areas). Annual crude production was determined for the 1) Athabasca North, 2) Cold Lake, 3) Conklin, 4) Peace River, and 5) Wabiskaw areas (as described in *Methodology and Appendix* I). Figure 4-i and 4-ii shows the annual production volumes for the various regions.

FIGURE 4
i) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS BY AREA



ii) ANNUAL CRUDE OIL PRODUCTION (BPD) FROM OIL SANDS BY AREA

	2002	2003	2004	2005	2006	2007	2008	2009	2010
ATHABASCA NORTH	548,031	626,848	733,869	654,428	816,442	829,825	787,655	904,831	941,981
COLD LAKE	201,715	226,665	237,534	246,594	276,332	285,400	293,347	286,669	323,505
CONKLIN	20,583	31,204	42,741	44,129	52,304	62,897	105,840	155,543	226,811
PEACE RIVER	9,965	12,328	15,167	21,864	20,077	36,087	38,633	41,133	36,947
WABISKAW	42,902	40,593	39,165	49,006	57,238	63,351	64,425	64,542	61,223
TOTAL	823,195	937,637	1,068,476	1,016,021	1,222,392	1,277,561	1,289,900	1,452,719	1,590,467

iii) ANNUAL CRUDE OIL GROWTH RATES FROM OIL SANDS BY AREA

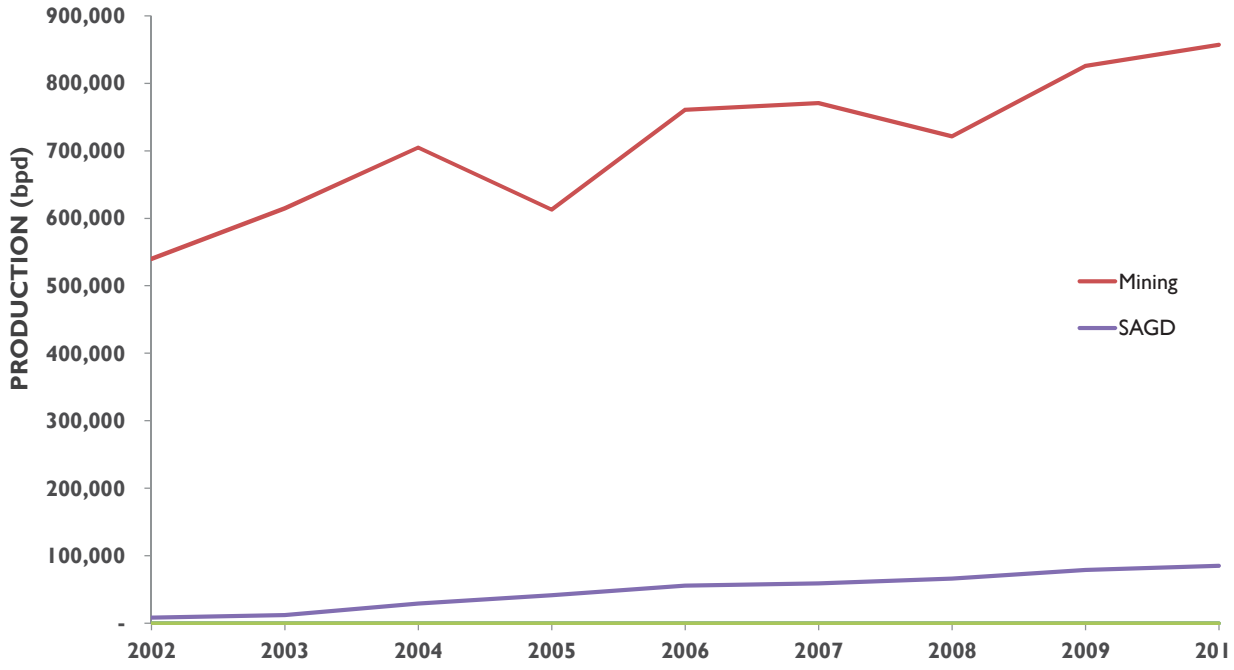
	AVERAGE GROWTH (BPD/YEAR)	COMPOUNDED ANNUAL GROWTH RATE
ATHABASCA NORTH	49,244	7.0%
COLD LAKE	15,224	6.1%
CONKLIN	25,779	35.0%
PEACE RIVER	3,373	17.8%
WABISKAW	2,290	4.5%

CAGRs were calculated for Athabasca North (7.0%), Cold Lake (6.1%), Conklin (35.0%), Peace River (17.8%) and Wabiskaw (4.5%) areas (Figure 4-iii). All areas exhibited CAGRs less than 10%, with the exception of the Peace River (17.8%) and Conklin areas (*Appendix II-iii*). The Conklin area exhibited exponential growth (*Appendix II-iv*).

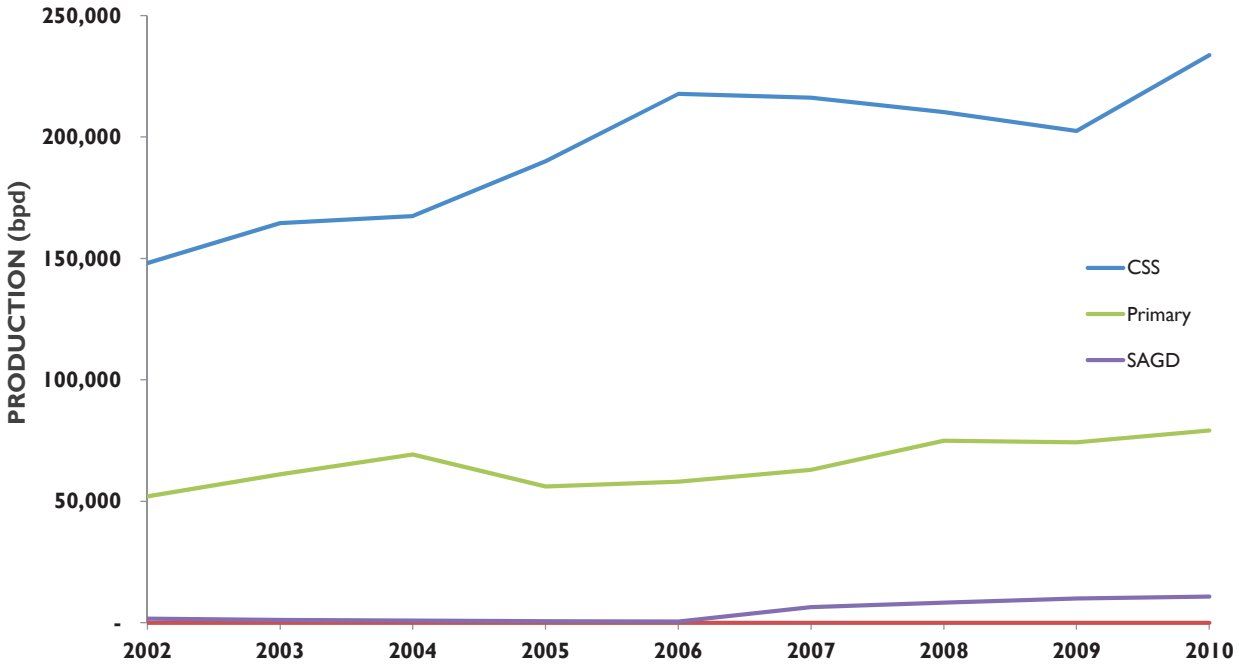
Annual Oil Sands Areas Production by Technology

Regional production volumes were further sub-divided on the basis of technology to determine production trends in each area. Results are shown in Figure 5-i to 5-vi.

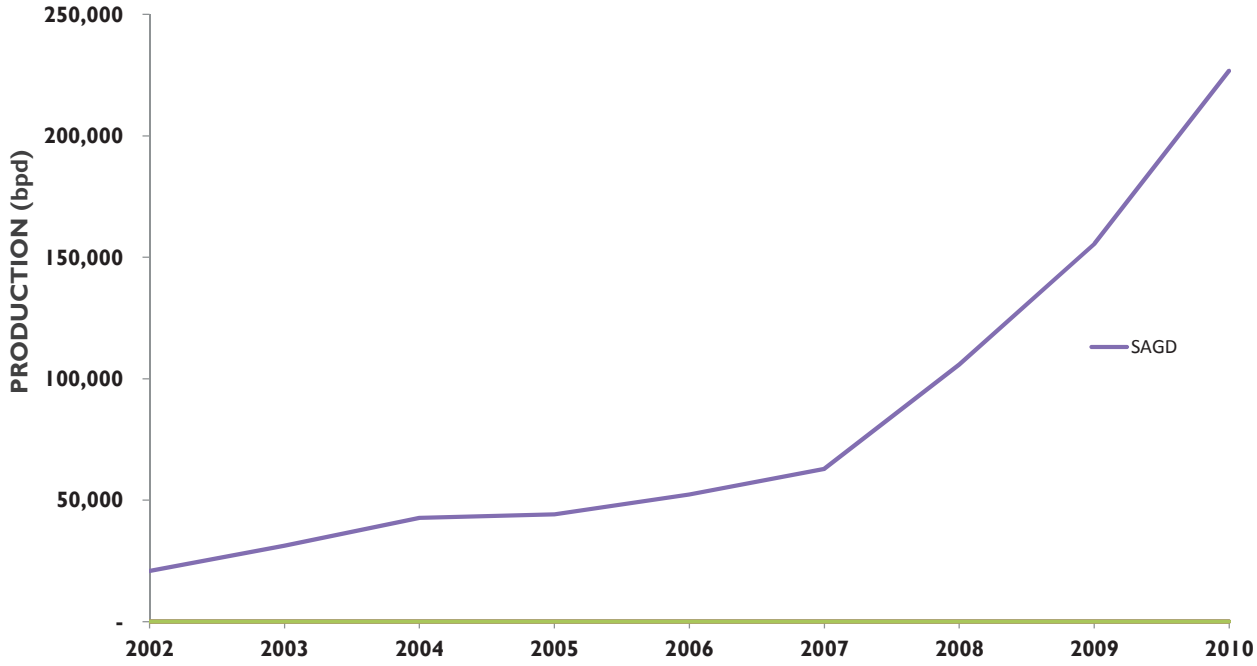
FIGURE 5
i) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS BY AREA – ATHABASCA NORTH



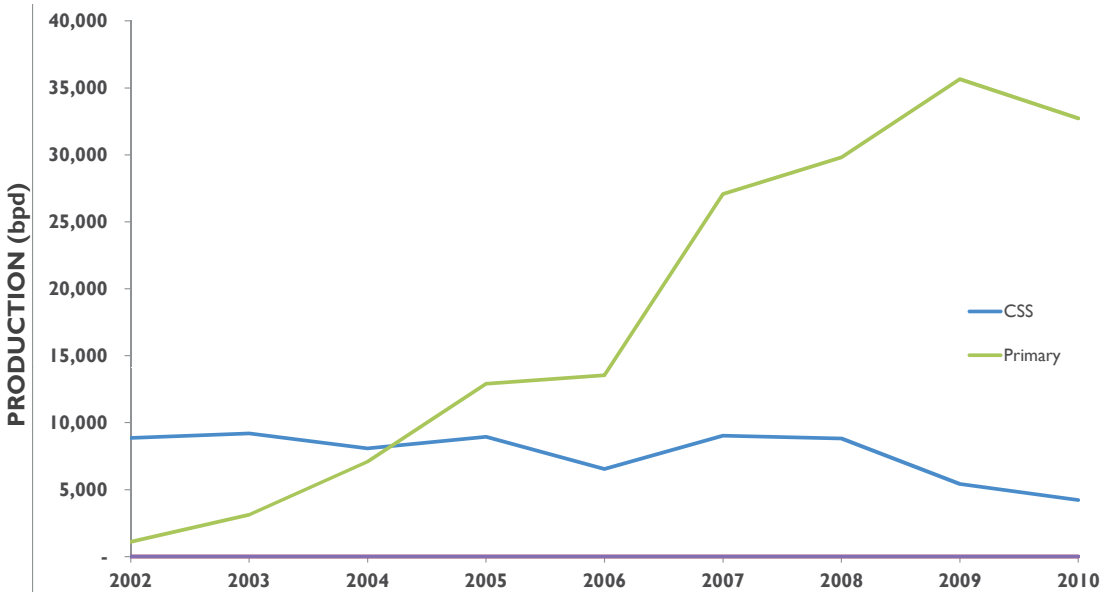
ii) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS BY AREA – COLD LAKE



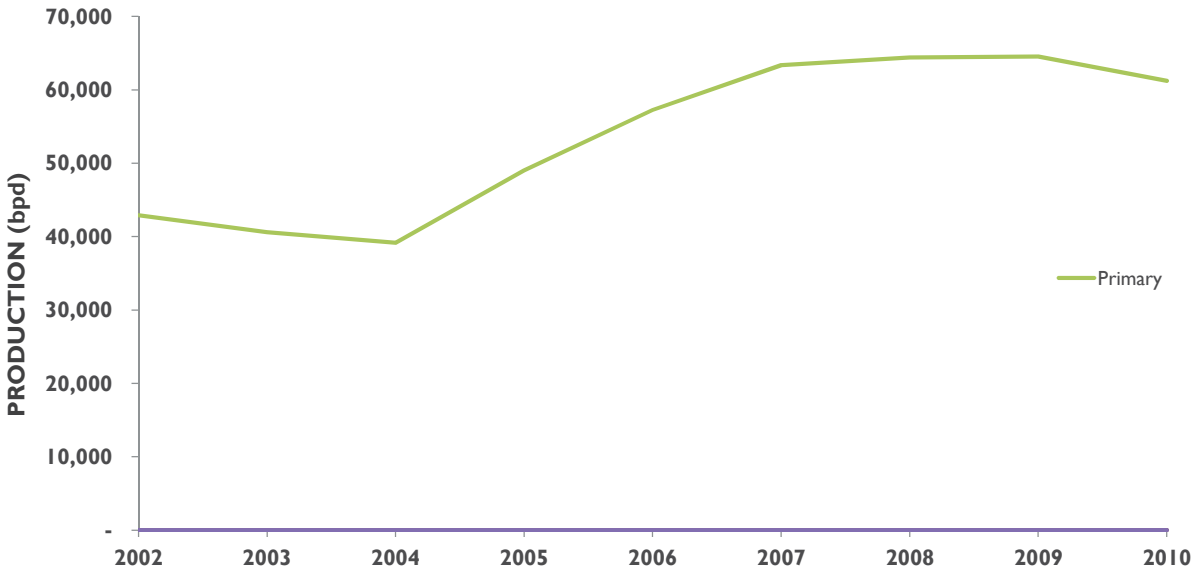
iii) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS BY AREA – CONKLIN



iv) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS AREA BY AREA – PEACE RIVER



v) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS AREA BY REGION – WABISKAW



vi) ANNUAL CRUDE OIL PRODUCTION (BPD) AND GROWTH RATES FROM OIL SANDS REGIONS BY TECHNOLOGY

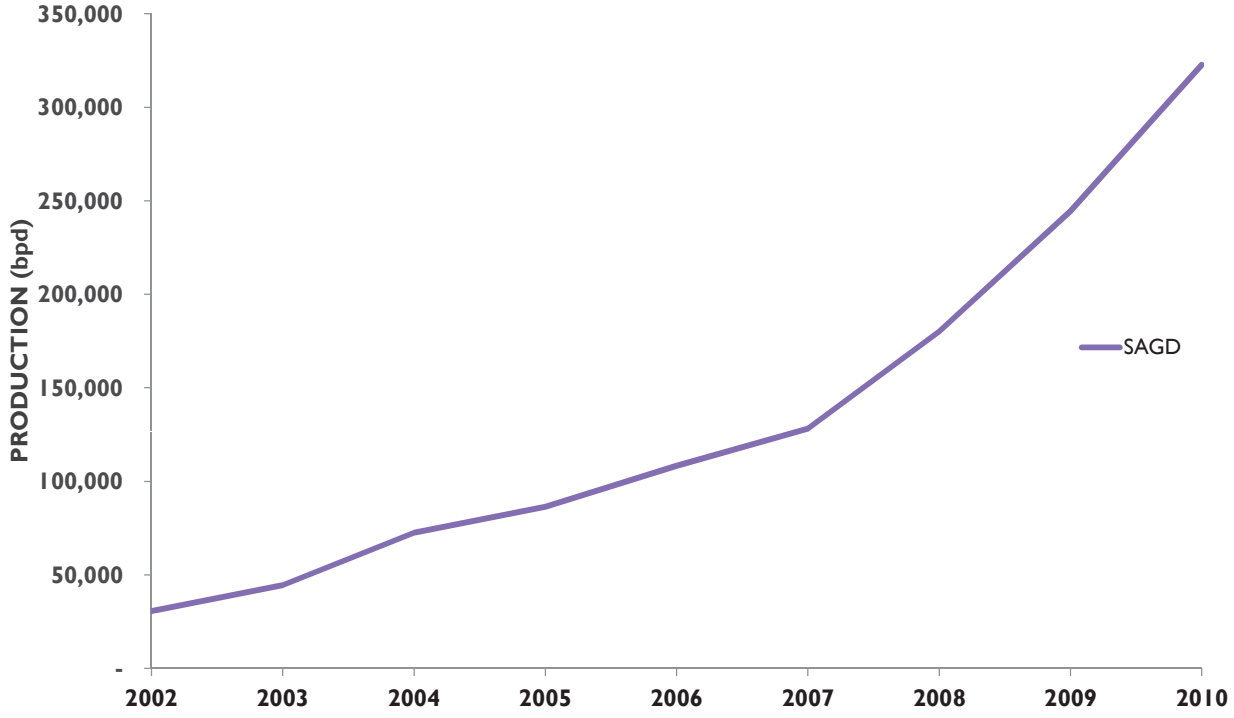
	2002	2003	2004	2005	2006	2007	2008	2009	2010	GROWTH RATE (bpd/y)	CAGR
ATHABASCA NORTH											
CSS	-	-	-	-	-	-	-	-	-	-	-
MINING	539,888	614,562	704,777	612,751	760,839	770,835	721,491	825,842	856,876	39,623	5.9%
PRIMARY	-	-	-	-	-	-	-	-	-	-	-
SAGD	8,142	12,286	29,092	41,677	55,603	58,990	66,164	78,989	85,105	9,620	34.1%
COLD LAKE											
CSS	148,045	164,464	167,455	189,912	217,747	216,196	210,217	202,468	233,681	10,705	5.9%
MINING	-	-	-	-	-	-	-	-	-	-	0.0%
PRIMARY	52,024	61,121	69,285	56,048	58,093	62,879	74,885	74,226	79,097	3,384	5.4%
SAGD	1,645	1,079	794	634	492	6,325	8,245	9,975	10,728	1,135	26.4%
CONKLIN											
CSS	-	-	-	-	-	-	-	-	-	-	0.0%
MINING	-	-	-	-	-	-	-	-	-	-	0.0%
PRIMARY	-	-	-	-	-	-	-	-	-	-	0.0%
SAGD	20,806	31,204	42,741	44,129	52,304	62,897	105,840	155,543	226,811	25,751	34.8%
PEACE RIVER											
CSS	8,854	9,203	8,080	8,948	6,530	9,021	8,812	5,430	4,212	(580)	0.0%
MINING	-	-	-	-	-	-	-	-	-	-	0.0%
PRIMARY	1,111	3,125	7,087	12,916	13,548	27,066	29,821	35,654	32,735	3,953	52.6%
SAGD	-	-	-	-	-	-	-	-	-	-	0.0%
WABISKAW											
CSS	-	-	-	-	-	-	-	-	-	-	0.0%
MINING	-	-	-	-	-	-	-	-	-	-	0.0%
PRIMARY	42,902	40,593	39,165	49,006	57,238	63,351	64,425	64,542	61,223	2,290	4.5%
SAGD	-	-	-	-	-	-	-	-	-	-	0.0%

CAGRs for technologies in all regions exhibited similar growth displayed by technologies in the overall Oil Sands area (Figure 3-iii), with SAGD based production showing (exponential) growth in every producing region but Peace River and Wabiskaw. Primary production in the Peace River area showed a significant CAGR (52.6%), with a relatively low production volume.

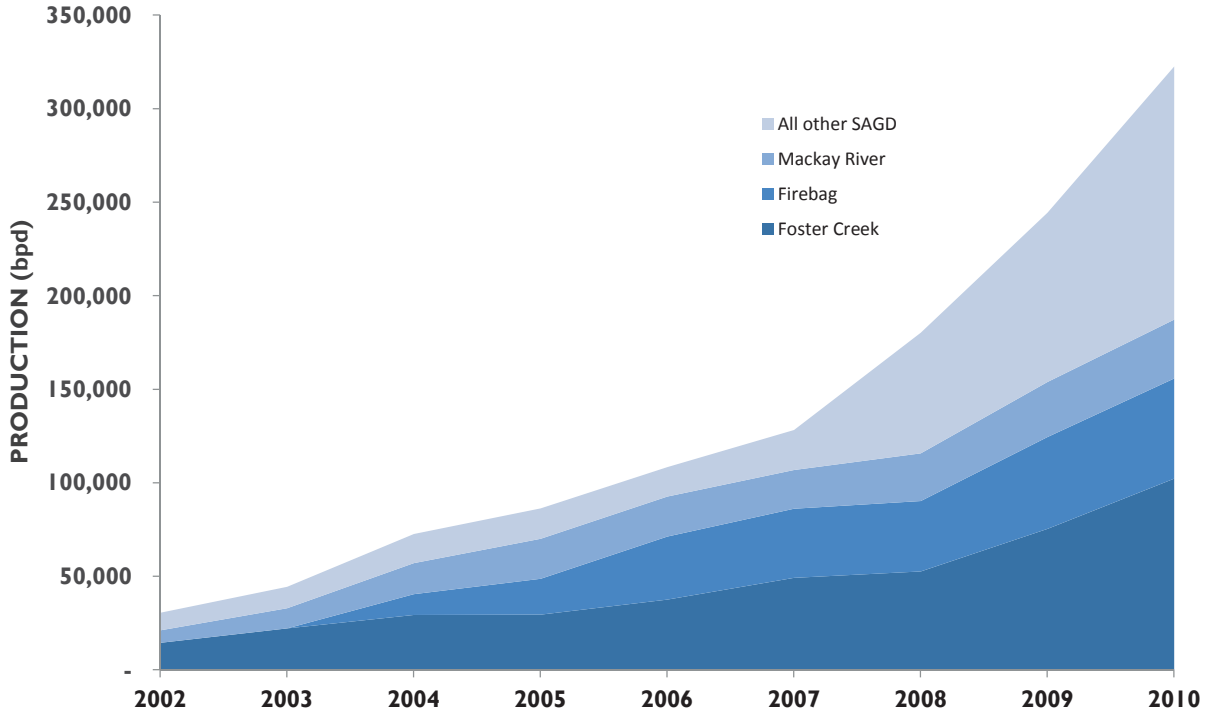
Annual Oil Sands Production - SAGD

To closer examine the exponential growth trends in the Conklin region, specifically, SAGD operations (Appendix II-iv and Appendix II-v), annual SAGD production was further analyzed to determine the top 3 projects based on absolute production. Top 3 SAGD producers were identified as 1) Foster Creek, 2) Firebag, and 3) Mackay River, according to the greatest production volumes (See Appendix I). Figure 6-ii highlights the top 3 projects and corresponding production.

FIGURE 6
i) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS FOR SAGD PRODUCTION



ii) ANNUAL CRUDE OIL PRODUCTION FROM OIL SANDS FOR TOP 3 SAGD PRODUCERS



iii) ANNUAL CRUDE OIL PRODUCTION (BPD) FROM OIL SANDS FOR TOP 3 SAGD PRODUCERS

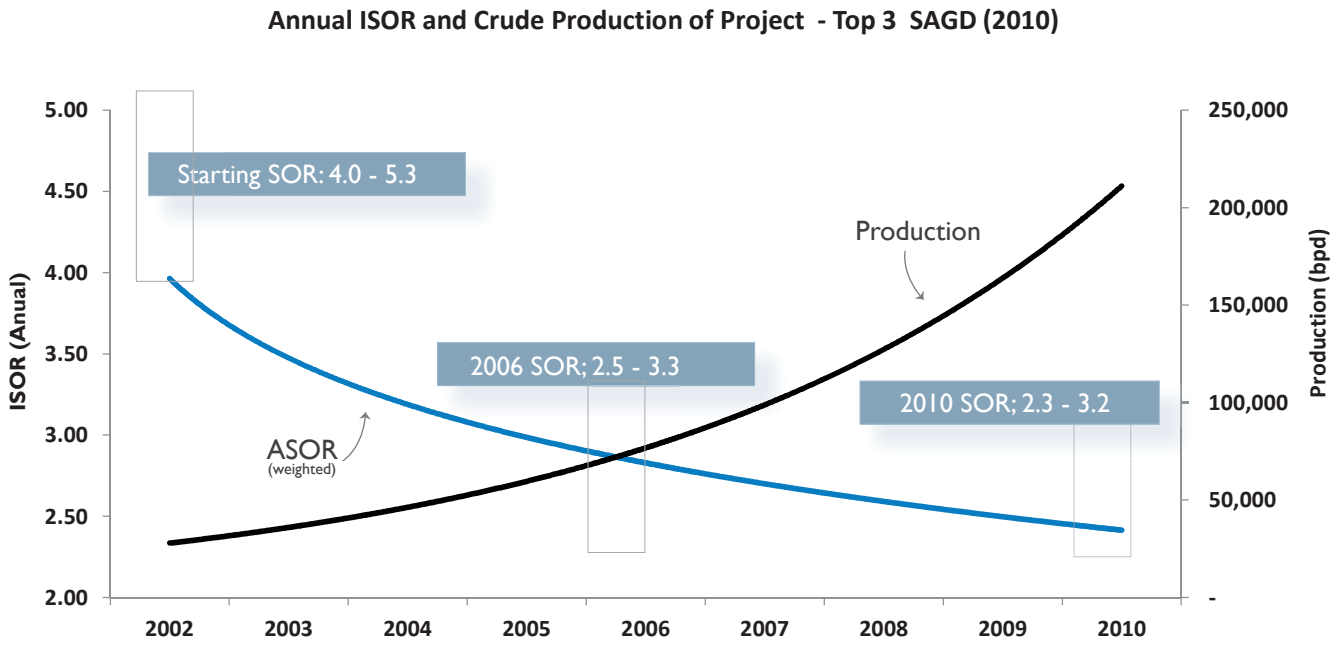
	2002	2003	2004	2005	2006	2007	2008	2009	2010
FOSTER CREEK	14,563	22,238	29,453	29,598	37,582	49,287	52,702	75,454	102,235
FIREBAG	-	32	11,031	19,194	33,680	36,936	37,680	49,075	53,609
MACKAY RIVER	6,672	10,716	16,596	21,297	21,419	20,631	25,414	29,348	31,496
TOP 3 SAGD	21,235	32,986	57,080	70,089	92,681	106,854	115,795	153,878	187,340
ALL OTHER SAGD	9,359	11,583	15,547	16,351	15,717	21,358	64,453	90,629	135,304
TOTAL SAGD	30,594	44,569	72,627	86,440	108,398	128,212	180,248	244,507	322,644

The annual steam-to-oil ratios (SORs) for the top 3 projects were examined to identify instantaneous (ISOR) and cumulative (CSOR) steam-to-oil ratios (Figure 7-i). SORs are a metric of energy use and efficiency for thermal projects like CSS and SAGD. The SOR is reported as the ratio of the volume of cold water needed to produce the required steam, over the volume of bitumen produced. A significant trend is the decrease in Annual ISOR and CSOR for the top 3 SAGD producers from the 2002-2010 production years, which represents 60% of current SAGD production (Figure 7-ii).

FIGURE 7
i) ANNUAL ISORS AND CSORS FOR TOP 3 SAGD PRODUCERS

		2002	2003	2004	2005	2006	2007	2008	2009	2010
MACKAY RIVER	**CSOR**	5.28	2.87	2.58	2.43	2.50	2.52	2.54	2.53	2.51
	ISOR	5.28	2.62	2.36	2.23	2.67	2.59	2.59	2.52	2.41
	(BPD)	6,672	10,716	16,596	21,297	21,419	20,631	25,414	29,348	31,496
FIREBAG	**CSOR**	-	-	5.02	4.26	3.75	3.58	3.42	3.34	3.31
	ISOR	-	-	4.19	3.82	3.29	3.28	3.01	3.12	3.20
	(BPD)	-	-	11,031	19,194	33,680	36,936	37,680	49,075	53,609
FOSTER CREEK	**CSOR**	3.51	2.76	2.66	2.60	2.56	2.56	2.51	2.51	2.45
	ISOR	4.00	2.52	2.52	2.46	2.46	2.55	2.31	2.51	2.27
	(BPD)	14,563	22,238	29,453	29,598	37,582	49,287	52,702	75,454	102,235
TOP 3 SAGD	**ISOR**	4.4	3.2	2.8	2.8	2.8	2.8	2.6	2.7	2.6
	(BPD)	21,235	32,954	57,080	70,089	92,681	106,854	115,795	153,878	187,340

ii) ANNUAL ISORS VERSUS PRODUCTION FOR TOP 3 SAGD PRODUCERS



APPENDIX I

2002 – 2010 Oil Sands Project Production Volumes

(Note: Oil Sands production volume information is currently being reviewed and an updated version will be posted. Should you have any questions in the interim, please contact Jesse Toor (jesse.toor@gov.ab.ca) or Martin Mader (martin.mader@gov.ab.ca).

APPENDIX II

Calculations

All Growth rates were calculated using Compounded Annual Growth Rate (CAGR) calculation:

$r = [(x1/x2)(1/n)] - 1$

Where:

r = Compounded annual growth rate

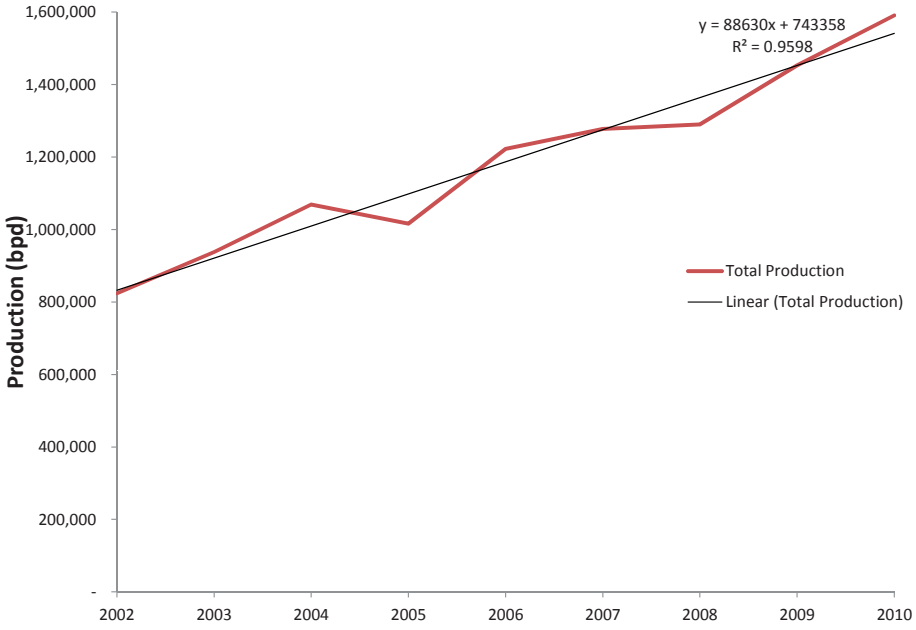
x1 = 2010 annual production value

x2 = 2002 Annual Production value

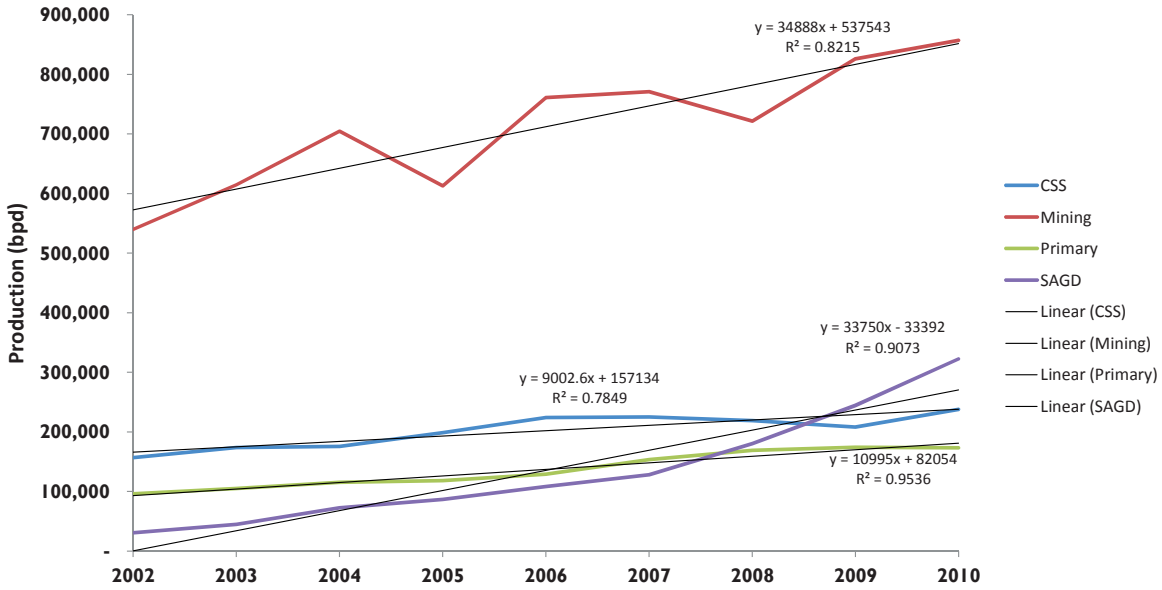
n = Production Years/Periods

Trend types and R-squared values were generated using Microsoft Excel. See Figure i-v below for corresponding equations.

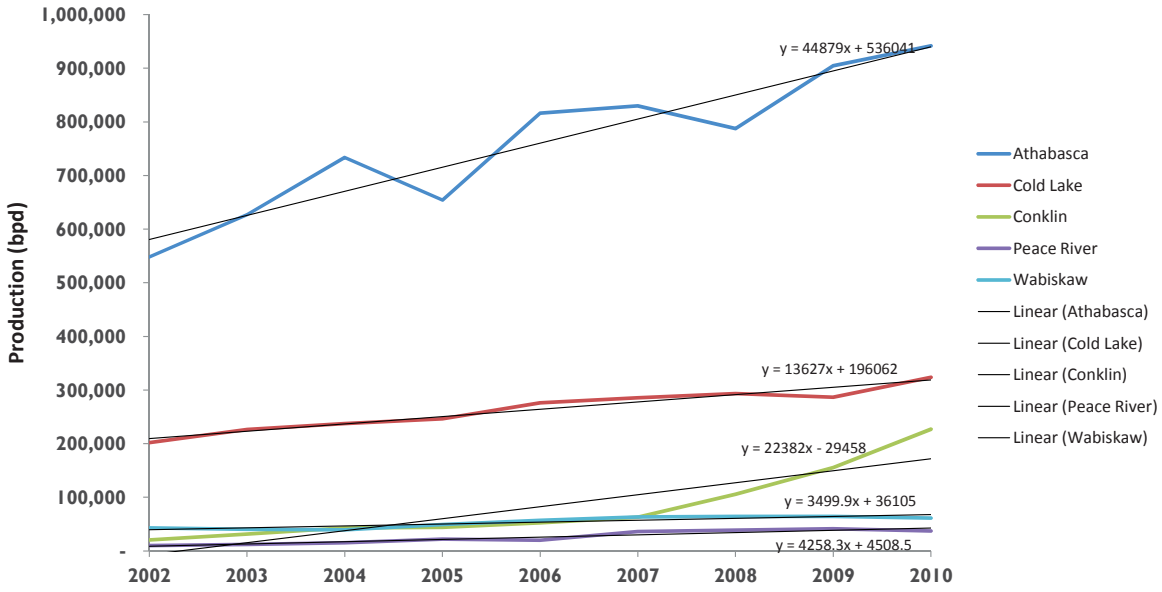
i) Annual Crude Oil Production from Oil Sands



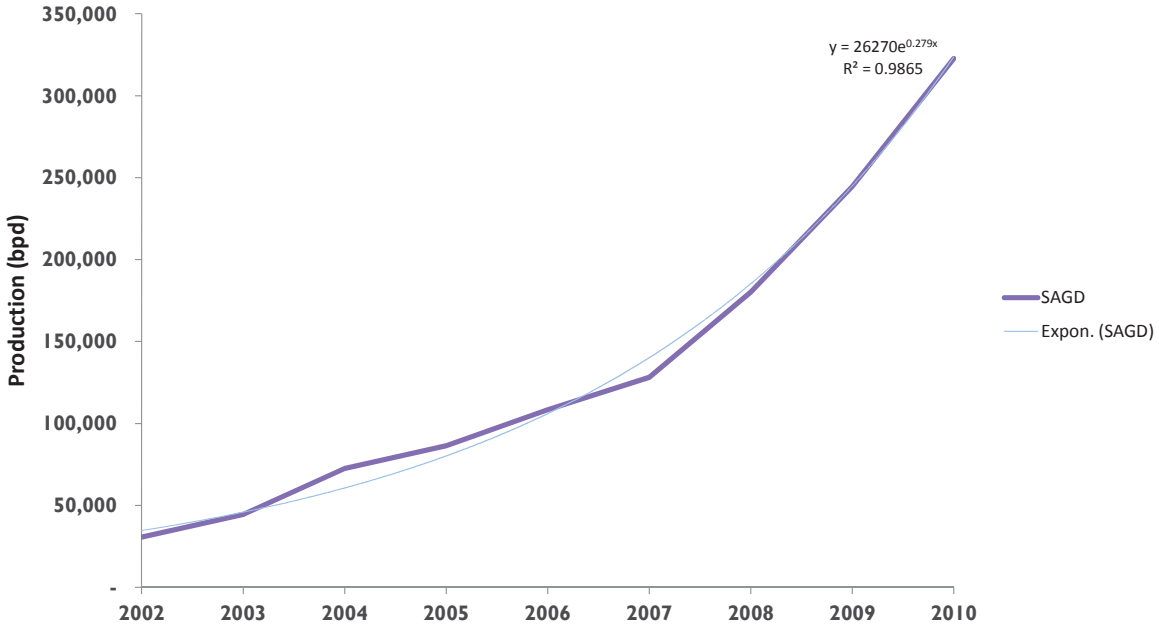
ii) Annual Crude Oil Production from Oil Sands by Technology



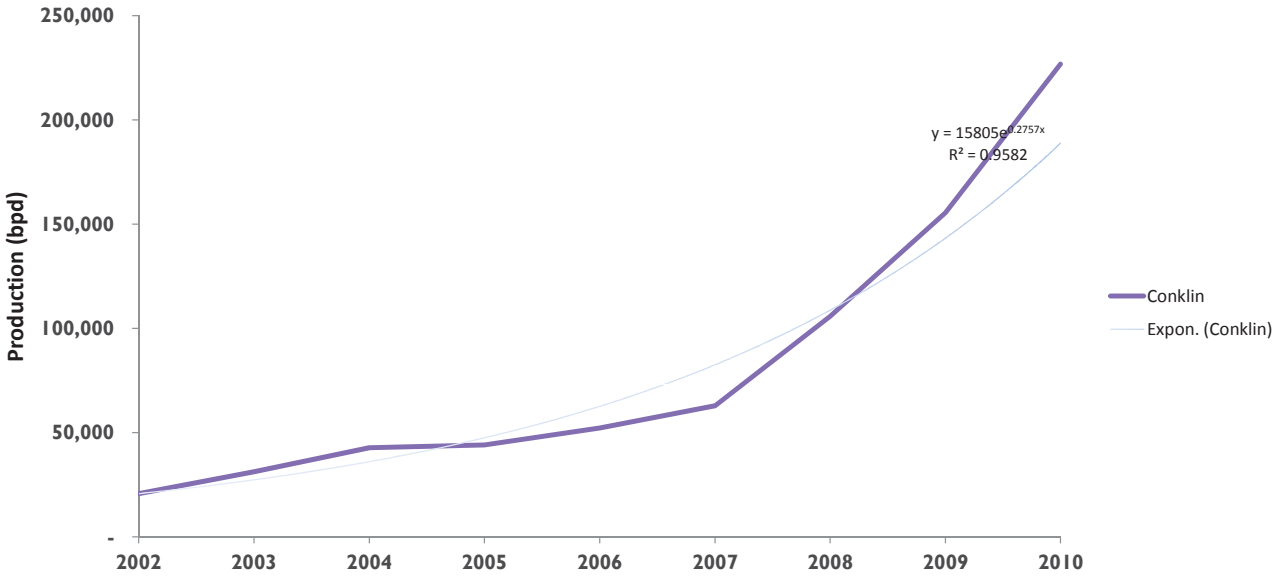
iii) Annual Crude Oil Production from Oil Sands by Area



iv) Annual Crude Oil Production from Oil Sands for SAGD Production



v) Annual Crude Oil Production from Oil Sands for SAGD Production



vi) Canada and Alberta Crude Oil Exports to the United States Petroleum Administration for Defense Districts (PADDs)

	CANADA[6] (m^3/day)	ALBERTA[7] (m^3/day)
PADD I	25,352.0	5,014.6
PADD II	194,530.8	145,504.3
PADD III	22,451.1	-
PADD IV	34,614.8	47,985.4
PADD V	28,391.1	18,862.3
TOTAL EXPORTS TO USA	305,339.8	217,366.6

The percentage of Alberta crude oil exports (of total Canadian exports) to the United States were calculated using Canadian National Energy Board (Total Crude Oil Exports by Destination) and Alberta Environment Resources Conservation Board (ST-3 – Oil Supply & Disposition) 2010 export volumes (m^3/day).

6 http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/sttstc/crdlndptrlmprdct/2010/ttlcrdlxprtdstntn2010.xls

7 http://www.ercb.ca/docs/products/STs/st3/2010/Oil_2010.xls