



“Greening” the Oil Sands?

Challenging the Myths and Confronting the Realities

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Overview of Presentation

Oil Sands

- What are oil sands?
- Where are they located, how much?
- How to recover and process?
- How big is the environmental footprint (land, water and air)?
- What research is underway to improve?
- Myths and realities

What are Oil Sands? “Technology Oil”

Oil Sands – combination of

- Bitumen (3 - 18%)
- Water (2 - 10%)
- Sand (50 - 75%)
- Clay (10 - 30%)



From Oil Sands



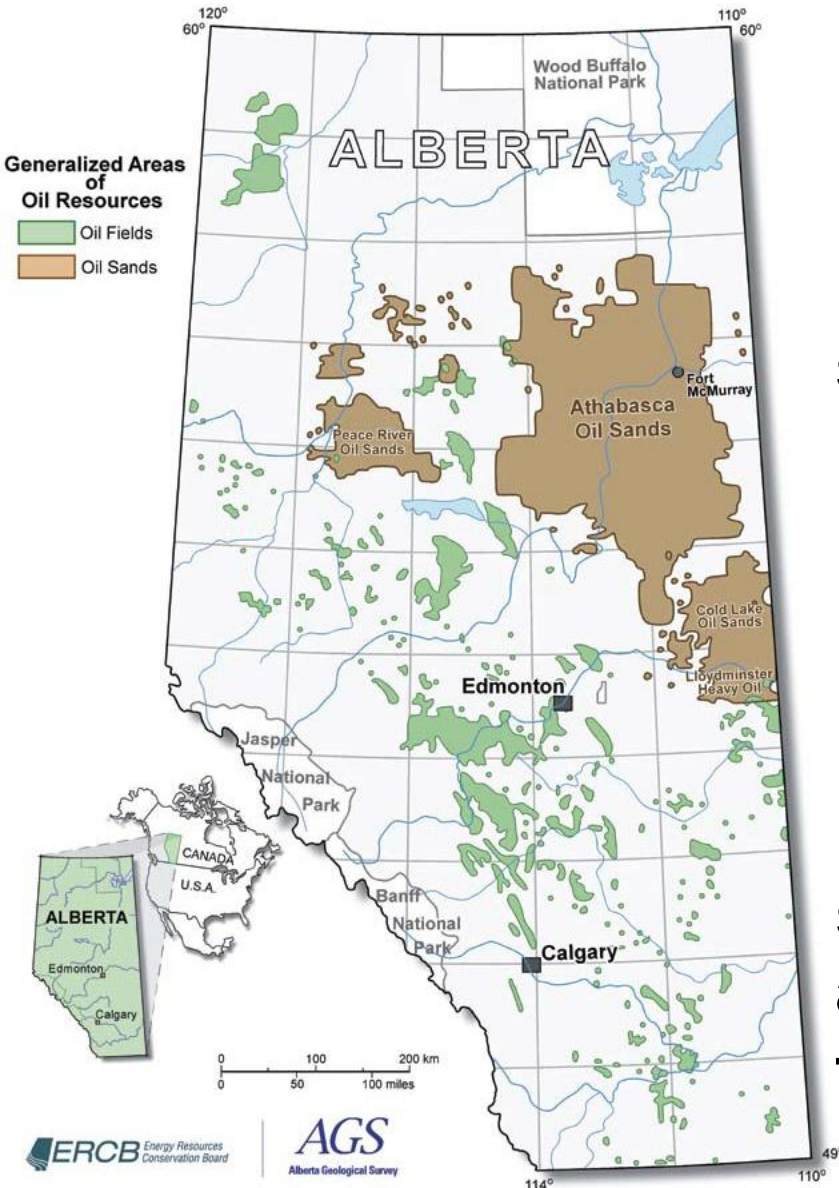
To Bitumen

(high viscosity, 4.5% Sulfur, contains Vanadium, Nickel, Nitrogen, Oxygen)



To Synthetic Crude Oil
(low viscosity, low Sulfur, low V, Ni, N, O)

Oil Sands (Bitumen) Deposits in Alberta



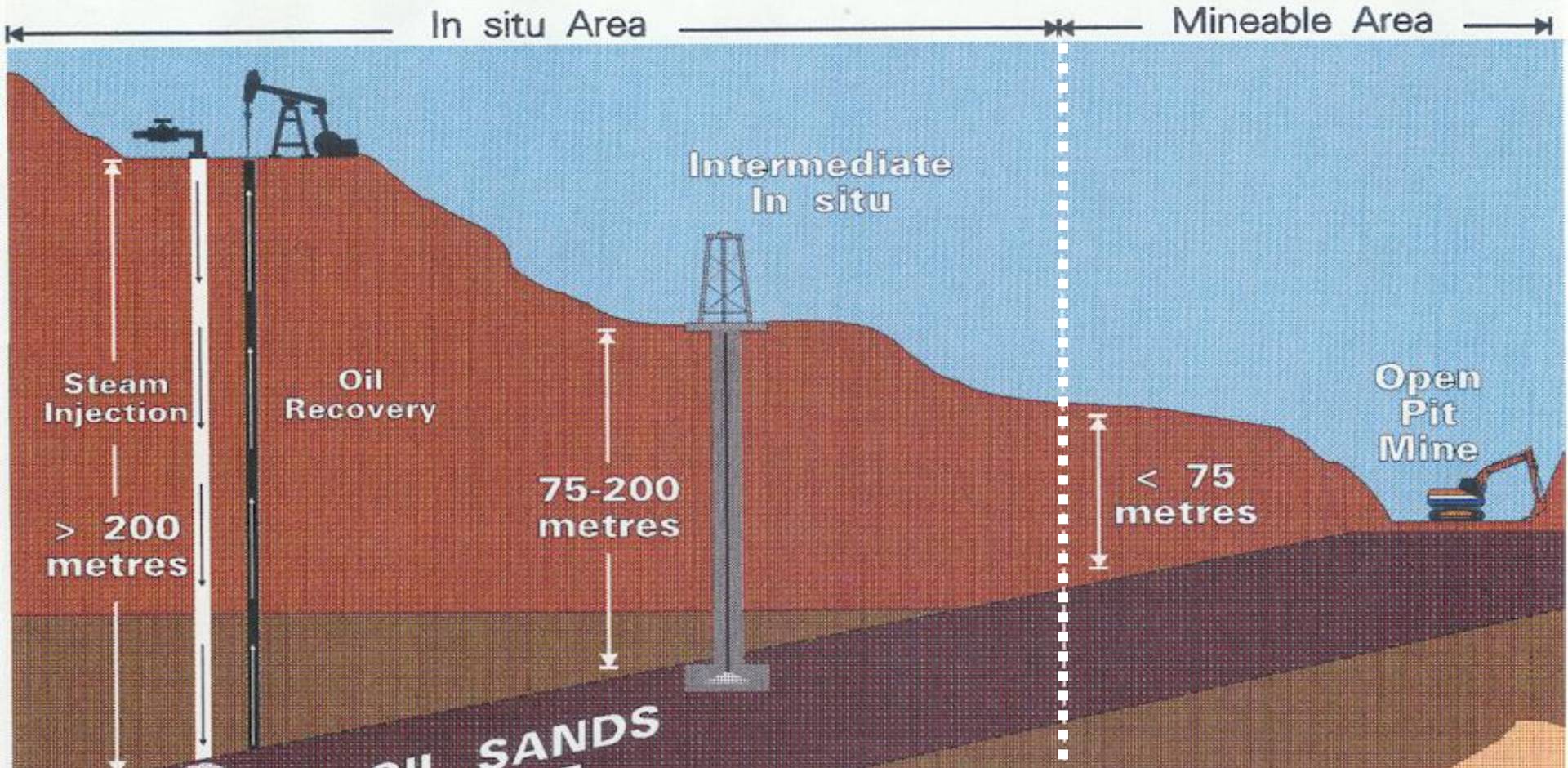
- Alberta land area: 661,848 sq. km
- Boreal forest area: 381,000 sq.km
- Oil Sands deposits area: 142,200 sq. km (Florida has 149,000 sq.km)
- Mineable oil sands area: 4,800 sq. km (approximately 0.7% of Alberta land area located mainly north of Fort McMurray)
- Active oil sands mining area: 602 sq. km (with 67 sq. km under active reclamation, 170 sq.km of tailings ponds – 0.03% of Alberta land area)



Size of Recoverable Oil Sands

- 1,800 billion barrels of bitumen in place
- 170 billion barrels of currently recoverable reserves (in sand)
- 315 billion barrels ultimately recoverable
- US petroleum consumption of 7.3 billion barrels/yr (approx. 20 million barrels/day from all sources – Canada is the largest exporter to the US - 2.5 M b/d)
- Recoverable oil sands represent the equivalent of 25 to 45 years of total US petroleum consumption
- Future technology developments will increase the amount recoverable via higher recovery factors, recovery from carbonates (406 billion barrels) and thin layers that are not yet commercially feasible

The Nature of the Oil Sands Resource



<i>Production Technology</i>	<i>Reserves</i>	<i>2009 Production, bbls/day</i>
Mining	20%	826,000
In Situ	80%	664,000

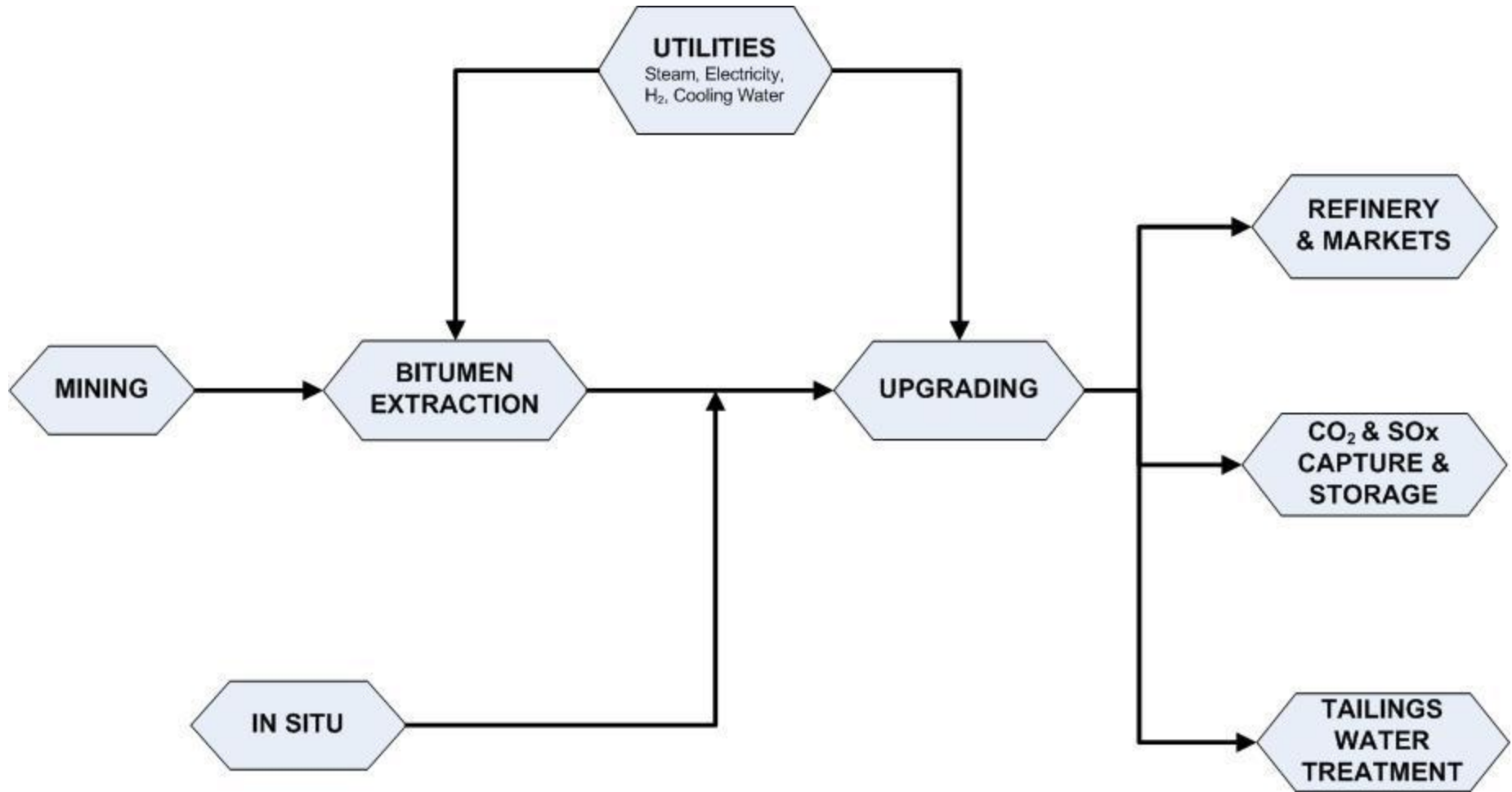


Oil Sands Impact on the Land

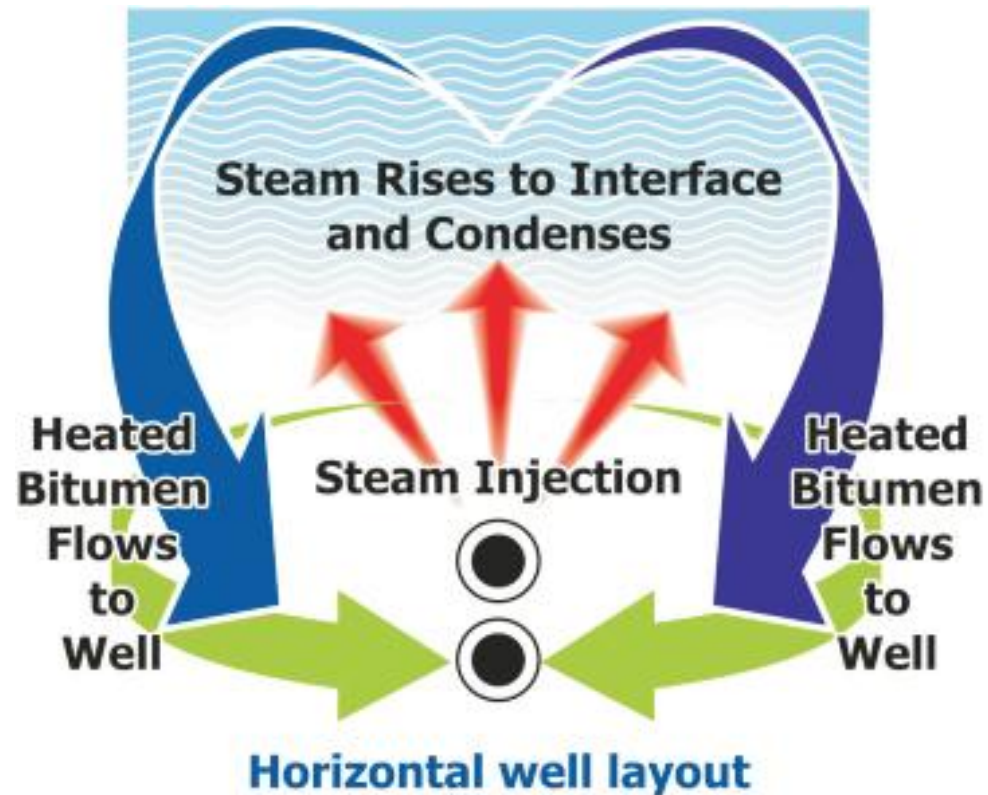
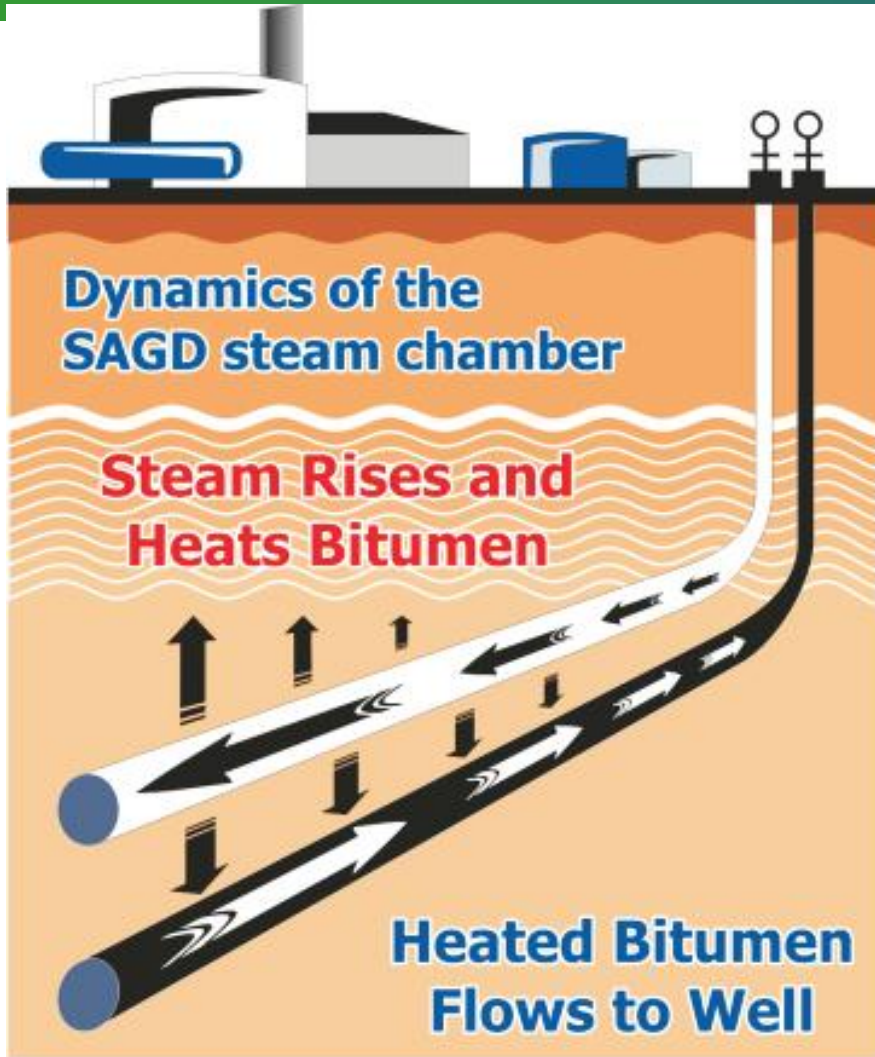
- **Myth**: Oil sands will strip mine an area equivalent to the size of Florida (149,000 sq.km.), or New York State (128,000 sq.m.), or England (130,000 sq.m.)
- **Reality**: Mineable oil sands will disturb a maximum of 4,800 sq.km. (but not all at one time due to progressive reclamation occurring)
- **Myth**: Oil sands development will cut down Alberta's boreal forest (381,000 sq.km. out of Canada's 3.2 million sq.km. of boreal forest)
- **Reality**: In situ oil sands recovery will disturb more land (perhaps 15,000 sq.km.) than mineable recovery but it will be spread over a much larger area (all oil sands areas disturbed by mining or in situ recovery must be reclaimed)



Oil Sands Process Flow Diagram



Courtesy Husky Energy





In Situ Recovery of Bitumen

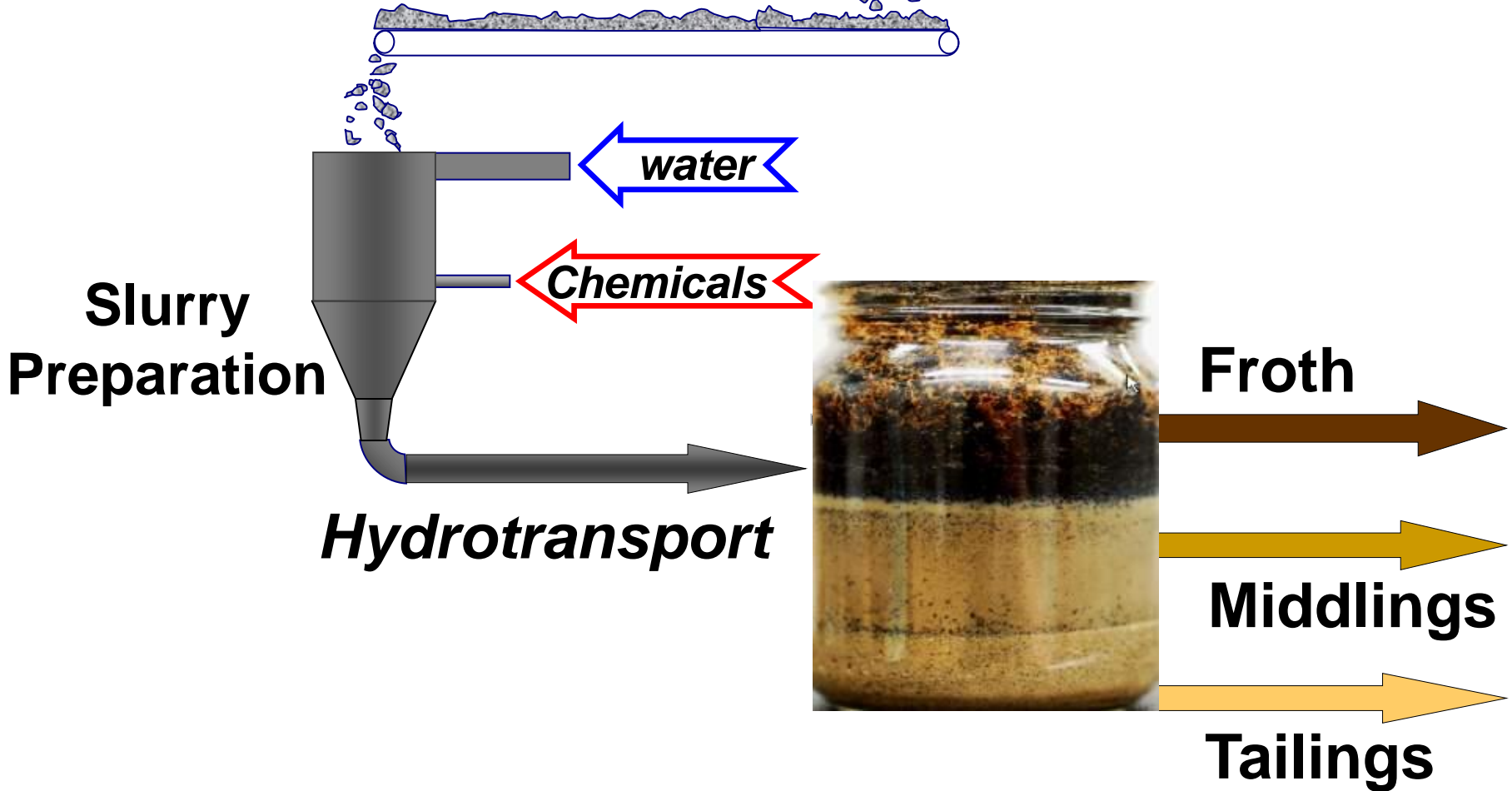


Land disturbance footprint for in situ bitumen recovery is significant when multiplied by thousands, eventually tens of thousands, of such facilities – for example, over 10,000 in situ bitumen and 100,000 conventional wells producing in AB





Mining and Extraction



Courtesy of Michael MacKinnon, Syncrude Canada



Suncor

**Syncrude Tailings Ponds
And Mines**

- Approximately 1 to 1.5 barrels of Mature Fine Tailings (MFT) produced for each barrel of oil
- MFT – 15% solids (mainly fine clay) by volume, or 30% by mass – not weight bearing, holds water
- Volume of MFT has been increasing with production (time)
- 170 sq.km tailings ponds out of 602 sq.km active oil sands area



**No polymer:
Slow solids
settling**



**With polymer:
Fast solids
settling**



Clear
water

Compact
sediment



Stabilizing/Reducing Tailings Ponds

- Paste and “beach” (Suncor TRO, Shell) technologies (flocclulants/polymers added to bind to clay)
- Consolidated tailings technologies: mix MFT with coarse sand and gypsum, or add CO₂ to tailings
- Centrifugation (also with polymer addition)
- Water capping over MFT in end pit lakes
- Freeze-thaw evaporative drying
- Significant progress, drawbacks for all technologies
- Energy Resources Conservation Board (ERCB)
Directive 74 – stabilizes the amount of fluid tailings by 2013 – tailings ponds will stop growing in size by 2016

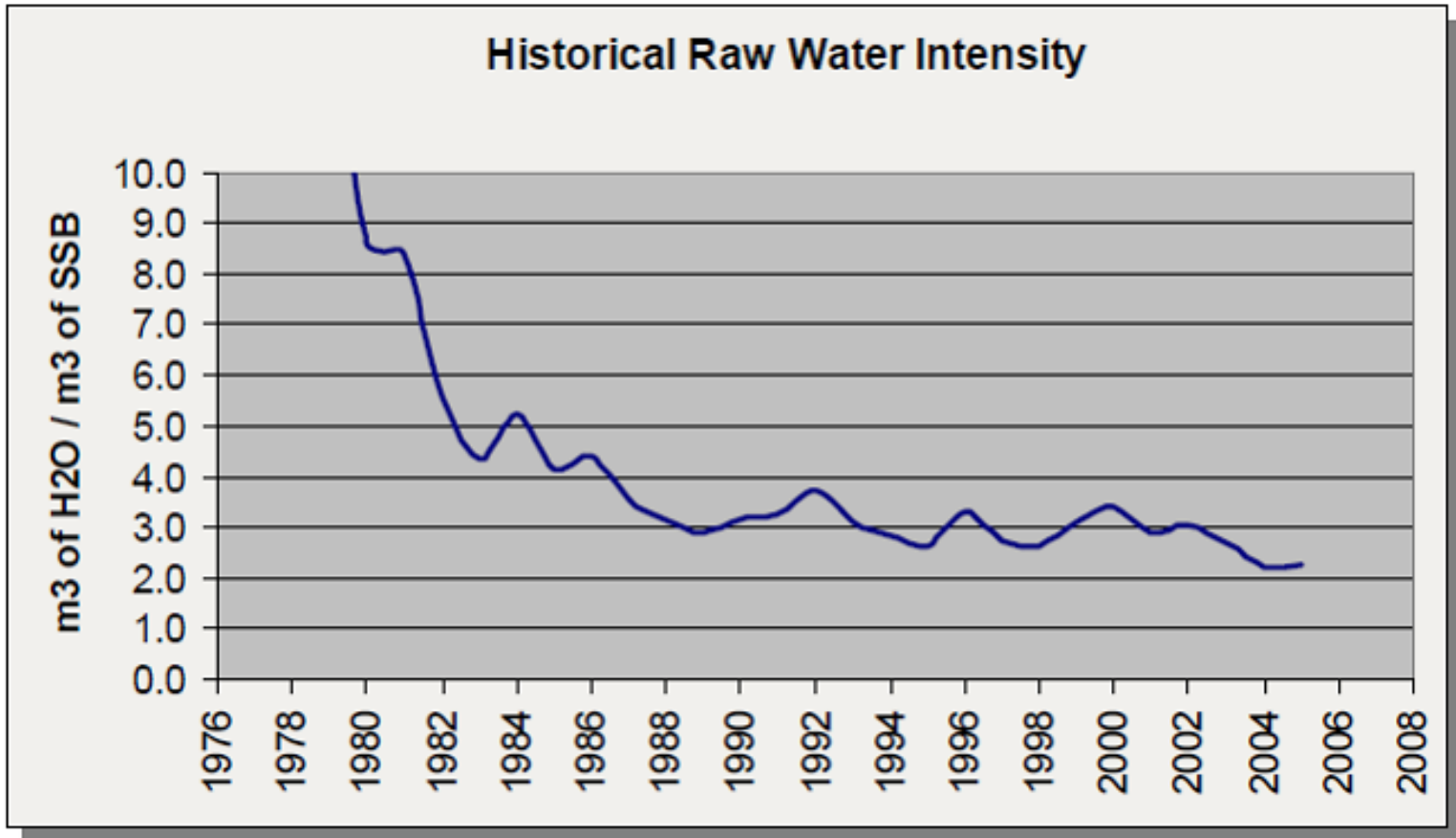


Stabilizing/Reducing Tailings Ponds

- **Myth**: No, or little, oil sands area has been reclaimed
- **Reality**: 67 sq. km of 602 sq. km of disturbed oil sands area has been reclaimed or is undergoing active reclamation – mainly mined areas, but reclamation certificate issued for only 0.1 sq.km.
- **Reality**: Obtaining the reclamation certificate means that control/use of land is returned to the public – no access by company – this is a problem if reclaimed area is in the middle of an active development area
- **Reality**: First tailings pond at Suncor has been reclaimed in 2010 (but the MFT was moved to another pond awaiting dewatering/consolidation treatment)
- **Reality**: All surface mines (not just oil sands) have a tailings pond which enables water re-use (recycle) to occur and reduces the need for use of fresh water



Mining Oil Sands Water Use





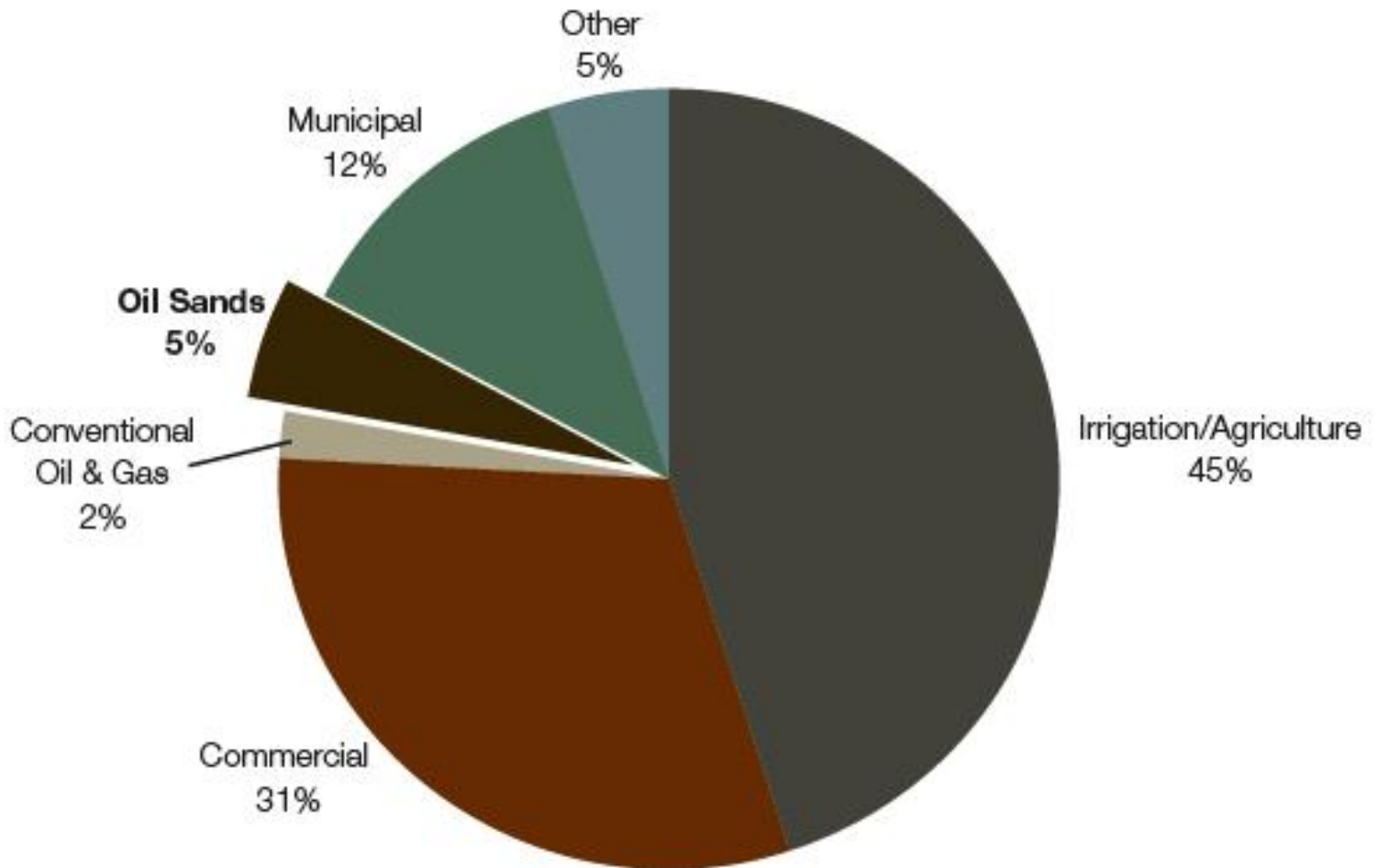
Water Use by Oil Sands

- **Myth**: Energy industry and oil sands in particular are using up Alberta's water supply
- **Reality**: Oil sands have 7% of Alberta's allocations of surface and ground water (in 2009), balance of energy industry has 2%, agriculture has 44%, commercial has 30% – but only 35% of all allocations are used
- **Reality**: Water will become increasingly in short supply, need to further reduce oil sands water use
- **Myth**: The mineable oil sands developments are draining the Athabasca River (AR)
- **Reality**: In winter, Athabasca River water use capped at 5% of low flow, AR is one of the most protected rivers in Alberta (e.g., some other rivers are 100% allocated, but full allocations are not actually used)



Oil Sands Water Use

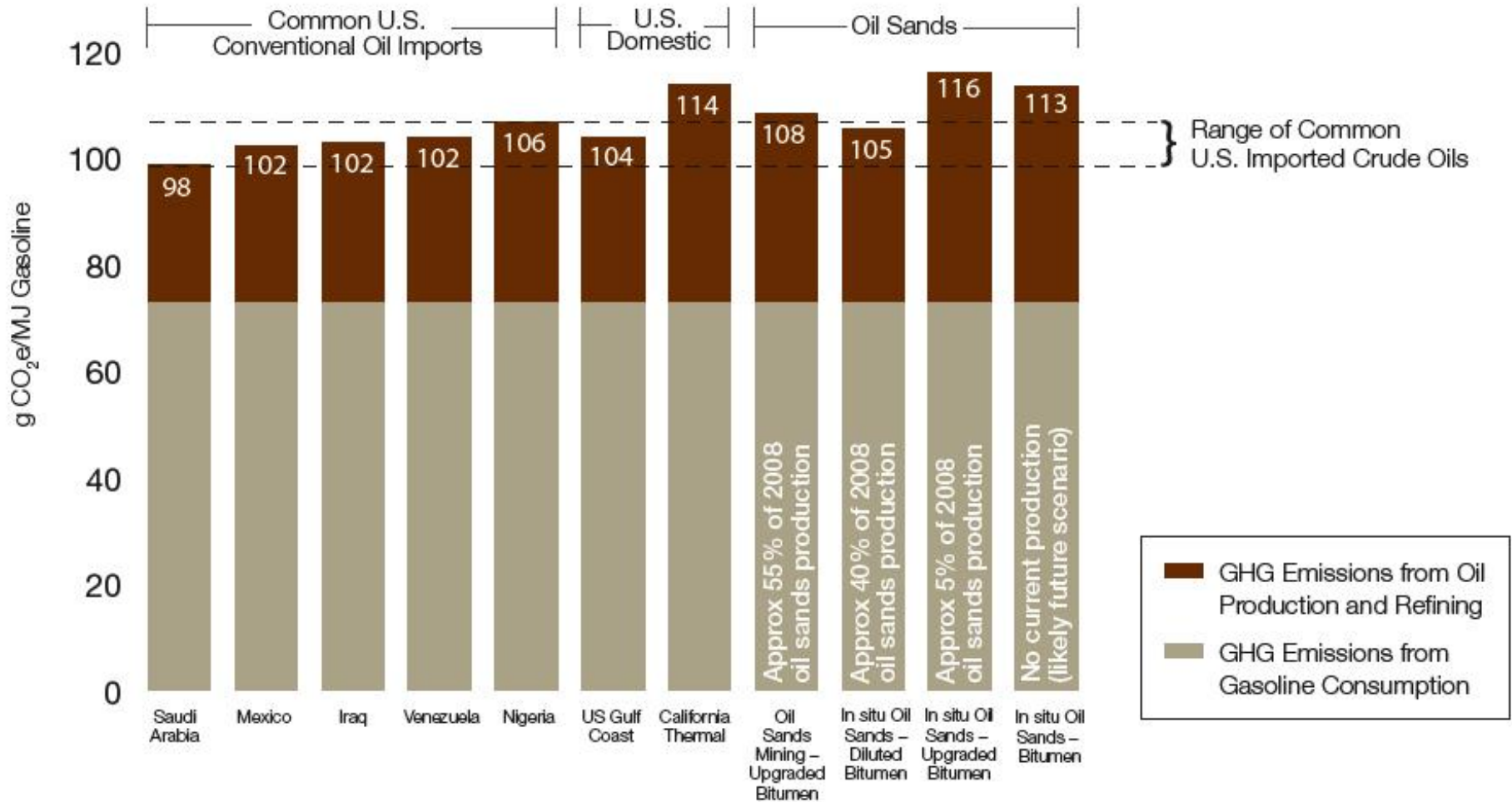
Alberta Water Allocations – 2007



Source: Alberta Environment



Life Cycle (Well to Wheels) GHG Emissions (“Dirty Oil” vs. Role of Consumers?)



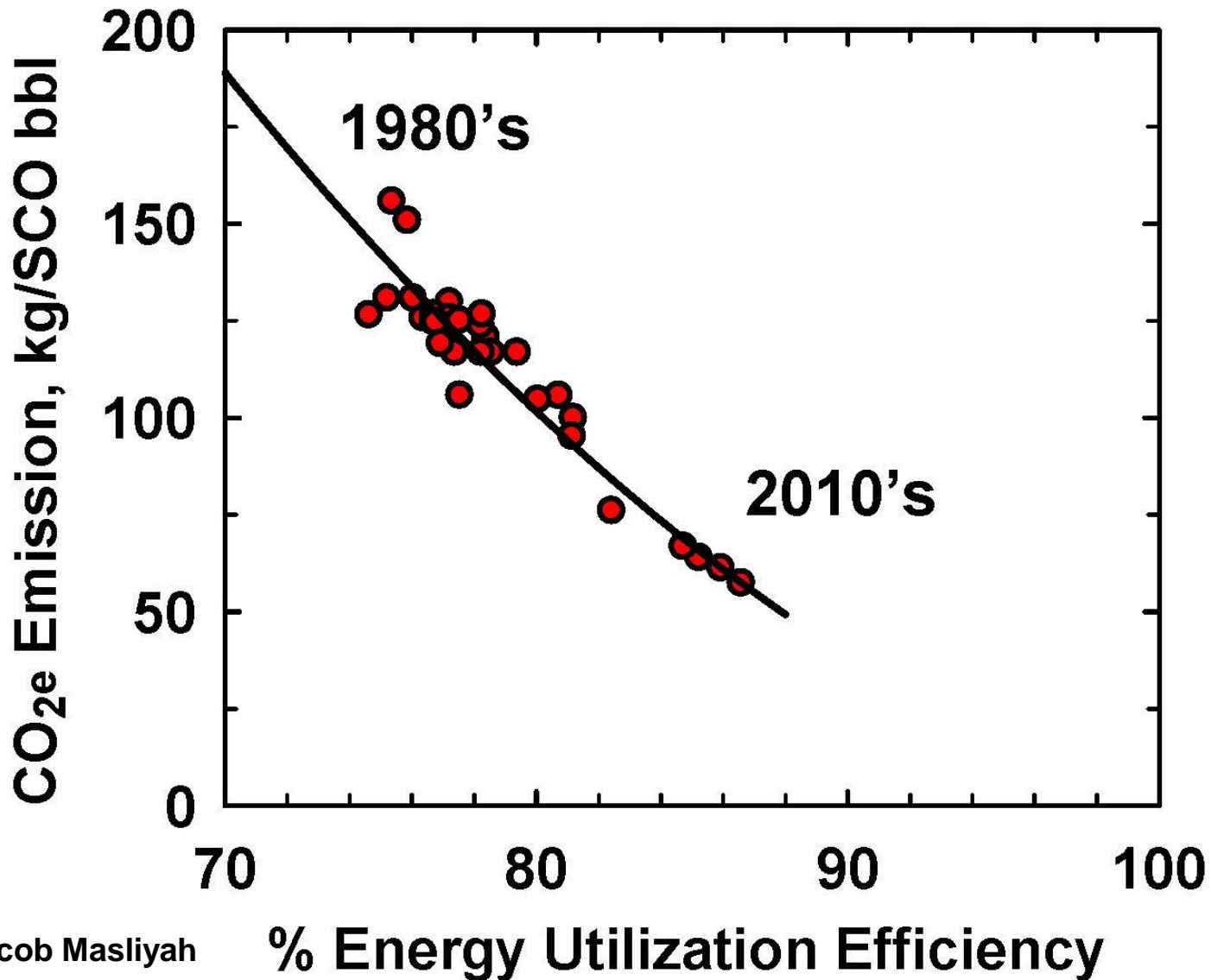
Source: Jacobs Consultancy, Life Cycle Assessment Comparison for North American and Imported Crudes, June 2009



Oil Sands Air Emissions

- **Myth**: Oil sands are the major source of greenhouse gases (GHGs), especially carbon dioxide, for Canada
- **Reality**: Oil sands currently produce approximately 37 Megatonnes/yr of CO₂ out of 246 Mt/y in Alberta and 734 Mt/y in Canada, i.e. 5% (200 Mt/y transportation, 120 Mt/y electricity production, 43 Mt/y homes/residential)
- **Reality**: Oil sands GHG production per barrel has decreased by over 50% since the 1980s
- **Reality**: Oil sands total GHG production has tripled but with a six-fold production increase since 1980s
- **Myth**: Oil sands produce three times as much GHG emissions per barrel as conventional oil
- **Reality**: On a full life cycle basis, oil sands result in 5% to 15% higher GHG emissions relative to typical crude oils

GHG Emissions (Mining & Upgrading)





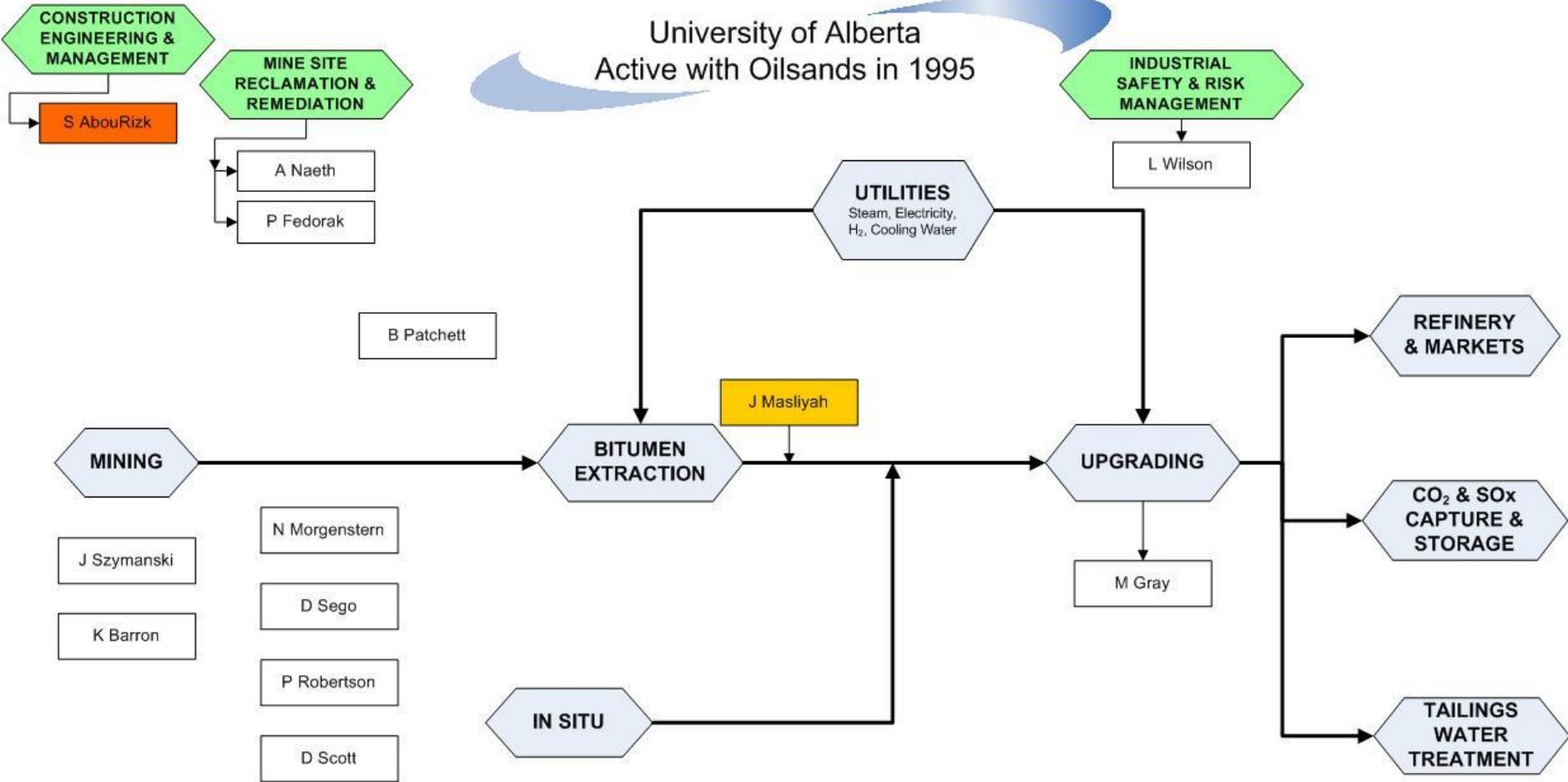
Collaborations with Oil Sands Industry



In response to needs expressed by industry, over the past 15 years the University of Alberta has hired faculty and established Centres & Chairs focused on:

- environmental footprint (land, water, air, CCS, non-aqueous extraction, remediation/reclamation, etc.)
- extraction/mineral processing
- upgrading processes
- control of operations/processes
- safety and risk management
- construction engineering and management
- welding and joining

University of Alberta Active with Oilsands in 1995



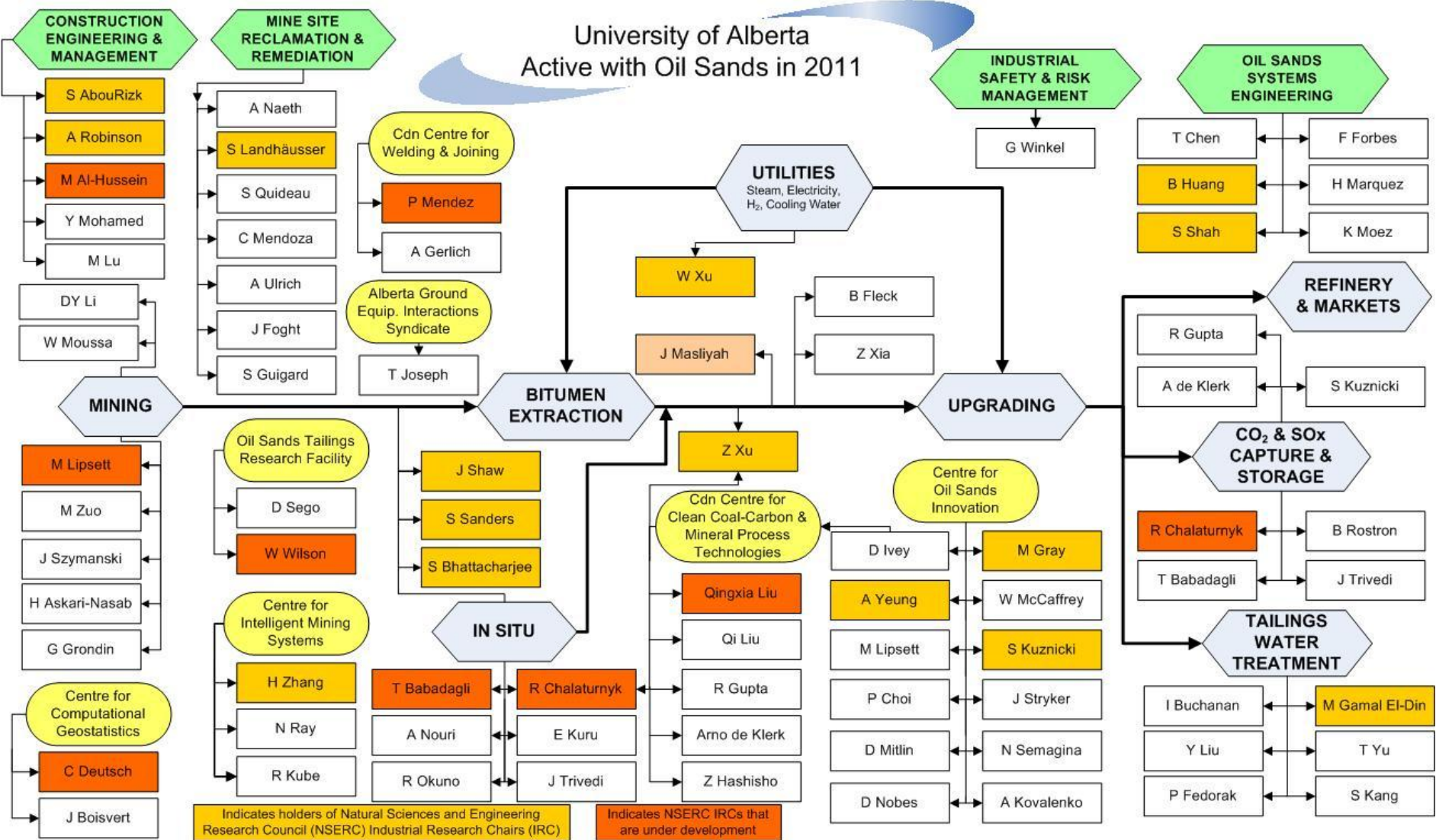
Indicates holders of Natural Sciences and Engineering Research Council (NSERC) Industrial Research Chairs (IRC)

Indicates NSERC IRCs that are under development



Oil Sands Innovation at U. Alberta in 2011

University of Alberta
Active with Oil Sands in 2011





Centres, Chairs and Programs



- **7 Centres and Major Facilities** (oil sands innovation, clean coal/carbon and mineral process technologies, oil sands tailings research facility, welding & joining, surface engineering and science, etc.)
- **15 NSERC Industrial Research Chairs** (focused on natural resource industry needs – aqueous and non-aqueous extraction, upgrading, multiphase pipeline transport, separations, petroleum thermodynamics, construction engineering, in situ water use, etc.)
- **8 additional NSERC Industrial Research Chairs** under advanced development (mine waste management, CCS, heavy oil/bitumen from carbonates, reliability of oil sands processes, mineral process, welding, geostatistics, etc.)



Development, Demonstration, Deployment



- All oil sands mining companies, and also many in situ producers, are supporting research at the University of Alberta across the full range of the oil sands process flow diagram - >70 faculty, >800 researchers at U of Alberta
- Many technology suppliers and materials suppliers are also supporting these research programs
- Several new technologies and technology improvements have moved from the research labs to commercial use
- Research has often been conducted as part of a consortium with provincial/federal matching of industry support resulting in very high leverage for each partner
- Faculty of Engineering at University of Alberta is working with industry and government to enhance the social, environmental & economic sustainability of the oil sands



Invention, Innovation, Industry Cycle



- Development and breakthroughs in oil sands production have involved long time lines for industrial implementation
- Mineable oil sands – hiring of Dr. Karl Clark (1920) by the University of Alberta and creation of the Alberta Research Council (1921) on the UofA campus leading to the first major commercial facility in 1967 (GCOS/Suncor), then 1978 (Syncrude), 2003 (Albian), 2009 (Canadian Natural)
- In situ technology – Imperial Oil (Dr. Roger Butler, 1969) and AOSTRA (1974) resulting in SAGD processes commercially applied in 2001 (Gov't-Industry-Univ.), now many implementations (but not without many challenges)
- Many recent improvements (hydrotransport, consolidated tailings, etc.) have involved long development timelines



In Situ Research and Development



- Focus on major reductions in use of water, increasing recycle of water, use of brackish/saline water, goal of zero liquid discharge
- Water purification and treatment technologies
- Use of mining tailings pond water for SAGD
- Combined use of solvents and steam
- Caprock integrity issues/risk for high pressure underground steam chambers explosive release
- In situ combustion approaches
- Electrical heating of bitumen deposits (both for deposits in sand and in carbonates)



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 - Natural Resources Canada