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**Overview**

-- Crude Quality Inc volunteered at the NPRA 2007 Q&A and Technology Forum to provide some insight into production techniques, regions, and development for the Western Canadian Sedimentary Basin (WCSB)

-- there is not a significant amount of detail with respect to crude quality specifics in the presentation

-- this will be a bit of a “hard hat” tour, but hopefully we can convey some basic knowledge of WCSB production, from which more specific questions and/or concerns can be addressed

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# Principal Geology

- Predominant Geology
  - PreCambrian Shield
  - Rockies, et al thrust zones
  - Western Canadian Sedimentary Basin (WCSB)
- Four Provinces, Two Territories
  - All have hydrocarbon reserves

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**Geology**

-- provincial boundaries overlay the predominant geological formations in the region

-- main features include the PreCambrian Shield (a hard rock, mineralized region in the green section in the northeast), the Rocky Mountain thrust zones (a limestone/shale region depicted by the orange strips to the west of the red zone), and the Western Canadian Sedimentary Basin (the red zone, and the home of western Canada's oil and gas reserves)

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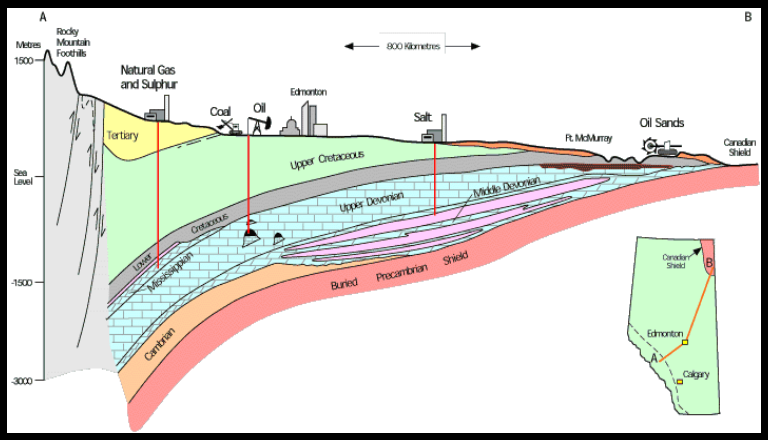
# Alberta – Subterranean Cross Section

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**Subterranean Cross Section**

-- this profile runs from the Rockies in the west (the gray zone on the left) to the exposed PreCambrian Shield in the northeast)

-- basically one long sweeping syncline running from southwest to northeast

-- moving from left to right on the diagram, close to the Rockies are the deep gas zones

-- oil and medium depth gas are located in “reefs” that are postulated to have been very similar to the Great Barrier Reef of Australia

-- shallow gas and heavy oil are found at slightly shallower depths to the “right” of the city of Edmonton

-- bitumen reserves (noted in brown) are at or near the surface in the northeast

-- though not exactly scientifically correct, it is easy to think of the hydrocarbon reserves being covered by a “porous cap rock”, and where the cap rock is thick the light ends have remained in the formation, whereas where the cap rock is thin or missing the light ends have evaporated from the petroleum reserves

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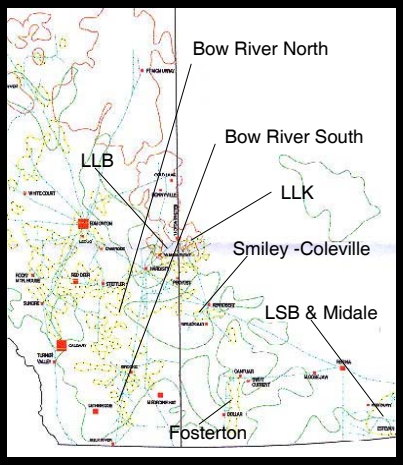
# Western Canadian Sedimentary Basin (WCSB)

- Heavy Conventional
- Medium Conventional
- Light Conventional
- Bitumen regions
  - Cold Lake
  - Athabasca
  - Wabasca
  - Peace River

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**WCSB Pools**

-- though this is a hard to read map, it does convey the conventional and non-conventional production areas in the WCSB

-- the non-conventional, bitumen based zones are noted with brown lines in the mid center of the map (Cold Lake), the upper center (Athabasca and Wabasca) and upper left (Peace River)

-- conventional production zones are noted in yellow lines

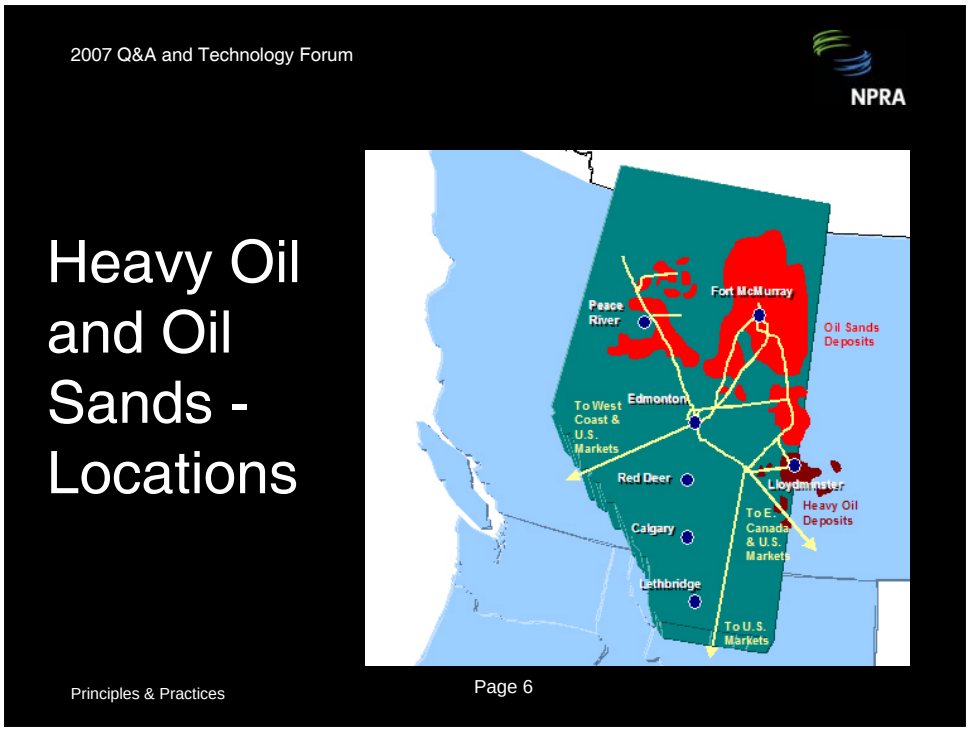
-- note that specific crudes are produced in specific zones, for example

-- Fosterton only comes from the one pool located in southwestern Saskatchewan

-- LSB and Midale come from southeastern Saskatchewan

-- LLK and LLB, though very similar in name and basic quality, are produced from different, though proximate, geological pools (therein close but not the same)

-- similarly Bow River North and Bow River South are produced from different regions and have slightly different quality characteristics

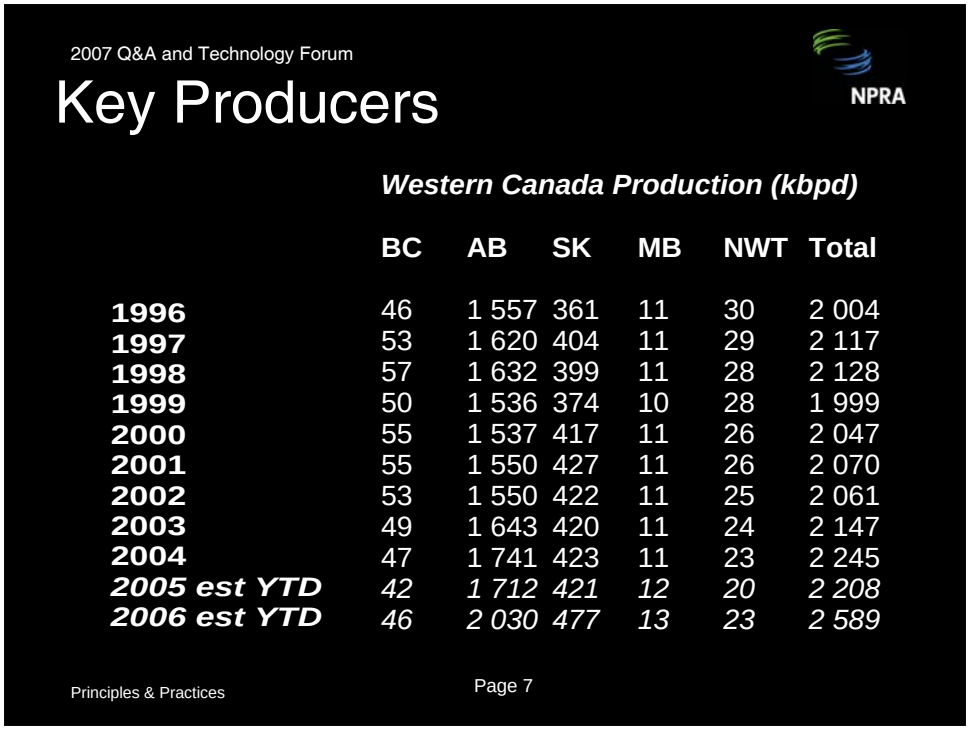



**Heavy Oil and Oil Sands**

-- if nothing else, please leave the room knowing that heavy oil refers to heavy conventional production, and that oil sands refers to bitumen production, and that they are not the same

-- produced from different zones, using different techniques

-- to repeat, heavy oil and bitumen are NOT the same




**Key Producers**

-- some statistics

-- important notes are that Alberta is responsible for about 80% of the WCSB production, and that total production has increased by 500 kbpd in the past decade

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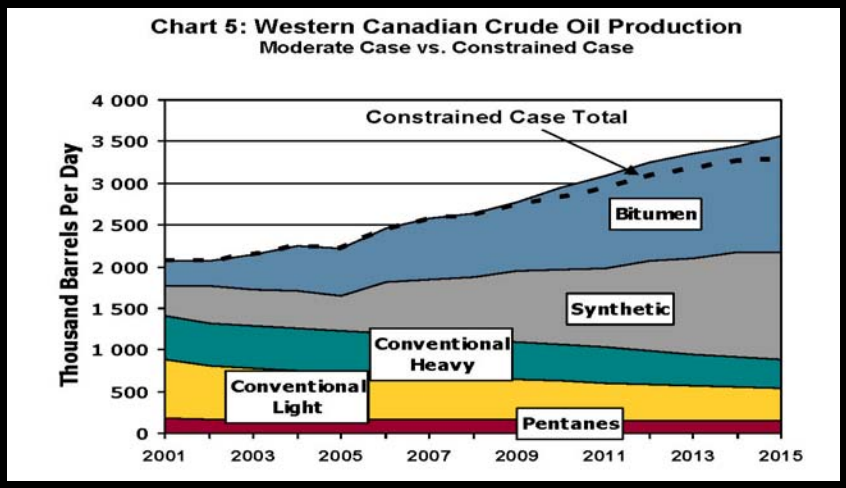
# WCSB Production Estimates

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**Production Estimates**

-- key points in this chart are that

-- conventional light includes conventional medium

-- pentanes production is projected flat forever

-- conventional production is predicted to decline

-- make up volumes and future growth are in synthetic and bitumen production, both of which are bitumen based, non-conventionally produced products

-- Canadian language lesson

-- we don't really call them pentanes, we call them diluent which we abbreviate as "dil"

-- we shorten synthetic to "syn", and synthetic, in Canadian, means "a blend of naphtha, distillate and gas oils containing NO fraction boiling above 1000 degrees F" -- synthetic is bottomless crude

-- we abbreviate bitumen as "bit"

-- being Canadian, we tend to blend things, to make dil-bit, syn-bit, dil-syn-bit, and (wait for it!!) dil-syn-bit crude

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# Production Techniques

- Conventional
  - Natural gas, light, medium, heavy crudes
  - Traditional drill a hole, mount a pump (if needed), connect a pipeline to a battery
- Non-conventional
  - Cyclic Steam Stimulation (CSS)
  - Steam Assisted Gravity Drainage (SAGD)
  - Vapour Extraction (VapEx)
  - Mining
  - Upgrading (full and partial)
  - Coal Bed Methane (CBM)

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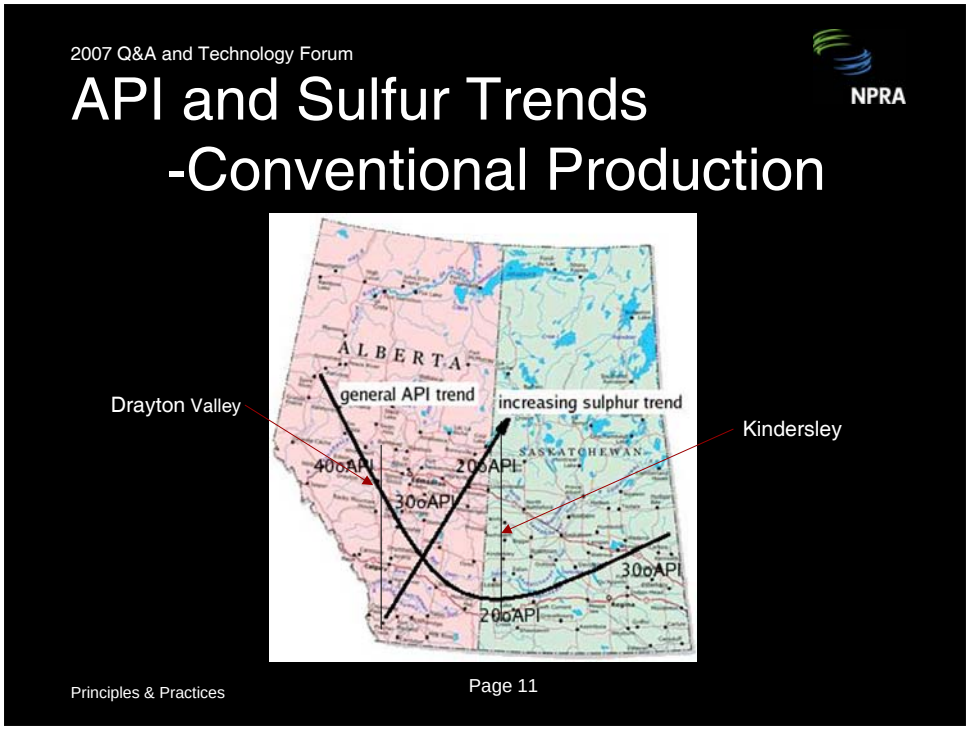
# Conventional Production Methods

- Natural gas, light, medium, heavy crudes
- Production Methods
  - Largely dependent on formation pressure, porosity, permeability, viscosity of the fluids and age of well
- "Pull" techniques
  - Reciprocating pumps (pump jacks)
  - Rotary pumps (vane submersibles, positive displacement)
- "Push" techniques
    - Water flood, gas/solvent flood, steam flood




**Guidelines for Production Quality**

-- this is an attempt to roughly predict the general quality of WCSB crudes

-- slide a vertical line across the map and the trendlines to the location of the crude production zone

-- estimate the API gravity and sulfur from where the vertical bar crosses the trendlines

-- the sulfur trendline runs from <0.5 to 3.0

-- by way of example, crude produced from Kindersley, Saskatchewan will be 20API and 3 percent sulfur, whereas crude from Drayton Valley Alberta is 38API and <0.5 sulfur

-- TAN levels in conventional crudes are always less than 0.5. TAN values over 1.0 only occur in bitumen (oil sands) production.

-- metals, salt, and sediment tend to track the inverse of the API gravity

PS. yours truly made this up, you will not find it anywhere other than in this presentation, and it only applies to conventional production


**Some Pictures**

-- scenic Rockies in the background of a tall rig ==> drilling for deep gas

-- standard pump jack in upper left corner

-- heavy oil pump jack and lease to the left of standard pump jack

-- length of the pump stroke and number of strokes per minute are directly proportional to the API of the crude (standard pump jack is about a 30 – 34API, and heavy oil is a 20API version)

-- while light and medium production will very seldom have a field tank, heavy conventional production will 99+% of the time have an insulated black field tank (to capture and retain heat) with a heater vent stack (to make heat) close to the well

-- heavy production is gathered from field tanks by trucks and brought to a central treater facility (big horizontal treaters with big firetubes -- lots of heat, lots of time, lots of demulsifier)

-- though it may look like molasses, heavy crude production does flow at production temperatures (bitumen does NOT flow at formation temperatures)

-- advances in directional drilling and the use of positive displacement pumps are replacing vertical drilling and pump jack techniques -- rotary positive displacement is the pump jack of the future!!

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# Non-Conventional Production

- Coal Bed Methane (CBM)
- Mining
- Cyclic Steam Stimulation (CSS)
- Steam Assisted Gravity Drainage (SAGD)
- Vapour Extraction (VapEx)
- THAI (Toe to Heel Air Injection)
- Upgrading (full and partial)


**Some Pictures**

-- it all started in 1967 with the Great Canadian Oil Sands Project (GCOS) using monster sized bucket wheel excavators to mine the bitumen reserves just north of  Fort McMurray, Alberta (the bucket wheels have been retired to the Oil Sands Museum)

-- modern day operations are all truck and shovel

-- those little Tonka trucks beside the shovels are 375 and 400 tonners, about 25 feet high, 687 tons dry, 3550HP, capable of 42 mph. The electric Bucyrus rope shovel is seven stories tall, and it moves 100 tons in each scoop. The smaller, more nimble O&K has twin 2200HP 3516 Cat's powering 5000 psi hydraulics capable of 235 tons breakout force and 85 tons per lift. Oil sands mining uses the largest boy toys on the planet.

-- that vertical wall in front of the Bucyrus shovel is the crude bitumen reservoir (aka the oil sands, and a good thing for the mine that bitumen does not flow at formation temperatures)

-- CSS production uses pump jacks since the bitumen is produced from deeper reservoirs

-- SAGD, the newest recovery method, uses the dual horizontal well technique

-- some facilities are planned combinations of SAGD and mining

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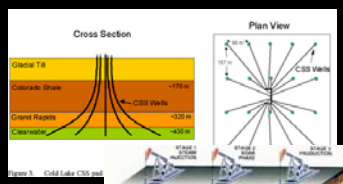
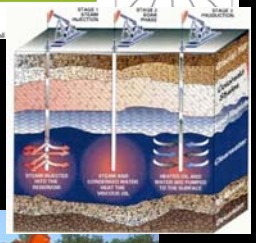
# Cyclic Steam Stimulation (CSS)

- Cold Lake bitumen production
- Production zones are deeper than in SAGD and mining operations
- Inject steam into zone, then allow heat to diffuse into formation
- Move in pump jacks and start production





**Cyclic Steam Stimulation**

-- CSS involves the use of directional or whipstock wells to drill a number of wells into the producing formation

-- steam is injected into the formation for a time period, and then the steam is shut off as the heat is allowed to diffuse into the pay zone

-- a battery of pump jacks are mounted on the wells, and each well is produced individually as part of a “pad” or “pod” of wells

-- typically multiple “pods” are involved, some on injection, some on diffusion, some on production modes of the cycle

-- multiple steam/diffusion/production cycles are used on a single “pod” to improve overall recovery of the bitumen reserves

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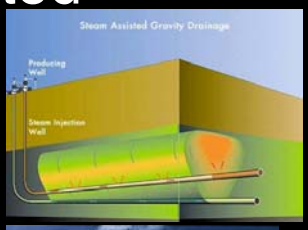
# SAGD (Steam Assisted Gravity Drainage)

- Series of horizontal wells (upper and lower)
- Steam is applied to upper well, formation is heated
- Bitumen and condensed steam produced from lower well
- Unlike CSS, heating and production are simultaneous

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**Steam Assisted Gravity Drainage**

-- two horizontal wells are bored through the pay zone

-- upper well is used for steam injection, lower well is production well

-- steam condensate and heated bitumen are recovered from the reservoir

-- steaming and production take place simultaneously, unlike CSS

-- significant investment in steam production

-- equally significant investment in water recovery, reuse and heat recovery

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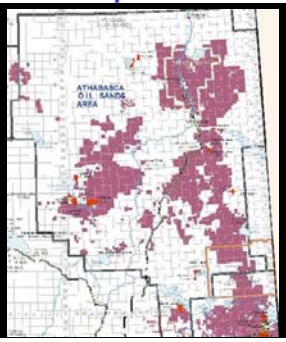
# Mining

- Driven by standard strip ratio, recovery economics
- All operations are now truck and shovel
- Bitumen production is fully or partially upgraded
- Current mining economics do have geographical limits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**Mining**

-- map of Fort McMurray to Fort Mackay showing involvement of many companies in the Athabasca oil sands area

-- mining operations are typically closer to the Athabasca River, while SAGD is more predominant further from the river

-- of all the oil sands leases in the province, only those in the enclosed northeastern most zone are currently economical to mine using today's crude prices and mining costs


**Upgrading**

-- I sometimes call upgrading GNINIFER, because it's really just refining in reverse

-- last unit on a crude mainline in the refinery is the coker, hydrocracker, visbreaker, LC finer, ebullated bed cracker, it's up front in an upgrader

-- take the product fractions and "deform" them (ring opening catalysts), hydrotreat the fractions, recombine them in the crude unit (we call it the blending manifold), then back into the crude tanks -- done.

-- upgrading typically done with delayed or fluid cokers, steam methane reformers providing hydrogen for hydrotreating

-- product is synthetic crude, a 36API, <0.25 wt% sulfur, bottomless barrel (no 1000°F+ components)

-- hydroocrackers are used instead of cokers in some facilities, HGO ring opening conversion new to the marketplace

-- supply shortage and higher prices for natural gas will drive bitumen gasification for hydrogen production

-- availability of bitumen and pipeline access will provide offsite, arm's length market upgraders with opportunities to produce synthetic crudes

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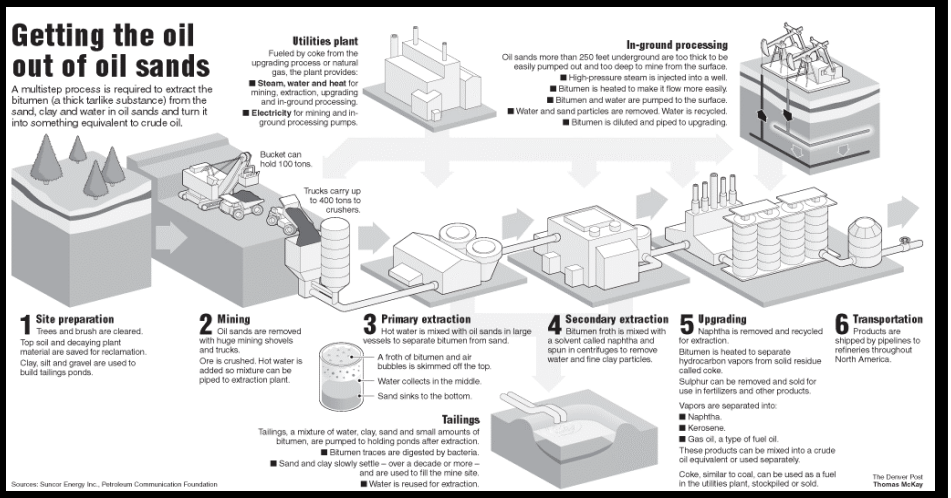
# Upgrading Mined Oil Sands






**The Basic Process**

-- details in the diagram

-- oil sands facilities should not be confused with refineries, these are mining operations

-- the hard rock parallel is pit to breaker to milling/concentrator (froth units) to dewatering to the smelter

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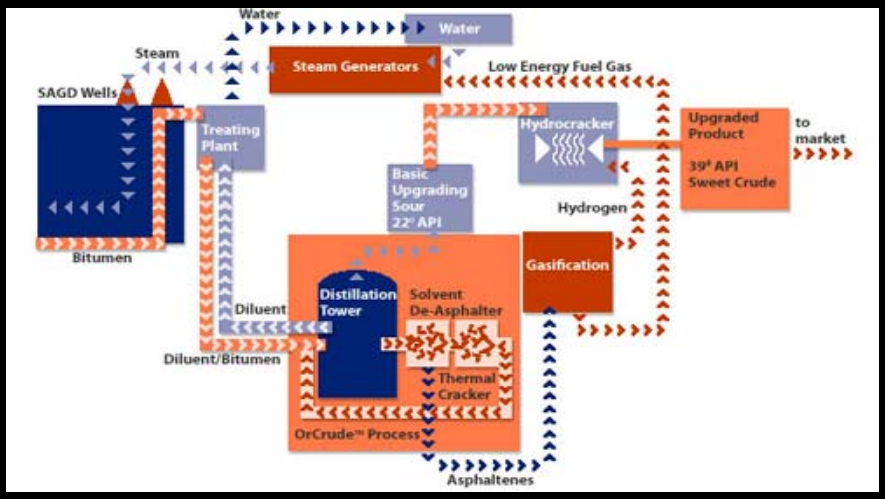
# Upgrading – New Version(s)






New Processes

-- above is from Nexen OPTI's Long Lake Project (www.longlake.ca)

-- note inclusion of gasification for hydrogen production

-- note use of deasphalting and partial upgrading in advance of hydrocracking

-- SAGD production operation, so notice emphasis on water/steam recovery and reuse

-- end product is light sweet synthetic crude

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# WCSB Product Quality

- Products
  - Conventional light, medium, heavy
  - Non-conventional dilbit, synbit, synthetic
  - Custom blended products
- Conventional streams should remain consistent into future though volumes are predicted to decrease
- Non-conventional streams will attempt to develop market differentiation (SSB→SSP, $OS_n$)
- Light/ heavy spread will determine upgrading versus direct-to-dilbit decisions

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# Q & A

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Crude Quality Inc.