

Final Report To PTAC Collaboration Group On 2013 and 2015 Surveys

November 2015



Sky Hunter Corporation

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PTAC statement:

The operators reviewed information, there is more to be done. The operators did indicate there is a relationship between Sky Hunter readings and formation thickness.



20 November 2015

Sky Hunter thanks Petroleum Technology Alliance Canada (PTAC) for their funding and management of this collaboration.

In addition, Sky Hunter thanks PTAC for its 2014 SME Commercialization Award.

The GeoViz Project in conjunction with VizworX forms a portion of this project.

We also want to thank the following for their funding, input and participation:

LOOKNorth

Remote Sensing innovation for responsible, sustainable development of Northern natural resources

Government of Alberta

Enterprise and Advanced Education

The Participating Oil Sands Operators

As this is a collaboration, the project was adjusted by the participants as information was received and evaluated. The time line increase was as a result of Sky Hunter's operational requirements. The recent data sets are undergoing continuing reviews by the project teams.

The introduction of new survey systems to the energy industry takes time and effort by all. We trust the results of this collaboration will lead to effective use of this environmentally friendly, oil and gas reservoir mapping system.

Again, a sincere thank you.

Ken Bradley Co-founder

Russ Duncan Co-founder

Letter To PTAC

Resource to Reserves Areas

These hydrocarbon microseep surveys cover large multi prospect areas with widely spaced flight lines for an exploratory scale overview defining new potentially prospective areas.

250 m Line Spacing **Yellow**

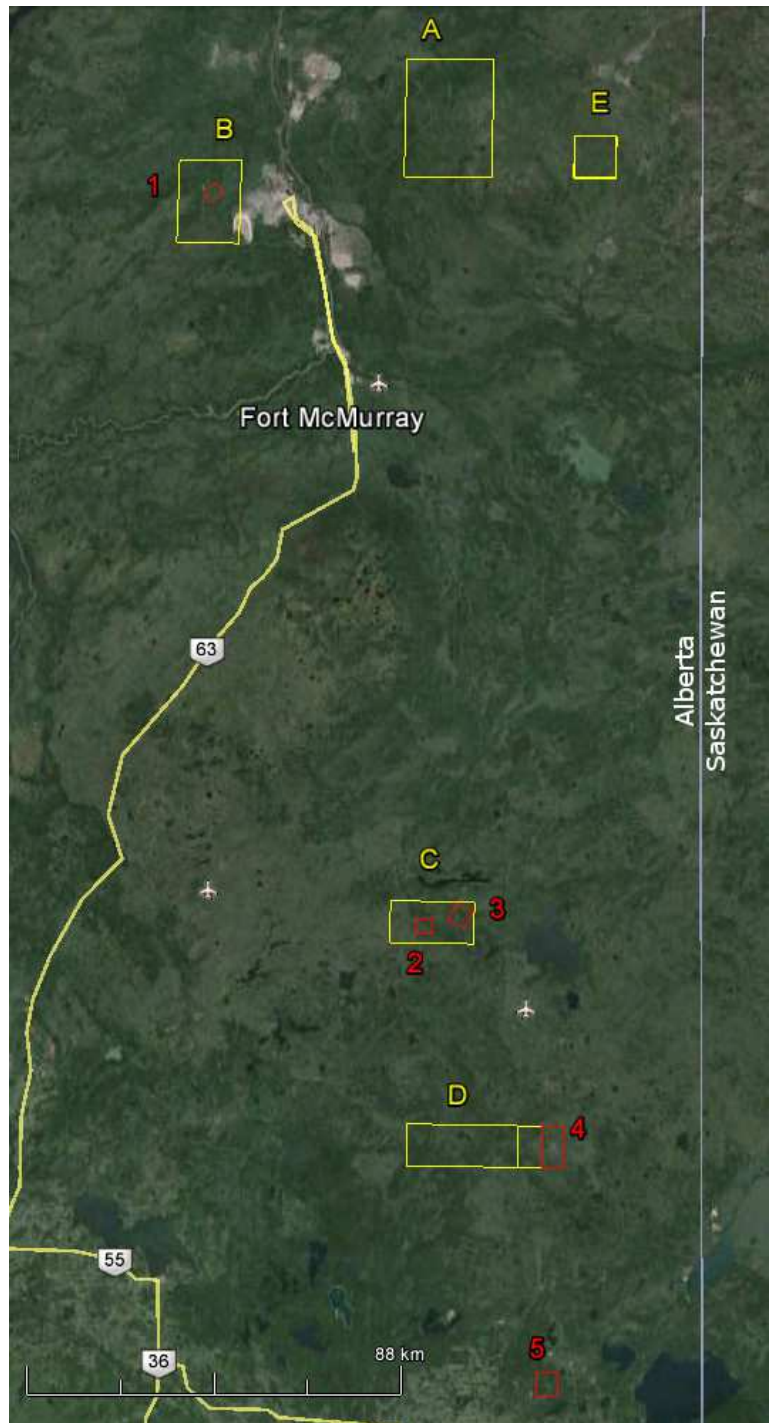
Project	Dates
A	Aug 2013
B	Aug 2013
C	Aug 2013
D	Sep 2013
E	May 2015

Steam Chamber Areas

These surveys have more closely spaced flight lines to highlight detail within existing SAGD projects. Follow-up surveys can be used to monitor changing reservoir conditions within active steam chambers over time, e.g. Jackfish 1.

50 m Line Spacing **Red**

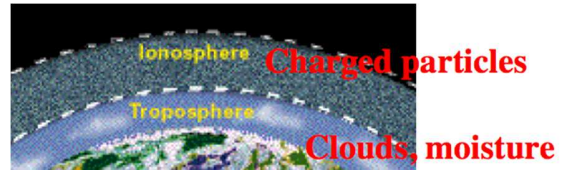
Project	Dates
1	Aug 2013
2	Aug 2013
3	Aug 2013 May 2015
4	Sep 2013
5	Sep 2013



10,585 Total Line Km Flown in 10 Surveys

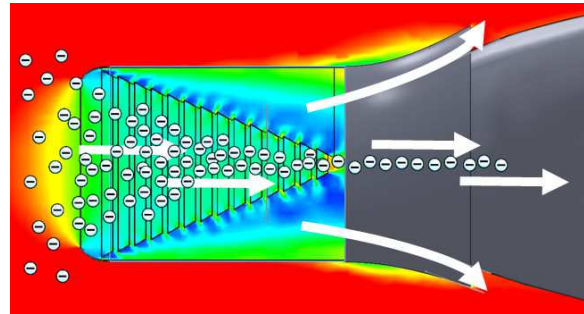
Ionosphere

The Ionosphere (100 km altitude) is positively charged to 500,000 Volts and thus attracts negatively charged hydrocarbon particles emanating above the earth's surface.



Concentration

Sky Hunter's proprietary "Hydrocarbon Nose" concentrates the negatively charged hydrocarbon particles and funnels them to the sensors inside the aircraft. The sensors detect the concentrations of three different suites of hydrocarbons originating from oil and gas reservoirs at depth.

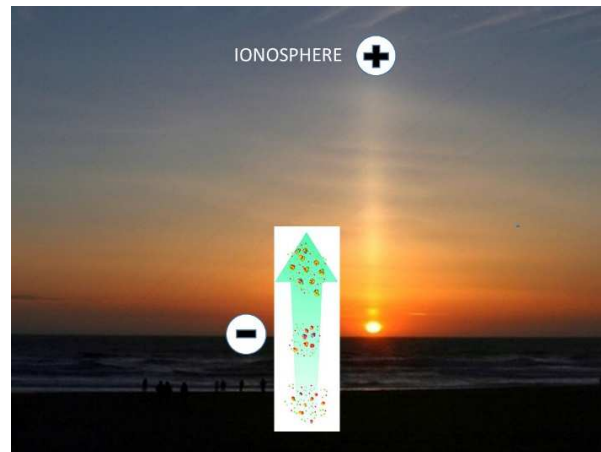


Nucleation



An independent White Paper from the University of Calgary Department of Physics and Astronomy describes and

confirms the mechanism for the creation of negatively charged aerosol particles in the lower atmosphere above hydrocarbon reservoirs. A nucleation process combines the organic hydrocarbon bearing particles with ubiquitous sulphur compounds, resulting in negatively charged particles that then travel upwards towards the Ionosphere.

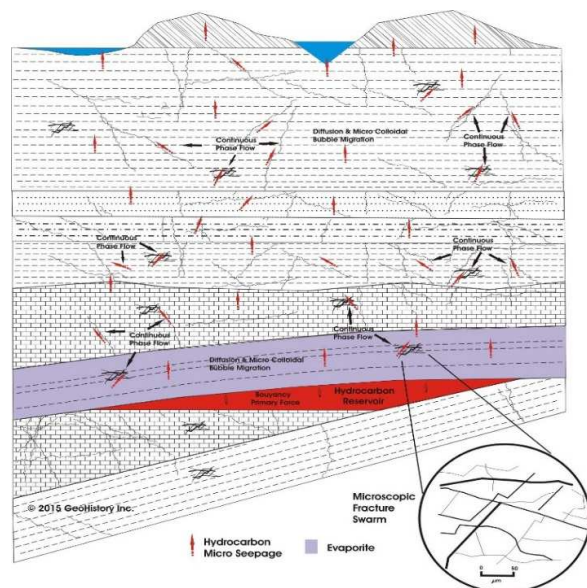


Buoyancy



A second White Paper produced by an independent Geological

Engineer describes the underground processes involved in vertical migration of hydrocarbons to the earth's surface. The primary driving force is the buoyancy of the hydrocarbons.



Hydrocarbons Migrate Vertically From Reservoirs

Aircraft

Aries Aviation owns and operates the aircraft that Sky Hunter utilizes for domestic and international operations.

A custom nose cone concentrates negatively charged hydrocarbon particles.

Sample air is routed to the sensors inside the aircraft.



Sensor System

MacDonald, Dettwiler and Associates (MDA) developed the custom Airborne Hydrocarbon Sensing System from an earlier Sky Hunter prototype.

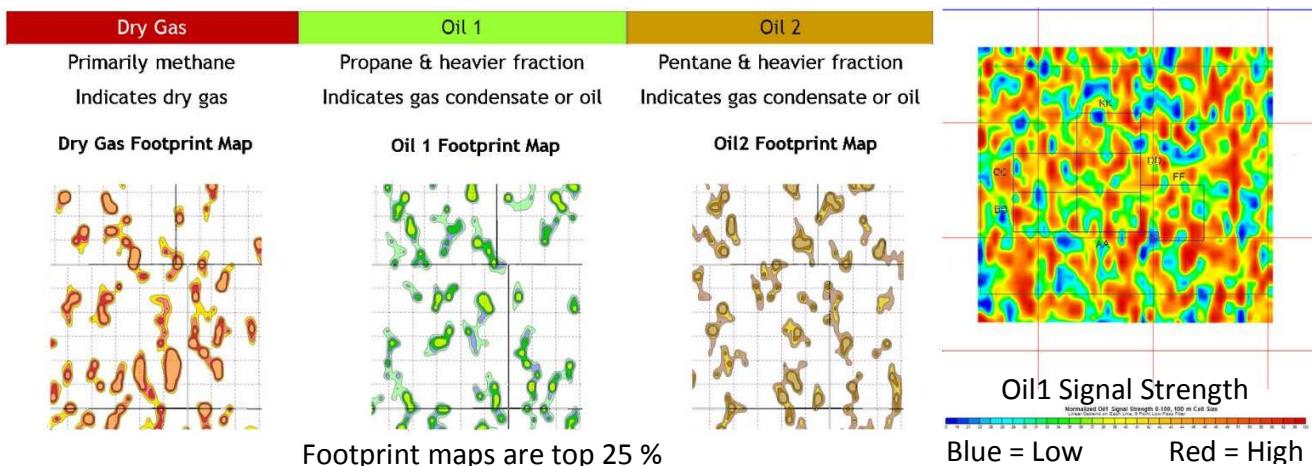
MDA also designed and built the Canadarm used on the Space Shuttle and the International Space Station, as well as RADARSAT.

Processing

Custom algorithms process the data gathered from the sensors to produce maps of gas and oil concentrations.



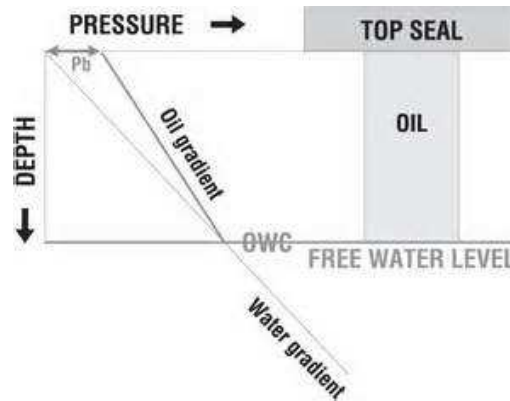
Three Sensors



Sensors Measure Both Oil and Gas Concentrations

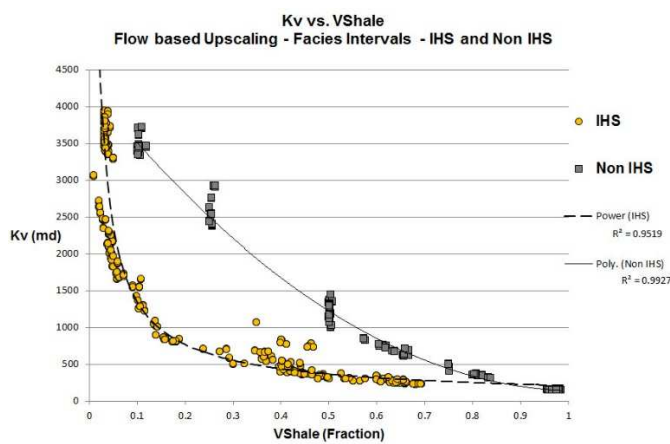
Buoyancy Pressure

Hydrocarbons are generally less dense than water and will tend to rise to the surface. The buoyancy force is proportional to the differential between the oil vs. water pressure gradients with depth.



Vertical Permeability

Clean homogeneous sands have high vertical permeability, resulting in strong microseepage. Increased shale content and shale interbedding reduces vertical permeability and thus microseepage.



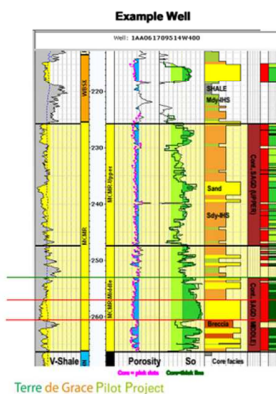
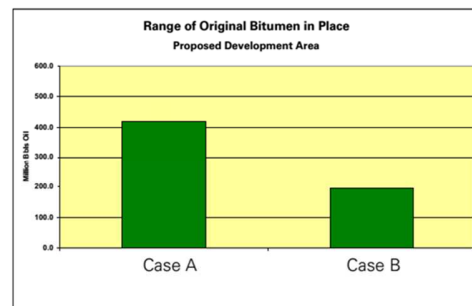
Original Bitumen In Place (OBIP) Estimates

The “SAGD-able” estimate of OBIP can be doubled or halved depending on reservoir cut off parameters.

SAGD-able Pay Definition and Range of Original Bitumen in Place (OBIP)



- OBIP values derived using the following cut-offs:
 - Case A: Vsh < 0.40, porosity >= 27%; So <= 25%; shale barrier <= 3m; h >= 15 m
 - Case B: Vsh < 0.25, porosity >= 30%; So <= 50%; shale barrier <= 1m; h >= 15 m



Terre de Grace Pilot Project

Complex Reservoirs Lead To Variations in Bitumen In Place Estimates

Complex stratigraphy

Ancient river/estuary systems result in inhomogeneous reservoirs, e.g. stacked and breached sand bodies. Oil sands deposits are not contiguous across project areas.



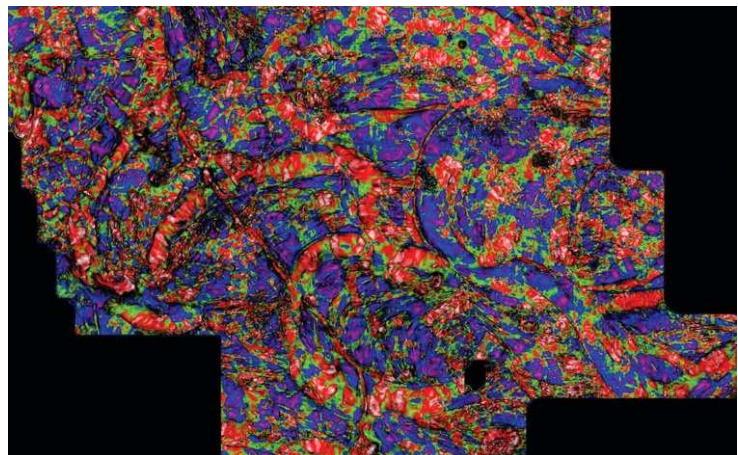
Seismic interpretation

Seismic shows the complexity of reservoirs.

“Nexen Kinosis

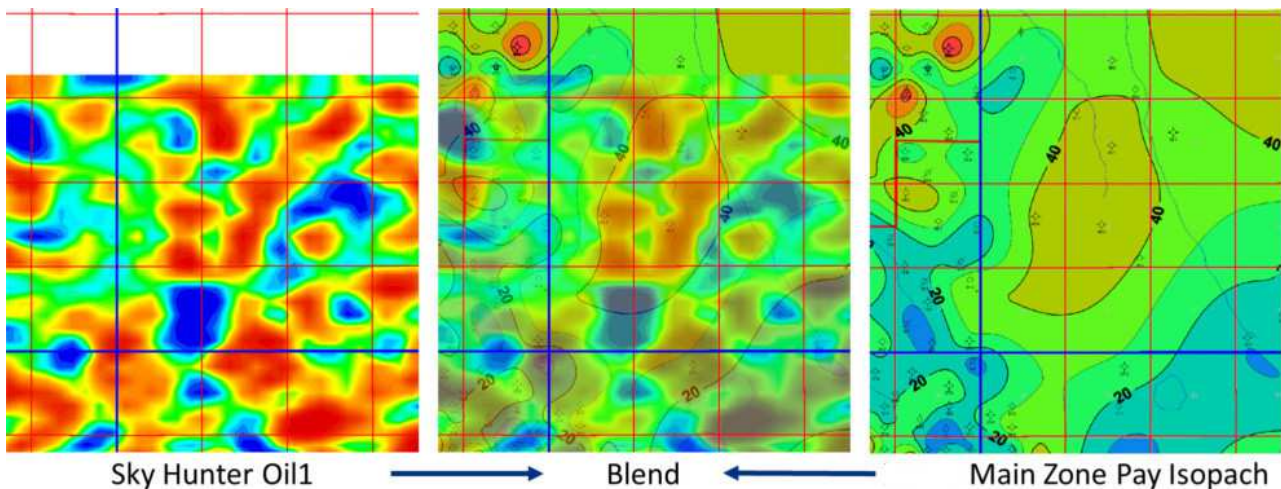
Figure 9. Structural curvature (K shape index).

Assuming differential compaction, blue indicates localized domes, likely sand-filled areas of the channel; red indicates localized bowls, likely mud-filled areas.”



Sky Hunter data supplements traditional O&G mapping

Sky Hunter maps oil directly and has higher data density than typical distribution of stratigraphic wells, resulting in better definition of potential pay zones.



Sky Hunter Data Combined With Seismic Defines Project Locations

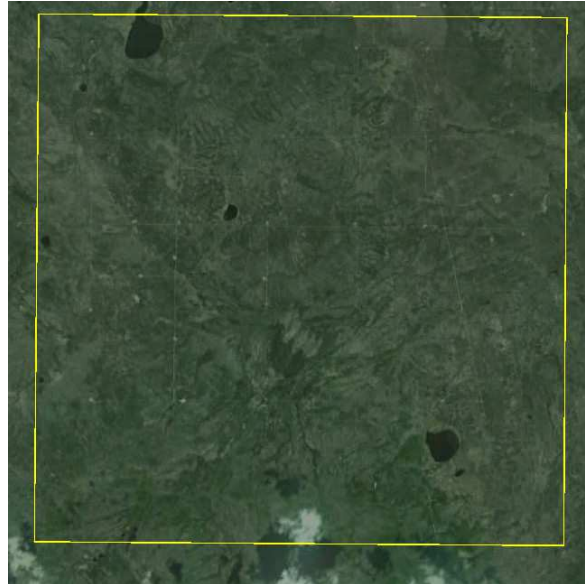
Repeat survey

Resource to Reserves E
Flown May 2015

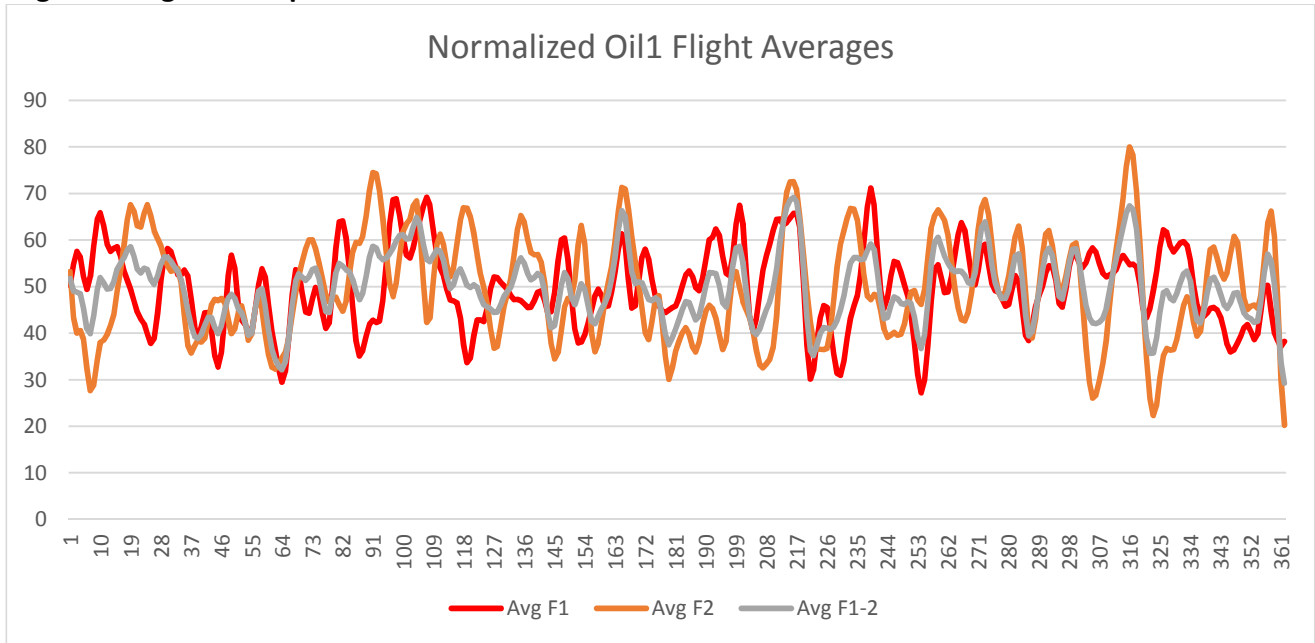
This project area has water over bitumen.

Multiple passes of the same north-south line were averaged together over two flights that were flown several days apart. Results show a good fit over much of the line.

The repeat surveys showed the SE quadrant of this township area had stronger signal than the average.



Flight Averages for Repeat Line

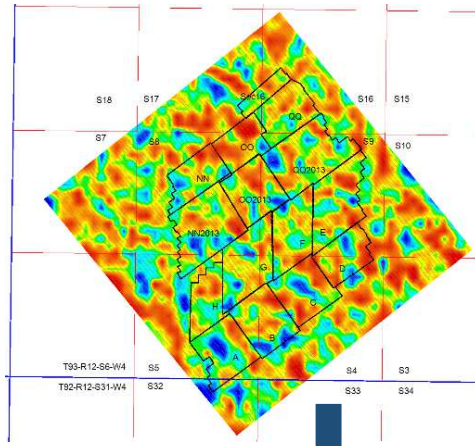
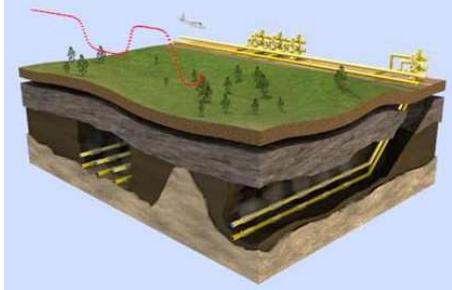


Oil1 Line 320 averages by flight (4 passes per flight)

Flight 1 Flight 2 Flights 1&2

Averaged Data Shows Repeatability

SAGD B 50m
Sky Hunter Oil1 Signal Strength
vs. BIP Estimates



Pad	OBIP 10 ⁶ m ³	Prod 10 ⁶ m ³	RemBIP 10 ⁶ m ³	"Volume"	Signal	Area	Points
				% x ha 1000	%	ha	(50m)
A	2.389	0.904	1.485	2.18	48.2	45.3	259
B	3.319	2.492	0.827	2.55	52.5	48.7	278
C	4.238	3.091	1.147	2.49	55.0	45.3	259
D	2.741	1.766	0.975	1.86	55.3	33.6	192
E	3.728	1.886	1.842	3.03	54.7	55.3	316
F	3.616	1.646	1.97	2.42	52.8	45.9	262
G	4.155	1.505	2.65	3.03	51.7	58.6	335
H	1.756	0.223	1.533	1.66	53.1	31.3	179
NN	4.453	0.400	4.053	5.42	51.6	105.2	601
OO	2.961	0.345	2.616	4.28	56.2	76.3	436
QQ	3.893	0.418	3.475	5.50	52.1	105.5	603
Sec16	0.711	0.108	0.603	0.78	52.4	14.9	85

Point (50m), 35 x 50 = 1,750m²
Point (250m), 35 x 250 = 8,750m²

Sky Hunter "Volume":

To compare the Sky Hunter data signal strength to the Remaining Bitumen in Place, the signal strength has been multiplied by the area of the pad.

The area times the signal strength is the "Volume".

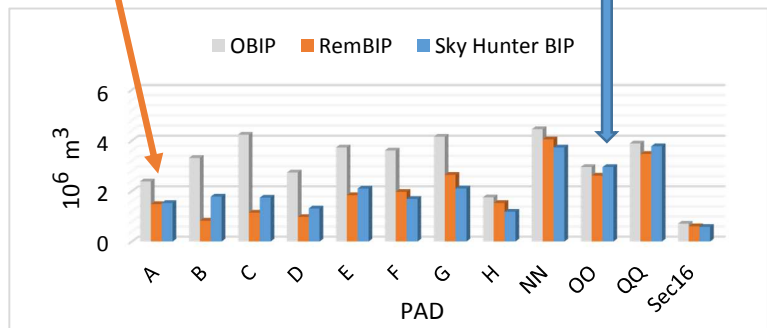
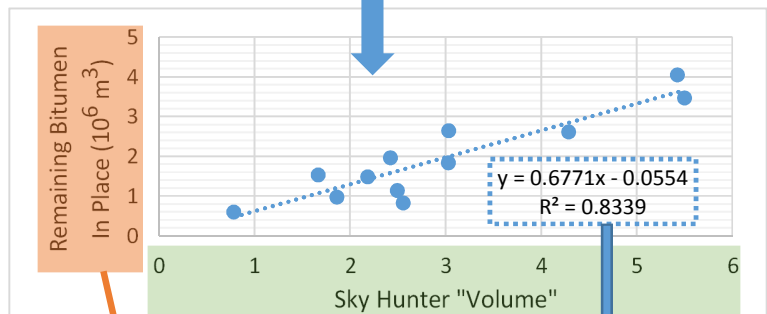
That "Volume" is compared to the Bitumen in Place (volume).

The area based on the number of data points per pad times the area for a 50 meter spacing or 250 meter spacing.

Data points average approximately 35 meters along line.

The product of the area and signal strength is divided by 1000 to provide easy comparison.

83% Correlation between Sky Hunter signal and operator's RBIP estimate is shown in this example.

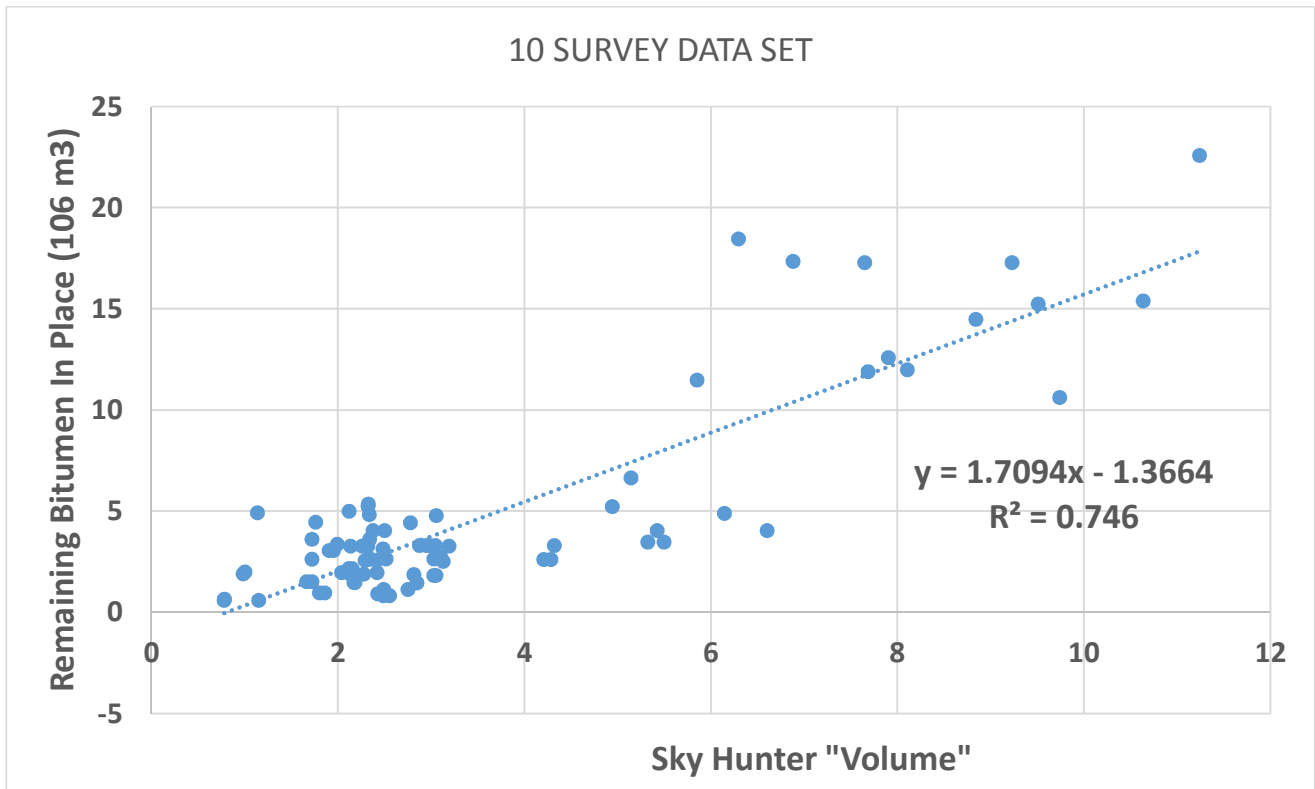


Signal Strength Correlates with Remaining Bitumen In Place

This graph shows the correlation between the estimated Remaining Bitumen in Place by the project operators for each pad and Sky Hunter’s signal strength over that area (“Volume”). The pads with the lowest Remaining Bitumen in Place that have been on production the longest are in the lower left and have a lower signal strength. Pads with larger area are generally in the top right of the plot.

This is a ten survey project summary with a strong correlation of 75%.

**Sky Hunter Oil1 Signal Strength
Vs. Operator RBIP Estimates by SAGD Pad**



Signal Strength Correlates with Remaining Bitumen In Place Over Multiple Projects

Estimating Net Pay from Sky Hunter data

To compare the Sky Hunter data signal strength to the Remaining Bitumen in Place, the signal strength has been multiplied by the area of the pad.

The area times the signal strength is the "Volume".

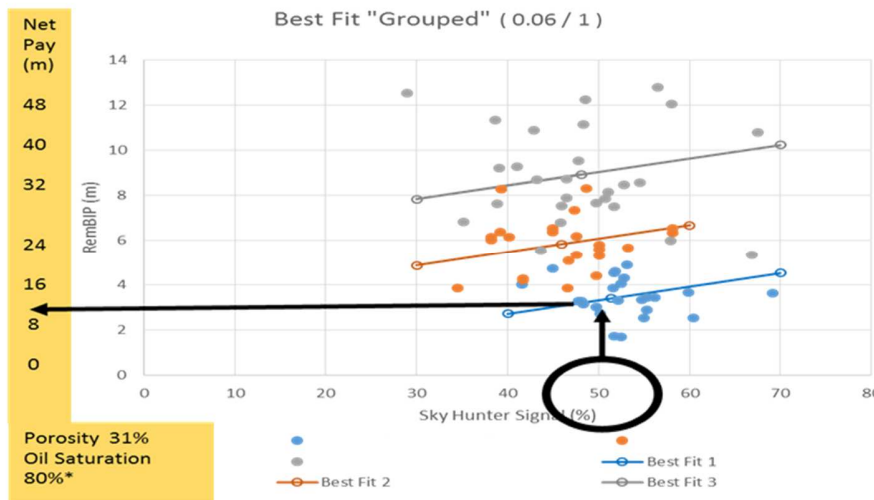
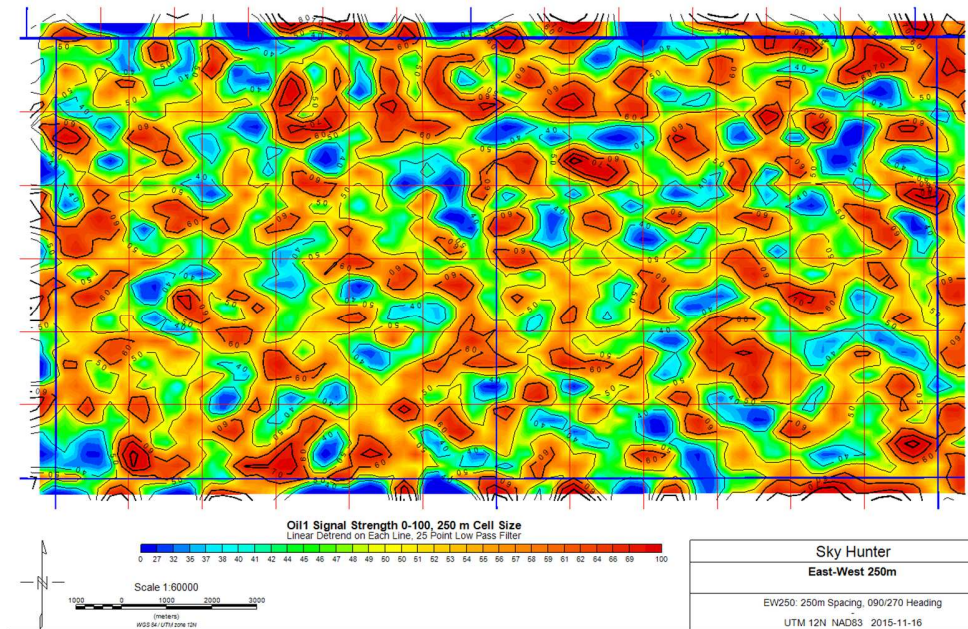
That "Volume" is compared to the Bitumen in Place (volume).

The area based on the number of data points per pad times the area for a 50 meter spacing or 250 meter spacing.

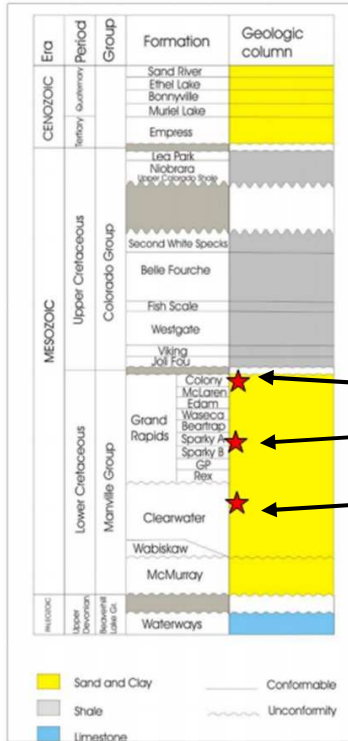
Data points average approximately 35 meters along line.

The product of the area and signal strength is divided by 1000 to provide easy comparison.

Net pay is calculated using meters of oil from Sky Hunter map using area porosity and oil saturation.



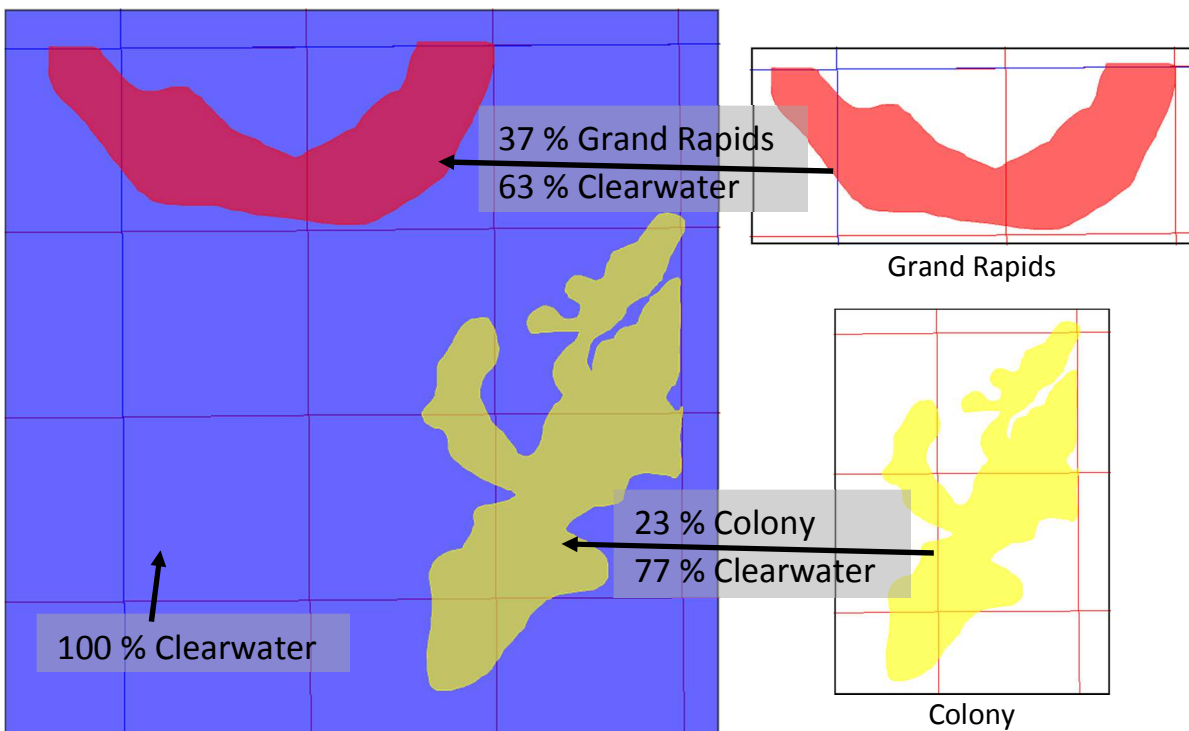
Combine Sky Hunter Data and Reservoir Model to Estimate Net Pay Contours



When two or more oil reservoirs are stacked, the Sky Hunter signal is the sum of these formations. As shown below, where the Grand Rapids and Clearwater are both present, based on average reservoir properties, 37 % of the signal would be from the Grand Rapids and 63 % from the Clearwater.

	Thickness (m)	Porosity (%)	Oil Saturation (%)	Meters of Oil (m)
Colony	10	30	79	2.4
Grand Rapids	30	29	55	4.8
Clearwater	45	31	57	8.0

Colony + Clearwater = 10.4 m of oil
 Grand Rapids + Clearwater = 12.8 m of oil



Sky Hunter Signal Strength Is the Sum of All Stacked zones

Production Profile

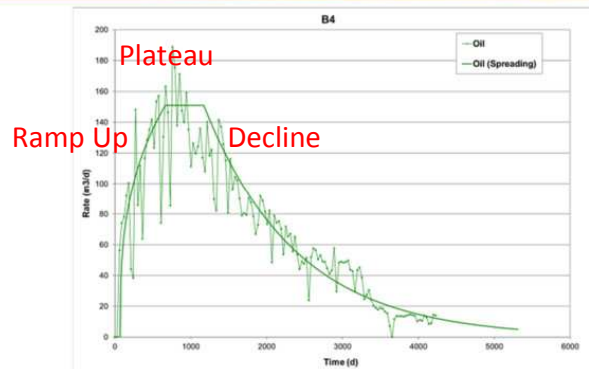
Production for a typical SAGD pad is shown as the Ramp-up, Plateau and Decline. Maximum production occurs at the Plateau when the steam front has reached the top of the bitumen pay.

With constant steam injection:

The “Ramp Up” will take longer and show a lesser signal in thick pay.

The “Plateau” will move more quickly through thinner pay than thicker pay.

Predicting Scheme Performance: SAGD Analytical Model

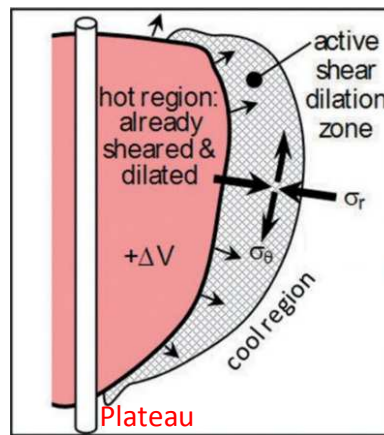


- Analytical model used to match performance history of wells in SAGD mode
- Focus on trend fitting current phase of well's life, not individual points
- Exponential decline is used for the falling phase
- Forecast describes reservoir deliverability only



Hydrocarbon Surge

As the steam front moves through the formation the leading edge has active shear. This shear together with the steam pressure lift the cap rock and overburden. This causes micro fractures that release a surge of hydrocarbons in the chimney above the leading edge of the steam front. This effect is measured during a steam chamber survey.



Plan view (CSEG Recorder)

Ramp Up Decline

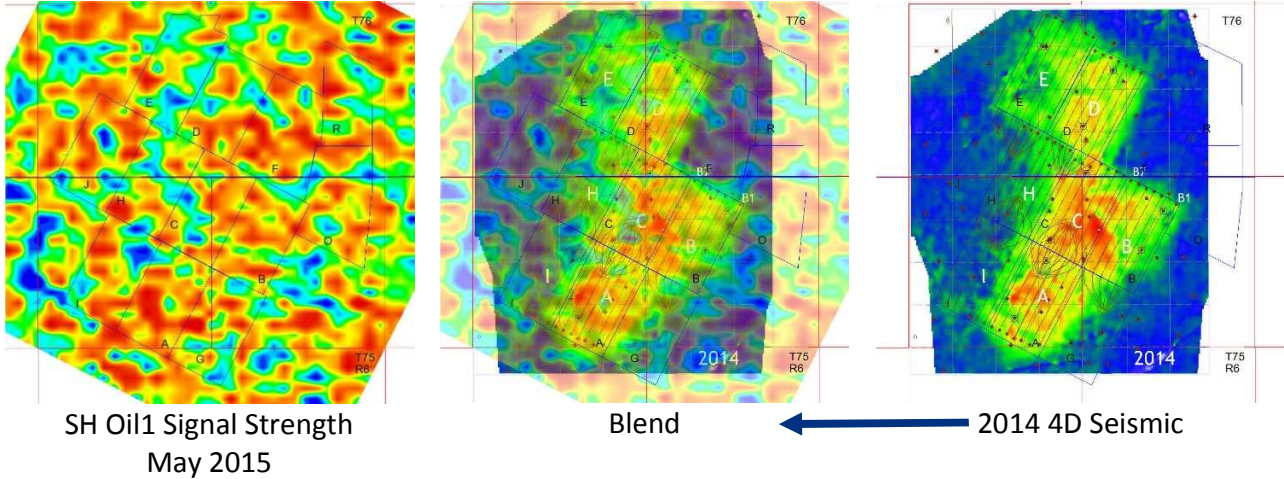
Fractures cutting a bedding plane

As the steam front moves the micro fractures open and then heal. The pattern of the high micro seep signals provide a plan view of the direction of the steam front. Lower signal behind the front indicates the effect of production and lower Remaining Bitumen In Place.



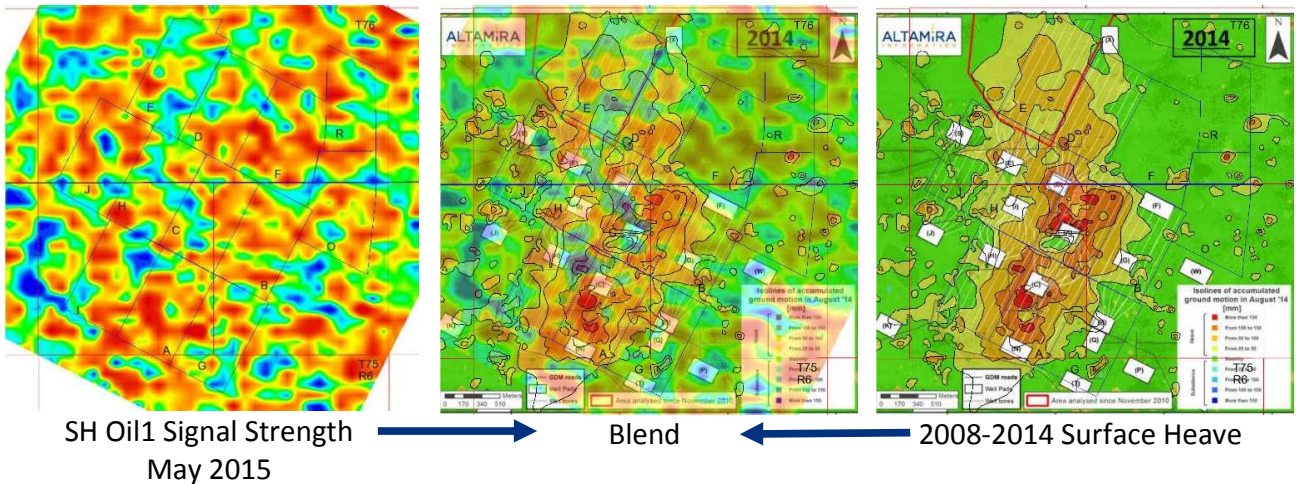
Microseep Signal Enhanced at Steam Front

4D Seismic



Sky Hunter survey results have been compared with 4D seismic interpretation over the SAGD projects for all four operators. There is a good correlation in the drainage mapped by 4D seismic and the Sky Hunter data. The Sky Hunter signal is low where the steam chamber is developed. The chimney surge needs to be considered in using absolute data.

Surface Heave



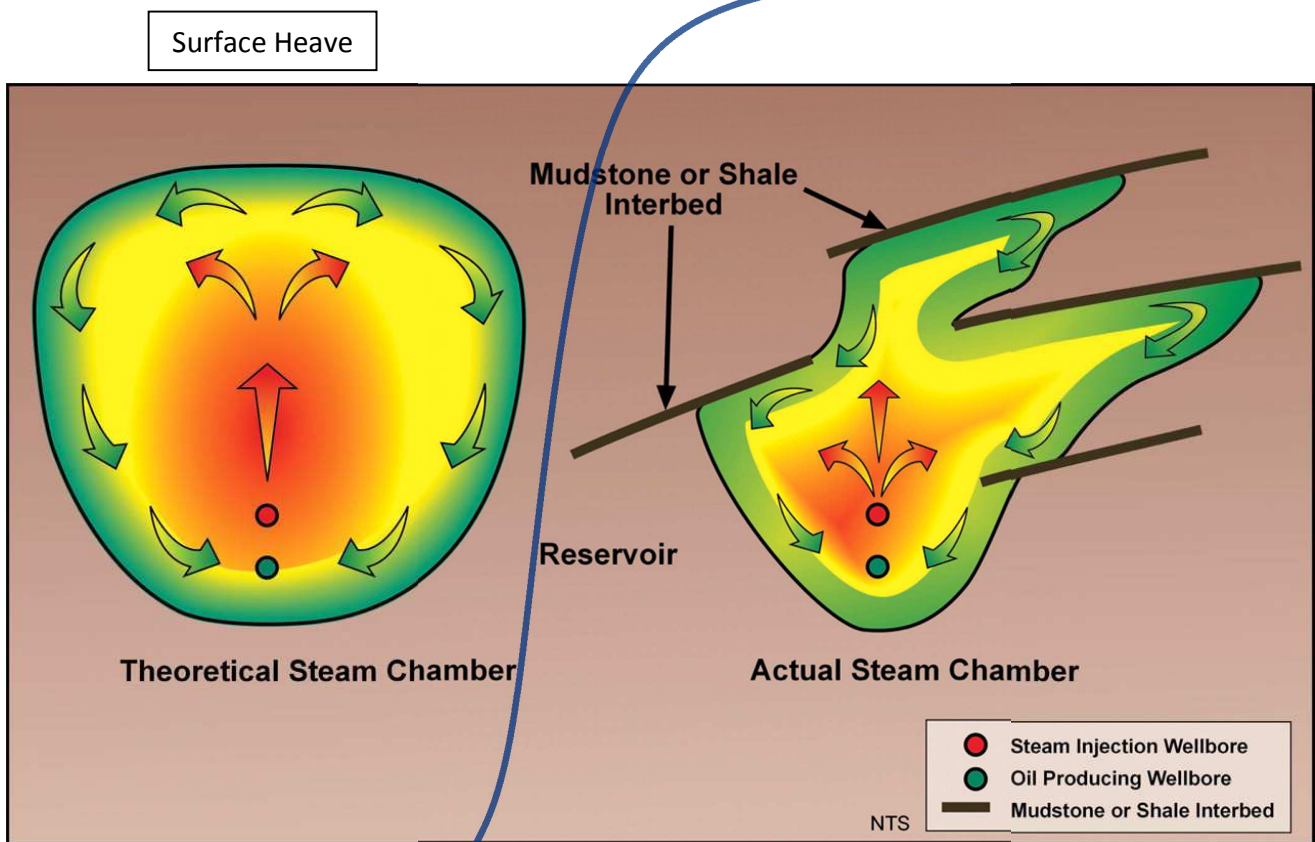
Sky Hunter data was also compared to surface heave maps. Surface heave occurs when the Plateau during the production cycle is reached. High intensity micro seep readings are seen on the Sky Hunter surveys outside the pad areas (next page).

The Combination of 4D Seismic, Surface Heave and Sky Hunter Mapping Aid in the Definition of Steam Chambers.

Theoretical Steam Chamber

Steam chamber growth is measured by both 4D seismic and surface heave measurements. The geomechanics in the formation, associated with plateau production, creates temporary increase in the microseepage rates at the edges of the steam chamber. These signal measurements must be considered in relationship to the total microseep system that existed in the project area prior to any steam injection.

Location of Temporary Microseep Increase



Actual Steam Chamber

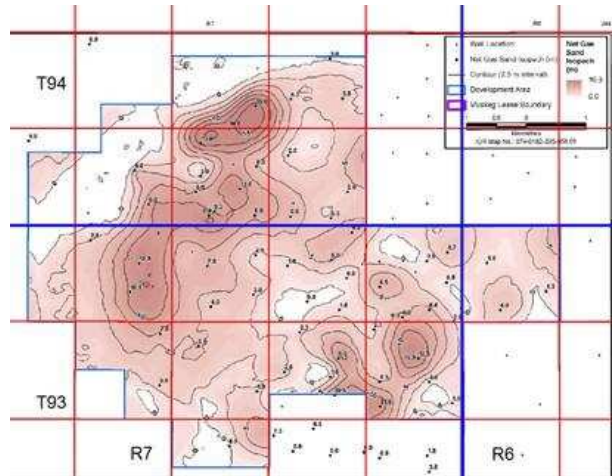
Repeating microseep surveys to monitor the change in the edge of the steam chamber growth will provide information for continued operation of steam injection as part of a controlled operation. Optimising the distribution of the steam will result in an effective steam oil ratio (SOR). Operational information can then be used to improve the parameters used in the complex reservoir models.

Signal Strength Can Be Used To Monitor Growth of Steam Chambers

Gas Over Bitumen

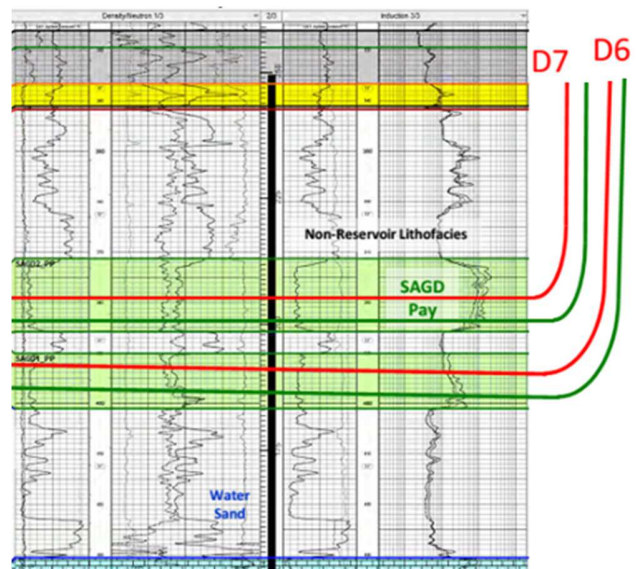
The survey data over the Aspen area indicated a depressed Oil1 signal over an area with high net Bitumen In Place mapping by the operator. The gas cap in that area was also mapped by the operator.

The depressed signal matched well with the area of the gas cap.



Horizontal Shale Breaks

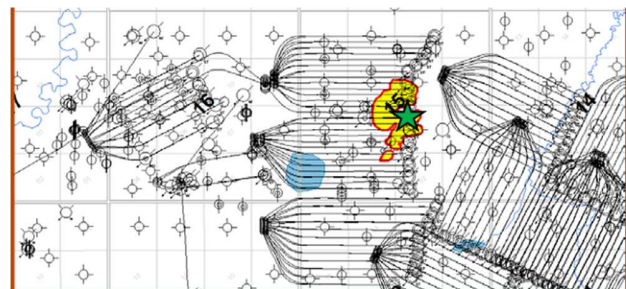
In a SAGD project a strong signal was noted in an area that had been on production for several years. On review of the information in that area it was noted that a horizontal shale had prevented the steam from rising to the top portion of the bitumen pay. The Sky Hunter survey indicated the approximate area of the bitumen yet to be recovered.



Up Hole Conductivity

It is noted that in a project not surveyed by Sky Hunter that steam had caused a significant change in the pressure of an up hole Wabiskaw sand. Based on the SAGD surveys in other projects, it has been suggested a Sky Hunter survey may detect a surge over an area experiencing this effect.

“Over-pressured Wabiskaw first identified in April 2013 while attempting to drill a steam chamber core.



Conductive heating of bitumen in low-perm Wabiskaw from underlying steam chamber created an increase in reservoir pressure from ~2000 kPa to ~6500 kPa.”

Additional Conclusions Remain To Be Gleaned from Sky Hunter Data

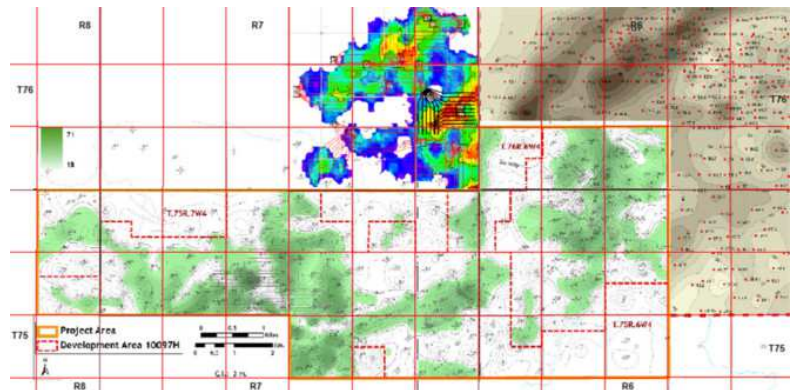
Collaboration

When comparing the maps of public data to the Sky Hunter information, the partners allocated funds to develop a tool to present layers of information with a user friendly platform. VizworX developed a system, called GeoViz, which encourages collaboration. The use of table top units and connection to off-site participants is proving to be of interest to industry. The system is not intended to do sub surface calculations, but to encourage collaboration using maps for all project participants.



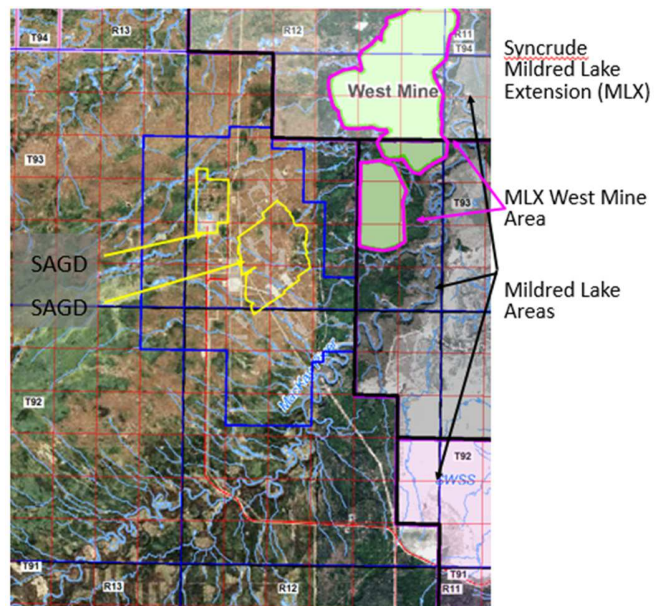
Multi Operator Mapping

The slide on the right shows the plan view net pay maps of the Bitumen In Place from three operators. The Sky Hunter survey over a portion of these three projects can be used to aid in collaboration.



Surface Topography

Using all sources of mapping, an operator can then present the subsurface bitumen areas together with the surface features to indicate how access to an area can be optimised and to focus seismic programs and evaluation well locations. This is a topographic map over both a SAGD and mine area.



Sky Hunter – GeoViz Focuses Stakeholder Collaboration

Reservoir Model

The Sky Hunter data has been matched with public information such as net pay, formation tops, bottom water and SAGD pad locations. This has provided a strong indication that the data is useful. However, when exploring for additional goodness of fit, it is apparent that a method to use the existing detailed 3D models needs to be established.

Reservoir Geomechanics Research

Research involving the correlation of Sky Hunter data with existing data sets, such as seismic, may prove to be beneficial in the definition of steam chamber growth.

Sensor Upgrade

The current sensor design works well. With requests for a more detailed data set the design has been completed which will improve the signal to noise ratio, add a calibration gas function and add additional atmospheric sensors. This system will enable the processing team to employ different algorithms in areas needing more detail, such as the oil sands.

4D Sky Hunter Surveys and Unmanned Airborne Vehicles (UAVs)

The mapping of the steam fronts will require 4D surveys at various time intervals depending on the project. Per suggestion, we are looking at ways to provide a sensor system to be mounted on a UAV for repeat surveys. Additional sensors could be mounted on such a system.

Ground Stations

A natural follow up in an area with high intensity would be a series of ground stations. Work is underway on this suggestion.

Visualization

As part of the work associated with the detailed 3D reservoir modelling, a project with the University of Calgary is being considered. This project will combine their expertise and actual oil sands data to best use and visualize all data sources.

Positive Outlook

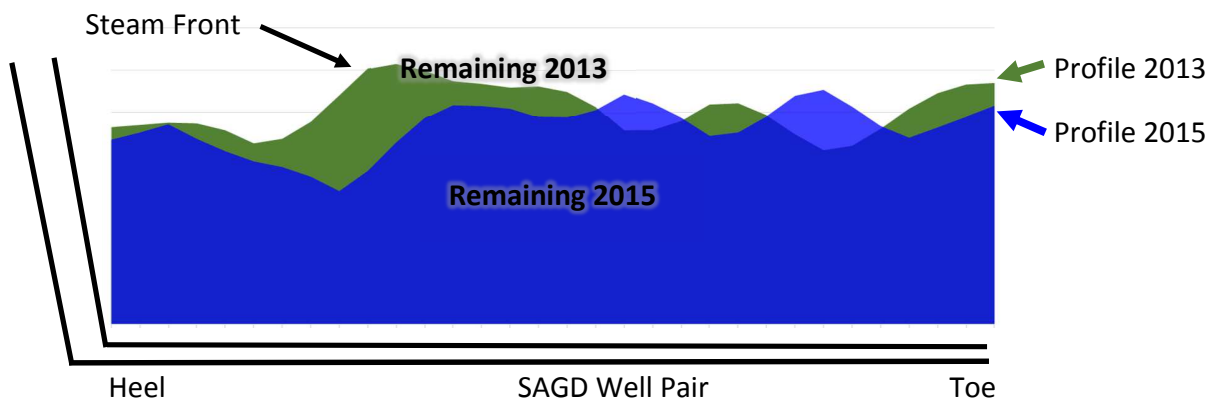
This collaboration has resulted in the following benefits:

Resource to Reserves

- The Sky Hunter data is proportional to the Remaining Bitumen In Place.
- For undeveloped areas this can focus surface activities to minimize costs.
- Delineation wells can be selected for best results.
- Seismic programs can be optimised.
- Areas with low potential can remain undisturbed.
- Reserves status can be upgraded with geophysical information.

SAGD well pairs can be monitored to improve Steam Oil Ratio (SOR)

- Survey data can be presented along well pairs (see page 15, Pad E).
- Since the signal is proportional to Remaining Bitumen In Place, the difference from survey to survey will indicate areas that are or have been drained.
- Steam can be re-directed to unproduced bitumen.
- Bitumen production from areas adjacent to the pad can be monitored.



Benefits of Collaboration



Commercialization of SME Technology Award

Sky Hunter Corporation (a private Canadian company) was honored to receive this recognition from the Board of Directors and Executive of PTAC (Petroleum Technology Alliance of Canada). Sky Hunter accepted this award at PTAC’s Annual General Meeting on May 26th-2014; at The Petroleum Club in Calgary. “This technology offers significant reductions in costs and in environmental footprint as compared to existing methods. Four initial air surveys were conducted and analyzed in 2013. The results led to additional surveys in 2014 ... Sky Hunter is currently building on this project to perform new surveys for clients...” Sky Hunter was selected for successfully validating and commercializing their innovative system which promotes the sustainable development of Canada’s hydrocarbon resources with a revolutionary, patented, hydrocarbon mapping technology.

In commenting on the award, Sky Hunter stated: “We are delighted with this industry recognition of our technology which in combination with a number of successful recent demonstrations of the technology’s effectiveness has created new opportunities for Sky Hunter to partner with additional operating companies engaged in both exploration, development and operations.” Sky Hunter’s aerial survey system uses sophisticated proprietary techniques to identify hydrocarbon deposits from the presence of molecules in the atmosphere over the deposit. Sky Hunter recently partnered with four major oil sands operators to demonstrate the effectiveness of the Sky Hunter system over each of their properties. One survey which was flown at 50m line spacing was able to accurately locate SAGD well pairs, bypassed pay, mud channels and spent zones. This revolutionary technology was recently patented in the USA (others pending) after thirteen years and over \$10M invested in research and development. Sky Hunter has proven capable of finding and mapping oil, NGLs and dry gas from an airplane on and offshore.

PTAC Award