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PETROLEUM RESOURCES
MINISTRY OF NATURAL RESOURCES

Ministry of Natural Resources
Petroleum Resources Center
659 Exeter Road
London
ON
N6E 1L3

Attention: Rudy Rybansky/Jug Manocha

Re: Application for Approval to Inject Gas
Sarnia 7-6-II Pool

Dear Sirs,

Den-Mar Brines Limited ("Den-Mar") hereby applies for approval under Section 11 of the Oil, Gas, and Salt Resources Act (the "Act") for a gas injection scheme to both conserve and reinject produced natural gas and partially repressure the Sarnia 7-6-II Guelph pool in Sarnia Township, Lambton County by reinjecting additional purchased natural gas.

As part of the scheme to reinject produced gas and purchased gas, Den-Mar will convert the Den-Mar #10: Sarnia 7-6-II well to an injection well and will add additional compression capacity if required to handle larger volumes of natural gas with a higher compressor discharge pressure. The ultimate goal of the injection scheme is to bring the Sarnia 7-6-II reservoir pressure back up to the 2,500 to 3,500 kPa (350 to 500 psi) range to provide additional reservoir drive to force brine contained in the reef to the remaining producing wells. To help maximize brine production from these producing wells, a packer may need to be installed in the Bryant et al Sarnia 7-6-II well to minimize gas production volumes as much as possible.

The Sarnia 7-6-II Pool is within 1.6 kilometers of the Designated Storage Area (DSA) for the Sarnia 5-3-II Pool, so this application will need to be forwarded to the Ontario Energy Board (the OEB) as per section 11.2 of the Oil, Gas, and Salt Resources Act. This gas injection scheme will have no affect on the gas storage operations within the Sarnia 5-3-II pool currently operated by Union Gas Limited.

In support of this application, please find attached the following information:

1) Production history table and graphs for the pool.
2) Decline curve based remaining recoverable brine plot if no pressure maintenance is initiated.
3) Decline curve based remaining recoverable gas plot if gas sales continue
4) Pressure history data for the pool.
5) Guelph structural contour map over the pool showing the existing unit boundary.
6) Guelph reef isopach over the pool.
7) Geological cross-section across the pool
8) Hypothetical gas-water relative perm plot
9) A table summarizing Gross Guelph isopach, net pay, and average porosity for wells within the pool.
10) Table listing Volumetric Water-in-Place and current recovery factor
11) An appendix discussing the material balance method used to determine the original water-in-place.
12) A downhole wellbore schematic for the Den-Mar #10 well illustrating the wellbore configuration as a gas injection well.
13) A downhole wellbore schematic for all other wells in the reef. Two schematics are included for the Bryant #9 well; one as it exists today, the second if a packer is required to minimize gas production in this open hole Guelph completion.
14) A table outlining the proposed schedule for the start of produced gas reinjection followed by both produced gas and purchased gas injection.
15) A discussion of purchased gas injection volumes required to both increase the pool pressure and to maintain the reservoir pressure constant assuming all produced gas is reinjected.
16) A cheque for $500.00 has previously been sent to the MNR to cover the application fee.

Pool Development

The Sarnia 7-6-II reef was discovered with Corden Sarnia 5-6-II in 1968. The Guelph zone in the well only had a small oil show along with brine and was plugged at the time of drilling. Shell Canada shot seismic over the crest of the reef and drilled Shell Sarnia 7-6-II in 1980 targeting the highest on-target part of the reef based on their seismic map (see attached structural contour and isopach maps). The Shell well only tested brine from the Guelph, and it was plugged at the time of drilling. Based on the quality of brine tested with the Shell well, Ron Bryant and Den-Mar Brines twinned the Shell well with Bryant et al Sarnia 7-6-II in 2004 to supply dust suppressant brine to Den-Mar Brines. With increasing brine requirements, Den-Mar has added two additional brine wells and a shallow Devonian well to the field since then. Listed below are all wells drilled at the Sarnia 7-6-II pool:

Well Name	Location	TD	Guelph Drilling Shows	Status
Corden	Sarnia 5-6-II	784.6m	Oil show, Brine	Plugged and abandoned
Shell	Sarnia 7-6-II	798.0m	Brine	Plugged and abandoned
Bryant et al	Sarnia 7-6-II	780.5m	Brine	Producing brine well
Den-Mar Brines #10	Sarnia 7-6-II	769.0m	Brine	Producing brine well
Den-Mar Brines #13	Sarnia 8-6-II	800.0m	Brine	Producing brine well
Den-Mar Brines #14	Sarnia 1-7-6-II	213.0m	Oil show	Suspended Dundee oil well

No gas shows were noted in any of the drilling records for wells in the reef, with all reef wells testing only water except for a small oil show in the Corden well.

Production History and Decline-Curve Based Remaining Brine and Gas Reserves

Den-Mar has produced the Sarnia 7-6-II pool as a brine production system since late 2004. The brine contained in the pool is of excellent quality for use as a dust suppressant and to dissolve and inhibit ice on bridge overpasses. Brine was produced from the pool to an above-ground tank battery, where tanker trucks picked up the brine and spread it on roads/bridges throughout south-western and central Ontario. To the end of July, 2012, 329,764m^3 (2,074 MBbl) of brine have been withdrawn from the reef. See the production history table and graph and water decline curve graph for monthly production volumes and history. The plotted monthly brine volumes except for 2012 year-to-date are based on annual volumes divided by 12. Total 2012 volumes will show a dramatic decline compared to the currently plotted volumes since actual brine volumes for the second half of 2012 will be much less than the 2012 production-to-date volumes since most of the dust suppression work is in the early part of each year. Based on the brine exponential decline curve attached, the remaining recoverable brine volumes from the reef under current operating conditions are only 274 10^3m^3 (1,723 MBbl), with the maximum spring-time production rate quickly falling below Den-Mar's daily brine hauling requirements. Of the three producing brine wells, Den-Mar #10 has the lowest brine production rate and the highest gas rate. In a gas injection scenario, this well is the logical well to convert to gas injection, since it will readily accept large volumes of gas and will minimize the daily volume of brine lost out of Den-Mar's current operations.

Initially, the wells in the pool produced with little or no natural gas. However, as the reservoir pressure was lowered due to brine withdrawal, natural gas production volumes became significant. Initially, any gas produced along with the brine was vented from the brine storage tanks. As the volume of gas produced along with the brine increased, gas conservation and sales were required. Gas sales from the pool were initiated in mid-2007, with produced gas compressed, dehydrated, and delivered to the Union Gas distribution system near the pool. To July, 2012, 10.34 10^6m^3 (365.1 MMcf) of natural gas sales have been reported from the pool, although actual produced volumes are higher than this amount since there was gas produced along with the brine for a few months prior to the initiation of gas sales. In the attached production history table I have estimated this

vented gas volume based on a constant annual Gas/Water Ratio (GWR). Including this estimated gas volume, total gas production from the pool to July, 2012 is about 12.08 10^6m^3 (426.4 MMcf). Peak gas production was during the second half of 2008 and the first half of 2009. Since then, the gas production volumes have dropped off dramatically. Based on the natural gas exponential decline curve attached, the remaining recoverable gas volumes from the reef under current operating conditions are only 0.45 10^6m^3 (15.9 MMcf).

Original Brine-in-Place and Gas/Water Ratio

The only two possible sources for the gas being produced along with brine from the Sarnia 7-6-II pool are as a result of gas breaking out of brine insitu due to lowering reservoir pressure, or if there was a small gas cap present in the pool that has expanded down to reach the producing wellbores. The pool isopach map is based on numerous north-south and east-west seismic lines shot across the pool. If there was a small gas cap closer to the Bridgen Sideroad (just west of the Bryant et al 7-6-II well), it is likely very small since the Bryant and Shell wells are very close to the seismically defined apex of the reef and neither well tested any free gas when the wells were originally drilled. For the remainder of this application, I have assumed all produced gas has been as a result of gas breaking out from gas-saturated brine in the reef as reservoir pressure has declined.

Both the Bryant et al Sarnia 7-6-II and the Den-Mar #10 Sarnia 7-6-II wells were completed as open hole Guelph completions, with the 178mm production casing set and cemented at the top of the Guelph. To attempt to minimize gas inflow, Den-Mar cased the Den-Mar Brine #13 Sarnia 8-6-II well through the Guelph and completed the well through perforations toward the base on the reef. Although this completion technique has reduced the producing Gas/Water Ratio (GWR) from the well relative to the Bryant et al and Den-Mar #10 wells, gas producing volumes remained significant until mid-2011, after which gas volumes declined dramatically. The maximum annual GWR (77.4 m^3/m^3, or 434 scf/bbl) for the pool was in 2009. With reduced reservoir pressure and accelerated gas sales in previous years, the annual pool GWR for 2011 was down to 21.7 m^3/m^3 (122 scf/bbl). This solution gas was providing the drive mechanism to help force reservoir brine to the producing wells. Without this drive mechanism, brine will continue to flow toward the producing wells, just at a much slower rate.

To help illustrate the flow mechanism active in any gas/water pool, I've attached a hypothetical gas/water relative perm plot. This graph illustrates the permeability available to both gas and water at various water saturations. At the initial water saturation of 100%, only water flows through the pore space in the reservoir as there is no relative permeability to gas. As gas breaks out from the water and starts moving through the reservoir as a separate, second phase, the gas saturation in the reef starts to increase, driving the water saturation lower. In the attached plot, at water saturations of 80% or higher (gas saturations of up to 20%), gas can start to flow through the reservoir. Because gas flows much easier through the reservoir than water due to the lower gas viscosity, any free gas is quickly transported through the reservoir even though the reservoir is still mostly saturated with water. Most of the reservoir energy and the drive mechanism in the

pool are due to relatively small volumes of gas absorbed by the water in the reservoir. With lowering reservoir pressure, the amount of gas that can be dissolved in water declines, meaning "solution" gas is released from the brine throughout the reservoir. This released gas flows preferentially through the reservoir due to its favorable viscosity, reaches a producing well quickly, and is produced. Quickly, the drive mechanism active in the pool is no longer available since there is minimal "solution" gas remaining absorbed in the water. It is very analogous to opening a pop bottle and allowing it to sit until all absorbed CO_2 has vented off. The pop bottle is still full of pop, but there is no longer any fizz or energy left. Just because the reservoir pressure has declined does not mean there is no water left in the reef. It only means that most of the solution gas originally dissolved in the water has been evolved off and been produced. The reason for this gas reinjection and pressure enhancement application is to add reservoir energy back into the pool to help increase the brine production rates.

A generally SW-NE structural cross section schematic is attached which illustrates the gross Guelph isopach and gross pay based on the existing wells drilled in the reef. Using a 4% porosity cutoff, most of the reef wells have net pays of about 100m. Only the Shell well has a reduced net pay (48m) as the top part of the A1/Guelph is tighter. Based on the Guelph isopach map, the main pool covers an area of about 33.7 ha (83 acres), with a SW-NE reef length of about 1025m and an average width of about 330m. Using a 4% porosity cutoff, the average porosity within the net pay sections of the wells is 9.1%. Assuming an average 88.4m net pay over 33.7 ha of areal extent with 9.1% porosity, the reef could contain about 2,700 10^3m^3 (17.2 MMBbl) of water. These reservoir properties and the resulting Original Water-in-Place are listed in the reservoir table included in the attachments. If this Original Water-in-Place (OWIP) value is correct, the cumulative production from the pool to the end of July, 2012 only represents a 12% water recovery factor. Obviously, there is a lot of brine water remaining in the pool.

To help confirm this volumetric OWIP estimate, a material balance analysis was performed using the pressure/production data from the pool. Since the "solution" gas dissolved in the brine water upon pool discovery is not well known and since there are no reliable correlations for the amount of gas that can be absorbed by water in reservoir conditions, the Gas/Water Ratio (GWR) is largely an unknown. Please see the Material Balance appendix for a description of the material balance methodology, particularly how it was applied to the data from this pool. The two best matches for combined OWIP and GWR are an OWIP of 3,000 10^3m^3 with an original "solution" gas/water ratio of 5.5 m^3/m^3 (30.9 scf/bbl) and an OWIP of 3,500 10^3m^3 with an original "solution" gas/water ratio of 4.8 m^3/m^3 (26.9 scf/bbl). Both of these OWIP values agree reasonably well with the volumetric OWIP value discussed above.

Gas Injection Discussion

To minimize gas production once gas reinjection has commenced, Den-Mar Brines will need to restrict or at least inhibit the production of reinjected gas. With the low viscosity of natural gas compared to water, the injected gas will tend to quickly drive down the water saturation near the injection wellbore, with the injected gas migrating away from

the injection well toward the pressure sinks caused by the brine producing wells. With the much lighter density, the natural gas will tend to rise as the gas flows through the reef matrix. The only mechanism available to try to reduce gas production is to only withdraw brine from the producing wells toward the base of the porosity within the wellbore's net pay. The Den-Mar #13 well is already perforated toward the base of the porosity. To help reduce produced gas from the Bryant et al well, the downhole producing configuration may need to be modified by installing an open hole packer on the tubing, with the packer set toward the base of the porosity in the reef, with all brine production coming from below the packer. All produced gas will need to be reinjected to maintain reservoir pressure and the associated drive mechanism. Over time, a gas cap should be created which will continue to provide reservoir pressure support for continued water withdrawals.

The ideal reservoir pressure is that which will both allow for continued brine withdrawals at economical rates and minimize gas production. This pressure will need to be empirically determined. If the reservoir pressure is increased too high, more free gas will be present in the reef, with a likely increase in the producing Gas/Water ratios. If insufficient reservoir pressure is present, insufficient drive will be available to keep water production rates at economical levels. With no turbulence in the reservoir as gas moves through, very little of the injected gas would be expected to re-dissolve in formation water, so essentially all of the injected gas will remain in the gas phase. Once the reservoir pressure has been increased to the optimum, only sufficient purchased gas in addition to produced gas reinjection will be required to maintain the reservoir pressure to make up for voidage withdrawals associated with brine production. With historical annual brine withdrawals of 35 to 45 10^3m^3 and remaining brine-in-place volumes of over 2,500 10^3m^3, there should be many years of economical brine production. After brine production is no longer economical, the pool could be converted to a natural gas storage reservoir, with gas injection and production from the entire porous sections in each I/W well. Additional brine production will be expected in a gas storage operation, but the primary value of the pool at that time would be for its gas storage potential.

With this gas injection/re-injection scheme, the reservoir pressure will likely be increased to the between 2,500 and 3,500 kPa (350 to 500 psi), well below the estimated original reservoir pressure of about 5,100 kPaa. With this low ultimate gas pressure within the Sarnia 7-6-II pool, this gas injection scheme will have no affect on the offsetting Sarnia 5-3-II gas storage operations.

Wellbore Discussion and Schematics

The attached wellbore schematic illustrates the downhole configuration that will be used in the Den-Mar #10 wellbore. Gas will be injected down the 178mm production casing. Both the 178mm production casing and 219mm intermediate casing were cemented with sufficient cement volumes to receive cement returns to surface. The Form 7 for the well indicates that cement returns to surface were not received on either cement job. With the high permeability of the Detroit River aquifer in the area, some of the cement from the 219mm cement job likely fed into this zone, with the cement top from the 219mm cement

job likely within the Detroit River zone. The 219mm primary cement job will be at least partially protecting the outside of the 219mm intermediate casing from corrosion. A cement bond log was run inside the 178mm casing on October 31, 2005. This bond log shows an excellent cement bond up to about 90m, with spotty cement from there to surface. Den-Mar tried to top up the cement job after the bond log was run, but the spaghetti string could only be forced a few feet down the annulus. The effective 178mm cement top is to surface. With the large cement jobs pumped for both the 219mm and 178mm casings, with new casings used in the well, and with the 178mm cement top at surface, there is minimal risk of injected natural gas leaking from the wellbore into any uphole aquifers especially since the anticipated maximum gas injection pressure is less than the pressure that would have been in this reef if it were a normally pressure gas-filled reef [6340kPa (920 psig) based on a 9.8kPa/m (.433 psi/ft) gradient]. For the corrosive Detroit River zone to attack the 178mm casing, the 219mm intermediate casing and cement would need to have been damaged or corroded sufficiently to allow the aquifer direct access to the cement protecting the 178mm casing. This is unlikely in the foreseeable future considering the 218mm casing was new when ran, and at least part of the Detroit River was cemented off with the 219mm cement job.

Wellbore schematics are attached for all other wellbores intersecting the Guelph reef in the Sarnia 7-6-II pool. Both the Corden and Shell wells were plugged to standards at the time, with minimum 8m long plugs.

With the casing and cementing techniques and volumes used in the Den-Mar wells and with the plugging techniques used on the Corden and Shell wells, there is minimal risk of any natural gas from the pool leaking through any of the existing reef penetrations. With the gas injection/brine production scenario as envisioned, the reservoir pressure will not be increased to above the original reservoir pressure.

Activity Scheduling, Timing, and Anticipated Purchase Volumes

DenMar Brines currently has individual gas flowlines installed from the annulus of each of the producing brine wells (Bryant et al, DenMar 10, and DenMar 13) to a central separator, compressor, and dehydrator facility. Annulus gas from the wells goes through the separator to ensure no liquid is entrained, with the gas off the separator piped to the suction of the on-site compressor. Currently, gas from the compressor discharge goes through the on-site dehydrator then enters the steel sales line from the dehy up to Churchill Line, then east along Churchill Line to the Union Gas sales point. The maximum allowable operating pressure (MAOP) of the Union Gas distribution line into which DenMar currently sells is just over 700kPa (just over 100 psi).

To initiate produced gas re-injection, DenMar simply needs to divert the compressor discharge gas back to the flowline from the DenMar 10 well and pull the submersible pump and tubing from DenMar 10. To minimize potential gas freeze-offs in the winter, the produced gas will likely still go through the dehydrator to remove water vapour. To initiate produced gas re-injection can be accomplished very quickly.

All that is required to allow for gas purchases to increase the pool pressure is to reverse the flow in the existing sales gas line from the Union Gas interconnect. Modifications will be required within the Union Gas meter station to allow reverse gas flow, as well as modifications at the discharge from the dehydrator at the DenMar central facilities to allow purchased gas to be re-routed to the compressor suction. With the Union Gas MAOP pressure limitation, all purchased gas through the Union Gas interconnect will require compression to overcome the DenMar 10 wellbore pressure as the pool pressure is increased.

The initial purchased gas injection rate will be higher than that required once the reservoir pressure has been increased to a stable pressure. Once a stable reservoir pressure is reached, the purchased gas volumes will only need to replace the voidage as a result of continued brine withdrawals, so the stabilized gas purchase volumes will be constant providing annual brine withdrawal volumes are fairly consistent each year. The enclosed appendix discusses both the stabilized gas purchase volumes and rates required once a stable pressure has been reached, and the charge gas volumes and rates required to bring the pool back up to various reservoir pressures. As an illustration from this appendix, 3.85 10^6m^3 (135.9 MMcf) of purchased gas would be required to bring the reservoir pressure back up to 2000kPa (290 psi), while annual purchased gas of only 988 10^3m^3/year (34.9 MMcf/yr) would be required to keep the reservoir pressure constant at that level. This equates to an initial charge plus voidage replacement gas volume of 8.0 10^3m^3/D (282 Mcfd) during an assumed 24 month charge period, with a stable gas injection rate of only 2.7 10^3m^3/D (96 Mcfd) once the pool is pressured up. The purchased gas volumes necessary to keep the reservoir pressure constant are fairly small compared to gas injection and withdrawal rates in gas storage-type Guelph reefs.

Pool Pressure Measurements

Since there is uncertainty in the past pool reservoir pressures and resulting uncertainty in the pressure and production inputs used in this analysis, periodic reservoir pressure measurements along with continued detailed brine production and gas production and injection measurements are important. These pressure measurements will allow a more exact Original Water-in-Place estimation and will help DenMar determine the optimum reservoir pressure to maximize brine withdrawal rates with minimal capital costs and ongoing gas purchase costs. Annual pressure falloff measurements will be obtained in the DenMar 10 well.

Once brine production becomes uneconomical or produced gas volumes become excessive, the pool may be converted to a gas storage reservoir, which will require a separate application brought before the Ontario Energy Board.

Please review this application at your earliest convenience. Den-Mar is anxious to install necessary compression to commence produced gas injection operations as soon as possible.

Yours truly,

J. W. (Jim) McIntosh, P. Eng.

cc: Dennis Marcus, Den-Mar Brines
Ron Bryant

Den-Mar Brines Limited
Samia 7-6-II Pool Production History

Date	Bryant et al Data License: T011103				Den-Mar Brines #10 License: T011294				Den-Mar Brines #13 License: T011818				Total Pool										Cumulative Production			
Month.Yr	Gas (10^3m^3)	Oil (m^3)	Water (m^3)	G/W Ratio (m^3/m^3)	Gas (10^3m^3)	Oil (m^3)	Water (m^3)	G/W Ratio (m^3/m^3)	Gas (10^3m^3)	Oil (m^3)	Water (m^3)	G/W Ratio (m^3/m^3)	Gas (10^3m^3)	Sales (GJ)	Equiv gas (10^3m^3)	Est Gas (10^3m^3)	Est G/W (m^3/m^3)	Tot Gas (10^3m^3)	Oil (m^3)	Water (m^3)	G/W Ratio (m^3/m^3)	Sales Gas (10^3m^3)	Ttl Gas (10^3m^3)	Oil (m^3)	Water (m^3)
Nov.2004			2,870.6													14.4	5.0	14.4		2,870.6		-	14		2,870.6
Dec.2004			2,870.6													14.4	5.0	14.4		2,870.6		-	29		5,741.3
Jan.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	60	27.5	8,878.8
Feb.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	91	55.0	12,016.3
Mar.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	123	82.5	15,153.8
Apr.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	154	110.0	18,291.3
May.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	186	137.5	21,428.8
Jun.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	217	165.0	24,566.3
Jul.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	248	192.4	27,703.8
Aug.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	280	219.9	30,841.3
Sep.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	311	247.4	33,978.8
Oct.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	342	274.9	37,116.3
Nov.2005		27.5	3,137.5													31.4	10.0	31.4	27.5	3,137.5		-	374	302.4	40,253.8
Dec.2005		27.5	3,137.5				25.0									31.6	10.0	31.6	27.5	3,162.5		-	405	329.9	43,416.3
Jan.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	460	329.9	46,157.1
Feb.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	515	329.9	48,897.9
Mar.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	570	329.9	51,638.7
Apr.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	625	329.9	54,379.5
May.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	680	329.9	57,120.3
Jun.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	734	329.9	59,861.1
Jul.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	789	329.9	62,601.9
Aug.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	844	329.9	65,342.8
Sep.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	899	329.9	68,083.6
Oct.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	954	329.9	70,824.4
Nov.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	1,008	329.9	73,565.2
Dec.2006			2,679.8				61.1									54.8	20.0	54.8		2,740.8		-	1,063	329.9	76,306.0
Jan.2007			3,218.6				12.8									96.9	30.0	96.9		3,231.4		-	1,160	329.9	79,537.4
Feb.2007			3,218.6				12.8									96.9	30.0	96.9		3,231.4		-	1,257	329.9	82,768.8
Mar.2007			3,218.6				12.8									96.9	30.0	96.9		3,231.4		-	1,354	329.9	86,000.3
Apr.2007			3,218.6				12.8									96.9	30.0	96.9		3,231.4		-	1,451	329.9	89,231.7
May.2007			3,218.6				12.8									96.9	30.0	96.9		3,231.4		-	1,548	329.9	92,463.1
Jun.2007			3,218.6				12.8									96.9	30.0	96.9		3,231.4		-	1,645	329.9	95,694.5
Jul.2007			3,218.6				12.8									96.9	30.0	96.9		3,231.4		-	1,742	329.9	98,925.9
Aug.2007	95.4		3,218.6	29.6			12.8						95.4	3,719	95.4			95.4		3,231.4	29.5	95.4	1,837	329.9	102,157.3
Sep.2007	74.7		3,218.6	23.2			12.8						74.7	2,913	74.7			74.7		3,231.4	23.1	170.1	1,912	329.9	105,388.8
Oct.2007	224.2		3,218.6	69.7			12.8						224.2	8,744	224.2			224.2		3,231.4	69.4	394.3	2,136	329.9	108,620.2
Nov.2007	214.6		3,218.6	66.7			12.8						214.6	8,369	214.6			214.6		3,231.4	66.4	608.9	2,351	329.9	111,851.6
Dec.2007	191.5		3,218.6	59.5			12.8						191.5	7,469	191.5			191.5		3,231.4	59.3	800.4	2,542	329.9	115,083.0
Jan.2008	48.9		1,269.3	38.5	48.9		1,269.3	38.5					97.8	3,814	97.8			97.8		2,538.5	38.5	898.2	2,640	329.9	117,621.5
Feb.2008	64.7		1,269.3	51.0	64.7		1,269.3	51.0					129.4	5,047	129.4			129.4		2,538.5	51.0	1,027.6	2,769	329.9	120,160.0
Mar.2008	49.7		1,269.3	39.1	49.7		1,269.3	39.1					99.3	3,873	99.3			99.3		2,538.5	39.1	1,126.9	2,869	329.9	122,698.5
Apr.2008	85.8		1,269.3	67.6	85.8		1,269.3	67.6					171.6	6,692	171.6			171.6		2,538.5	67.6	1,298.5	3,040	329.9	125,237.0

Den-Mar Brines Limited
Sarnia 7-6-II Pool Production History

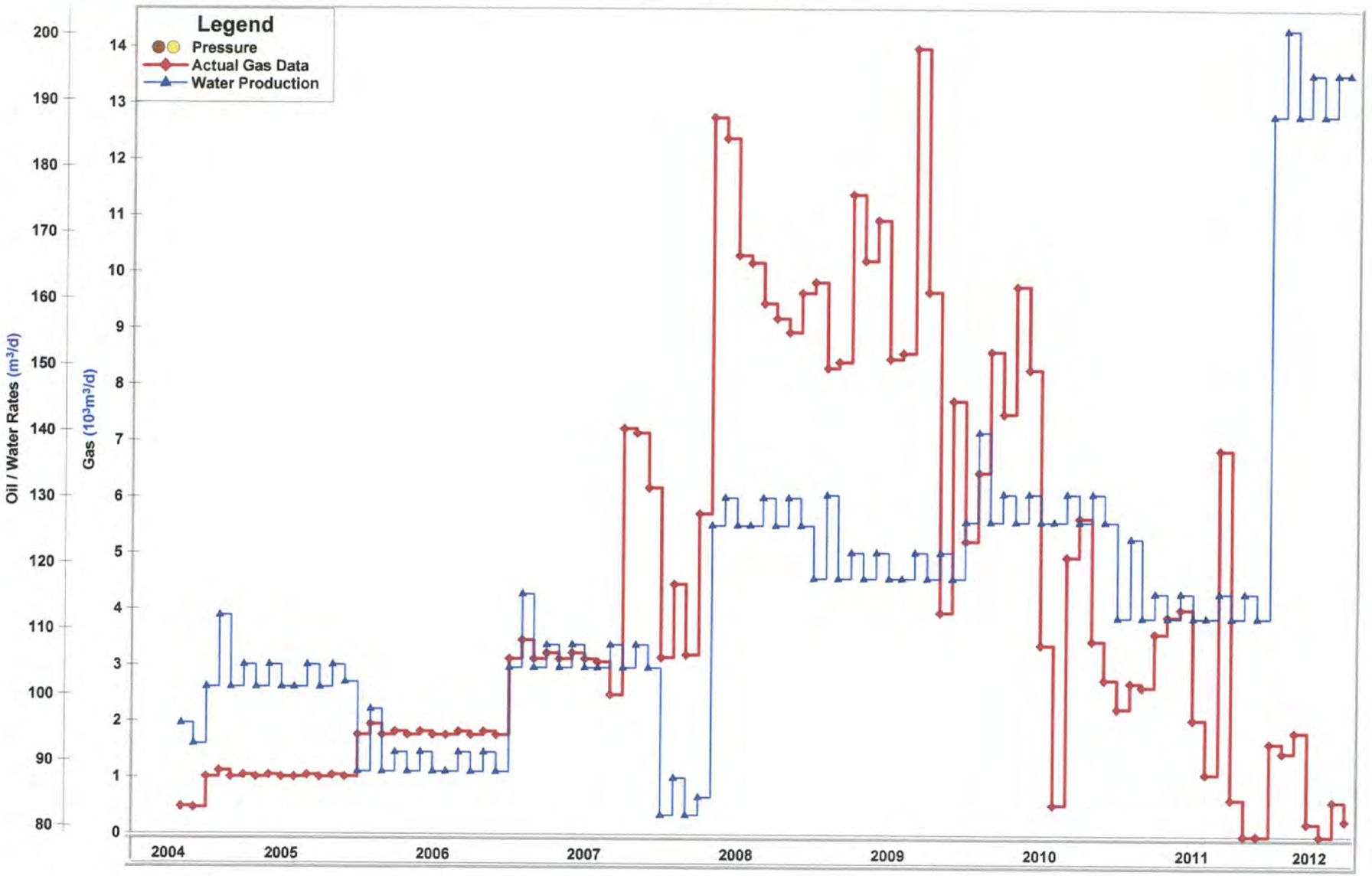
Date	Bryant et al Data License: T011103				Den-Mar Brines #10 License: T011294				Den-Mar Brines #13 License: T011818				Total Pool								Cumulative Production			
Month.Yr	Gas (10^3m^3)	Oil (m^3)	Water (m^3)	G/W Ratio (m^3/m^3)	Gas (10^3m^3)	Oil (m^3)	Water (m^3)	G/W Ratio (m^3/m^3)	Gas (10^3m^3)	Oil (m^3)	Water (m^3)	G/W Ratio (m^3/m^3)	Gas (10^3m^3)	Sales (GJ)	Equiv gas (10^3m^3)	Est Gas (10^3m^3)	Est G/W (m^3/m^3)	Tot Gas (10^3m^3)	Oil (m^3)	Water (m^3)	G/W Ratio (m^3/m^3)	Sales Gas (10^3m^3)	Ttl Gas (10^3m^3)	Oil (m^3)	Water (m^3)
May.2008	131.9		1,269.3	103.9	131.9		1,269.3	103.9	131.9		1,362.8	96.8	395.7	15,432	395.7			395.7		3,901.3	101.4	1,694.2	3,436	329.9	129,138.3
Jun.2008	124.0		1,269.3	97.7	123.9		1,269.3	97.6	123.9		1,362.8	90.9	371.8	14,501	371.8			371.8		3,901.3	95.3	2,066.0	3,808	329.9	133,039.5
Jul.2008	106.6		1,269.3	84.0	106.6		1,269.3	84.0	106.6		1,362.8	78.2	319.8	12,472	319.8			319.8		3,901.3	82.0	2,385.8	4,128	329.9	136,940.8
Aug.2008	105.3		1,269.3	83.0	105.2		1,269.3	82.9	105.2		1,362.8	77.2	315.7	12,312	315.7			315.7		3,901.3	80.9	2,701.5	4,443	329.9	140,842.0
Sep.2008	94.7		1,269.3	74.6	94.6		1,269.3	74.5	94.6		1,362.8	69.4	283.9	11,072	283.9			283.9		3,901.3	72.8	2,985.4	4,727	329.9	144,743.3
Oct.2008	95.1		1,269.3	74.9	95.0		1,269.3	74.8	95.0		1,362.8	69.7	285.1	11,119	285.1			285.1		3,901.3	73.1	3,270.5	5,012	329.9	148,644.5
Nov.2008	89.5		1,269.3	70.5	89.5		1,269.3	70.5	89.5		1,362.8	65.7	268.5	10,472	268.5			268.5		3,901.3	68.8	3,539.0	5,281	329.9	152,545.8
Dec.2008	99.8		1,269.3	78.6	99.7		1,269.3	78.6	99.7		1,362.8	73.2	299.2	11,669	299.2			299.2		3,901.3	76.7	3,838.2	5,580	329.9	156,447.0
Jan.2009	101.7		1,369.9	74.2	101.7		1,369.9	74.2	101.7		913.4	111.3	305.0	11,899	305.1			305.1		3,653.3	83.5	4,143.2	5,885	329.9	160,100.3
Feb.2009	77.7		1,369.9	56.7	77.7		1,369.9	56.7	77.7		913.4	85.0	233.0	9,083	232.9			232.9		3,653.3	63.8	4,376.1	6,118	329.9	163,753.5
Mar.2009	87.0		1,369.9	63.5	87.0		1,369.9	63.5	87.0		913.4	95.2	261.0	10,187	261.2			261.2		3,653.3	71.4	4,637.1	6,379	329.9	167,406.8
Apr.2009	114.0		1,369.9	83.2	114.0		1,369.9	83.2	114.0		913.4	124.8	342.0	13,338	342.0			342.0		3,653.3	93.6	4,979.1	6,721	329.9	171,060.0
May.2009	105.7		1,369.9	77.1	105.7		1,369.9	77.1	105.7		913.4	115.7	317.0	12,361	316.9			316.9		3,653.3	86.8	5,296.1	7,038	329.9	174,713.3
Jun.2009	109.3		1,369.9	79.8	109.3		1,369.9	79.8	109.5		913.4	119.9	328.2	12,806	328.4			328.4		3,653.3	89.8	5,624.3	7,367	329.9	178,366.5
Jul.2009	87.7		1,369.9	64.0	87.7		1,369.9	64.0	87.7		913.4	96.0	263.0	10,253	262.9			262.9		3,653.3	72.0	5,887.3	7,629	329.9	182,019.8
Aug.2009	88.7		1,369.9	64.7	88.7		1,369.9	64.7	88.7		913.4	97.1	266.0	10,377	266.1			266.1		3,653.3	72.8	6,153.3	7,896	329.9	185,673.0
Sep.2009	140.0		1,369.9	102.2	140.0		1,369.9	102.2	140.0		913.4	153.3	420.0	16,376	419.9			419.9		3,653.3	115.0	6,573.3	8,315	329.9	189,326.3
Oct.2009	100.0		1,369.9	73.0	100.0		1,369.9	73.0	100.0		913.4	109.5	300.0	11,691	299.8			299.8		3,653.3	82.1	6,873.3	8,615	329.9	192,979.5
Nov.2009	39.7		1,369.9	29.0	39.7		1,369.9	29.0	39.7		913.4	43.4	119.0	4,640	119.0			119.0		3,653.3	32.6	6,992.3	8,734	329.9	196,632.8
Dec.2009	80.0		1,369.9	58.4	80.0		1,369.9	58.4	80.0		913.4	87.6	240.0	9,355	239.9			239.9		3,653.3	65.7	7,232.3	8,974	329.9	200,286.0
Jan.2010	54.0		1,306.8	41.3	54.0		1,306.8	41.3	54.0		1,306.8	41.3	162.0	6,336	162.5			162.5		3,920.3	41.3	7,394.3	9,136	329.9	204,206.3
Feb.2010	60.3		1,306.8	46.2	60.3		1,306.8	46.2	60.3		1,306.8	46.2	181.0	7,057	180.9			180.9		3,920.3	46.2	7,575.2	9,317	329.9	208,126.5
Mar.2010	89.0		1,306.8	68.1	89.0		1,306.8	68.1	89.0		1,306.8	68.1	267.0	10,413	267.0			267.0		3,920.3	68.1	7,842.2	9,584	329.9	212,046.8
Apr.2010	75.0		1,306.8	57.4	75.0		1,306.8	57.4	75.0		1,306.8	57.4	225.0	8,782	225.2			225.2		3,920.3	57.4	8,067.2	9,810	329.9	215,967.0
May.2010	101.0		1,306.8	77.3	101.0		1,306.8	77.3	101.0		1,306.8	77.3	303.0	11,809	302.8			302.8		3,920.3	77.3	8,370.2	10,112	329.9	219,887.3
Jun.2010	83.0		1,306.8	63.5	83.0		1,306.8	63.5	83.0		1,306.8	63.5	249.0	9,703	248.8			248.8		3,920.3	63.5	8,619.2	10,361	329.9	223,807.5
Jul.2010	35.0		1,306.8	26.8	35.0		1,306.8	26.8	35.0		1,306.8	26.8	105.0	4,101	105.2			105.2		3,920.3	26.8	8,724.2	10,466	329.9	227,727.8
Aug.2010	5.7		1,306.8	4.3	5.7		1,306.8	4.3	5.7		1,306.8	4.3	17.0	651	16.7			16.7		3,920.3	4.3	8,741.2	10,483	329.9	231,648.0
Sep.2010	49.7		1,306.8	38.0	49.7		1,306.8	38.0	49.7		1,306.8	38.0	149.0	5,800	148.7			148.7		3,920.3	38.0	8,890.2	10,632	329.9	235,568.3
Oct.2010	58.3		1,306.8	44.6	58.3		1,306.8	44.6	58.3		1,306.8	44.6	175.0	6,830	175.1			175.1		3,920.3	44.6	9,065.2	10,807	329.9	239,488.5
Nov.2010	34.7		1,306.8	26.5	34.7		1,306.8	26.5	34.7		1,306.8	26.5	104.0	4,052	103.9			103.9		3,920.3	26.5	9,169.2	10,911	329.9	243,408.8
Dec.2010	28.7		1,306.8	21.9	28.7		1,306.8	21.9	28.7		1,306.8	21.9	86.0	3,353	86.0			86.0		3,920.3	21.9	9,255.2	10,997	329.9	247,329.0
Jan.2011	23.3		1,156.8	20.2	23.3		1,156.8	20.2	23.3		1,156.8	20.2	70.0	2,730	70.0			70.0		3,470.4	20.2	9,325.2	11,067	329.9	250,799.4
Feb.2011	25.3		1,156.8	21.9	25.3		1,156.8	21.9	25.3		1,156.8	21.9	76.0	2,964	76.0			76.0		3,470.4	21.9	9,401.2	11,143	329.9	254,269.8
Mar.2011	27.3		1,156.8	23.6	27.3		1,156.8	23.6	27.3		1,156.8	23.6	82.0	3,198	82.0			82.0		3,470.4	23.6	9,483.2	11,225	329.9	257,740.3
Apr.2011	36.0		1,156.8	31.1	36.0		1,156.8	31.1	36.0		1,156.8	31.1	108.0	4,212	108.0			108.0		3,470.4	31.1	9,591.2	11,333	329.9	261,210.7
May.2011	40.3		1,156.8	34.9	40.3		1,156.8	34.9	40.3		1,156.8	34.9	121.0	4,719	121.0			121.0		3,470.4	34.9	9,712.2	11,454	329.9	264,681.1
Jun.2011	40.3		1,156.8	34.9	40.3		1,156.8	34.9	40.3		1,156.8	34.9	121.0	4,719	121.0			121.0		3,470.4	34.9	9,833.2	11,575	329.9	268,151.5
Jul.2011	21.3		1,156.8	18.4	21.3		1,156.8	18.4	21.3		1,156.8	18.4	64.0	2,496	64.0			64.0		3,470.4	18.4	9,897.2	11,639	329.9	271,621.9
Aug.2011	11.3		1,156.8	9.8	11.3		1,156.8	9.8	11.3		1,156.8	9.8	34.0	1,326	34.0			34.0		3,470.4	9.8	9,931.2	11,673	329.9	275,092.3
Sep.2011	68.7		1,156.8	59.4	68.7		1,156.8	59.4	68.7		1,156.8	59.4	206.0	8,034	206.0			206.0		3,470.4	59.4	10,137.2	11,879	329.9	278,562.8

Den-Mar Brines Limited
Sarnia 7-6-II Pool Production History

Date	Bryant et al Data License: T011103				Den-Mar Brines #10 License: T011294				Den-Mar Brines #13 License: T011818				Total Pool								Cumulative Production			
Month.Yr	Gas	Oil	Water	G/W Ratio	Gas	Oil	Water	G/W Ratio	Gas	Oil	Water	G/W Ratio	Gas	Sales	Equiv gas	Est Gas	Est G/W	Tot Gas	Oil	Water	G/W Ratio	Sales Gas	Ttl Gas	Oil	Water
	(10^3m^3)	(m^3)	(m^3)	(m^3/m^3)	(10^3m^3)	(m^3)	(m^3)	(m^3/m^3)	(10^3m^3)	(m^3)	(m^3)	(m^3/m^3)	(10^3m^3)	(GJ)	(10^3m^3)	(10^3m^3)	(m^3/m^3)	(10^3m^3)	(m^3)	(m^3)	(m^3/m^3)	(10^3m^3)	(10^3m^3)	(m^3)	(m^3)
Oct.2011	6.7		1,156.8	5.8	6.7		1,156.8	5.8	6.7		1,156.8	5.8	20.0	780	20.0			20.0		3,470.4	5.8	10,157.2	11,899	329.9	282,033.2
Nov.2011			1,156.8	-			1,156.8	-			1,156.8	-	-	-	-			-		3,470.4	-	10,157.2	11,899	329.9	285,503.6
Dec.2011			1,156.8	-			1,156.8	-			1,156.8	-	-	-	-			-		3,470.4	-	10,157.2	11,899	329.9	288,974.0
Jan.2012	17.0		1,942.4	8.8	17.0		1,942.4	8.8	17.0		1,942.4	8.8	51.1	1,994	51.1			51.1		5,827.2	8.8	10,208.4	11,950	329.9	294,801.2
Feb.2012	14.3		1,942.4	7.4	14.3		1,942.4	7.4	14.3		1,942.4	7.4	43.0	1,676	43.0			43.0		5,827.2	7.4	10,251.3	11,993	329.9	300,628.4
Mar.2012	19.1		1,942.4	9.8	19.1		1,942.4	9.8	19.1		1,942.4	9.8	57.3	2,235	57.3			57.3		5,827.2	9.8	10,308.6	12,050	329.9	306,455.6
Apr.2012	2.2		1,942.4	1.2	2.2		1,942.4	1.2	2.2		1,942.4	1.2	6.7	263	6.7			6.7		5,827.2	1.2	10,315.4	12,057	329.9	312,282.8
May.2012	-		1,942.4	-	-		1,942.4	-	-		1,942.4	-	-	-	-			-		5,827.2	-	10,315.4	12,057	329.9	318,110.0
Jun.2012	6.1		1,942.4	3.2	6.1		1,942.4	3.2	6.1		1,942.4	3.2	18.4	718	18.4			18.4		5,827.2	3.2	10,333.8	12,075	329.9	323,937.2
Jul.2012	2.7		1,942.4	1.4	2.7		1,942.4	1.4	2.7		1,942.4	1.4	8.2	320	8.2			8.2		5,827.2	1.4	10,342.0	12,084	329.9	329,764.4

Name Sarnia 7-6-II Pool
Pool Sarnia 7-6-II
Field Sarnia

Data Chart



Name Sarnia 7-6-II Pool
Pool Sarnia 7-6-II
Field Sarnia

Decline Analysis

Current
Analysis Water Analysis 1

Analysis Parameters
Type Exponential

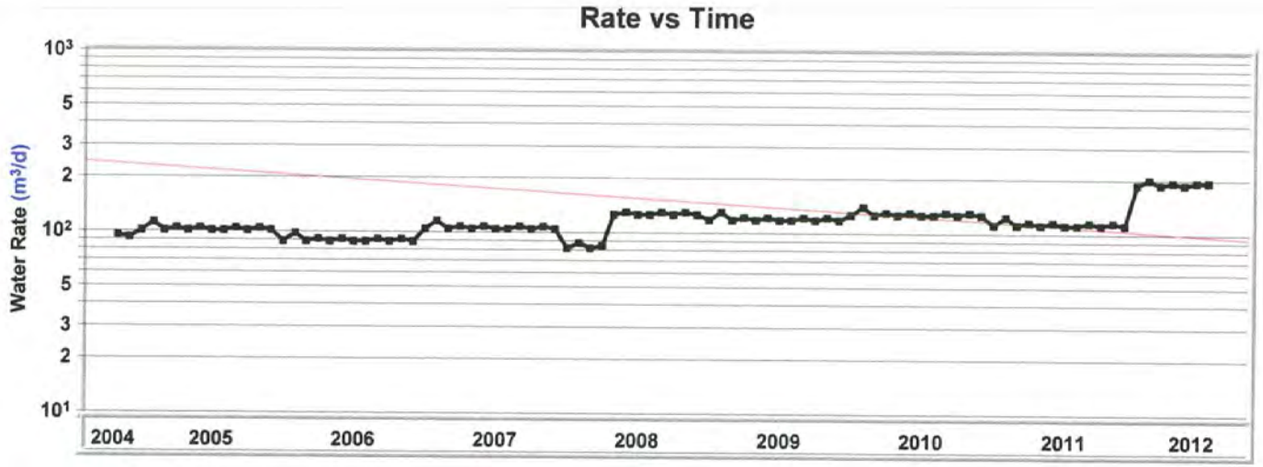
b	0.000	
D	0.115	
D_e	10.89	%
D_{lim}		%
Start	31/07/2012	DD/MM/YYYY
q_i	96.6	m^3/d
Q_i	329.764	10^3m^3
End	02/04/2032	DD/MM/YYYY
q_f	10.0	m^3/d
Q_f	604.183	10^3m^3

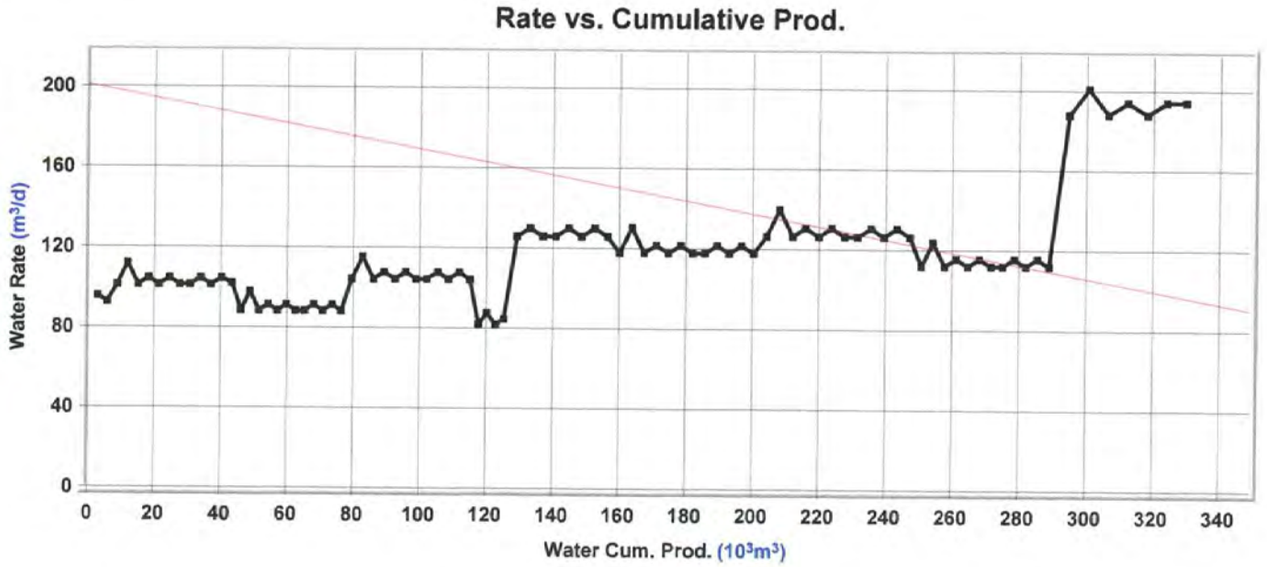
Results

E.U.R.	604.183	10^3m^3
R.R.	274.419	10^3m^3
P_{wf}		kPa
Area		ha
OWIP		10^3m^3

Production History

T_0	31/07/2012	DD/MM/YYYY
G_p	12.084	10^6m^3
N_p		10^3m^3
W_p	329.764	10^3m^3





Name Sarnia 7-6-II Pool
Pool Sarnia 7-6-II
Field Sarnia

Decline Analysis

Current
Analysis Gas Analysis 1

Analysis Parameters
Type Exponential

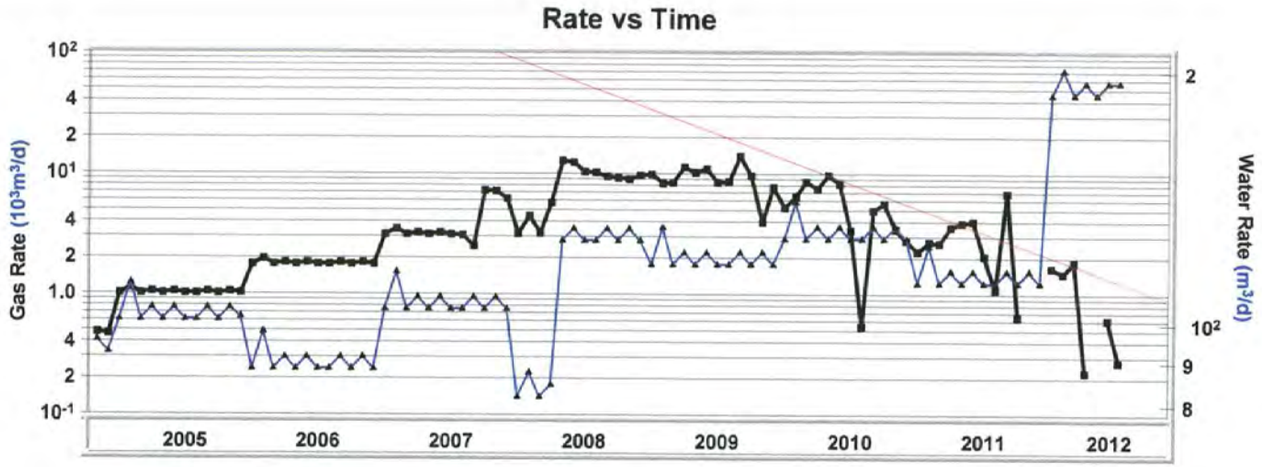
b	0.000	
D	0.938	
D_e	60.87	%
D_{lim}		%
Start	31/07/2012	DD/MM/YYYY
q_i	1.174	$10^3m^3/d$
Q_i	12.084	10^6m^3
End	21/07/2016	DD/MM/YYYY
q_f	0.028	$10^3m^3/d$
Q_f	12.530	10^6m^3

Results

E.U.R.	12.530	10^6m^3
R.R.	0.446	10^6m^3
P_{wf}		kPa
Area		ha
OGIP		10^6m^3

Production History

T_0	31/07/2012	DD/MM/YYYY
G_p	12.084	10^6m^3
N_p		10^3m^3
W_p	329.764	10^3m^3



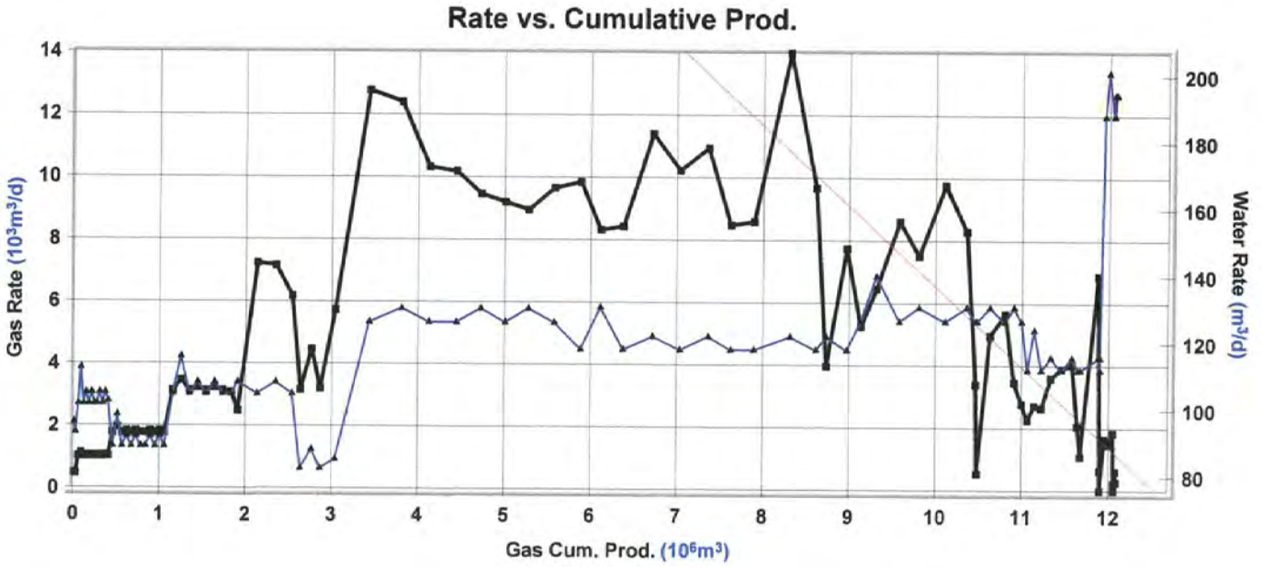


Table 1: Den-Mar Brines Sarnia 7-6-II Pressure History Data

Datum: -518 m ss
Fluid gradient: 12.1 kPa/m based on 1.235 specific gravity brine

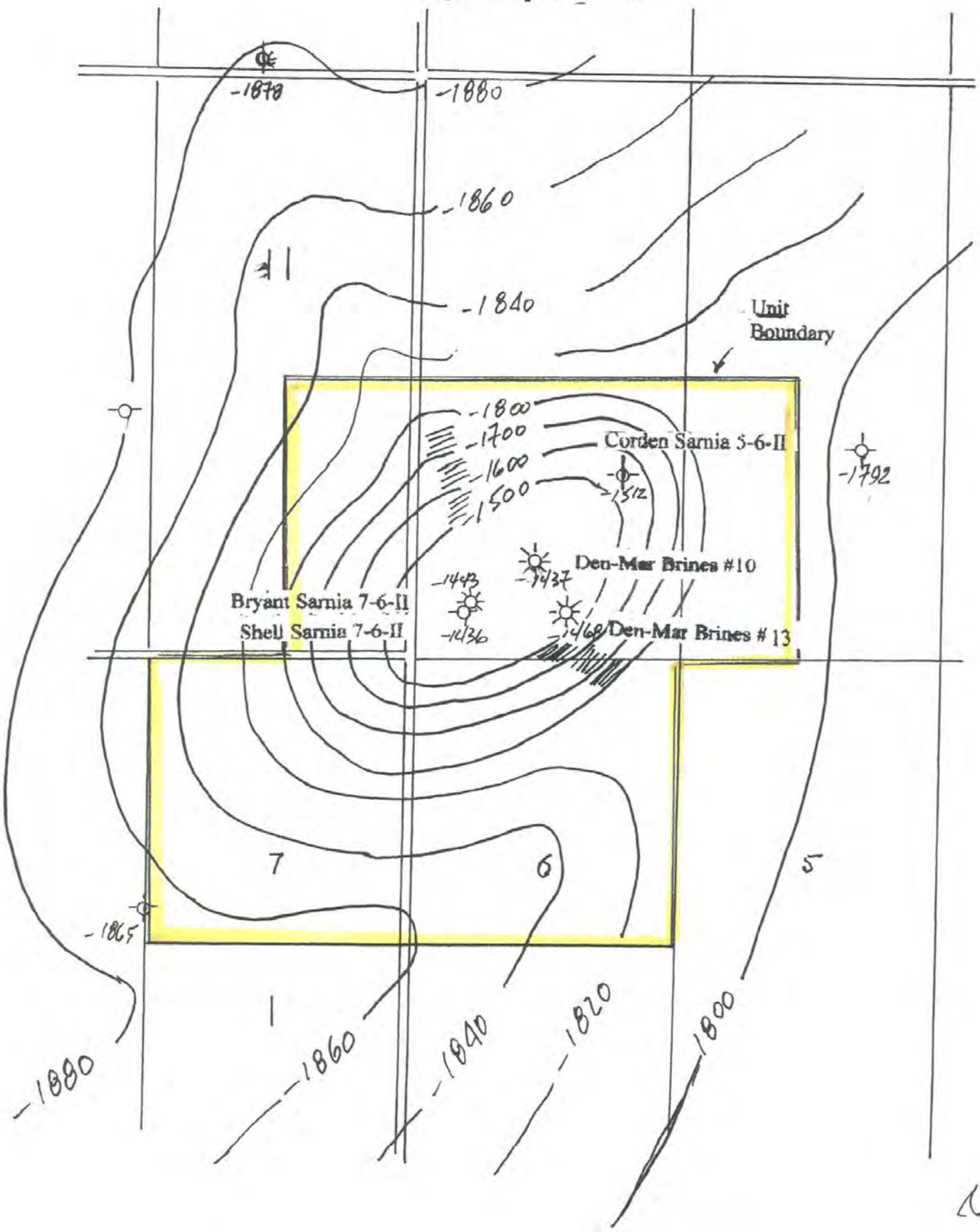
Date	Location	Ground Elev (m asl)	Datum Depth (m Gd)	Fluid Level (m Gd)	Surface Pressure (kPa)	Surface Pressure (psig)	Datum Pressure (kPag)	Datum Pressure (psig)	Cum BrineProd'n (10^3m^3)	Cum BrineProd'n (MBbl)	Comments
1-Jan-80	Shell Sarnia 7-6-II	193.0	711.0	300	0	0	4,979	722.2	-	0.0	Form 107
27-Jul-04	Bryant et al Sarnia 7-6-II	193.2	711.2	295	0	0	5,042	731.3	-	0.0	Morning reports
10-Nov-05	Den-Mar #10 Sarnia 7-6-I	193.3	711.3	357	0	0	4,292	622.5	37.1	233.5	Morning reports
6-Jul-06	Bryant et al Sarnia 7-6-II	193.2	711.2	634	3303	479	4,238	614.7	59.9	376.5	Bryant notes
1-Sep-08	Den-Mar #13 Sarnia 8-6-I	194.5	712.5	366	0	0	4,198	608.9	140.8	885.9	Form 107
13-Nov-08	Den-Mar #10 Sarnia 7-6-I	193.3	711.3		1620	235	2,515	364.8	148.6	934.9	Flow test data
8-Dec-08	Den-Mar #13 Sarnia 8-6-I	194.2	712.2		1034	150	2,951	428.0	152.5	959.5	Flow test data
12-May-11	Bryant et al Sarnia 7-6-II	193.2	711.2				1,041	151.0	262.5	1650.8	Flow test data
25-May-11	Den-Mar #13 Sarnia 8-6-I	194.2	712.2				338	49.0	262.5	1650.8	Flow test data
7-Jun-11	Den-Mar #10 Sarnia 7-6-I	193.3	711.3				1,041	151.0	265.6	1670.8	Flow test data
1-Jan-11									265.6	1670.8	MNR Form 8's

Least Squares fit on Data

Initial Reservoir Pressure, P_R			5,163	kPag
Pressure/production ratio			-15.79	kPa/10^3m^3 brine production
Potenial total brine prod'n			326.9	10^3m^3 total brine production
Total Brine prod'n to	700	kPa P_r =	282.6	10^3m^3 total brine production
Rem Brine prod'n to	700	kPa P_r =	17.0	10^3m^3 remaining brine production
Total Brine prod'n to	350	kPa P_r =	304.8	10^3m^3 total brine production
Rem Brine prod'n to	350	kPa P_r =	39.1	10^3m^3 remaining brine production
Total Brine prod'n to	0	kPa P_r =	326.9	10^3m^3 total brine production

DEN-MAR BRINES

Sarnia 7-6-II Reef
Structure Contours on
Top of Guelph Formation



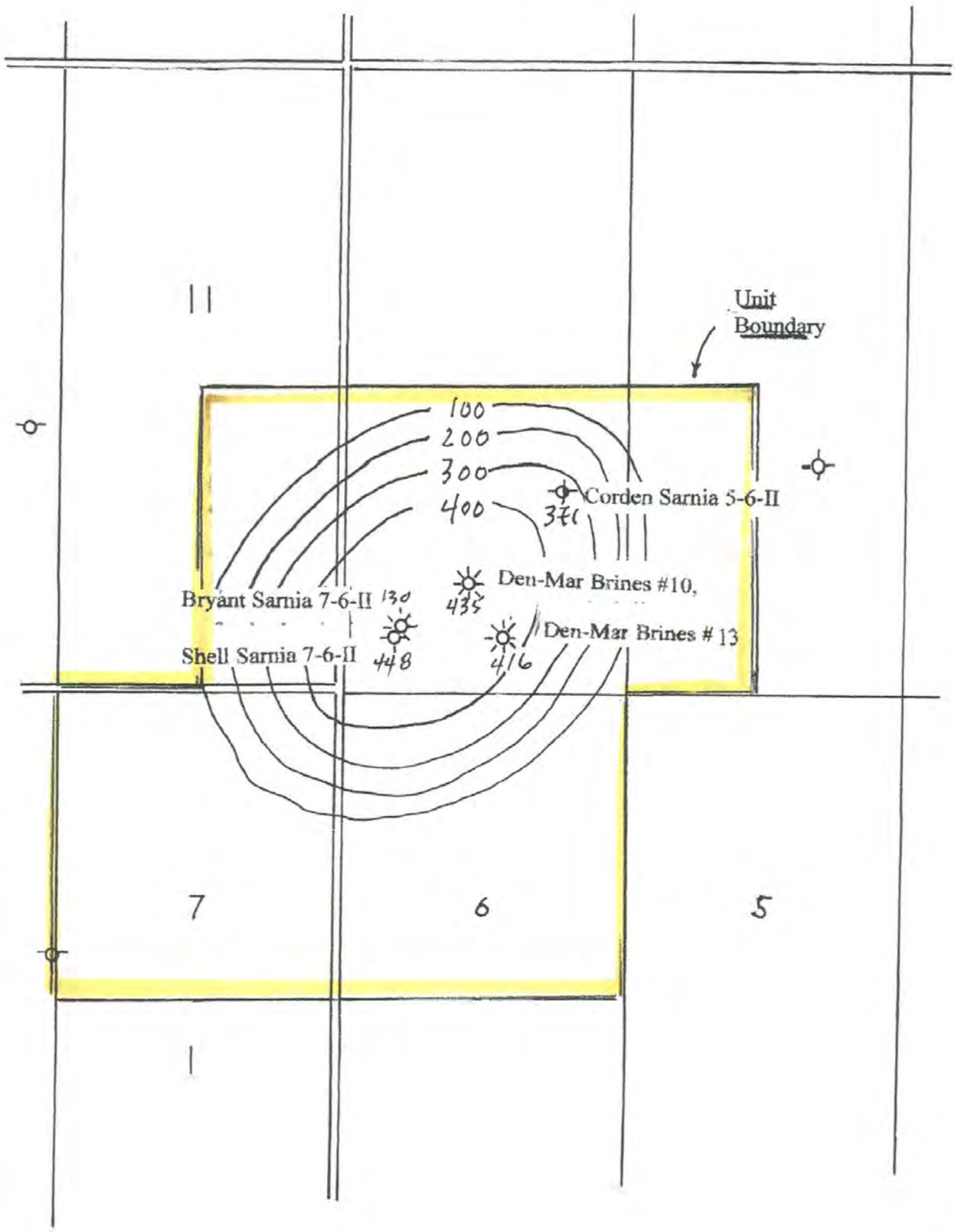
Data derived from Reeftop Report June 2008

Contour Interval 20'
Scale 1" = 1000'

DEN-MAR BRINES

Sarnia 7-6-II Reef

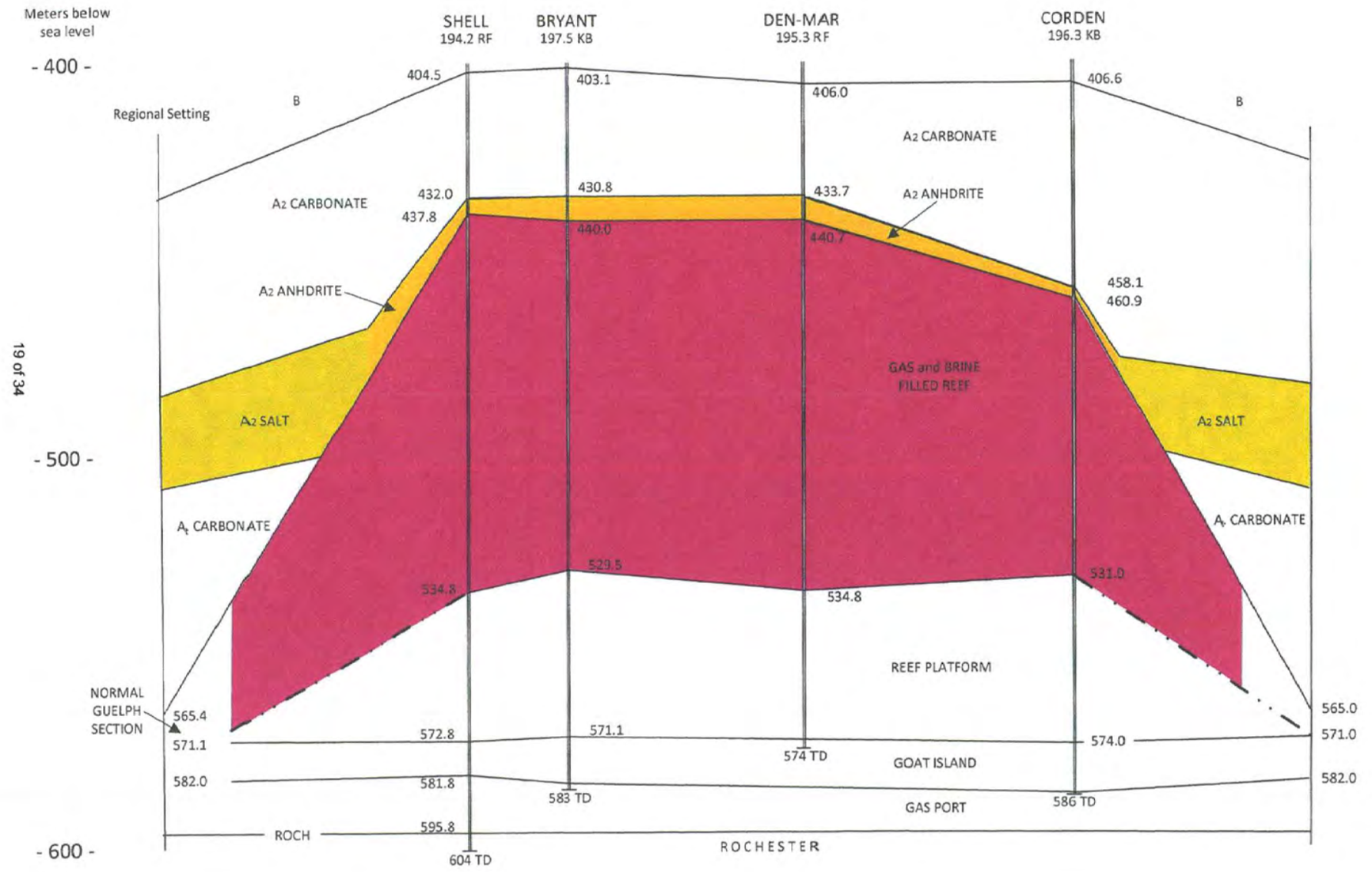
Guelph Reef Isopach

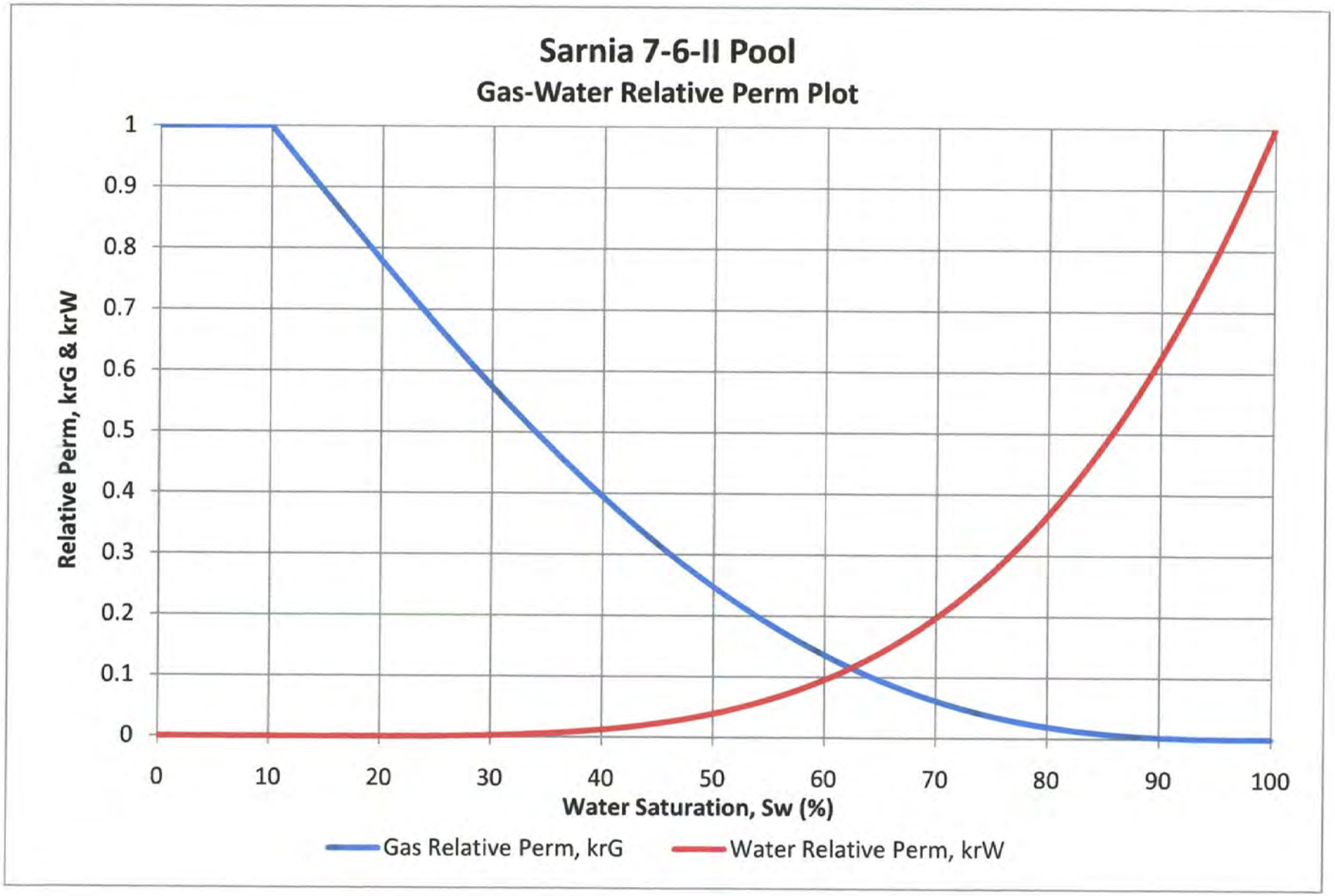


Data derived from
Reeftop Report June 2008

Scale 1" = 1000'

S.W. – N.E. CROSS-SECTION OVER SARNIA 7-6-II REEF




Sarnia 7-6-II Pool
Gas-Water Relative Perm Plot
Relative Perm, krG & krW
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100
Water Saturation, Sw (%)
Gas Relative Perm, krG
Water Relative Perm, krW

Sarnia 7-6-II Pool Well Log Summary

Porosity Cutoff: 4%

Well Name	Bryant et al	Den Mar #10	Shell	Den Mar #13	Overall
Location	Sarnia 7-6-II	Sarnia 7-6-II	Sarnia 7-6-II	Sarnia 8-6-II	average
Gross Pay	121.1 m	133.0 m	166.0 m	120.1 m	135.1 m
Net Pay	99.0 m	102.5 m	48.1 m	104.0 m	88.4 m
Net/Gross	82%	77%	29%	87%	65%
Net Por*h	10.228 m	7.701 m	3.038 m	11.25 m	8.1 m
Average Por	10.3%	7.5%	6.3%	10.8%	9.1%
MPP	715.5 m KB	711.8 m RF	711.5 m RF	716 m RF	
	-518.0 m ss	-516.5 m ss	-517.3 m ss	-518.5 m ss	

Pool Datum: -518.0 m ss

Sarnia 7-6-II Pool Original Water-in-Place and Current Recovery Summary

Areal Extent of Pool	33.7	ha (	83.3	acres)
Gross Pay	135.1	m (	443.3	ft)
Average Net Pay	88.4	m (	290.0	ft)
Porosity	9.1%		9.1%	
Water Saturation	100%		100%	
Water Formation Volume Factor	0.99		0.99	
Original Water-in-Place	2,738	10^3m^3 (	17.2	MMBbl)
Cumulative Water Production	329.8	10^3m^3 (	2.1	MMBbl)
Current Recovery Factor	12.0%		12.0%	

Sarnia 7-6-II Pool Application for Gas injection
Material Balance Discussion

Material Balance (MB) analysis is a powerful tool to estimate gas, oil, and water in-place volumes in a reservoir completely separate from any geological data. The MB technique is particularly accepted and accurate in dry gas reservoirs, where a plot of P/z versus Cumulative Production is a graphical representation of the MB equation.

In its most general form, the Material Balance equation has 2 parts, the left-hand side of the equation (LHS) and right-hand side of the equation (RHS). The LHS lists all changes in reservoir fluids, rock properties, and water inflows from outside the reservoir as a result of changing reservoir pressures. The RHS lists all fluid withdrawals and injections into the reservoir. When the Original Gas-in-Place (OGIP), Original Oil-in-Place (OOIP), and Original Water-in-Place (OWIP) and associated formation volume factors, Gas-Oil Ratios (GOR's) and Gas-Water Ratios (GWR's) are estimated correctly, the change in reservoir pressure as a result of production or injection will match the change in reservoir fluid properties as a result of the change in reservoir pressure.

The most general MB equation can be presented as described below:

> Expansion of Initial Oil + Volume Occupied by Liberated Solution Gas + Gas-Cap Expansion + Water Expansion + Rock Expansion = Oil Production + Liberated Solution Gas Production + Gas-Cap Gas Production + Water Production – Gas Injection – Water Injection – Water influx

For the Sarnia 7-6-II pool, there is no oil, the gas cap, as discussed in the body of the report, is very small to non-existent, and there is no water influx. The general MB equation can be reduced to the following for the Sarnia 7-6-II pool:

> Water Expansion + Volume Occupied by Liberated Solution Gas + Rock Expansion = Liberated Solution Gas Production + Water Production

Where:

> $W * (B_w - B_{wi})$ = Water expansion
> $W * (R_{wi}-R_w) * B_g$ = Liberated Solution Gas Volume
> $(GV-PV) * c_f * (P_{Ri}-P_R)$ = Rock Expansion
> $W_p * B_{wi}$ = Water Production
> $(G_p-W_pR_{wi}) * B_g$ = Liberated Solution Gas Production

With these insertions, the MB equation becomes:

$$W * (B_w - B_{wi}) + W * (R_{wi}-R_w) * B_g + (GV-PV) * c_f * (P_{Ri}-P_R) = W_p * B_{wi} + (G_p-W_pR_{wi}) * B_g$$

W = Initial Water-in-Place [STm^3]
B_w = Water Formation Volume Factor at any particular pressure [Rm^3/STm^3]
B_{wi} = Water Formation Volume Factor at Discovery Pressure Conditions = 0.9980 [Rm^3/STm^3]
B_{watm} = Water Formation Volume Factor at Atmospheric Conditions = 0.9985 [Rm^3/STm^3]
R_{wi} = Gas/Water ratio at Discovery Pressure Conditions [m^3/m^3]
R_w = Gas/Water ratio at any particular pressure [m^3/m^3]
R_{watm} = Gas/Water ratio at Atmospheric Conditions = 0 [m^3/m^3]

B_{gi} = Gas Formation Volume Factor at Discovery Pressure Conditions [Rm^3/STm^3]
B_g = Gas Formation Volume Factor at any particular pressure [Rm^3/STm^3]
c_f = Formation Compressibility = $7.2 * 10^{-7}$ [1/kPaa]
P_{Ri} = Initial Reservoir Pressure = 5100 [kPaa]
P_R = Average Reservoir Pressure [kPaa]
W_p = Cumulative Water Production [STm^3]
G_p = Cumulative Gas Production [STm^3]
GV = Gross Pool Volume [Rm^3]
PV = Pool Pour Volume = GV * Porosity * N/G Ratio
Assumed Average Porosity in Net Pay sections based on well logs = 9.1%
Assumed Pool Net/Gross Ratio from all well logs = 0.65

To simplify calculations, the Water Formation Volume Factor, B_w, and Gas/Water ratio, R_w, were calculated as a linear relationship between discovery pressure and atmospheric pressure conditions:

$Bw = (0.9985 - 0.9980)/5100 * P_R$

$R_W = (R_{Wi} - 0)/5100 * P_R$

Once the reservoir pressure at any particular time is known, all factors in the MB equation are known except for the Initial Water-in-Place, W, and the Gas/Water Ratio at Discovery Pressure, R_{Wi}.

Reservoir pressure at any point in time can either be calculated if the static fluid level, surface pressure if any, and fluid gradient in the well are known, or if the pressure can be measured directly at the reservoir face. The initial static fluid levels in the Shell and Bryant et al wells allow the initial reservoir pressure to be calculated. The produced brine from the Sarnia 7-6-II pool has a density of $1235kg/m^3$ which, in combination with the static fluid levels listed on the Form 7's for the two wells, leads to an average initial reservoir pressure of 5000kPag, or 5,100kPaa. The electric submersible pumps used by DenMar Brine to produce brine from the 3 wells have built in pressure sensors which read out pump inlet pressure continually. After the pool has been shut in for an extended period, the initial pump inlet pressure will be the reservoir pressure at that point in time. These two reservoir pressure measurement techniques allow the reservoir pressure in the Sarnia 7-6-II pool to be calculated/measured over time, with the reservoir pressure data and associated source listed below:

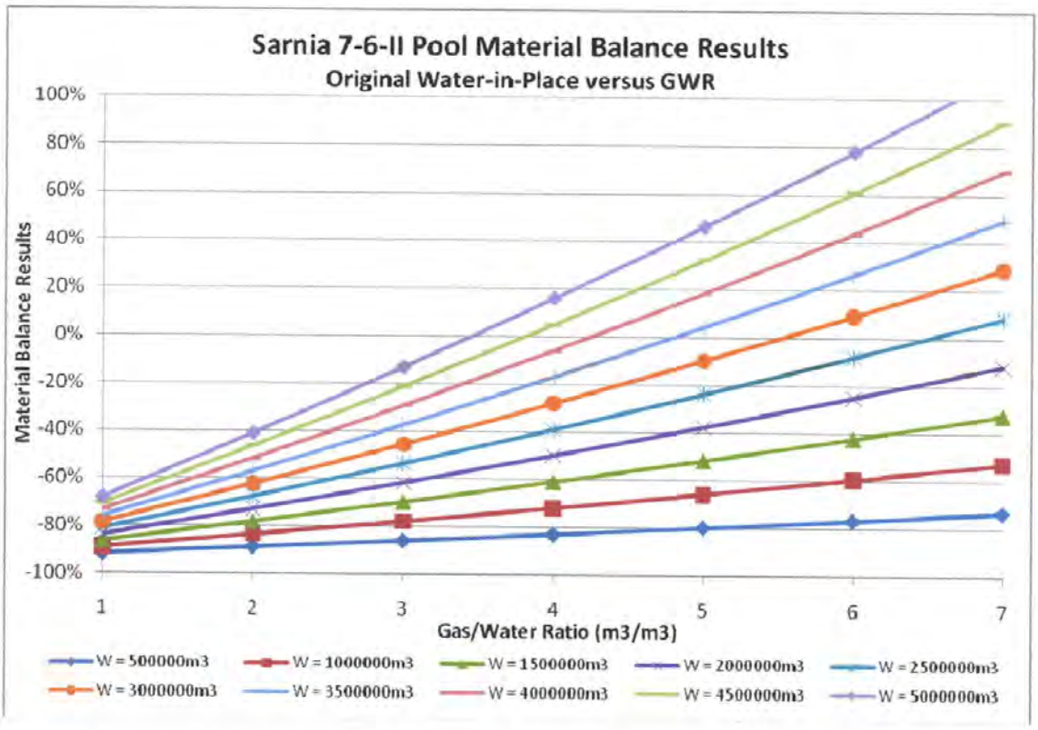
Date	Location	Fl Level (mGd)	Sur Pres (kPaa)	Datum Pressure (kPaa	Cum Wtr Prod'n (10^3m^3)	Cum Gas Prod'n (10^3m^3)	Comments
Jan 1, 1980	Shell	300	0	5078	0	0	Form 7
Jul 27, 2004	Bryant et al	295	0	5141	0	0	Morning reports
Nov 10, 2005	DenMar 10	357	0	4391	37.1	374	Morning reports
Jul 6, 2006	Bryant et al	634	3303	4337	59.9	789	Bryant notes
Sep 1, 2008	DenMar 13	366	0	4297	140.8	4727	Form 107
Nov 13, 2008	DenMar 10			2614	148.6	5012	Pump data
Dec 8, 2008	DenMar 13			3050	152.5	5281	Pump data
May 12, 2011	Bryant et al			1140	262.5	11333	Pump data
May 25, 2011	DenMar 13			437	262.5	11333	Pump data
Jun 7, 2011	DenMar 10			1140	265.6	11454	Pump data

With the reservoir pressure at various cumulative water and gas productions from the Sarnia 7-6-II pool, the MB equation can be completed. Because we have two unknown,

an exact answer is not possible. All we can do is calculate the LHS and RLS of the equation at each reservoir pressure point, and compare answers. The table below shows the average percentage difference between the RHS and LHS of the MB equation for all the reservoir pressures listed above with various combinations of W and R_{Wi}.

RHS vs LHS percentage differences

R_{Wi}:	1	2	3	4	5	6	7
W							
500,000	-92%	-89%	-86%	-83%	-80%	-76%	-73%
1,000,000	-89%	-83%	-78%	-72%	-66%	-59%	-53%
1,500,000	-86%	-78%	-70%	-61%	-52%	-42%	-32%
2,000,000	-84%	-73%	-61%	-50%	-38%	-25%	-12%
2,500,000	-81%	-67%	-53%	-39%	-24%	-8%	9%
3,000,000	-78%	-62%	-45%	-28%	-10%	9%	29%
3,500,000	-76%	-57%	-37%	-17%	4%	27%	50%
4,000,000	-73%	-52%	-29%	-6%	18%	44%	70%
4,500,000	-71%	-46%	-21%	5%	32%	61%	90%
5,000,000	-68%	-41%	-13%	16%	46%	78%	111%



The 0% line on the graph represents the combination of W and R_{Wi} values that lead to the best matches with all the pressure/production data for the Sarnia 7-6-II pool. The best matches at each W value are listed below:

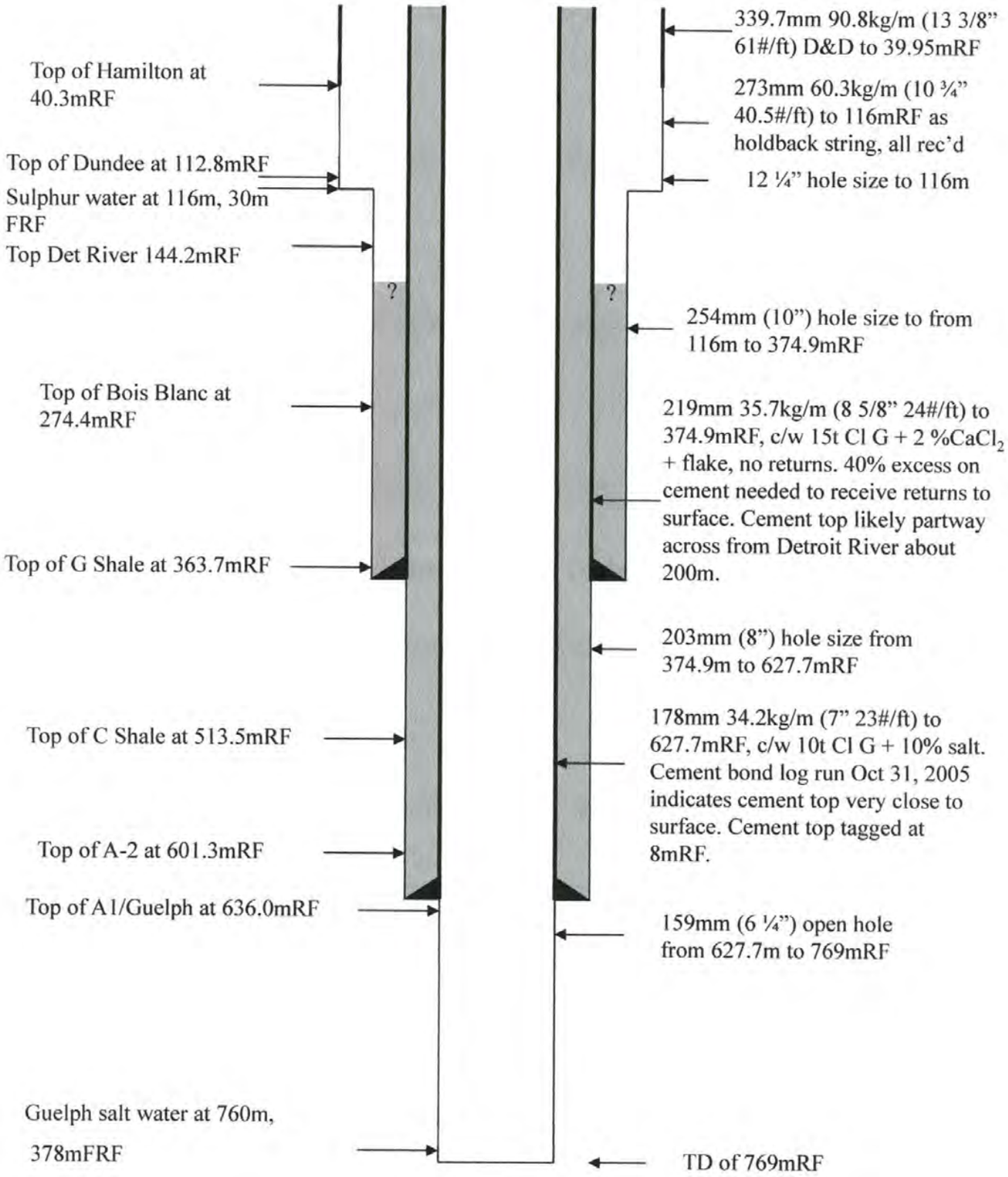
Original Water-in-Place W (m^3)	Initial Gas/Water Ratio to get MB match R_{Wi} (m^3/m^3)
500,000	No match possible
1,000,000	No match possible
1,500,000	No match possible
2,000,000	No match possible
2,500,000	6.5
3,000,000	5.5
3,500,000	4.8
4,000,000	4.2
4,500,000	3.8
5,000,000	3.4

The amount of natural gas that brine water can absorb under reservoir conditions is not a well understood value. Intuitively, water cannot absorb nearly as much solution gas as oil, so a low Gas/Water ratio would be expected. To get a match to the MB equation for the lower "W" values (the ones with "No match possible" listed above), the "R_{Wi}" value would need to be much higher, which is unrealistic. In light of the volumetric water-in-place estimate, W values of between 2,500,000 to 3,500,000 look reasonable, with the higher W value having a lower R_{Wi} value.

Wellbore Schematic Diagram

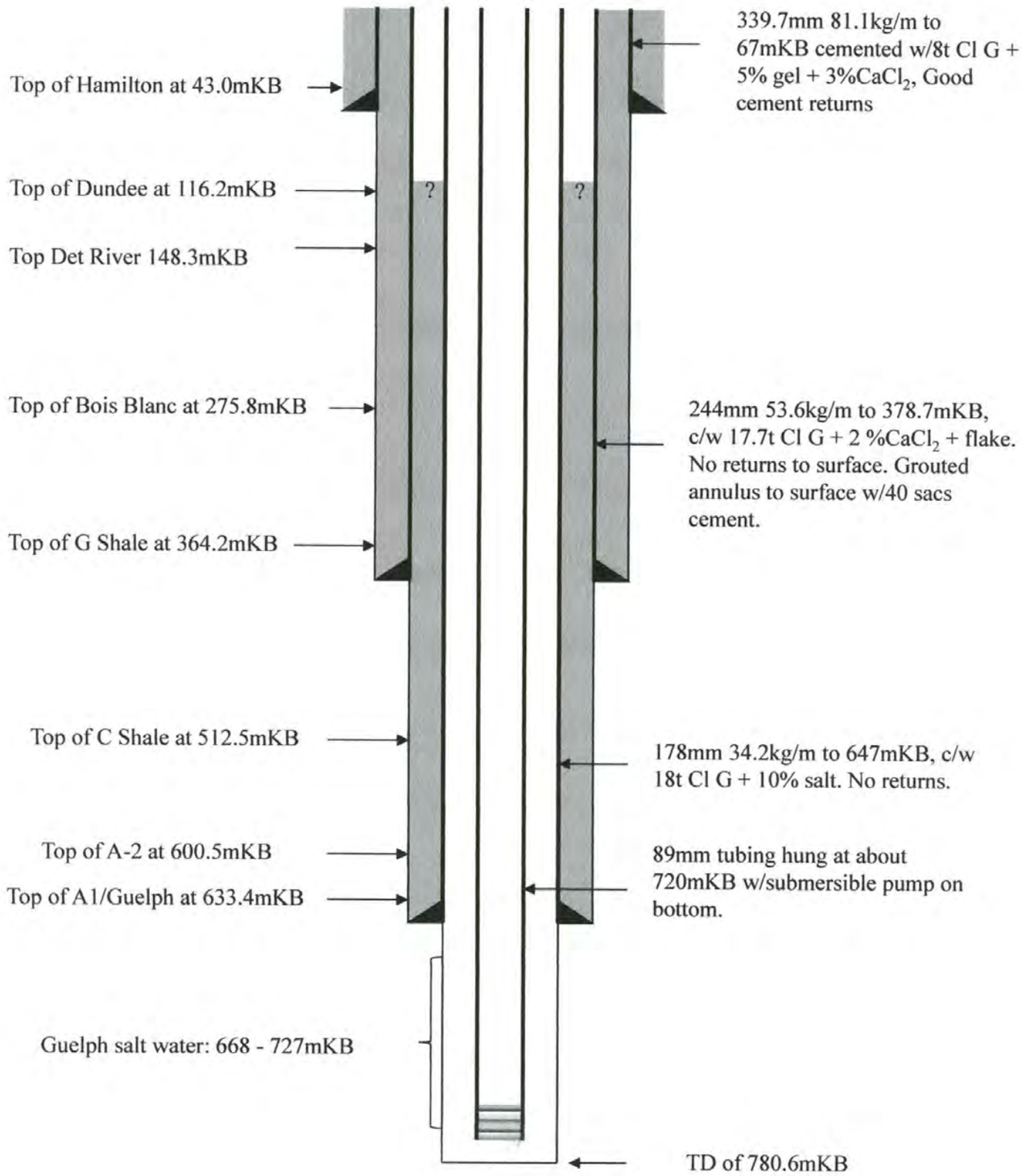
Den-Mar #10: Sarnia 7-6-II Wellbore

As Gas Injection Well for Secondary Recovery



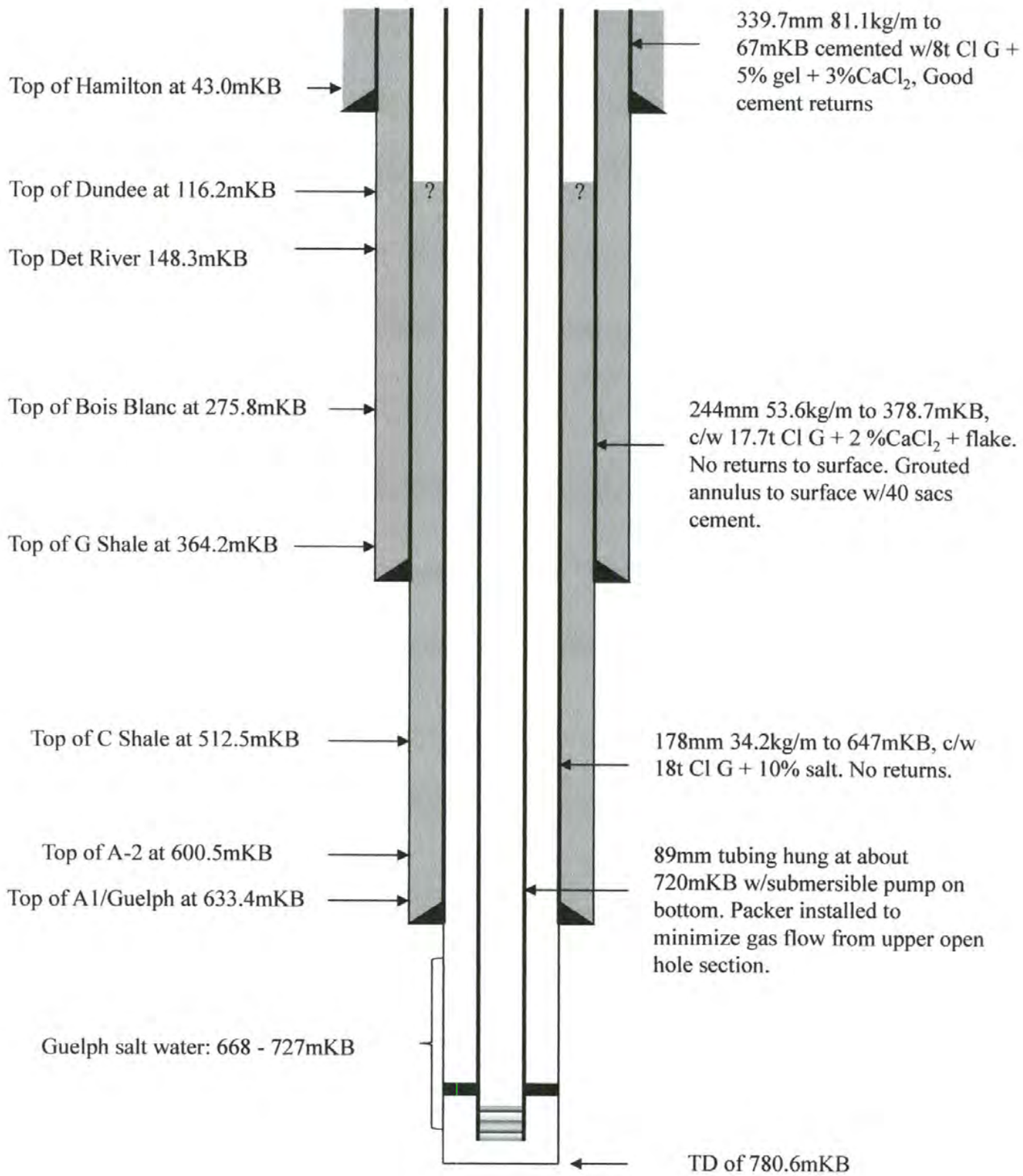
Wellbore Schematic Diagram

Bryant et al Sarnia 7-6-II Current Wellbore



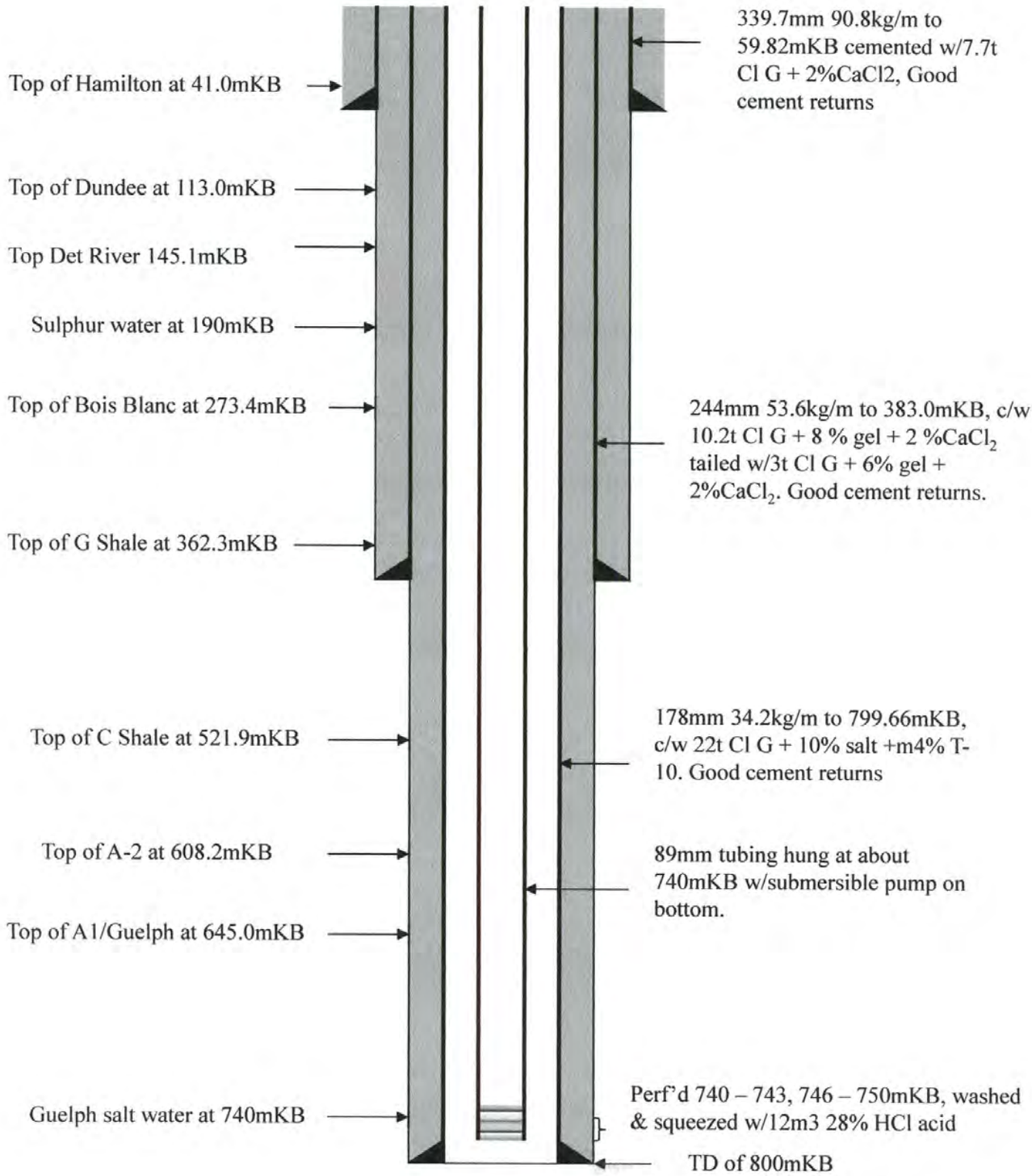
Wellbore Schematic Diagram

Bryant et al Sarnia 7-6-II Wellbore with Packer



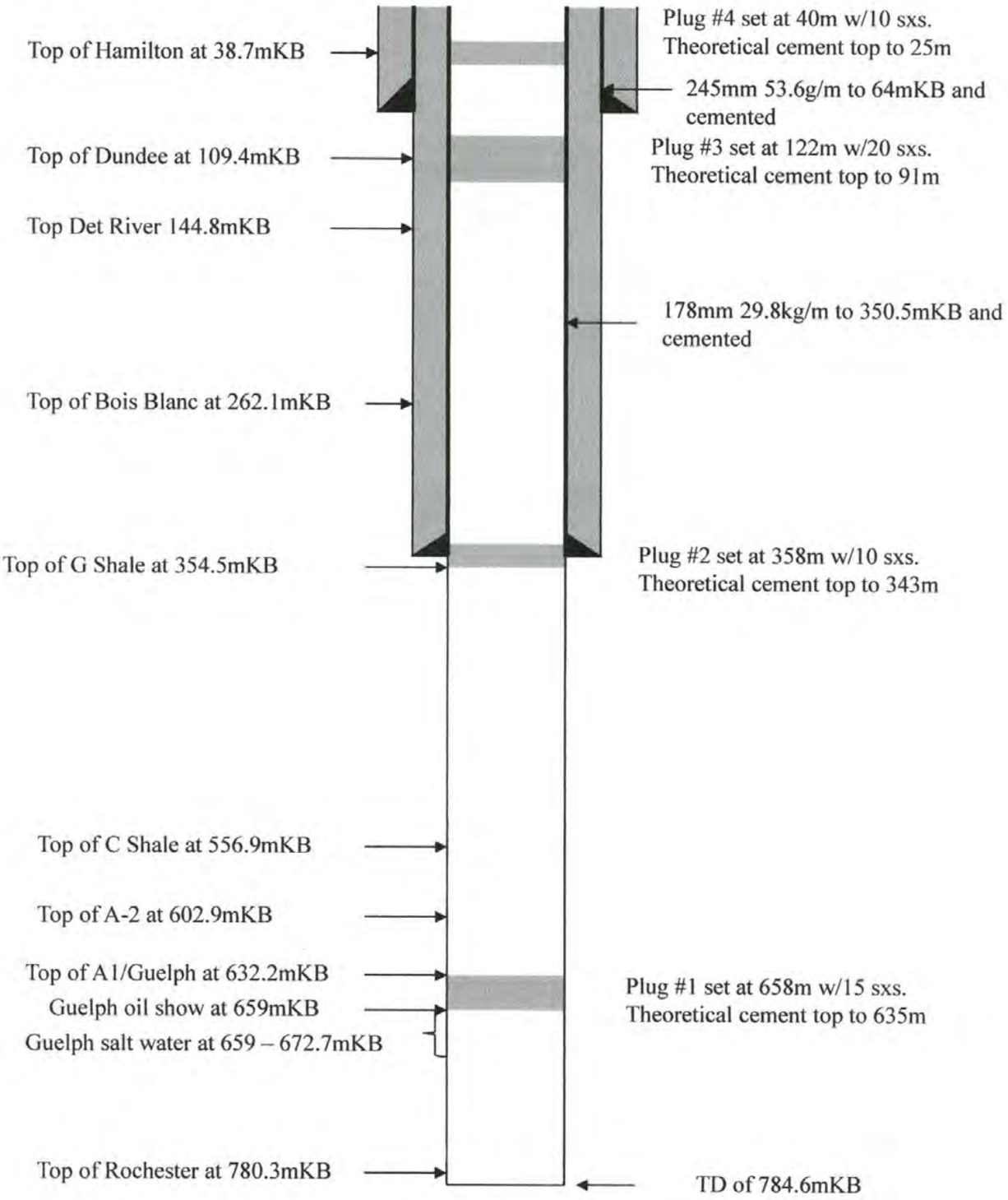
Wellbore Schematic Diagram

Den-Mar #13: Sarnia 8-6-II Wellbore



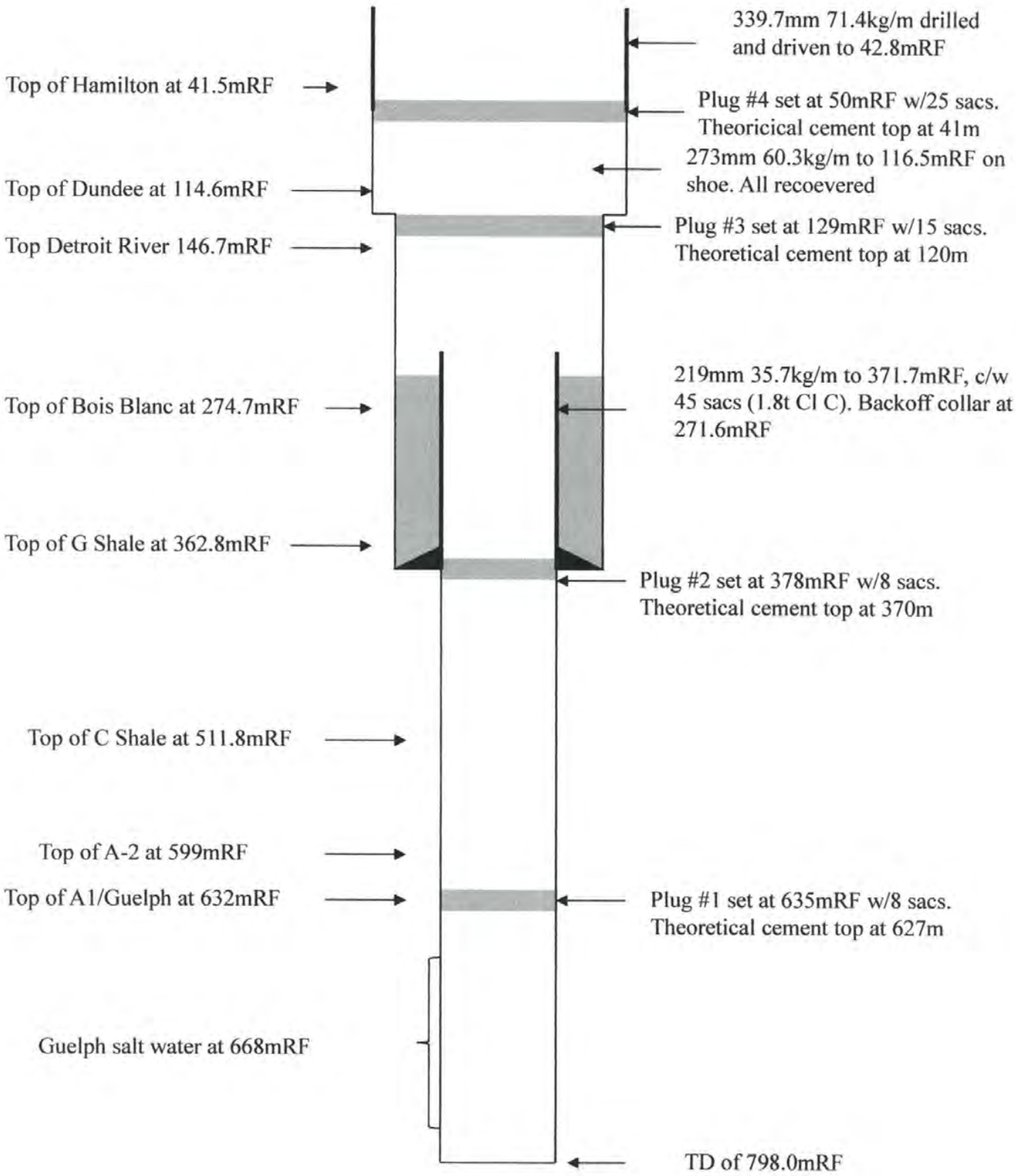
Wellbore Schematic Diagram

Corden: Sarnia 5-6-II Wellbore



Wellbore Schematic Diagram

Shell Sarnia 7-6-II Wellbore



Proposed Schedule for Start of Gas Injection, and Start of Purchased Gas Injection

Activity	Description	Estimated Start Date
MNR/OEB approval	Approval to inject from MNR and OEB	Dec, 2012
Produced Gas Injection	Convert DenMar 10, re-route compressor discharge to DenMar 10	Jan, 2013
Gas pressure makeup	Reconfigure current gas sales connection with Union Gas to allow for gas deliveries to DenMar	Spring, 2013
Modify compressor	Increase compressor sizing if produced gas exceeds current compressor capability	To be determined
Packer in Bryant et al	Install packer in Bryant et al well to minimize gas production rates	Only if required

Sarnia 7-6-II Pool
Material Balance Forecast

For constant reservoir pressure, P_R, the LHS of the MB equation does not change with time or production. Assuming all produced gas is reinjected, the reservoir volume of brine produced equals the reservoir volume of additional gas injected:

$W_p B_{wi} = G_i B_g$

Assuming that all produced gas is reinjected, the table below lists the average annual purchased gas injection required at various reservoir pressures necessary to maintain constant reservoir pressure.

Annual brine prod'n	Reservoir Pressure	Annual Purchased Gas Injection		Daily Average Purchased Gas Injection Rate	
(m^3)	(kPa_a)	(10^3m^3)	(MMcf)	(10^3m^3/D)	(Mcfd)
50,000	1000	494	17.4	1.35	48
50,000	1500	741	26.2	2.03	72
50,000	2000	988	34.9	2.71	96
50,000	2500	1,235	43.6	3.38	119
50,000	3000	1,482	52.3	4.06	143

Accelerated gas injection will be required initially to increase the pool pressure up to the desired reservoir pressure. The optimum reservoir pressure will be that pressure at which brine withdrawal volumes are sufficient to meet DenMar's needs, yet produced gas volumes are as low as practical, since increase gas production volumes will necessitate a larger compressor and more capital costs. Using the gas production/reservoir pressure history, an estimate of additional required gas purchase volumes to increase the pool pressure to various levels can be estimated. The table below lists the estimated gas volumes required to increase the pool pressure back up to various reservoir pressures, and converts these additional purchased gas volumes to equivalent daily injection rates during the initial gas purchase period while the reservoir pressure is rising. The rate at which the pool pressure can be increased up to a higher pressure will be somewhat dependent upon how much gas Union Gas can allow to be withdrawn from their system yet still allow Union to delivery guaranteed year-round gas volumes to all customers currently on the line.

Reservoir Pressure	Past Prod'n to Res Press	Charge gas to get back to stable reservoir pressures[2] Ttl Purchased Gas		Charge Gas Rate[1]		Total Initial Gas Rate	
(kPa_a)	(10^3m^3)	(10^3m^3)	(MMcf)	(10^3m^3/D)	(Mcfd)	(10^3m^3/D)	(Mcfd)
1000	11,500	600	21.2	0.8	29	2.2	77
1500	9,870	2,230	78.7	3.1	108	5.1	180
2000	8,250	3,850	135.9	5.3	186	8.0	282
2500	6,630	5,470	193.1	7.5	265	10.9	384
3000	5,000	7,100	250.6	9.7	344	13.8	487

Note 1: The charge gas rate to bring the pool pressure up to the various reservoir pressures is calculated assuming the pool pressure is increase over a 24 month period.

Note 2: Charge gas required to be purchased in this table assumes cumulative production of 12,100 10^3m^3 when gas sales cease and gas re-injection starts.