# MAR 20100004: PEACE RIVER

Received date: Feb 04, 2010

Public release date: Jun 10, 2011

# PART B

# TECHNICAL REPORT

# AND

# APPENDICES

# METALLIC AND INDUSTRIAL MINERAL PERMIT

# NUMBER O09 9308050787

# PEACE RIVER PROJECT

# 84/C/6

**Submitted by**
**James Howard Punt**

**January 30, 2010**

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# 1.0 Introduction

The Peace River silica sand deposit is situated approximately 10 km north of the town of Peace River, Alberta. The mineral agreement 093 930808050787 represents a known sandstone formation outcropping on both banks of the Peace River, which are referred to as the East and West Blocks in this report. Map 1.0

This technical report provides geological data, including resource calculations from previous investigations, evaluation of the previous data, assessment of the new data, review of the present opportunity and discussion about the transportation advantages inherent to the project.

Proppant or frac sand supply has been the main focus of the investigations of the Peace River silica deposit dating back to the mid 80's. This investigation also targets the supply of "frac sand", however is focused on the Horn River Basin in northern British Columbia.

Natural Gas consumption in USA had reached 23.2 trillion cubic (tcf) in 2008, primarily sourced from conventional gas reserves. The pursuit of shale/tight gas, unconventional gas in North America has had "game changing" effect on the industry. Unconventional gas reserves have expanded in the past couple of years to a point where North America, no longer has short term energy concerns.

Located in northeast British Columbia, one of these large unconventional gas reserves are emerging with-in the Horn River Basin. The Horn River Basin is among a number of "shale gas" regions ready to replenish North America's declining conventional gas production.

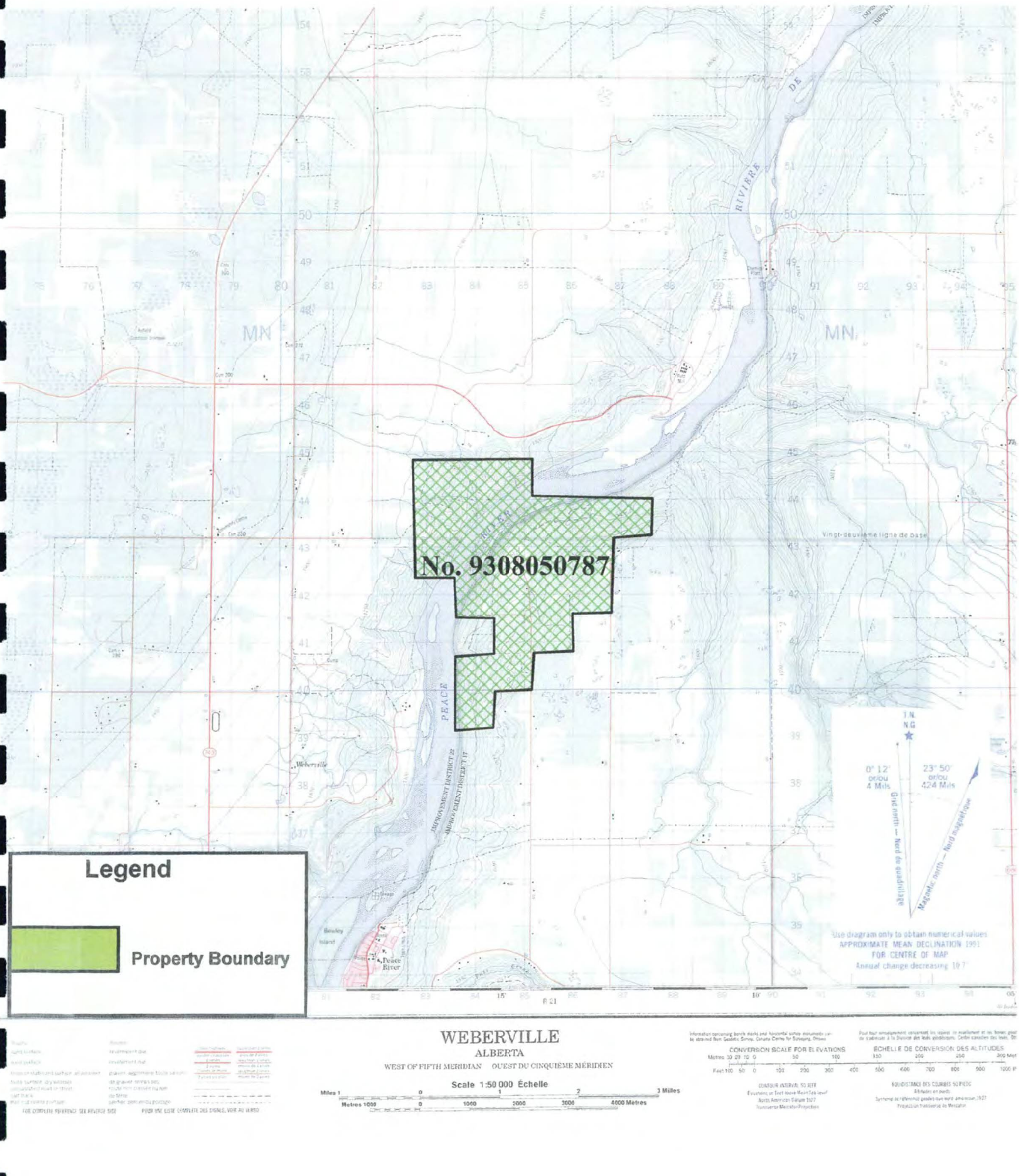
Technological innovations, including horizontal drilling and fracturing technologies are opening up these vast natural gas reservoirs. These technologies are driving suppliers to source new and old supply chains of materials required to drill and fracture these wells. North America's low natural gas prices are pushing these suppliers even further to attain supplies with lower costs making more gas economic. Many silica sand resources close to the burgeon shale plays are being assessed for potential frac sand materials.

The industry prefers the highest quality natural silica sands, as the primary fracturing material (proppants). Proppants that are rounded and spherical, which by nature creates the strongest material to prop open the fractures creating a porous conduit for the gas or oil to escape the bonds of the formation. However, these new technologies, with commodity price pressures, supply issues, infrastructure restrictions are considering materials that could perform in these more unconventional formations.

The commercialization of the sandstone at Peace River depends on the characteristics of the sandstone, the transportation costs and the potential competition from other sources.

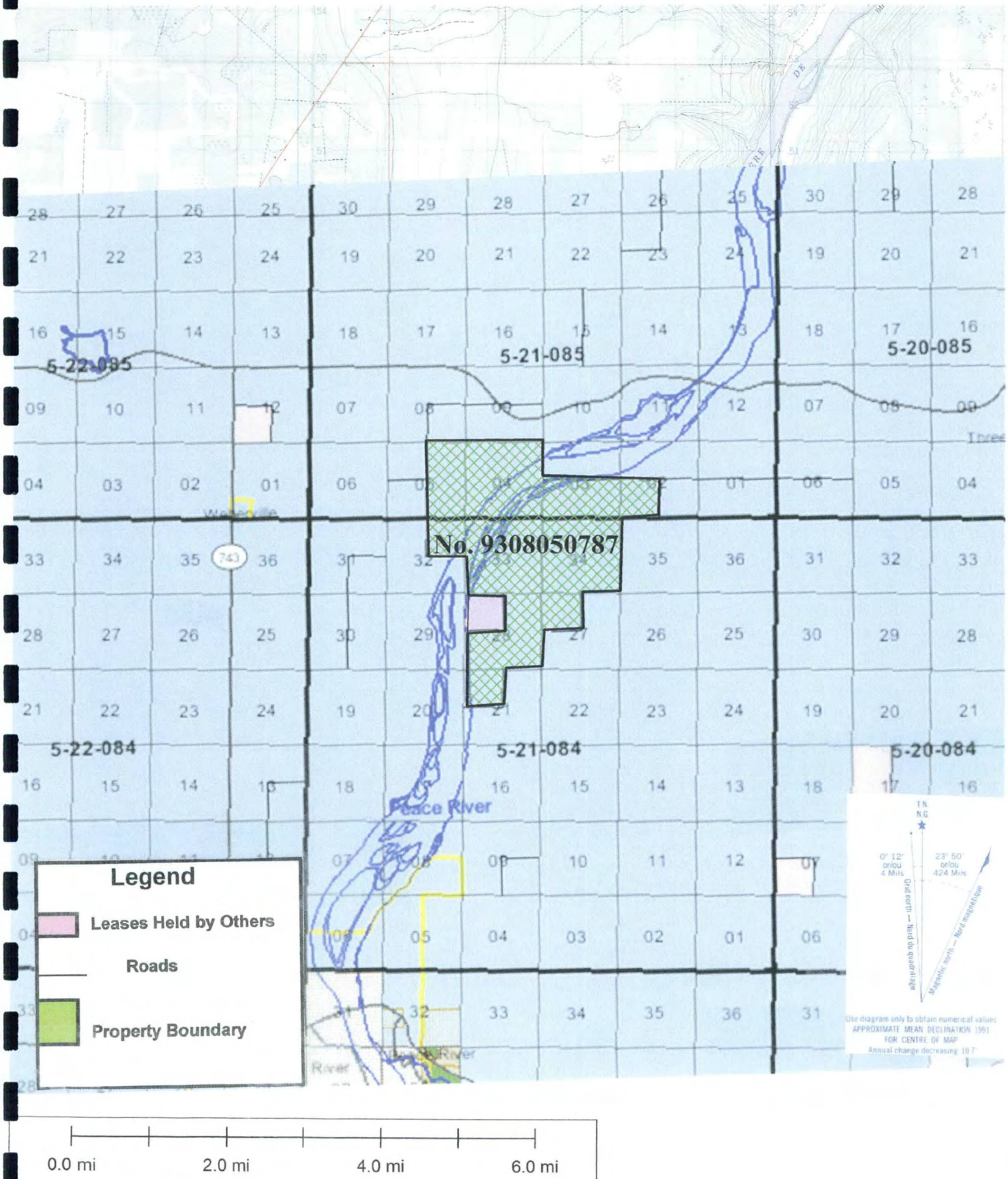
This assessment report discusses the critical factors affecting the Peace River Deposit.

# Peace River Deposit




Boundary Map

# Peace River Deposit




Boundary Map ATS GRID

# MINERAL ASSESSMENT
# EXPENDITURE BREAKDOWN BY TYPE OF WORK

☐ **Estimated Expenditure** (submitting with **Statement of Intent to File**)

X **Actual Expenditure (for Part B of Report**; Must match total filed in Part A)

Project Name: Peace River Project

| | AMOUNT |
|---|---|
| 1. Prospecting | $**984.25** |
| 2. Geological Mapping & Petrography | $**36.00** |
| 3. Geophysical Surveys | |
| a. Airborne | $ |
| b. Ground | $ |
| 4. Geochemical Surveys | $ |
| 5. Trenching and Stripping | $ |
| 6. Drilling | $ |
| 7. Assaying & whole rock analysis | $**3,660.00** |
| 8. Other Work: Commercialization | |
| | $**2,310.00** |
| **SUBTOTAL** | **$6,990.25** |
| 9. Administration (up to 10% of subtotal) | $**699.03** |
| **TOTAL** | $**7,689.28** |

James H Punt
SUBMITTED BY (Print Name)

**4/6/2010**
DATE

[redacted]
SIGNATURE

## 1.2 Previous Exploration and Assessments

1) M.B.B Crocford (1949) from the research Council of Alberta mapped the silica exposures along the river between 1947 and 1949. Size and chemical ana;lysis of samples collected from three west bank trenches.

2) W.F. Banbield (1954) trench samples and sizeable bulk samples. Comprehensive report of the work was submitted. Three of trench were concluded as representative and were used in a later 1989 report by Hamilton.

3) C.C.Bevan (1978) drilling program, Halliburton Services and Alberta Research Council.

4) Trigg Woolett Consultants (1978) mapped the stratigraphy in five exposures of silica.

5) BBT Geotechnical Consultants (1980-1981) 68 boreholes and one test pit excavated. 586 samples submitted for grain size analysis

6) Drilling program (1982) 17 bore holes samples submitted for sieve and crush analysis.

7) **Hamilton (1989) Alberta Research Council 5 drill holes and analysis according to American Petroleum Institute RP56 series of tests. Resource Calculations were completed.**

8) EBA Engineering Consultants (1994) Feasibility Assessment Peace River Deposit.

9) Sherritt Inc. (1995) metal analysis on samples.

10) Drill program (1977) 7 boreholes and chemical analysis completed.

11) **J.D Godfrey (1998) Summary of Geological Exploration of Peace River Sand Deposit.**

12) Ultrasonic Industrial Sciences Ltd. Frac Sand Development (1999 to 2001). Construction and Implantation of Frac Sand Plant.

13) Canadian Silica Corporation (2008) Re-establish Frac Sand Plant.

# 2.0 Geology

## 2.1 Regional Geology

Peace River district lies within the broadly defined Alberta Syncline (Mossop, 1995). A thick package of marine sedimentary rocks within the Western Canadian Sedimentary Basin rests on the floor (Precambrian) having a southwesterly dip towards the Rocky Mountains. The westerly thickening sedimentary package has been the host of numerous oil and natural gas discoveries, particularly during the past 50 years and is also associated with extensive coal beds and oil sands.

The regional geology has been described historically and refined in more recent publications (McLearn 1918, Rutherford 1930, Jones 1966, Mossop and Shetsen 1995) and local studies have added considerable detail to the understanding and interpretation of the sections exposed in and adjacent to the Peace River Valley (Crockford 1949; Smith, D.G. Zorn, C.E. and R.M. Sneider, 1984; Leckie et al. 1990; correlations of the geology at Peace River Town and Central Alberta as published by Leckie and Singh (1991).

Sedimentary rocks resting unconformably on the Precambrian in this part of Alberta range are aged from Devonian period, through the Paleozoic and Mesozoic Era's. They are overlain in turn by Lower and Upper Cretaceous strata which immediately underlie the Peace River region.

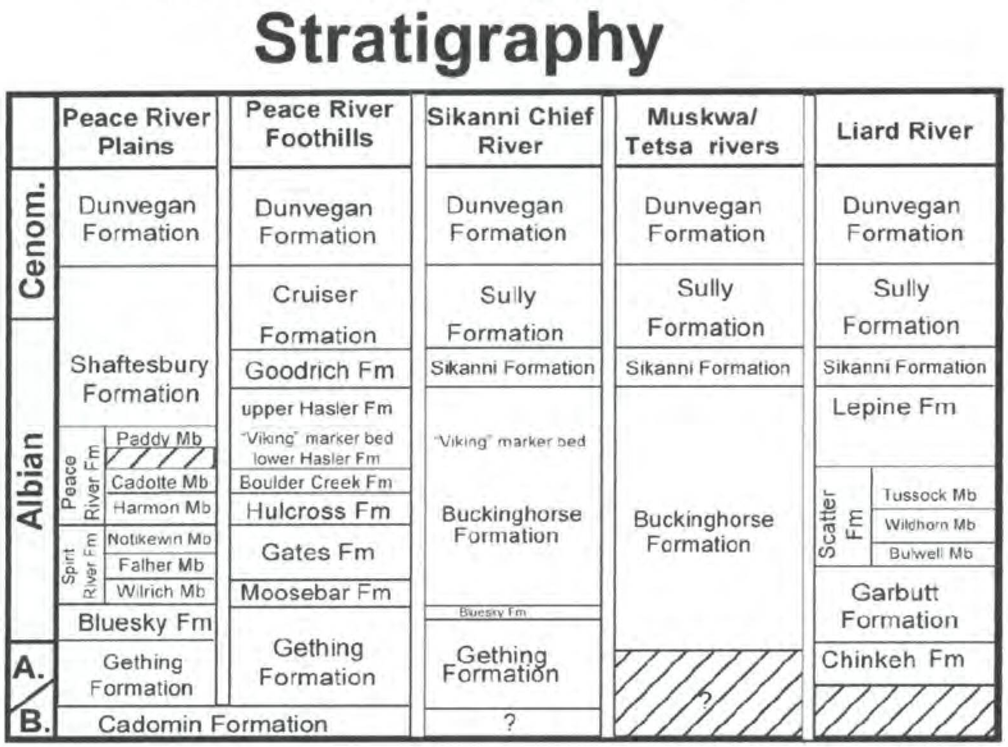
This report deals with the lower cretaceous Fort St. John Group, which contains in the subsurface (northwestern Alberta) the Spirit River Formation overlain by the Peace River Formation. The Spirit River formation is subdivided into Wilrich, Falher and Notikewin members. The Peace River Formation contains the Harmon, Cadotte and Paddy members **(Figure 2.0-1)**.

The Peace River plains is west of the target area, outcrops at Dinosaur Lake expose the Moosebar, Gates, Hulcross and Boulder Creek formations, and the Hasler Formation with the Viking marker bed along the Moberly Lake Road.

The basal transgressive surface of the Moosebar/Clearwater Sea is a distinct regional log marker separating coastal plain and shoreface deposits (Gething and Bluesky formations respectively) from marine mudstones (Wilrich Member and Buckinghorse Formation).

Cross sections running in an east-west direction between Peace River and Trutch show the disappearance of the Notikewin sandstones and change into marine shales of the Buckinghorse Formation in westerly direction. The western region is characterized by mudstones-dominated deposition, possible due, at Notikewin time, to eastward flowing mud dominated river systems into an area of increased accommodation space. Distribution of these upper Notikewin sands along the eastern margin of the foredeep is likely the result of counterclockwise marine circulation allowing for predominated northward transportation and distribution of sediments from the Notikewin delta along the eastern side of the foredeep.

**Figure 2.0-1 – Regional Stratigraphic Chart**




Stratigraphic framework modified from Stott (1982),

As the influence of coastal sedimentation decreases in a northern direction, further up-section transgressive / regressive cyclity in the Albian Sea is still distinctly recognized in northern distal settings. Each new sea level rise is marked by a distinct flooding surface seen on logs, allowing for regional correlations. The distinct sandstones of the Paddy and Cadotte members, as observed in the south, are not present in the more distal northern basin. In the Peace River region the Paddy Member unconformably overlies the Cadotte Member (Leckie and Singh, 1991). It appears that marine sedimentation is preserved between these two units to the north.

## 2.2 Local Geology

The Peace River silica sands were deposited in marine and non-marine sediments of the Cretaceous Fort St. John Group **(Table 2.1-1)**, which in the project area is overlain by Pleistocene deposits. The Peace River formation's members Paddy and Cadotte sandstones define the silica sand deposit within the project area which straddles the Peace River. Erosion by the Peace River has removed much of the original silica sand, dividing the deposit into two remnant segments on the east and west banks of the river.

**Table 2.1-1 Fort St. John Group**

| Formation | Member | Facies | Lithology |
|---|---|---|---|
| Dunvegan | | Marine | Sandstone and shale with occasional coal beds |
| Shaftesbury | Upper | Marine | Silty and sandy shale |
| | Lower | Marine | Fissile shale |
| Peace River | Paddy | Non-Marine | Sandstone and sand with occasional coal beds |
| | Cadotte | Marine | Sandstone and siltstone with varying amounts of shale |
| | Harmon | Marine | Shale |

(Alberta Research Council 1989)

### 2.2-1 Peace River Formation

The sequence of Harmon Member open marine conditions grading upwards to shallowing waters of the Cadotte sandstone, followed by the partial fluvial nature of the Paddy Member sandstone records a general marine withdrawal (regression) or hiatus, followed by a Shaftesbury marine re-invasion (transgression).

The Paddy Member silica sands were deposited in a coastal environment involving a variety of energy regimes and fluctuating sea levels that interacted with such features and phenomena as: offshore sand bards, beaches, sheltered lagoons, deltaic and estuarine – tidal conditions and possibly eolian activity;

In the course of the Rocky Mountain uplift, the shallow Cretaceous inland sea withdrew, setting the stage for lasting continental conditions and the Pleistocene Continental Glaciations and the latter eroded part of the Shaftesbury Formation and underlying Paddy member in the East Block. Subsequent post-glacial erosion during entrenchment of the Peace River also removed a wide section of Cretaceous strata meanwhile separating the Paddy Member silica sands on the property into the well-defined West and East Blocks. The resultant river valley outcrops provide an excellent opportunity for the study of these strata.

### Harmon Member

The Harmon Member is dominated by dark grey, thin bedded marine shales. They can be seen at the base of the west bank in the recent excavation for the rail line extension to the Daishowa Pulp Mill, situated just downstream from the West bank of the property. This geological interval is interpreted as having had open sea conditions but trending towards shallow water as the following Cadotte Member is represented by marine sandstones.

### Cadotte Member

The Cadotte sandstone overlies the Harmon Member and is a well sorted, uniformly fine grained, and poorly cemented sandstone which forms the lower part of the prominent cliffs extending for several miles along the valley of the Peace River. Its bedding tends to be tabular, thick bedded and massive and appears to have a nearly horizontal structure as viewed from the river. It weathers grey to brown due to a lichen cover with local rusty zones approximately aligned with the bedding surfaces. The maximum local thickness could be between 15 and 34 meters based on information from Crockford (194) and Lichtenbelt (1982).

### Paddy Member

The Paddy Member rests on the Cadottee Member with an erosional (disconformable) surface that may be marked by a thin, discontinuous coal/bituminous seam or a gravel layer. The erosional surface has been reported to have a relief of up to 5 feet or so, and the Paddy sandstone occupies, at least locally, a valley fill stratigraphic relationship. It is a clean, medium to coarse grained, basically uncemented sandstone; typically with cross-bedded, trough-bedded to tabular bedded forms, reversed herring bone tidal bedding and occasional thin silty clay beds. Discontinuous, rusty stained zones of 1 foot or so in thickness mark the beds uncommonly. Thin (less than 1 foot), somewhat better cemented, tabular bedded, argillaceous beds can be found occasionally within the Paddy Member.

The Paddy Member appears to have been deposited in a coastal environment with local high to moderate or even low energy variations that include wave washed off-shore bars, sheltered backwater lagoons, possibly with a deltaic influence in part and tidal estuarine conditions. The sub-aerial off-shore bars were stable long enough for swamp conditions and a vegetation cover that later gave rise to thin coal seams overlying sections of the higher elevations of the silica sand.

It has been suggested that the Paddy Member sandstone has results from the reworking of the underlying Cadotte Member. However, unless there are sections of the Cadotte elsewhere that are of coarser grain size, one must look further afield for another source of the abundant coarse-grained component in this texture. Perhaps the property was down current of a delta that introduced coarse fluvial sand into a coastal environment.

The mature, clean nature of the sand strongly suggests a second cycle material, and the restricted heavy mineral suite and characteristically well-rounded quartz grains point towards a high-energy, wave washed sand bar. Furthermore, eolian activity on exposed beaches and sand bards, lacking a vegetation cover, would be very proficient in the rounding of sand grains.

The accessory minerals reported by Crockford (1949) include: magnetite, ilmenite, zircon, titanite (sphene), limonite and feldspar. The first four heavy mineral suite species fit the pattern of mature sand and the limonite could be secondary after an iron-bearing oxide. But, the detrital feldspar is anomalous; it is not a normal stable end product of long-term weathering, and therefore its presence suggests another source of detritus is entering the system. Perhaps a nearby fluvial (deltaic) source which could also account for the introduction of the coarser quartz sand grains in the Paddy Member sands.

Subsidence and a marine flooding of the coastal region to deeper, quieter water conditions allowed deposition of silty clays closer inshore and clays farther out as a facies variation within the marine Shaftesbury Formation

The Paddy Member silica sand has a measured thickness in the East Block of the Peace River property that ranges from just less than 10 feet up to 42.5 feet, with an average thickness from about 25 to 30 feet.

**Shaftesbury Formation**

The uniform, brown to grey weathering, dark grey (fresh) carbonaceous marine shales are characteristic of the Shaftesbury Formation. A discontinuous thin coal seam and lag gravel bed are found at the base of the Shaftesbury Formation in the East Block and can be used locally as a marker horizon.

## 2.3 Surficial Geology

Jones (1966) identified five groups of surficial deposits (soils) which cover the Cretaceous bedrock. These deposits are discussed below, although very little engineering data is available from work done on the lease to date.

### 2.3-1 Pre-Glacial Deposits

Channel deposits, consisting of sand and gravel, overlie the bedrock and underlie glacial and recent deposits. Three levels of the deposit have been identified:

- Deeply buried sands and gravels located in pre-glacial channels
- Intermediate level terrace deposits
- Shallow, high level sand and gravel (grimshaw gravels) which predate the other two types of deposit

The buried sands and gravels may affect the engineering design of the operation Jones (1966) reports 3m to 10m of buried sands and/or gravels at 10m to 30m below the surface in the Weberville area. Neither the grimshaw gravels nor terrace deposits should be a concern.

### 2.3-2 Glacial Moraine Deposits

Exposures of till are not evident in the site area, although ground moraine probably underlies the glacialacustrine deposits.

### 2.3-3 Glaciolacustrine Deposits

A proglacial lake once covered much of the Peace River area. As a result, varved deposits are present. Jones (1966) notes that sediments deposited in the area of the present day Peace River are typically silty and unvarved. Leslie (1994) indicates that the West Block is covered with glaciolacustrine sediments.

### 2.3-4 Glaciofluvial Deposits

Previous investigations of the silica deposit on the east bank of the river have encountered 6 to 21 m of boulders, gravel and sand overlying the silica (Alberta Research Council, 1989).

### 2.3-5 Recent Deposits

Most slopes along the Peace River and ravines are covered with a veneer of colluvium, generally occurring from the erosion of surficial glaciolacustrine sediments. Extensive slumping (colluvium) also occurs along the Peace River valley. These are most extensive in areas where deep buried channels intersect present rivers and streams.

## 2.4 Hydrogeology

Borneuf (1981) provides a recent assessment of the hydrogeology in the Peace River area, which is summarized below.

Three main buried channels, which act as good aquifers, are located in the Peace River area. One of these, the Shaftesbury Channel, runs parallel to the Peach River in a southwest-northeast direction and crosses the present river valley, between the town and the south end of the West Block. This channel is filled with up to 240m of sediments including sand and gravel. Slope instability in this area may be influenced by groundwater condition in the subsurface channel.

Recharge occurs in upland areas, such as the Whitemud Hills to the west and in low-lying areas with high permeability, such as the Grimshaw Gravels, northwest of the Town of Peace River. Discharge occurs at rivers and in an area south to southwest of Cardinal Lake, where flowing conditions occur. Springs which develop from bedrock aquifers do not flow much due to low permeabilities.

Aquifers in the area come from both surficial and bedrock sources, with varying yield amounts such as 0.1 to 38 l/sec (1 to 500 gallons per minute). Generally, buried channel aquifers have the highest yields.

### 2.4-1 Structure

Dip of the strata in the vicinity of the deposit is less than one degree to the southwest. No faults or other dislocations of the strata have been observed in any of the outcrops or interpreted from boreholes. However, localized slumping of the Shaftsbury Shales is evident on the West Bank.

### 2.4-2 Topography

The deposit is separated into the East and West blocks by the Peace River erosional channel. On the East Bank the elevations range from 450 m along the uplands terrain down to 300 m along the river edge. The terrain on the west bank is that of a 5 – 8 degree slope starting at the 500 m elevation and descending to the river level with 45 m vertical cliffs. The slope of the river valley is dissected by two creeks, one of which flows all year. One has a gully 30 m or more with steep walls that generally dip around 40 degrees from the horizontal. In places some are almost vertical.

## 2.5 Drill Hole Program (1989)

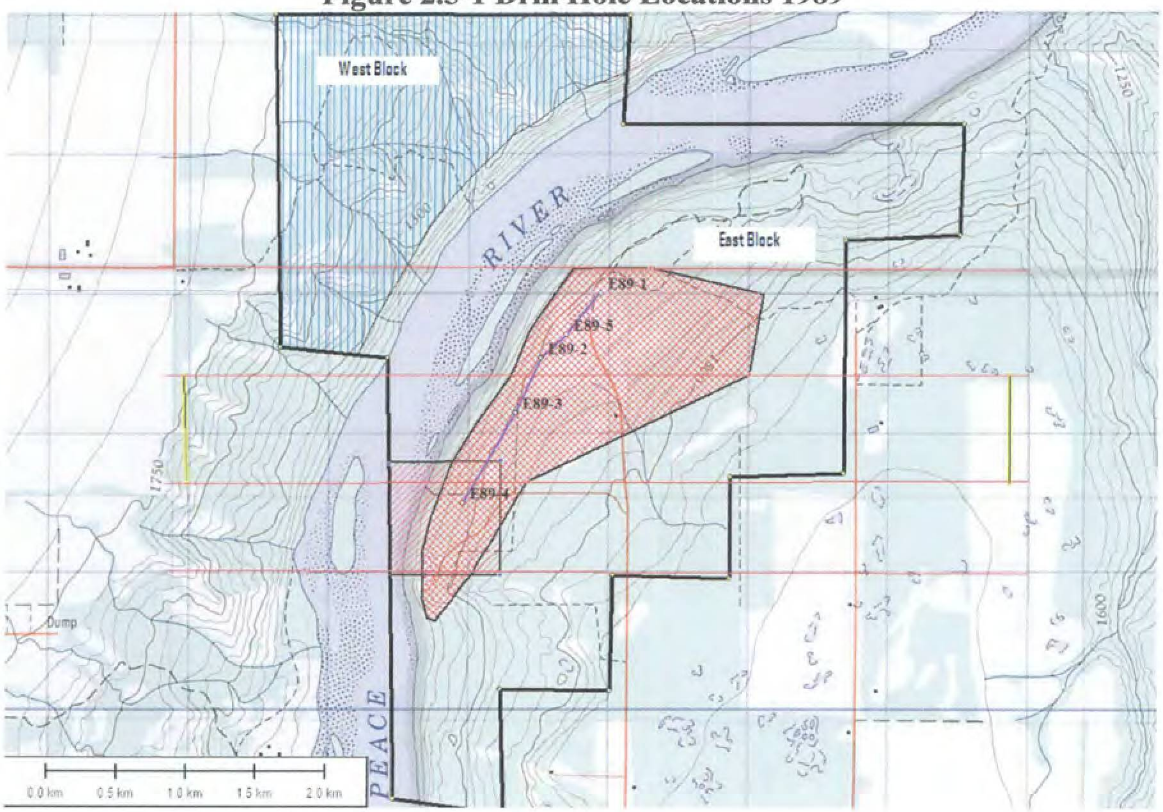
Five Test holes were drilled in March 1989, along the extent of the deposit on the east side of the Peace River. **Figure 2-5-1** shows the locations of the drill holes. The drill holes provided silica sand samples for testing completed by BBT Hardy (1989). These holes were located in such a manner as to characterize the East Bank of the deposit. Samples were taken from both the Paddy and Cadotte Members. **Table 2-5-1** shows some of the information available from the drilling program. Numbers in brackets, following the sample description, indicate how many samples were taken from each hole.

**Table 2.5-1 1989 Drill Hole Data**

| Hole | Location | Interval | Description (Samples) |
|---|---|---|---|
| E-89-1 | 11,512.32N | 1-.66 ft | Topsoil |
| | 9,765.45E | .66 to 29.5ft | Gravel, Sand |
| | 382.87 M | 29.5 to 86.5 | Shaftesbury |
| | | **86.5 to 108ft** | **Paddy (7)** |
| | | 108 to 109 ft | Coal |
| | | **109 to 120 ft** | **Cadotte** |
| E-89-2 | 11,62.60 N | 0 to .5 ft | Topsoil |
| | 9,375.08 E | .5 to 18.0 ft | Gravel, Sand |
| | 387.80 M | 18.0 to 100.5 ft | Shaftsbury |
| | | **100.5 to 130.5 ft** | **Paddy (15)** |
| | | 130.5 to 132 ft | Coal |
| | | **132 to 148 ft** | **Cadotte (6)** |
| E-89-3 | 10,538.20 N | 0 -.66ft | Tpsoil |
| | 9,157.75 E | .66 to 1.0 | Sand |
| | 391.47 M | 1.0 to 108. ft | Shaftsbury |
| | | **108 to 123.5** | **Paddy (8)** |
| | | 123.5 to 124.5 | Clay |

| | | | |
|---|---|---|---|
| | | **124.5 to 150.5** | **Paddy** |
| E-89-4 | 9,893.17 N | 0 to .5 | Top Soil |
| | 8,765.60 E | .5 to 44.5 | Shaftsbury |
| | 363.63 M | 45.5 to 48.0 | Siltstone |
| | | 48. to 51 | Gravel, sand |
| | | 51 to 52 ft | Coal |
| | | 52 to 54 ft | Gravel, sand |
| | | **54 to 67ft** | **Paddy (4)** |
| | | 67 to 68 ft | Coal |
| | | **68 to 127 ft** | **Cadotte (1)** |
| E-89-5 | 11,223.47 N | 0-32ft | Gravel, Sand |
| | 9,628.26 E | 32 to 110 ft | Shaftsbury |
| | 391.01 EL | **110 to 138 ft** | **Paddy (14)** |
| | | 138.0 to 148 ft | Coal |
| | | **148. to 150 ft.** | **Cadotte (1)** |

**Figure 2.5-1 Drill Hole Locations 1989**




## 3.0 Resources

The Cadotte and Paddy Member sandstones are evidenced by the prominent cliffs, set back a short distance from the Peace River in the subject area. The Peace River separates the West Block (right) and East Block (left) on subject property.

The East block is 3,000 m long in the N-S direction and 1,000 m wide in the E-W direction. The west side of the deposit outcrops from 45 to 52 m above and on the banks of the Peace River. It pinches out at the north end of the block with the east and south limits yet to be defined. Maximum thickness is 12.9 metres in hole E-89-3.

The West Block is approximately 3,300 long in the N-S direction and 800 m wide in the W-E direction. As in the East block, the Paddy sands outcrop on the bank of the Peace River. The overall thickness of the deposit ranges between 2 m at the north end to 16.4 metres in Hole 112 located near the center of the deposit.

### 3.1 Volume

The resource estimates used in this report were prepared by (1989 Hamilton) and confirmed by (1997 Godfrey) and were measured by planimetering (a defined area multiplied by an average thickness creating an area cubed). The data used by Hamilton include drill holes, channel samples, and trenches. Geologic control was provided by 48 tests holes on the East Block and 10 test holes, 7 trenches and 5 outcrop localities on the West Block. Total sand resources within each block were calculated from these data points and were presented as measured and inferred resources (Table 3.0-1).

Measured resources are tonnages computed from data revealed in outcrops, trenches and boreholes from which the density and quality of points of observations are sufficient to allow a reliable estimate of sand unit thickness.

Inferred resources estimates are computed by projection of thickness, sample and geological data from outcrops, trenches and drill holes for a 250 metre distance.

**Table 3.1-1 Resources Measured and Inferred**

| Location | Measured (tonnes) | Inferred (tones) | Total |
|---|---|---|---|
| East Block | 13,670,000 | 8,590,000 | 22,260,000 |
| West Block | 14,890,000 | 10,970,000 | 25,860,000 |
| **Total** | **28,560,000** | **19,560,000** | **48,120,000** |

The Paddy Member has a measured thickness in the East Block ranging from 13 to 42 feet with an average thickness of 26.8 feet and the West Block ranging from 8.5 to 46.5 feet with an average thickness of 26.5 feet.

A thorough review of the previous work was carried out to compile the data for the resource and quality estimations of the deposit presented by (1989) Hamilton. Geological work completed by

Crockford (1947), Banfield (1953), and Lichtenbelt (1982), was considered to be the most acceptable as these individuals provided the necessary geologic control and descriptions.

John Godfrey P. Geol., Ph.D on behalf of Ultrasonic Industrial Sciences Ltd. (UIS) confirmed (1989) Hamilton resource estimates, while employed by the UIS group. "There has been no additional exploration work on the West Block since the Hardy-BBT/ARC field program in 1989, so the reserves calculation for the West Block remains unaffected. The additional UIS field work of September, 1997 affects the southern extremity of the East Block only and the reinterpretation of that portion of the isopach map for the Paddy Member amounts to a refinement with an insignificant impact on the overall reserves picture, either negatively or positively."

Hamilton used an isopach map to itemizing areas where the resource is calculated. This isopach map has been over laid on a 1:50,000 scale map, showing the location of the resources. The area highlighted in red shows the overlaid area on the East Bank. The overlay is located in a figure in a previous Section 2.5-1.

For the purposes of this assessment report, removing the volumes associated with the ¼ section, held by others does not serve any purpose. This 1- ¼ section is actually 150.12 acres with-in a property package 23 sections or 14,720 acres.

The isopach map is located in Appendix 1. Figure 1-3 Tables 2-2 and 2-3 provided the area designations, area sq.ft, along with the thickness of the each area. The resource calculations are also presented in these tables.

## 3.2 Gradation of the Sand Deposit

Weight average grain sizes computed for the whole deposit were also presented by (1989 Hamilton) and are based on 200 samples from 21 bore holes in the East Block, and 105 samples from 7 boreholes and 3 bulk trenches in the West Block are presented in **Table 3.2-1.**

**Table 3.2-1 Gradation of Sand Deposit**

| US Sieve Size | East Block | West Block |
|---|---|---|
| **0-12** | 1.0% | .2% |
| **12-20** | 2.8% | 6.2% |
| **20-40** | 16.4% | 22.5% |
| **40-60** | **20.2%** | **30.5%** |
| **60-100** | **31.4%** | **21.3%** |
| **100-200** | **14.4%** | **14.9%** |
| Minus 200 | 13.8% | 4.4% |
| Total | 100% | 100% |

In **Appendix 2** - Tables 2.4 and 2.5 from (1989 Hamilton) illustrate the data used in the calculations. It is apparent a significant variation in the distribution of grain size throughout the deposit exists.

### 3.3 Chemical Properties

A limited number of chemical analyses were carried out in the past, but no detailed conclusions can be reached from these results since the small number of samples cannot be considered representative of the whole deposit. General indications are that the sand is sufficiently pure for frac sand (1989 Hamilton) **Table 3.3-1.**

**Table 3.3-1 Chemical Properties**

| Description | East Block | West Block |
|---|---|---|
| $SiO_2$ | 98.20% | 98.36% |
| $Fe_2O_3$ | .478% | .153 |
| AL2O3 | .127 | .782 |
| TiO2 | .08 | .257 |
| CaO | .16 | .04 |
| Mgo | .007 | <.1 |
| Na20 | .009 | .162 |
| K20 | .089 | .23 |
| Mn0 | .0039 | - |
| Total | .99.555% | 99.984% |

### 3.4 Grain Characteristics

Various laboratory studies have been conducted to determine the size, shape and other properties of the particles with a particular emphasis on the suitability of the sand for use as a proppant (Frac Sand) in the petroleum industry.

1989 Hardy BBT Limited report (Appendix 3) shows information on 5 boreholes in 1989. The report provides information on grain size distribution, sphericity and roundness, acid solubility, turbidities and crush resistance of the 20/40 component only. Hardy BBT adhered to the American Petroleum Institute series of recommended practices for testing Sand Used in the Hydraulic Fracturing Operations, API RP56.

API specifications are typically completed on production samples. All testing done by Hardy BBT was done on lab samples. This information is helpful; however caution must be used in reviewing these results. The API tests are as much of a review of the processing plant capabilities as the deposit itself.

The sphericity, roundness and chemical properties of the Peace River deposit can be taken from Hardy BBT's work and it's assumed, by this assessment report, that appropriate processing would be used to attain the API results listed Appendix 2.

Of importance is Table 3-7 (Hardy BBT Report) which is duplicated below in Table 3.4-1 with Formation, Sphericity, Roundness and Crush Tests reported. The tests were conducted on 20/40 portion of the sample.

**Table 3.4-1 (Table 3-7 Hardy Report 1989)**

| Bore Hole No. | Sample No | Depth (feet) | Formation | Average Sphericity | Average Roundness | Crush |
|---|---|---|---|---|---|---|
| E89-1 | 3 | 98-100 | Cadotte | .7 | .5 | 13.9 |
| E-89-3 | 9 | 124-126 | Paddy | .7 | .6 | 10.8 |
| E-89-3 | 10 | 126-128 | Paddy | .8 | .6 | 15.6 |
| E-89-3 | 11 | 128-130 | Paddy | .7 | .6 | 12.5 |
| E-89-3 | 13 | 138-140 | Paddy | .7 | .6 | 12.1 |
| E-89-3 | 14 | 140-141 | Paddy | .7 | .6 | 11.7 |
| E-89-3 | 18 | 150-150.5 | Paddy | .7 | .5 | 13.7 |
| E-89-4 | 3 | 60-65 | Paddy | .8 | .5 | 13.0 |
| E-89-4 | 4 | 65-67 | Paddy | .7 | .5 | 14.7 |
| E-89-5 | 4 | 116-118 | Paddy | .7 | .6 | 12.9 |
| E-89-5 | 5 | 118-120 | Paddy | .7 | .6 | 11.9 |
| E-89-5 | 6 | 120-122 | Paddy | .7 | .6 | 13.9 |
| E-89-5 | 7 | 122-124 | Paddy | .7 | .6 | 14 |
| E-89-5 | 8 | 124-126 | Paddy | .8 | .7 | 15.2 |
| E-89-5 | 9 | 126-128 | Paddy | .8 | .7 | 14.8 |
| E-89-5 | 10 | 128-130 | Paddy | .7 | .7 | 16.7 |
| E-89-5 | 12 | 132-134 | Paddy | .7 | .7 | 15.0 |
| West Bank #4 | | | | .6 | .6 | 14.6 |

In comparison to the API RP 56 standards the Peace River deposit, as measured by the 20/40 size fraction, did not meet the API standards. This had been reported on numerous occasions in previous writings. More specifically one must understand the grain characteristics to determine why:

- The sphericity of all samples averaged greater than .7 meaning the spherical nature of the grains is between .7 and .8, which is as good as any "Ottawa Type" API premium sand available.

- The roundness in all samples (average) ranges between .5 to .7 with the API standard being .6. The .5 is of concern, as an average of .5 ensures a number of grains are .1 to .3 on the roundness scale. These are the grains that cause the sandstone under stress to be weak, creating fines in the fracturing process. The Crush Resistance API standard is 14% at 4,000 psi, however Premium "Ottawa Type Sands" have crush results between 1 and 2% in the 20/40 category.

Assumptions can only be made concerning the washing, scrubbing, and sizing of the sand particles. It is not practical or possible to change the individual grain characteristic from angular to round to improve these results. The writer believes that attrition testing in a lab does not realistically duplicate a processing plant designed to process 100's of thousands of tonnes annually. The API standards are as much a measurement of the processing systems as the sands themselves.

The final API test assessing the grain characteristics is the crush test. This test measures by a quantitative measurement the grain competence or strength of a silica pack under pressure. This crush test ultimately is the measurement used in assessing the grain characteristics.

## 3.5 2009 Site Investigation

In the spring of 2009 a site visit was undertaken to investigate work by the previous operator and determine the potential of the site, as a fra sand supply source for the burgeoning shale plays in North East British Columbia.

Since the early 80's the Peace River Deposit has been investigated for a 20/40 Frac Sand deposit, however it had not been assessed for sands used in the recent shale gas development. The Horn River Shale gas exploration wells currently are using two sand proppants 40/70 and 50/140 in the development phase.

### 3.5-1 Resources

Volume calculations prepared by Hamilton 1989, **Table 3.5-1** shows the measured and inferred tonnes of sandstone available on the Peace River property.

**Table 3.5-1-1 Measured and Inferred Tonnes**

| Location | Measured (tonnes) | Inferred (tones) | Total |
|---|---|---|---|
| East Block | 13,670,000 | 8,590,000 | 22,260,000 |
| West Block | 14,890,000 | 10,970,000 | 25,860,000 |
| Total | 28,560,000 | 19,560,000 | 48,120,000 |

As Hamilton 1989, and others have demonstrated that 66% of the sandstone within the East Block and 66.7% of the sandstone within the West Block passes the 40 mesh size fraction and is retained with-in the 140 mesh screen as shown in **Table 3.5-2.**

**Table 3.5-1-2 Gradation of Sand Deposit - Retained**

| US Sieve Size | East Block | West Block |
|---|---|---|
| 0-12 | 1.0% | .2% |
| 12-20 | 2.8% | 6.2% |
| 20-40 | 16.4% | 22.5% |
| **40-60** | **20.2%** | **30.5%** |
| **60-100** | **31.4%** | **21.3%** |
| **100-200** | **14.4%** | **14.9%** |
| Minus 200 | 13.8% | 4.4% |
| Total | 100% | 100% |

Basic volume calculations indicate that greater than 31,680,000 tonnes of material exist between 40 to 140 fractions within the property package

### 3.5-2 Geology

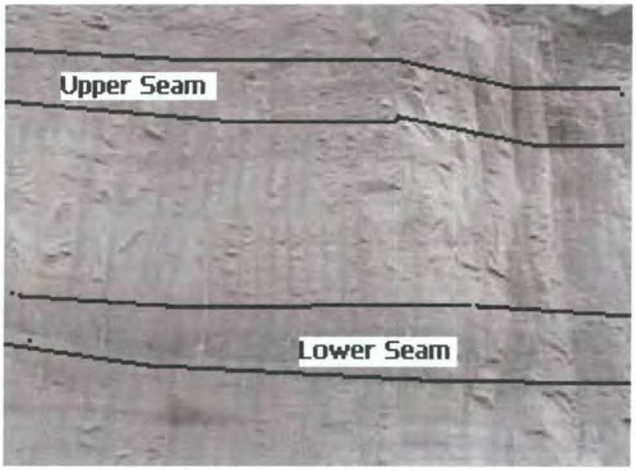
The local geology is exposed on a pit face within the property boundaries. The sandstone is a classic sedimentary marine deposit described in Section **2.1-1b.** Evidence of sedimentary nature of the sandstone layering exists with defined seams visible on the pit's open face. **Figure 3.5-2-1** and **Figure 3.5-2-2** show photographs of the upper seam. The upper seam is a varying 2 to 3 feet coarser grading seam (Sample PR2).

**Figure 3.5-2-1 Upper Coarse Seam**

**Figure 3.5-2-2 Coarse Nature of Upper Seam**

**Figure 3.5-2-3** shows the relationship between the 2 coarse seams with the balance of the sandstone being much finer. The seams are defined as upper and lower.

**Figure 3.5-2-3 Upper and Lower Coarse Seams**




The coarse seam's gradations are reflected in the **Table 3.5-3**, Sample – PR 2 tests the upper and Sample PR 4 tests the lower. The results indicate the seams are considerably coarser than surrounding sandstone and reflect the targeted sands by UIS and tested by Hamilton 1989.

Samples PR5, PR6 and PR7 provide indications of what can be expected by the majority of the sandstone in the formation.

**Table 3.5-3** shows gradations of the 6 samples, which were prepared in a laboratory and 2 production samples retrieved from the previous operators stock piles.

**Table 3.5-3 Peace River Sand Gradations**

| 2009 Sample | Retained | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **20** | **30** | **40** | **45** | **50** | **70** | **140** | **Pan** | **Total** |
| PR 1 | 0.7 | 1.4 | 3.5 | 3.7 | 5.7 | 22.1 | 62.1 | 0.9 | 100.1 |
| PR 2 | 14.4 | 23.8 | 25.4 | 12.4 | 10.1 | 9.7 | 3.8 | 0 | 99.6 |
| PR 3 | 0 | 0.2 | 0.1 | 0.7 | 2.4 | 12.4 | 83.3 | 0.9 | 100 |
| PR 4 | 17.8 | 33.2 | 21.7 | 5.3 | 4.7 | 6.9 | 9.7 | 0.4 | 99.7 |
| PR 5 | 0 | 0 | 0.4 | 1 | 5.4 | 29 | 63.5 | 0.5 | 99.8 |
| PR 6 | 0 | 0 | 0 | 0.2 | 11.4 | 18.9 | 67.8 | 1.3 | 99.6 |
| PR 7 | 0 | 0.8 | 0.8 | 3.2 | 4.3 | 22.4 | 65.8 | 1.8 | 99.1 |
| PR 8 | 7.6 | 11.2 | 18 | 13 | 14.9 | 18.1 | 16.8 | 0.3 | 99.9 |

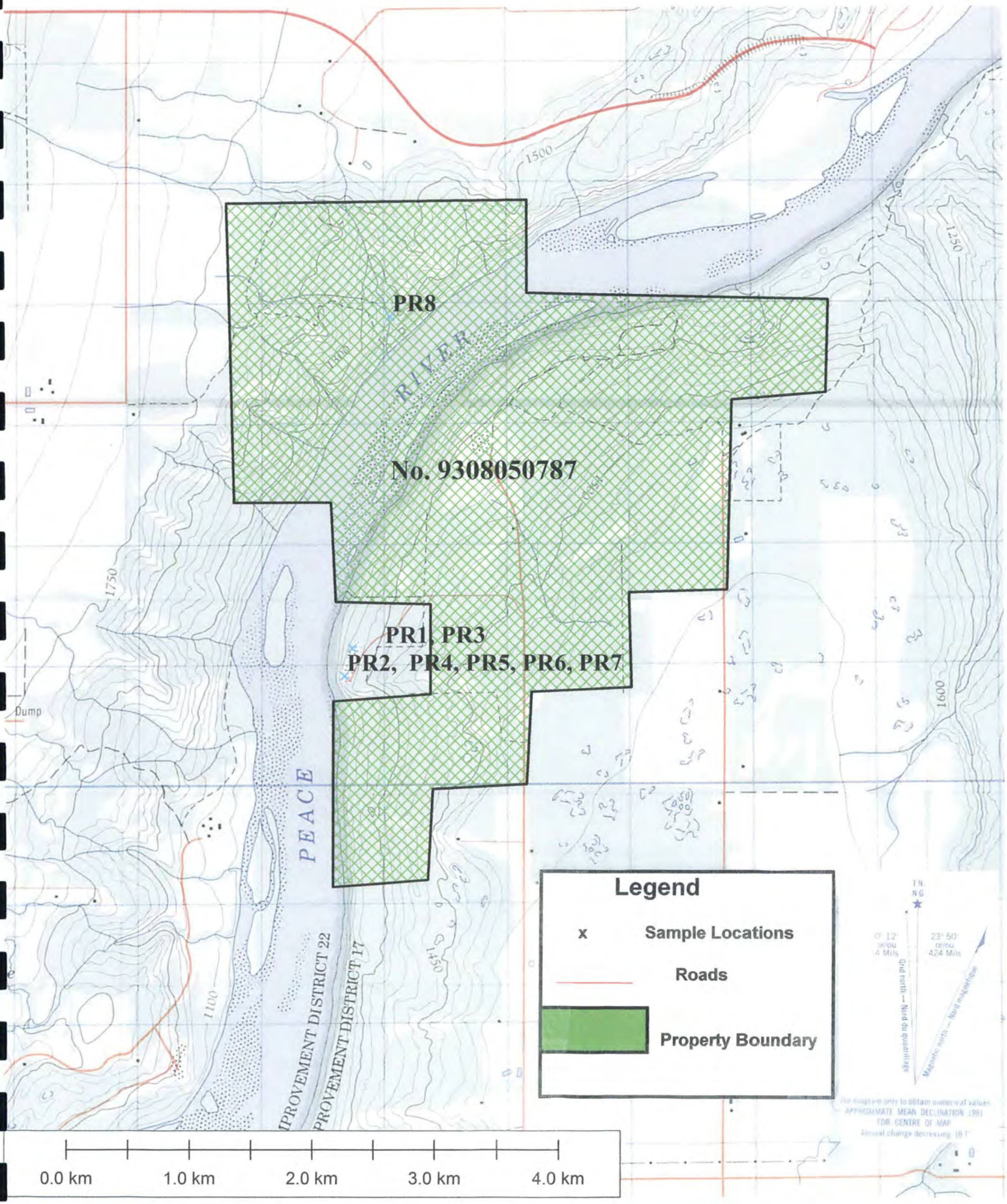
**Table 3.5-4** shows the locations of 8 samples retrieved from the Peace River Sand Deposit on May 5, 2009. **Figure 3.5-4 shows a map of the sample locations.** UTM Coordinates – Zone 11. The samples taken were to determine the local geology of the formation. Samples PR2, PR4, PR5, PR6, PR7 were taken largely from the same area (with-in 15 metres). For the purposes of this report are reported from the same location as is the case with samples PR1 and PR3.

**Table 3.5-4 Location of Samples**

| Sample # | North Location | West Location | Description |
|---|---|---|---|
| PR1 | 6241155 | 483783 | Production Sample – stock pile |
| PR2 | 6240917 | 483692 | Raw sample – coarse seam – 1-2 feet – on surface – Pit Wall |
| PR3 | 6241155 | 483783 | Production sample – stock pile |
| PR4 | 6240917 | 483692 | Raw Sample – coarse seam 2- 3 ft – at 10 foot mark – Pit Wall |
| PR5 | 6240917 | 483692 | Raw Sample – Typical – Pit Wall – upper sample |
| PR6 | 6240917 | 483692 | Raw Sample - Typical – Pit Wall – lower sample |
| PR7 | 6240917 | 483692 | Raw Sample - Typical – Pit Wall – lower sample |
| PR8 | 6243851 | 484049 | Raw Sample taken from the cliffs of West Bank |

American Petroleum Institute (API) standards are based upon production samples. The information presented is based on samples that have been washed in a lab, duplicating a processing plant, where 4 to 6% of the materials finer than 140 mesh have been removed. The samples in **Table 3.5-3** had been prepared based upon the API RP 56 standards.

# Peace River Deposit




Sample Location Map - Figure 3.5-4

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### 3.5-1 Grain Characteristics

Roundness and Sphericity and Cluster testing is part of API RP56 series of test. This test alone describes the shape of the individual sand crystals, providing a very good indication if the sands are suitable for fracturing oil and gas wells. The standard defined by API recommends that both Roundness and Sphericity is .6 or better. The Krumbein Scale defines a 1.0 to be a perfect circle or a perfectly round object. The Krumbein Scale is presented in Figure 3.5-1a.

**Figure 3.5-1a Krumbein Roundness Scale**

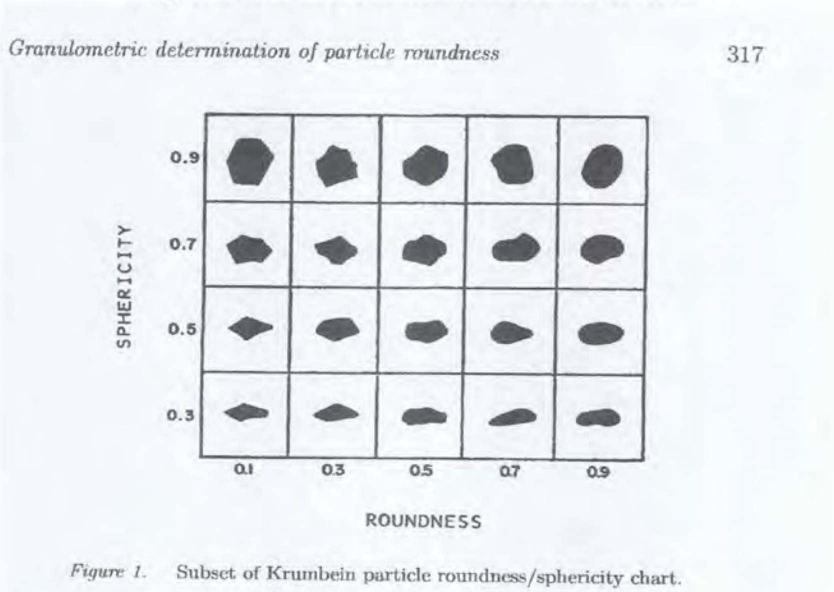



*Figure 1.* Subset of Krumbein particle roundness/sphericity chart.

The Roundness and Sphericity testing completed in 2009, indicate the finer sands (50/140 and 40/70) are similar to Hamilton 1989 findings, regarding the 20/40 fraction with-in the Peace River Deposit. Hamilton 1989 found the Sphericity to be .7 and Roundness between .5 and .7 for the 20/40 sands. Table 3.5-1a shows an example of the 50/140 sand and Table 3.5-2a shows the 40/70 Sphericity and Roundness of Sample PR4 taken form stock piles from the previous operator.

**Table 3.5-1a Sample PR4 50/140 Fraction**

| No. | Sphericity | Roundness | | No. | Sphericity | Roundness |
|---|---|---|---|---|---|---|
| 1 | 0.5 | 0.1 | | 11 | 0.5 | 0.1 |
| 2 | 0.9 | 0.5 | | 12 | 0.7 | 0.5 |
| 3 | 0.7 | 0.3 | | 13 | 0.9 | 0.7 |
| 4 | 0.7 | 0.3 | | 14 | 0.5 | 0.1 |
| 5 | 0.5 | 0.3 | | 15 | 0.9 | 0.5 |
| 6 | 0.7 | 0.7 | | 16 | 0.7 | 0.5 |
| 7 | 0.5 | 0.5 | | 17 | 0.7 | 0.5 |
| 8 | 0.7 | 0.1 | | 18 | 0.9 | 0.5 |
| 9 | 0.5 | 0.1 | | 19 | 0.5 | 0.3 |
| 10 | 0.7 | 0.1 | | 20 | 0.7 | 0.3 |
| | | | | **Average** | **.67** | **.35** |

**Table 3.5-2a Sample PR4 40/70 Fraction**

| No. | Sphericity | Roundness | No. | Sphericity | Roundness |
|---|---|---|---|---|---|
| 1 | 0.1 | 0.1 | 11 | 0.7 | 0.5 |
| 2 | 0.5 | 0.3 | 12 | 0.5 | 0.3 |
| 3 | 0.7 | 0.3 | 13 | 0.3 | 0.3 |
| 4 | 0.7 | 0.3 | 14 | 0.9 | 0.3 |
| 5 | 0.5 | 0.5 | 15 | 0.7 | 0.3 |
| 6 | 0.9 | 0.7 | 16 | 0.7 | 0.5 |
| 7 | 0.9 | 0.3 | 17 | 0.9 | 0.3 |
| 8 | 0.5 | 0.5 | 18 | 0.7 | 0.3 |
| 9 | 0.9 | 0.7 | 19 | 0.5 | 0.3 |
| 10 | 0.9 | 0.3 | 20 | 0.9 | 0.3 |
| | | | **Average** | **.67** | **.37** |

The Sphericity and Roundness test takes 20 grains and compares those grains to the Krumbien Roundness scale. In reviewing these results it is apparent that many grains are not very round and fail API standards.

These results are consistent with samples submitted to Stim Lab in December 2009 (Table 3.05-3). Stim Lab is a Core Lab company and is recognized by the Oil and Gas industry as the leading testing company for proppants in the United States.

It is important to understand that the Sphericity and Roundness test is an objective test comparing sand grains to a chart. This becomes evident when reviewing the photographs of the samples presented below.

Each sample submitted to Stim Lab had been prepared (washed and graded) in a laboratory in Canada. The Stim Lab report can be found in Appendix 3.

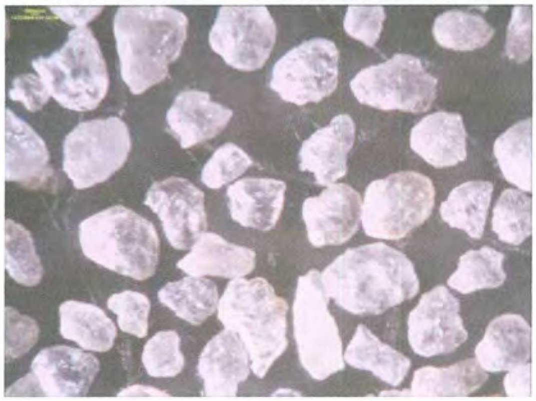
**Table 3.5-3a Stim Lab Results**

| Sample Number | Fraction | Sphericity | Roundness |
|---|---|---|---|
| PR2 | 40/50 | 0.6 | 0.6 |
| PR4 | 40/50 | 0.7 | 0.6 |
| PR8 | 40/50 | 0.7 | 0.6 |
| PR 2 | 50/140 | 0.7 | 0.5 |
| PR4 | 50/140 | 0.7 | 0.5 |
| PR5 | 50/140 | 0.7 | 0.5 |
| PR6 | 50/140 | 0.7 | 0.6 |
| PR7 | 50/140 | 0.7 | 0.5 |
| PR8 | 50/140 | 0.7 | 0.4 |

The following photographs show the Sphericity and Roundness on the Peace River proppants.

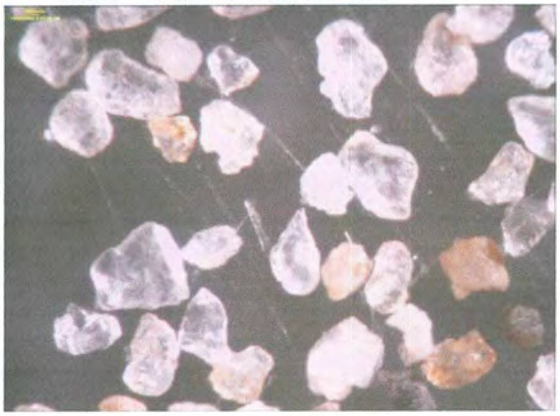
**PR 2 – 40/50 Fraction S=.6 R=.6**

**PR 2 – 50/140 Fraction S=.7 R=.5**

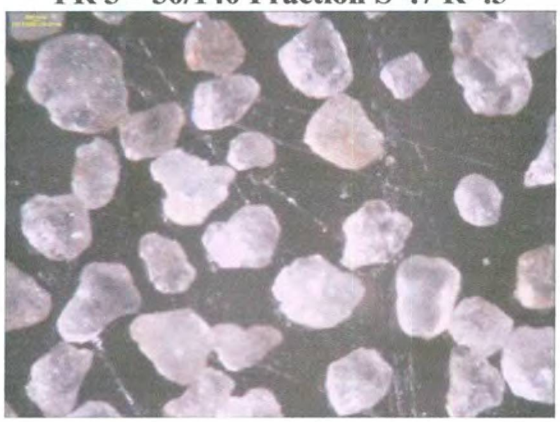


**PR 4 - 40/50 Fraction S=.7 R=.5**

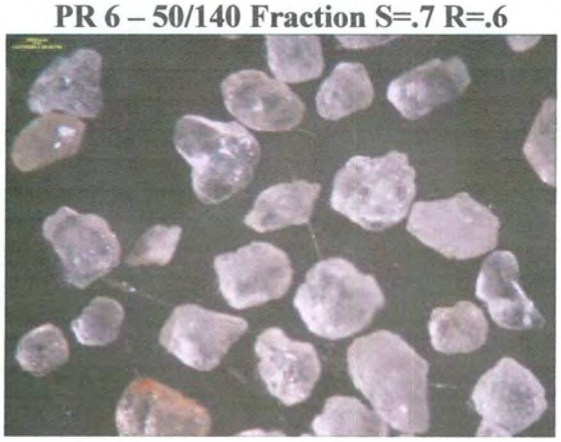
**PR 4 – 50/140 Fraction S=.7 R=.5**



**PR 5 – 50/140 Fraction S=.7 R=.5**



**PR 6 – 50/140 Fraction S=.7 R=.6**

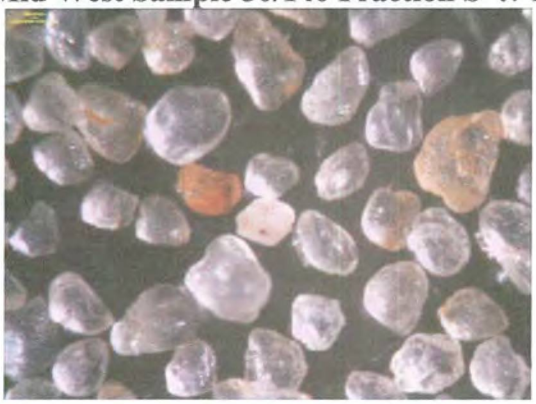


**PR 7 – 50/140 Fraction S=.7 R=.5**

For comparative purposes, photographs from Stim Lab are presented of other proppants supplied in the Horn River Basin.

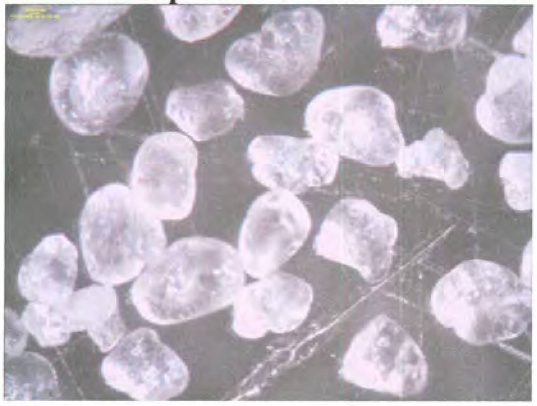
The photograph below is a 50/140 sample from an "Ottawa Type" US Mid-West sand deposit. [Reported by Stim Lab]

**US Mid West Sample 50/140 Fraction S=.7 R=.6**



The photograph below is a 50/140 sample from an "Ottawa Type" Canadian sand deposit. [Reported by Stim Lab]

**Canadian Sample 50/140 Fraction S=.6 R=.6**



### 3-5-1a Crush Test

Crush Testing had been completed by 1989 Hamilton on the 20/40 fraction with the results located in Table 10 of the Hardy BBT report in Appendix 3. The 20/40 sands were deemed suitable to fracture shallow gas wells, however failed the API standards. This failure was primarily a result of the crush test. The shape of the crystals, while quite spherical are not consistently round enough to meet the API standards, hence are not strong enough under load

Crush Testing completed December 2009, on the Sample PR6 50/140 had a result of 6.1% fines at 5,000 psi. These results indicate that the compressive strength is less than "Ottawa Sands". And likely would fail the API standards. Stim Lab states that 50/140 is not an API size sand and a recommendation for fines in this size fraction is not available, however the closest fraction is 40/70 at 6% at 5,000 psi. The sample sent to Stim Lab is a finer sand 50/140. **This may not be important due the role the 50/140 plays in the fracturing process of Shale Gas Wells**.

## 3.6 Overview of Past Commercial Operations at Peace River

The Hardy BBT report and Hamilton 1989 resource work was focused around identifying a source of 20/40 frac sand suitable to fracture oil and gas wells in Alberta. Ultrasonic Industrial Sciences Ltd (UIS) used this information and established a processing plant in 1998 and started marketing a 'sub par 20/40 frac sand", as a comparable alternative to the "Ottawa Type Sands" being used. Management concluded that some oil and gas bearing formations in Alberta did not require the API standard and that the sands of Peace River would be suitable. While this conclusion was correct the company was ultimately unsuccessful.

When reviewing the drill logs from the 5 holes completed by Hardy BBT it's not surprising to see that a very high percentage of the sandstone is finer than 40 mesh material. Modern processing plants wash and process 100% of the sand in order to separate the fractions that may be of value. The Peace River deposit, as per Hardy BBT /Hamilton is a relatively fine deposit, 40 to 140 mesh rather than a coarse 20 to 40 deposit. In the UIS case, it appears, they processed 100% of the sandstone and received an insufficient volume of 20/40 to sustain operations. The below table summaries the 5 bore holes, which shows that on average the Peace River deposit yields less than 20% product that could be called 20/40. **Table 3.6-1** shows each drill hole and the amount of material passing the 40 mesh screen.

**Table 3.6-1 Passing 40 Mesh**

| 40 Mesh | E-89-1 | E-89-2 | E89-3 | E89-4 | E89-5 |
|---|---|---|---|---|---|
| Passing | 88.84% | 95.65% | 80.2% | 74.38% | 56.84% |

It is well documented that considerable variation in the grain size proportions both laterally and vertically exist in most sandstone deposits. It appears the recoverable 20/40 component is less than initially perceived. The seams evident in the pit are no wider than 2 to 3 feet, between 8 to 10 feet of very fine materials.

Operations at Peace River did not achieve commercial success, as it's believed less than 5,000 tonnes of 20/40 were sold.

Canadian Silica Corporation purchased the assets of UIS from the receiver and have reestablished the processing plant and currently are supplying product to The Horn River Basin.

# 4.0 Commercialization Horn River – Natural Gas Opportunity

## 4.1 Overview

With commercial success of several shale gas plays (**Figure 4.1-1)** in the United States and Canada, shale gas plays are now being recognized as potential gas bearing reservoirs. The Horn River Basin in Northern British Columbia is estimated to have the potential capacity to hold 250 to 1,000 trillion cubic feet (Tcf) of gas in place.

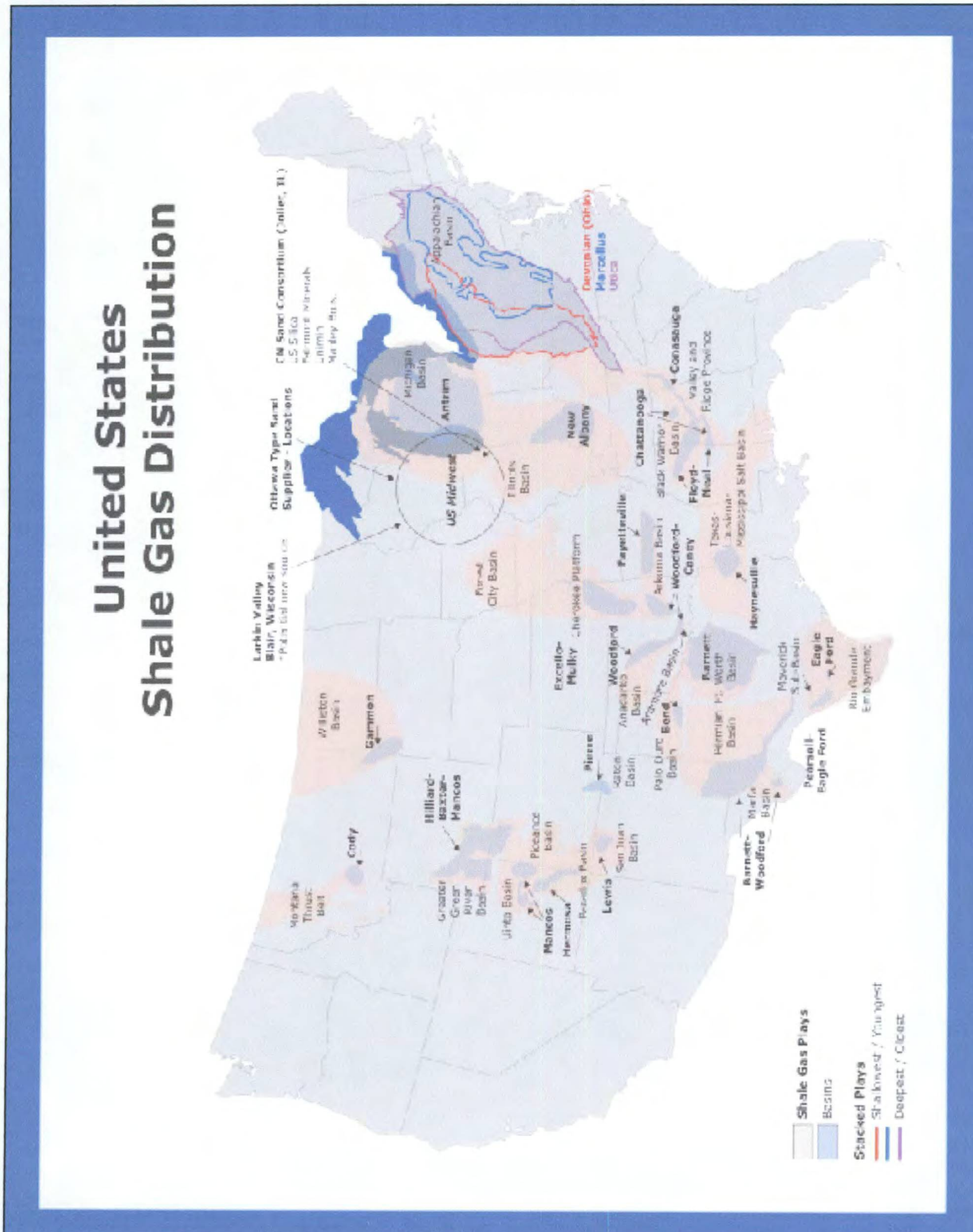
Horn River Basin has recently seen unprecedented land sale activity, corresponding to growing interest in shale gas plays. The area has now captured the interest of major producers looking to unlock the potential of the organic rich shales. Shale Gas formations in the Western Canada Sedimentary Basin contain large volumes of natural gas. The technology key to facilitating economical recovery of natural gas from shale is hydraulic fracturing. Hydraulic fracturing is a formation stimulation practice used in the industry to create additional permeability in a producing formation to allow gas to flow more easily toward the wellbore for purposes of production.

The current practice for hydraulic fracture treatments of gas shale reservoirs are events which can require thousands of barrels of water-based fracturing fluids mixed with silica sand (proppant) materials to be pumped in a controlled and monitored manner into the shale formation. This treatment can be conducted as many as 23 times per horizontal well.

Apache and EnCana, among others have pioneered the shale play in the Horn River Basin and each has a 50-percent interest in 425,000 gross acres - the leading acreage position in the play. Apache tested the shale potential in a recompletion of a vertical well in the Ootla area in March 2005. Thus far, the two companies have drilled 28 wells and brought 10 horizontal wells on production, and expect to have 32 wells on production by the first quarter of 2010. Apache is not shy about their plans for the Horn River basin stating that they plan to drill 2,000 to 3,000 wells over the next 2 decades. Apache Corporation has recently released drilling results at the Horn River Basin which have strengthened earlier estimates *that* ***individual horizontal wells in the play potentially can recover 10 billion cubic feet of natural gas***.

EOG released results recently, indicating 1 well produced initial rates of 23,000,000 cubic feet of natural gas per day, with 2 other well exceeding 18,000,000 cubic feet of natural gas in the Horn River Basin.

EOG Resources Inc, Imperial Oil Canada, Nexen Oil and Gas, Quicksilver Oil and Gas, Stone Mountain Resources, Penn West Energy Trust, and PetroBakken are all slated to have 2010 programs. Others such as Devon Energy, Conaco Phillips, Ram's Horn have plans to established programs in 2011.



Three recent wells at Two Island Lake, operated by Apache's joint venture partner EnCana, have been brought on line at gross initial production rates of more than 16 million cubic feet (MMcf) per day and continue to produce 8-10 MMcf per day after two to three weeks.

The proppant materials currently used for the Horn River Basin are fine sands in the size range of 40/70 and 50/140 mesh designations. Peace River Sand deposit contains over 30 million tonnes of sand in this size fraction that may be suitable to frac the wells in the basin.

### 4.2 Proppants, Volumes and Placement

In hydraulic fracturing, proppants are used to hold a created fracture open against formation stresses, after the fracturing pressure is removed. The propped fracture provides a flow path of higher conductivity than the intact rock mass and improves the flow of gas from the geologic formation to the wellbore. Proppants are solid particles that vary in material type, dimension, density, crush strength, and temperature stability. Selection criteria for proppants, include the ability to remain suspended and be transported by the fracturing fluid, the ability to physically fit in the induced fractures, the ability to remain intact under the fracture closure stresses, and ultimately provide hydraulic conductivity of the proppant-filled fracture.

Proppants generally consist of relatively inert materials. The most common material is sand, but lightweight ceramics, sintered bauxite, and even walnut shells have been used. Small diameter particles and less dense materials have better transport characteristics than heavier, larger particles that settle more quickly. The specific gravity of proppants ranges from 3.55 for sintered bauxite to 1.08 for ultra-lightweight neutral density materials, with sand being the most common proppant at 2.65. sand can also be coated with resins, allowing sand to be used at greater depths and for other purposes like "tailing in". Proppants can also be man made, called "ceramics" which are very nearly perfectly round and spherical steel like balls.

Conventional fracturing generally requires larger particles 20/40, as many tight gas shale stimulation projects ***require smaller fractions such as 40/70 and 50/140 mesh.***

Proppant volumes, API quality and placement are currently "the buzz" in unconventional shale gas fracturing and is being debated in most shale gas formations in North America. The question being asked is what is really happening?

From a proppant standpoint, many wells have been successfully fractured with no proppant at all, but in some cases the high initial flow rates fell off shortly into production. Other horizontal drilled wells in shale have attained commercial rates with only 5,000 to 10,000 lb. of proppant, although hundreds of thousands of pounds per well is more common in most shale plays.

Data on seven stimulation designs in Barnett Shale wells from 2001 to 2007 show proppant concentrations of 0.15 to 1.02 pounds of sand per gallon of frac fluid, and from 200 to 1500lb per horizontal foot of well, with the higher sand quantities corresponding to multistage stimulations. An analysis of 3,400 frac stages completed in 2008 in the Woodford Shale in

Oklahoma and the Barnett Shale reported the total amount of proppant used equaled 1,100,000,000 lbs, or 323,500 lb. per stage.

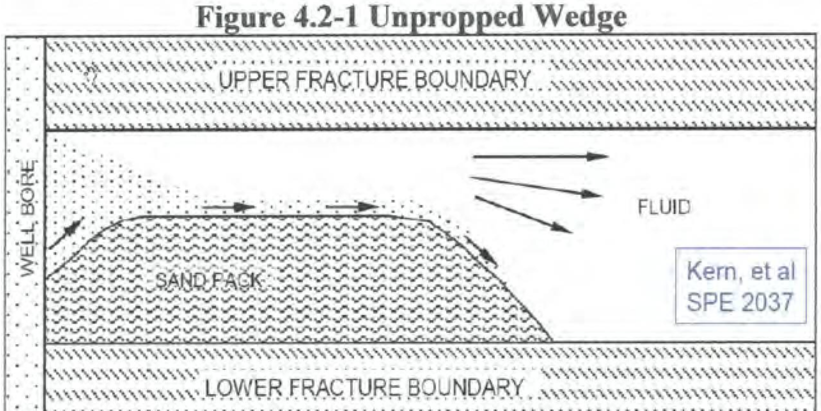
Current thinking (2009) in the Horn River Basin suggests 14 to 23 zones per well with 440,000 lbs per stage.

Proppant (1) SPE Paper is important to stimulation results by extending the effective wellbore radius and serves the purposes by propping open at the very least the main part or "trunk" of the hydraulic fracture system. Proppant typically settles rapidly in water frac systems, forming a proppant bed along the bottom of the fracture; an equilibrium bed height is quickly established then proppant is transported along the top of the bed toward its terminus. Within the bed, propped width is equal to the pumping width achieved during the pad stage of the treatment, resulting in a conductive multi-layer proppant pack.

Perhaps more importantly, a highly conductive, open channel (unpropped wedge) can persist along the top of the settled bed.

The below **Figure 4.2-1** shows the "unpropped wedge" effect or called banking /bridging effect.

**Figure 4.2-1 Unpropped Wedge**




In the unpropped wedge scenario, fine mesh proppants (40/70 and 50/140) can produce similar and sometimes better results as compared to 20/40 mesh proppants, since smaller proppant particles have less tendency to bridge and pack off in the fracture.

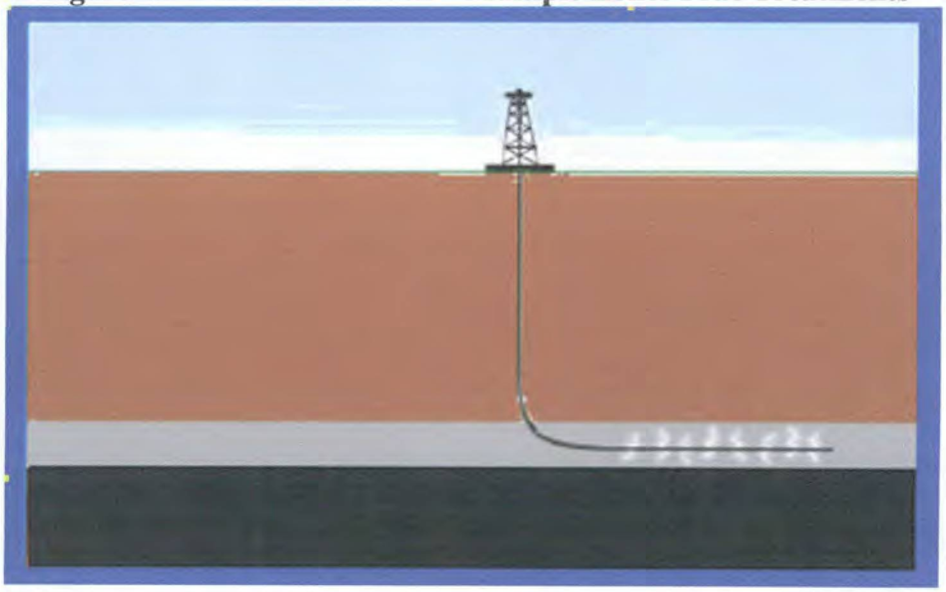
The properties of an unpropped wedge are likely to be insensitive to material characteristics of the proppants. ***Consequently, wells treated with non API spec proppants can produce similarly to wells treated with standard API proppants. If the unpropped wedge mechanism is validated in a particular application, formerly substandard sources of proppant could be approved for use.***

The 100 mesh (50/140) proppant is also used as a scouring agent and limiter of fluid loss to crossed fissures. Being extremely fine, it can abrade and enlarge narrow flow-path restrictions, which exist in the annulus of the cement sheath and drilled hole, and may be able to penetrate fracture branches and resist fracture rehealing. The 100 mesh sand enables the propagation of additional primary hydraulic fracture length and minimizes the potential for proppant bridging at hydraulic fracture/cross-fissure nodes. Under this scenario Ottawa or API sands is not required.

Typically exploration drilling and completions are underway in the Horn River Basin with most wells being tested with either the "Ottawa Type Sands" or South Saskatchewan River sands. It is the writer understanding the Peace River deposit 40/140 mesh sands will be tested in the winter of 2010.

**Figure 4.2-2** below shows a horizontal well with a multi stage fracture design.

**Figure 4.2-2 Horizontal Well – Multiple Zones Frac Treatments**



## 4.3 Proppant Supplies

### 4.3-1 Ottawa Type

Cambrian or Ordovician Sandstones are typically found in the US Midwest and in Canada within the provinces of Saskatchewan and Manitoba. These sands are typically spherical, well rounded, 99% pure silica crystals and regarded as premium white sands suitable for fracturing conventional and unconventional oil and gas wells.

**Badger Mining** – Badger has two mines in Wisconsin, the Taylor and Fairwater Plants. The Taylor Plant specializing in Frac Sand from the Wonewoc Formation and is located on the CN Rail. Badger supplies both US and Canadian Markets. Badger has dominated the Canadian market for the past 15 years in quality and volume of supply available. Products available are 12/20, 16/30, 20/40, 30/50 and 40/70 mesh sizes. Badger typically has North American Supply arrangements with a number of service companies. Badger sands are also used as substrate for resin coated sands.

**Unimin Corporation** – the largest supplier of frac sand in the United States. Unimin has numerous mines throughout United States. The supplies typically bound for Canada come from Kasota, Ottawa and Le Sueur, Minnesota and Ottawa, Illinois. Unimin mines the Jordan formation in Minnesota and St. Peter formation in Illinois. Products available are 12/20, 16/30, 20/40, 30/50 and 40/70 and 100 mesh.

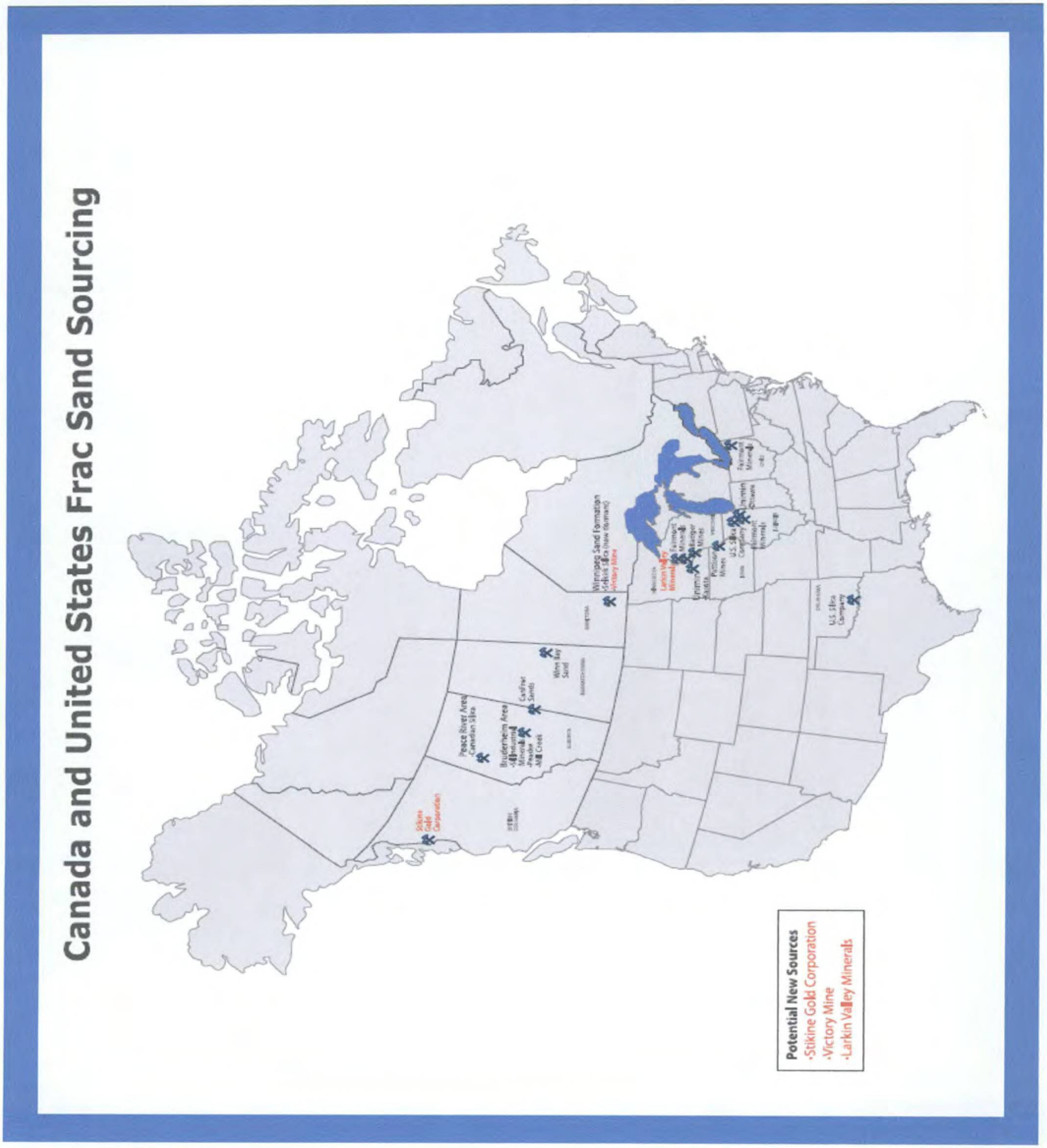
Unimin typically has North American Supply arrangements with a number of service companies. The Minnesota plants operate off the Union Pacific Railroad. Unimin typically restricts product going to Canada, when the US market is active. Unimin distribution is unique, as they typically store their products in rail cars, rather than use Trans Load facilities. This practice encourages hoarding of product by their clients and ultimately requires the rail car to be a storage vessel. Sending cars to Canada reduces the turns on their cars; hence keeping the cars in the US turns these cars quicker.

**Fairmount Minerals** – Fairmount operates two frac sand mines, one in Wisconsin (underground) and a second at Wedron, Illinois. Fairmont operates under the name Sandtrol, as they have a very big focus on resin coated sands. They mine both the Jordan and St. Peter formations. Products available are 12/20, 20/40, 30/50 and 40/70 and 100 mesh. Typically they do not market there sands in Canada to any great degree.

**US Silica** – US Silica operates out of Ottawa, Illinois and mines the St. Peter formation. Historically they had marketed there 20/40 products through Badger Mining and focused on the their core business glass and foundry products. Recently they have taken back control of the 20/40 fraction, which previously was marketed by Badger Mining. US Silica in June 2009 announced a 500,000 ton expansion of the Ottawa, Illinois facility. Products available are limited 20/40, 30/50 and vary abundant 40/70 and 100 mesh.

**Figure 4.3-1** shows some of the sand sources, potentially considered for the Horn River Basin.

**Figure 4.3-1 Canada and US Frac Sand Sources**



**Pattison Sand LLC** – Pattison Sand operates out of Clayton, Iowa. They mine the St. Peter formation along the banks of the Mississippi River. They are located on the ICE railroad, recently purchased by Canadian Pacific and are approximately 32 miles from the Canadian National Rail Line. Products available are limited 20/40 and 30/50 plus 40/70 and 100 mesh. They are the newest Ottawa White sand producer.

**Winn Bay Sand LP** – Winn Bay operates the only premium white sand deposit in Western Canada. The company mines Ordovician era white sandstone similar to the US Ottawa sands in quality. Products available are limited 12/20, 20/40, 30/50 and 40/70 and 100 mesh. Winn Bay has provided the majority of the sand to date in the Horn River Basin.

### 4.3-2 River Based Sources

Along the North Saskatchewan River, in Alberta and Saskatchewan numerous quarry locations extract spherical rounded silica sand. These sands typically do not meet the American Petroleum Institutes (API) standards, however are quite spherical and rounded. The deposits typically are 94% pure silica and contain 6% other materials.

The other material (6%) potentially becomes problematic. Unconventional reservoir rock is usually chemically unreactive to water as pore throats are too small to accept much fluid and the majority of flow and leak off occurs to fractures. **Mobile or swelling clay materials are not usually a component of fracture-filled material.** The River based sands potential introduce this material, which becomes an issue when its physical properties, high density and capillary pressure gradient in small pore networks become rather immobile in low energy systems.

River based sands typically fail the API RP 56 on the strength (crush) tests and acid solubility.

**SIL Industrial Minerals** operating out of Bruderheim, Alberta. SIL has rail facilities in the Horn River Basin. SIL has provided most of the non API sands in the basin. Recent concerns have surfaced over the impact of the clays and other materials associated with there products.

**Peaskie Minerals** operating out of Thorhild County 40 miles north east of Edmonton, Alberta, near Red Water.

**Can Frac Sands Ltd**. is located in Lloydminster, Saskatchewan area.

### 4.3-3 Marine Type

Located near Peace River Alberta, the Paddy member sandstone of the Fort St. John Group has been worked by an inland sea, like the Cambrian and Ordovician sandstones creating rounded spherical grain characteristics. The sand grains characteristics are more similar to the river based sands; however the grains are pure 99% silica. These sands do not meet the API standards due to roundness only as they are quite spherical. The compressive strength is similar to River based sands.

**Canadian Silica Sands** are located in Peace River, Alberta. Canadian Silica refurbished the United Industrial Services location in 2009. Canadian Silica has ¼ section of land within the Peace River Silica Deposit and operates the old UIS plant.

## 4.4 Transportation

The following table defines the rail or truck miles that each competing deposit must travel to reach the Horn River Basin to supply the Fort Nelson B.C. market. Silica sand is a low valued commodity and transportation costs often define who has the advantage in the target market **Table 4.4-1.**

**Table 4.4-1 Transport Miles and Rates**

| | FOB Fort Nelson | | | | | | |
|---|---|---|---|---|---|---|---|
| Locations | Wisconsin | Illinois | Iowa | Saskatchewan Channing | Texas | Bruderheim | Peace River |
| Type | Premium White | Premium White | Premium White | Premium White | | Local - River | Local - Marine |
| Rail Miles | 2456 | 2750 | 2526 | 1796 | 3298 | 1022 | |
| Trucking Miles | | | | | | | 390 |
| Rail Rate per Mile | $ 3.60 | $ 3.60 | $ 3.70 | $ 3.65 | $ 3.70 | $ 4.25 | |
| Rail Rate Total - CDN$ | $ 8,841.60 | $ 9,900.00 | $ 9,346.20 | $ 6,555.40 | $ 12,202.60 | $ 4,343.50 | |
| Rail Rate per Mile | $ 96.10 | $ 107.61 | $ 101.59 | $ 71.25 | $ 132.64 | $ 47.21 | |
| Fuel Surcharges - CDN$ | $ 169.46 | $ 189.75 | $ 174.29 | $ 123.92 | $ 227.56 | $ 70.52 | |
| Fuel Surcharges Rate per mile | $ 0.07 | $ 0.07 | $ 0.07 | $ 0.07 | $ 0.07 | $ 0.07 | |
| Fuel Surcharge per tonne | $ 1.84 | $ 2.06 | $ 1.89 | $ 1.35 | $ 2.47 | $ 0.77 | |
| Sub Total Rail Costs Fort Nelson | $ 97.95 | $ 109.67 | $ 103.48 | $ 72.60 | $ 135.11 | $ 47.98 | |
| Car Costs Month Tonne | $ 15.00 | $ 15.00 | $ 15.00 | $ 15.00 | $ 18.00 | $ 10.00 | |
| Total Rail Costs Fort Nelson | **$ 112.95** | **$124.67** | **$118.48** | **$87.60** | **$153.11** | **$57.98** | |
| Trucking Costs - per tonne Tonne | N/A | N/A | N/A | N/A | N/A | N/A | **$55.00** |
| Transist Times Days | 12 | 12 | 15 | 10 | 15 | | 2 |

| Assumptions | |
|---|---|
| CDN$ to US$ | $ 0.93 |
| Short Ton to Metric Tonne | 0.907 |

The above table shows the significant advantage the Peace River deposit has over other commercial "Ottawa Type" and River Based sand deposits.

### 4.4-1 The Sierra Yoyo Desan Road

The Sierra-Yoyo-Desan Road (SYD), located north and east of Fort Nelson, starts 15 kilometres from Fort Nelson (mile 1 on Alaska Highway) and extends 173 kilometres eastward and then north to the South Helmet airstrip.

EnCana/Apache/ has a 95 kilometer lease access road called the "Komme Lake Road" at Kilometer marker 121 of the SYD. The Kommie is often down due to weather conditions i.e. excessive rain, through break-up, summer and fall. EnCana's access road can be closed for days at a time.

The Provincial Road – Sierra Yoyo Desan is typically subject to road bans from April to Mid June. (70% weights or 18 tonne loads on tandem trailers and 30 tonne loads on Super B configurations.)

Alternate Access to the Sierra Yoyo Desan Road – Winter Road Access is available typically from Dec 15 to April 15, (if maintained) from Rainbow Lake, Alberta. Husky Energy, a large Canadian integrated oil and gas company, usually builds and maintains the road.

This access road is very flat, typically through muskeg. The winter road meets the SYD at kilometer 95. This road does not have weight restriction. From Rainbow Lake we estimate the junction with the SYD to be 75 kilometers.

### 4.4-2 Current Status Rainbow Lake Winter Road– October 2008

The Province of British Columbia has not made any commitments regarding the construction of its portion of the Fort Nelson - Rainbow Lake connector. Alberta does not have any immediate plans to construct a road from Rainbow Lake to the B.C border.

The widening of Highway 58 between High Level and Rainbow Lake is currently under way.

### 4.4-3 Distances

EnCana Site on Kommie Road from Rainbow Lake – 196 kilometers.
High Level -Rainbow Lake - 141 kilometers.
Peace River to Rainbow Lake – 450 kilometers.

Total Peace River to EnCana Kommie Lake Site – 607 kilometers.
Total Peace River to EnCana Kommie Lake Site, via Fort Nelson – 840 kilometers

## 5.0 Conclusions

The Peace River Silica project is a good opportunity to achieve commercial success due to grain size characteristics, shale gas technologies and the location of the Peace River sand deposit to the Shale Gas development in the Horn River Basin.

Property investigations have demonstrated that suitable volumes of materials are present for a 20 year operation, processing greater than 1,000,000 tonnes annually.

The 2009 investigation presents the 50/140 mesh size fraction as a suitable alternative to the typically used "Ottawa Type" proppants used in conventional well fracturing. The sand characteristics while inferior to the API standards are less important due to the fracturing technology and resultant "bridging affect" taking place with in the fracture systems. In addition the 50/140 mesh materials are used less as a propping agent but rather than a scouring or etching agent helping to extend the fracture systems, ultimately creating greater permeability than currently exists within the formation.

The inherent advantage due to the Peace River location compared to other sources of suitable proppants is significant. This deposit has a considerable advantage over the existing suppliers to The Horn River Basin. In addition, Peace River allows the operator an opportunity to truck product to market rather than use the rail line. This advantage cannot be underscored due to the levels of congestion, predicted on the Fort Nelson rail line. Alternate routes through Rainbow Lake, Alberta to the gas fields are also available improving the economics of the truck option.

"Ottawa Type Sands" have largely been used in the exploration and early development phases of the Horn River Basin. Sands from with-in the Peace River deposit will be tested in early 2010, marking the way for future development of the resource.

## 6.0 Authors Qualifications

I, James H. Punt, reside at Vancouver, British Columbia, Canada and do hereby certify that:

1. I am a sales, logistics and technical expert regarding Cambrian and Ordovician sandstones suitable for fracturing oil and gas wells, working as a consultant for Winn Bay Sand LP, Site 412, Box 281, RR4 Saskatoon, Saskatchewan. Winn Bay is currently the only Canadian supplier of "Ottawa Type" sand proppants in Canada. Winn Bay has been selling and proppants since 2003.

2. I have been studying and investigating sandstones suitable for fracturing oil and gas wells since 1998.

3. I am the developer of the Winn Bay Sand deposit at Hanson Lake Saskatchewan in 2001.

4. I am an independent prospector investigating sandstone deposits through the US Midwest and parts of Manitoba and Saskatchewan and Alberta.

5. I completed this report and hold 100% interest ownership in the mineral permit (093 930808050787) pertaining to this report.

6. I am not aware of any material fact or material change with respect to the subject matter of the Report that is not reflected in the report, or the omission to disclose which makes the Report misleading.

[redacted]

James H Punt
Vancouver, British Columbia Canada

Dated January 31, 2010

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Wells of the Fayetteville Shale.

## Appendix 1

Figure 1-3 Resource Areas for Net Frac Sand Tonnage Estimates (East Block)

Table 2-2 East Block Resource Estimates

Table 2-3 West Block Resource Estimates

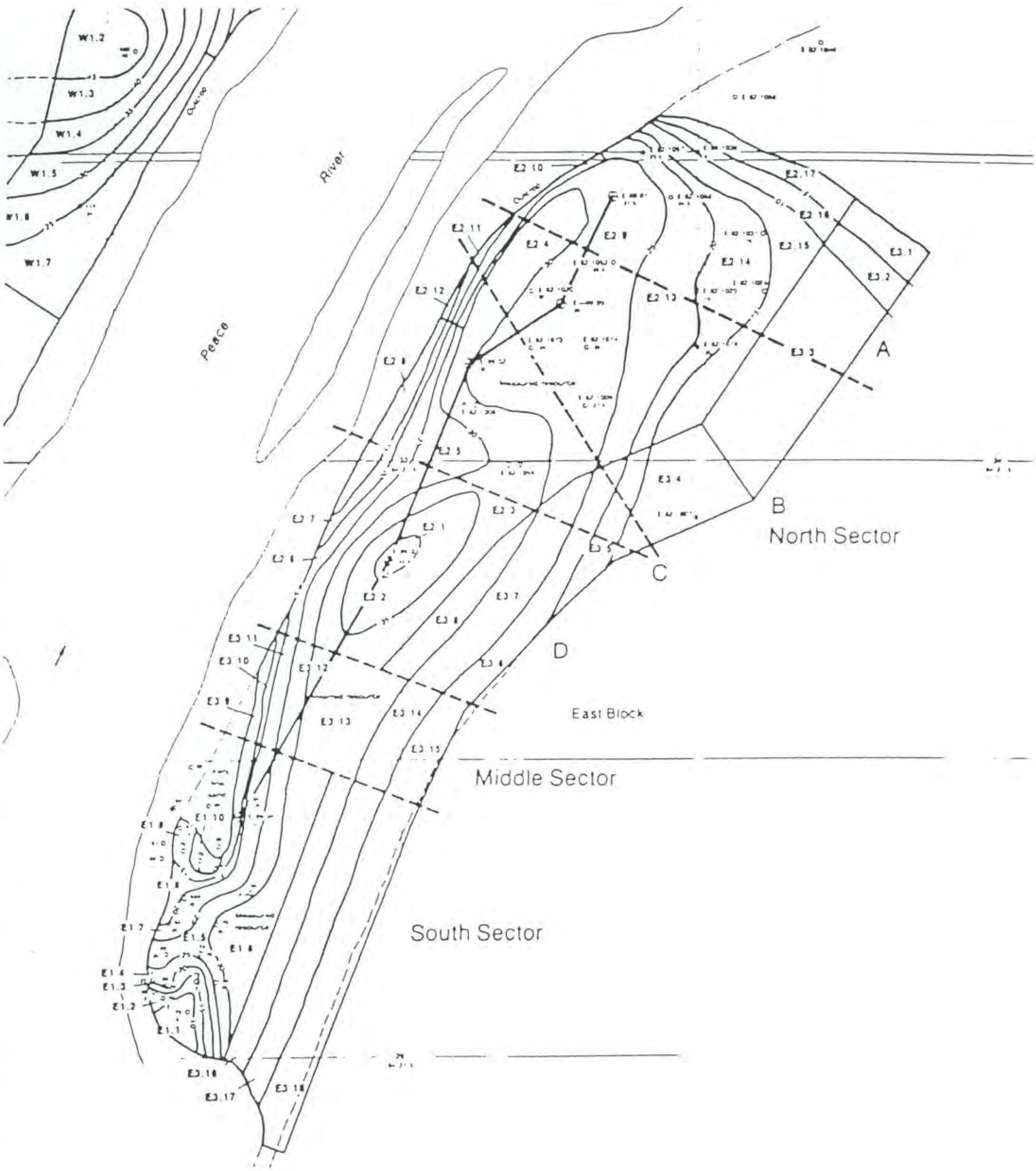


Figure 1-3 Resource Areas for Net Frac Sand Tonnage Estimates (East Block)

The detailed resource calculations are presented in the following Tables 2-2 and 2-3.

Table 2-2. East Block Resource Estimate

| AREA DESIGNATION[t] | AREA SQUARE FEET | THICKNESS FEET | CUBIC YARDS |
|---|---|---|---|
| Measured Category | | | |
| E1.1 | 139,671 | 10 | 51,730 |
| E1.2 | 113,483 | 12.5 | 52,538 |
| E1.3 | 96,024 | 17.5 | 62,238 |
| E1.4 | 122,212 | 22.5 | 101,843 |
| E1.5 | 494,087 | 27.5 | 503,237 |
| E1.6 | 673,913 | 30.0 | 748,792 |
| E1.7 | 310,768 | 22.5 | 258,973 |
| E1.8 | 134,433 | 17.5 | 87,132 |
| E1.9 | 165,859 | 12.5 | 76,786 |
| E1.10 | 57,614 | 10.0 | 21,338 |
| E2.1 | 80,310 | 41.25 | 122,696 |
| E2.2 | 712,323 | 35.50 | 936,573 |
| E2.3 | 1,099,910 | 32.50 | 1,323,966 |
| E2.4 | 1,024,837 | 30.0 | 1,138,707 |
| E2.5 | 588,264 | 27.5 | 599,260 |
| E2.6 | 314,260 | 22.5 | 261,883 |
| E2.7 | 165,859 | 17.5 | 107,501 |
| E2.8 | 235,695 | 15.0 | 130,942 |
| E2.9 | 2,548,999 | 27.5 | 2,596,203 |
| E2.10 | 122,212 | 22.5 | 101,843 |
| E2.11 | 61,106 | 17.5 | 39,606 |
| E2.12 | 13,967 | 15.0 | 7,759 |
| E2.13 | 1,220,377 | 22.5 | 1,016,980 |
| E2.14 | 944,520 | 17.6 | 612,193 |
| E2.15 | 928,813 | 12.5 | 430,006 |
| E2.16 | 293,309 | 7.5 | 81,475 |
| E2.17 | 322,989 | 2.5 | 29,906 |
| | 12,985,920 | 23.9* | 11,502,105 |

Silica sand (dry tons) = 1.31** x 11,502,105 = 15,067,757
(or 13,669,168 metric tonnes)

[t]See Map 2-2.

*Weighted average thickness of silica sand unit within the East Block measured category is 23.91 feet or 7.29 metres.

**Density = 1.31 tons per cubic yard

| AREA DESIGNATION[1] | AREA SQUARE FEET | THICKNESS FEET | CUBIC YARDS |
|---|---|---|---|
| Inferred Category | | | |
| E3.1 | 239,186 | 2.5 | 22,147 |
| E3.2 | 235,695 | 7.5 | 65,471 |
| E3.3 | 1,566,100 | 13.5 | 783,050 |
| E3.4 | 745,495 | 13.5 | 372,747 |
| E3.5 | 305,530 | 17.5 | 198,029 |
| E3.6 | 576,143 | 22.5 | 480,119 |
| E3.7 | 778,666 | 27.5 | 793,085 |
| E3.8 | 406,792 | 31.25 | 470,824 |
| E3.9 | 96,850 | 12.5 | 44,838 |
| E3.10 | 66,789 | 17.5 | 43,289 |
| E3.11 | 156,719 | 22.5 | 130,599 |
| E3.12 | 196,440 | 27.5 | 200,078 |
| E3.13 | 825,806 | 30.0 | 917,562 |
| E3.14 | 345,686 | 27.5 | 352,087 |
| E3.15 | 352,669 | 22.5 | 293,890 |
| E3.16 | 554,679 | 30.0 | 616,310 |
| E3.17 | 723,232 | 27.5 | 736,625 |
| E3.18 | 846,607 | 22.5 | 705,506 |
| | 9,019,084 | 21.6* | 7,225,256 |

Silica sand (dry tones) = 1.31 x 7,226,256 = 9,466,395
(or 8,587,724 metric tonnes)

[1]See Map 2-2.

*Weighted average thickness of silica sand unit in East Block inferred category is 21.6 feet or 6.58 metres.

Table 2-3. West Block Resource Estimate

| AREA DESIGNATION[t] | AREA SQUARE FEET | THICKNESS FEET | CUBIC YARDS |
|---|---|---|---|
| Measured Category | | | |
| W1.1 | 2,593,488 | 21.0 | 2,017,157 |
| W1.2 | 462,661 | 46.5 | 796,805 |
| W1.3 | 525,513 | 42.5 | 827,196 |
| W1.4 | 604,078 | 37.5 | 838,997 |
| W1.5 | 787,396 | 32.5 | 947,791 |
| W1.6 | 1,174,984 | 27.5 | 1,196,743 |
| W1.7 | 899,133 | 22.5 | 749,277 |
| W1.8 | 1,763.349 | 22.5 | 1,469,457 |
| W1.9 | 167,605 | 17.5 | 108,633 |
| W1.10 | 97,769 | 44.0 | 159,327 |
| W1.11 | 41,901 | 17.5 | 27,158 |
| W1.12 | 293,309 | 25.0 | 271,582 |
| W1.13 | 335,210 | 50.0 | 620,759 |
| W1.14 | 522,012 | 35.0 | 676,694 |
| W1.15 | 422,505 | 45.0 | 704,175 |
| W1.16 | 199,765 | 25.0 | 184,967 |
| W1.17 | 177,559 | 15.0 | 98,644 |
| W1.18 | 1,309,417 | 9.0 | 436,472 |
| | 12,377,663 | 26.46* | 12,131,834 |

Silica sand (dry tons) = 1.35 x 12,131,834 = 16,377,975
(or 14,887,771 metric tonnes)

[t]See Map 2-2.

*Weighted average thickness of silica sand unit within the West Block measured category is 26.5 feet or 8.06 metres.

| AREA DESIGNATION[t] | AREA SQUARE FEET | THICKNESS FEET | CUBIC YARDS |
|---|---|---|---|
| Inferred Category | | | |
| W2.1 | 8,461,551 | 26.45 | 8,289,186 |
| W2.2 | 2,113,676 | 8.5 | 665,416 |
| | 10,575,227 | 22.8* | 8,954,602 |

Silica sand (dry tons) = 1.35 x 8,954,602 = 12,088,713
(or 10,966,638 metric tonnes)

[t]See Map 2-2.

*Weighted average thickness of silica sand unit within the West Block inferred category is 22.8 feet or 6.95 metres.

Table 1-1 Estimated Net Frac Sand Resource Tonnage - East Block, Peace River Deposit

| Area Designation | Control Testhole | Total Sand tonnes | 20/40 Mesh % | 20/40 Mesh tonnes | Frac Sand Recovery Factor | Net Frac Sand tonnes |
|---|---|---|---|---|---|---|
| Measured Resource | | | | | | |
| North Sector (E2.1 to E2.17) | | | | | | |
| Segment A | E-89-1 | 2,401,167 | 10.3 | 247,320 | .8 | 198,000 |
| Segment B | E-89-5 | 3,077,838 | 33.4 | 1,027,998 | .6 | 617,000 |
| Segment C | E-89-2 | 2,570,187 | 4.8 | 123,369 | .8 | 107,000 |
| Segment D | E-89-3 | 3,285,225 | 12.5 | 410,653 | .9 | 370,000 |
| South Sector (E1.1 to E1.10) | E-89-4 | 2,334,750 | 13.1 | 305,852 | .9 | 275,000 |
| Total (Measured) | | 13,669,168 | | 2,115,192 | | 1,567,000 |
| Inferred Resource | | | | | | |
| North Sector (E3.1 to E3.8) | | | | | | |
| Segment A | E-89-1 | 508,927 | 10.3 | 52,419 | .8 | 42,000 |
| Segment B | E-89-5 | 994,753 | 33.4 | 332,248 | .6 | 200,000 |
| Segment C | E-89-2 | 418,648 | 4.8 | 20,095 | .8 | 16,000 |
| Segment D | E-89-3 | 1,829,006 | 12.5 | 228,626 | .9 | 206,000 |
| Middle Sector (E3.9 to E3.15) | E-89-3 & E-89-4 | 2,334,480 | 12.7 | 296,479 | .9 | 267,000 |
| South Sector (E3.16 to E3.18) | E-89-4 | 2,501,911 | 13.1 | 327,750 | .9 | 295,000 |
| Total (Inferred) | | 8,587,724 | | 1,257,617 | | 1,026,000 |

## Appendix 2

East Block Grain Size Estimation (Table 2-4)

West Block Grain Size Estimation (Table 2-5)

## EAST BLOCK GRAIN-SIZE ESTIMATION

TABLE 2-4

EAST BLOCK SOUTH END (TOTAL UNIT)

| HOLE | NUMBER OF SAMPLES | THICKNESS | SCREEN SIZE - % RETAINED +4 | +10 | +20 | +40 | +60 | +100 | +200 | -200 |
|---|---|---|---|---|---|---|---|---|---|---|
| 63A | 10 | 20 | - | 1.1 | 7.1 | 12.0 | 5.5 | 14.7 | 48.5 | 10.8 |
| 64 | 10 | 20 | 0.4 | 1.5 | 3.8 | 11.0 | 7.9 | 19.6 | 39.1 | 16.1 |
| 66 | 14 | 28 | - | 0.9 | 3.2 | 4.9 | 7.1 | 37.1 | 39.1 | 7.5 |
| 67 | 11 | 22 | 0.8 | 2.4 | 6.7 | 9.8 | 7.1 | 20.9 | 38.7 | 13.1 |
| 68 | 12 | 24 | - | 0.4 | 6.9 | 17.8 | 15.6 | 34.2 | 18.6 | 6.4 |
| 73 | 6 | 12 | - | - | 0.7 | 7.8 | 29.6 | 55.3 | 5.1 | 1.4 |
| 74 | 14 | 28 | 0.1 | 1.2 | 6.1 | 17.8 | 14.1 | 45.6 | 10.7 | 4.1 |
| 75 | 15 | 30 | - | 0.6 | 3.7 | 8.9 | 13.7 | 50.9 | 16.0 | 8.4 |
| 77 | 4 | 8 | - | 0.70 | 10.8 | 19.2 | 10.3 | 12.0 | 30.6 | 13.0 |
| 78 | 3 | 6 | - | 5.7 | 14.3 | 25.3 | 8.3 | 12.3 | 22.0 | 11.3 |
| 79 | 6 | 12 | - | 4.0 | 6.2 | 14.3 | 6.3 | 15.2 | 26.2 | 27.1 |
| 87 | 7 | 14 | - | 1.1 | 3.4 | 15.9 | 28.0 | 28.2 | 11.1 | 11.4 |
| 92 | 10 | 20 | - | 1.0 | 5.3 | 20.2 | 18.5 | 33.8 | 12.2 | 8.9 |
| 94 | 13 | 26 | - | 0.2 | 3.0 | 8.0 | 17.8 | 53.8 | 12.6 | 4.5 |
| E-89-4 | 4 | 13 | - | 0.1 | 3.7 | 27.6 | - | - | 5.4 | 4.5 |
| Weighted Average [illegible] | | | 0.1 | 1.2 | 5.1 | 13.1 | 13.3 | 34.4 | 22.7 | 10.1 |

EAST BLOCK - NORTH END (TOTAL UNIT)

| HOLE | NUMBER OF SAMPLES | THICKNESS | +8 | +10 | +16 | +20 | +30 | +40 | +50 | +100 | +200 | -200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E-89-1 | 7 | 21.5 | - | 0.1 | 0.2 | 0.6 | 2.6 | 7.7 | 21.5 | 42.5 | 15.3 | 9.5 |
| E-89-2 | 8 | 30 | - | 0.1 | 0.1 | 0.5 | 1.5 | 3.3 | 12.8 | 41.4 | 24.3 | 16.0 |
| E-89-3 | 15 | 42.5 | - | 0.1 | 0.2 | 1.1 | 1.8 | 10.7 | 15.7 | 25.8 | 24.8 | 19.8 |
| E-89-5 | 13 | 20 | - | 0.1 | 1.6 | 4.9 | 12.5 | 20.9 | 23.3 | 18.3 | 11.9 | 6.5 |
| E-81-1 | 8 | N/A | - | 0.1 | 2.6 | 1.7 | 9.6 | 18.0 | 30.2 | - | - | - |
| E-81-2 | 10 | N/A | 0.1 | 0.1 | 4.9 | 3.2 | 8.4 | 12.3 | 27.3 | - | - | - |
| | | | 0.1 | 0.1 | 1.3 | 1.9 | 5.4 | 11.6 | 20.20 | 32.1 | 12.7 | 14.6 |

AVERAGE GRAIN SIZE EAST BLOCK
MESH RANGE

| | WEIGHTING | +10 | 10-20 | 20-40 | 40-100 | 100-200 | -200 |
|---|---|---|---|---|---|---|---|
| SOUTH END | 17% | 1.3 | 5.1 | 13.1 | 47.7 | 22.7 | 10.1 |
| NORTH END | 83% | 0.2 | 3.2 | 17.0 | 52.3 | 12.7 | 14.6 |
| | 100 | 3.5 | 3.5 | 16.4 | 51.6 | 14.4 | 13.8 |

WEST BLOCK - SOUTH END (TOTAL UNIT)

| HOLE | NUMBER OF SAMPLES | THICKNESS (feet) | +4 | +10 | +20 | +40 | +60 | +100 | +200 | -200 |
|---|---|---|---|---|---|---|---|---|---|---|
| 117 | 13 | 26 | - | 0.4 | 5.2 | 0.5 | 24.6 | 31.5 | 23.9 | 7.5 |
| 119 | 10 | 20 | - | 2.0 | 7.9 | 23.3 | 13.6 | 10.0 | 20.9 | 6.2 |
| 120 | 11 | 22 | - | 0.2 | 6.0 | 23.0 | 35.2 | 13.0 | 15.3 | 4.0 |
| | | | - | 0.3 | 6.2 | 17.0 | 24.9 | 22.1 | 22.5 | 6.2 |

AVERAGE GRAIN SIZE - WEST BLOCK
MESH RANGE

| | WEIGHTING | +10 | 10-20 | 20-40 | 40-100 | 100-200 | -200 |
|---|---|---|---|---|---|---|---|
| SOUTH END | 50% | 0.3 | 6.2 | 17.0 | 47.0 | 22.5 | 6.2 |
| NORTH END | 50% | 0.1 | 6.3 | 27.2 | 56.4 | 7.3 | 2.7 |
| | | 0.2 | 6.2 | 22.5 | 51.7 | 14.9 | 4.4 |

## 2.5 Quality

### 2.5.1 Grain Size

In the East Block, 200 silica sand samples collected from 21 boreholes were used to estimate the grain size average percentages. In the West Block, 105 samples from 7 boreholes were combined with the results from 3 bulk trench samples to estimate the average grain size of the sand. Tables 2-4 and 2-5 illustrate the database used in the calculation. It is apparent that there is significant variation in the distribution of grain size throughout the deposit.

The weighted average grain sizes computed for the deposit are as follows:

| U.S. Standard Sieve No. | East Block | West Block |
|---|---|---|
| 0-12 | 1.0 | 0.2 |
| 12-20 | 2.8 | 6.2 |
| 20-40 | 16.4 | 22.5 |
| 40-60 | 20.2 | 30.5 |
| 60-100 | 31.4 | 21.3 |
| 100-200 | 14.4 | 14.9 |
| Minus 200 | 13.8 | 4.4 |
| | 100.0% | 100.0% |

## Appendix 3

Hardy BBT Limited – Testing Results

Stim Lab Report December 17, 2009

**Hardy BBT Limited**

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

Our Project No

Your Reference No EA-11423

April 24, 1989

Peace River Silica Sand Ltd.
14010 - 128 Avenue
EDMONTON, Alberta
T5L 4M8

Attention: Mr. Joe M. Grguras, President

Subject: Field Investigation and Laboratory Testing Program
Silica Sand Deposit
Near Peace River, Alberta

Gentlemen:

## 1.0 INTRODUCTION

As requested, a field and laboratory test program was recently undertaken in accordance with your letter of authorization dated February 20, 1989. The work scope undertaken was in general conformance with the Hardy BBT Limited proposal for the subject project dated January 10, 1989. The program involved advancing five boreholes, recovering selected sand samples, and conducting a series of tests utilizing the American Petroleum Institute, Recommended Practices, for Testing Sand Used in Hydraulic Fracturing Operations, API RP56, First Edition, March, 1983.

The field work portion of the study was completed in March, 1989 and although the laboratory work is nearly complete, the results and findings compiled to-date are presented in this letter-report. The laboratory work scope still underway consists of the sand mineralogical analyses (x-ray differention tests) which are being conducted by the Alberta Research Council. This phase of the study is expected to be completed and available by the end of May, 1989.

## 2.0 FIELD EXPLORATION

The field work portion of the investigation, including site reconnaissance, borehole drilling, and soil sampling, was conducted during the time period of March 5 to 12, 1989. A total of five boreholes were drilled to depths ranging from 127 feet to 150.5 feet below the existing ground surface elevations. The boreholes were advanced at locations determined and surveyed by representatives of, or acting on behalf of, Peace River Silica Sand Ltd. The locations of the boreholes are shown on the

4810 - 93 STREET, P.O. BOX 746, EDMONTON, ALBERTA T5J 2L4 TELEPHONE (403) 436-2152 TELEX 037-3750 FAX (403) 435-8425

attached site plan, Drawing No. EA11423-1. Continuous logs of the subsurface conditions, as encountered in the boreholes, were recorded at the time of drilling and are presented on the attached borehole logs, Drawing Nos. EA11423-2 to -6. Drilling was accomplished with a truck mounted Becker drill rig utilizing a combination of casing and hammer, and tri-cone drilling.

Soil sampling consisted of recovering disturbed soil samples from the drill cuttings at selected depths in all of the boreholes. Additionally, two sand samples were recovered from sand deposits within the area, at locations identified by representatives of Peace River Silica Sand Ltd. All soil samples recovered in the field were sealed to prevent moisture loss and were taken to the Edmonton laboratory for testing and analysis.

## 3.0 LABORATORY TESTING

Selected sand samples were tested in the laboratory to determine certain physical properties of the material relative to the use of the sand for use in hydraulic fracturing operations. Grain size analyses were conducted on a majority of the recovered sand samples to determine the particle size distributions. On the basis of the grain size distributions, a limited number of sand samples were selected for additional testing. The samples were prepared for this phase of the testing by washing and sieving in order to achieve a grain size analysis for each sample which satisfied the 20/40 fractured sand size designation as given in Table 4.1 - API RP 56, First Edition, March, 1983. Subsequent to the processing, the individual samples were tested to determine sphericity and roundness, solubility in acid, turbidity, and crush resistance determinations. All of the above tests were conducted in accordance with the recommended practices of the American Petroleum Institute, API RP 56, First Edition, March, 1983.

The test data and supplementary notes are presented on the attached Table Nos. 1 to 10. Test results which indicated compliance or non-compliance of materials with the American Petroleum Institute recommended criterion are identified.

If there are any questions please contact this office.

Respectfully submitted

Hardy BBT Limited

[redacted]

D.F. Cox, P.Eng.
Senior Engineer
Materials Engineering

DFC/jh/EA11423LDFC

Distribution: (12) Addressee

Enclosures: Table Nos. 1 to 10
Drawing Nos. EA11423-1 to -6

TABLE 3-1

GRADATION ANALYSES CONDUCTED ON SAND DEPOSITS
BOREHOLE NO. E89-1

Total Percent Passing (By Mass)

| Sieve Designation* | Sample No. / Depth (feet) | 1 / 94-96 | 2 / 96-98 | 3 / 98-100 Sample tested | 4 / 100-102 | 5 / 102-104 | 6 / 104-106 | 7 / 106-108 |
|---|---|---|---|---|---|---|---|---|
| 8 | | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 10 | | 100 | 100 | 100 | 99.9 | 99.9 | 99.4 | 100 |
| 16 | | 99.9 | 100 | 99.8 | 99.6 | 99.8 | 99.3 | 99.8 |
| 20 | | 99.5 | 99.6 | 98.4 | 98.7 | 99.3 | 99.0 | 99.4 |
| 30 | | 13.5 97.0 | 11.9 97.4 | 20.1 92.4 | 14.0 95.1 | 5.7 97.8 | 3.3 98.0 | 3.5 98.2 |
| 40 | | 86.0 | 87.7 | 78.3 | 84.7 | 93.6 | 95.7 | 95.9 |
| 50 | | 53.0 | 56.6 | 49.5 | 58.2 | 78.4 | 87.6 | 88.1 |
| 100 | | 11.7 | 15.1 | 10.5 | 10.0 | 18.4 | 40.7 | 40.5 |
| 200 | | 3.0 | 4.6 | 3.1 | 2.7 | 5.1 | 9.9 | 11.2 |

* U.S.A. Sieve Series (ASTM E 11-81)

8.4% = 7000 594 135 119 201 14 57 33 35 20/40

EA11423L.DEC

TABLE 3-2

GRADATION ANALYSES CONDUCTED ON SAND DEPOSITS
BOREHOLE NO. E89-2

Total Percent Passing (By Mass)

| Sieve Designation* | Sample No. 1, Depth 100-102 ft | 3, 104-106 | 5, 108-110 | 7, 112-114 | 9, 116-118 | 11, 120-122 | 13, 124-126 | 15, 128-130 | 18, 132-134 | 20, 136-141 | 22, 144-148 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 10 | 100 | 100 | 100 | 100 | 99.9 | 99.8 | 100 | 100 | 100 | 99.9 | 99.9 |
| 16 | 99.3 | 100 | 100 | 100 | 99.9 | 99.7 | 100 | 100 | 99.9 | 99.8 | 99.9 |
| 20 | 96.3 | 99.6 | 99.9 | 99.9 | 99.8 | 99.6 | 99.9 | 99.9 | 99.8 | 99.8 | 99.8 |
| 30 | 87.4 | 97.5 | 99.8 | 99.7 | 99.8 | 99.6 | 99.7 | 99.4 | 99.8 | 99.5 | 99.2 |
| 40 | 77.0 | 90.2 | 98.5 | 97.8 | 99.6 | 99.4 | 98.5 | 95.8 | 99.7 | 98.5 | 97.2 |
| 50 | 65.2 | 77.7 | 79.3 | 72.7 | 97.8 | 98.5 | 86.7 | 76.3 | 99.4 | 93.6 | 93.2 |
| 100 | 42.7 | 57.3 | 20.3 | 14.1 | 68.2 | 71.5 | 23.5 | 25.4 | 88.4 | 60.1 | 75.8 |
| 200 | 25.1 | 30.0 | 7.3 | 4.5 | 19.2 | 23.4 | 9.2 | 9.7 | 27.4 | 21.6 | 43.2 |

Handwritten notes: "Nothing tested"; beside the 30 row: 19.3 9.4 1.4 2.1 .2 .2 1.3 4.1 1.1 1.3 2.6

2.2% 11,000/237 94 14 21 2 2 13 41 11 13 26

* U.S.A. Sieve Series (ASTM E 11-81)

EA11423L.DFC

## TABLE 3-3

### GRADATION ANALYSES CONDUCTED ON SAND DEPOSITS BOREHOLE NO. E89-3

Total Percent Passing (By Mass)

| Sample No. | 1 | 3 | 5 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (feet) | 108-110 | 112-114 | 116-118 | 120-122 | 122-124 | 124-126 | 126-128 | 128-130 | 130-138 | 138-140 | 140-141 | 141-144 | 144-147 | 147-150 | 150-150.5 |
| Sieve Designation* | | | | | | | | | | | | | | | |
| 8 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 10 | 100 | 100 | 99.9 | 99.9 | 99.5 | 100 | 100 | 99.9 | 100 | 100 | 100 | 99.9 | 100 | 100 | 99.9 |
| 16 | 99.9 | 99.9 | 99.8 | 99.9 | 99.3 | 99.9 | 100 | 99.8 | 100 | 99.4 | 99.5 | 99.8 | 100 | 99.0 | 97.6 |
| 20 | 99.5 | 99.5 | 99.8 | 99.8 | 99.0 | 99.5 | 99.7 | 99.0 | 99.8 | 98.2 | 98.8 | 99.4 | 100 | 91.9 | 76.8 |
| 30 | 98.7 | 98.8 | 99.5 | 99.8 | 97.6 | 96.1 | 99.3 | 91.9 | 95.7 | 88.3 | 89.2 | 97.0 | 99.9 | 81.1 | 48.6 |
| 40 | 97.9 | 98.4 | 99.3 | 99.7 | 90.1 | 80.2 | 72.8 | 63.6 | 73.3 | 63.3 | 65.6 | 88.4 | 98.9 | 72.9 | 38.6 |
| 50 | 94.5 | 97.8 | 98.8 | 99.6 | 79.3 | 57.9 | 28.1 | 20.3 | 39.7 | 36.2 | 43.6 | 74.2 | 91.3 | 59.8 | 30.6 |
| 100 | 74.9 | 80.0 | 89.9 | 90.1 | 62.2 | 42.0 | 12.3 | 6.4 | 9.0 | 6.1 | 10.3 | 21.6 | 27.8 | 21.4 | 14.4 |
| 200 | 32.1 | 34.0 | 36.2 | 33.4 | 31.2 | 30.2 | 7.3 | 2.8 | 4.8 | 2.4 | 4.9 | 7.0 | 12.0 | 10.8 | 8.8 |

* U.S.A. Sieve Series (ASTM E 11-81)

TABLE 3-4

## GRADATION ANALYSES CONDUCTED ON SAND DEPOSITS
## BOREHOLE NO. E89-4

| Sieve Designation* | | Total Percent Passing (By Mass) | | | | |
|---|---|---|---|---|---|---|
| | Sample No. | 1 | 2 | 3 | 4 | 5 |
| | Depth (feet) | 54-56 | 56-60 | 60-65 | 65-67 | 112-114 |
| 8 | | 100 | 100 | 100 | 100 | 100 |
| 10 | | 100 | 100 | 100 | 99.7 | 100 |
| 16 | | 100 | 99.9 | 99.5 | 97.6 | 99.9 |
| 20 | | 99.6 | 99.7 | 94.5 | 89.9 | 99.8 |
| 30 | | 90.9 | 95.8 | 74.4 | 71.0 | 99.2 |
| 40 | | 72.1 | 83.0 | 62.0 | 56.6 | 98.2 |
| 50 | | 49.9 | 64.2 | 51.4 | 47.3 | 96.6 |
| 100 | | 4.7 | 9.3 | 8.1 | 21.2 | 93.2 |
| 200 | | 2.5 | 4.2 | 4.0 | 8.6 | 29.1 |

Sampled; 13 ft; Crush Boundaries 13.0 .5; 14.7 .5; 27.5; 16.7; 32.5; 33.3; 27%; 4000 / 1100; 275; 167; 325; 333

* U.S.A. Sieve Series (ASTM E 11-81)

TABLE 3-5

# GRADATION ANALYSES CONDUCTED ON SAND DEPOSITS
## BOREHOLE NO. E89-5

Total Percent Passing (By Mass)

| Sieve Designation* | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (feet) | 110-112 | 114-116 | 116-118 | 118-120 | 120-122 | 122-124 | 124-126 | 126-128 | 128-130 | 130-132 | 132-134 | 134-136 | 136-138 |
| 8 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 10 | 100 | 99.9 | 99.9 | 100 | 99.9 | 99.9 | 99.8 | 100 | 99.9 | 99.9 | 99.9 | 100 | 100 |
| 16 | 100 | 98.7 | 95.5 | 98.8 | 98.4 | 96.5 | 96.7 | 99.0 | 97.9 | 98.8 | 98.3 | 99.1 | 98.3 |
| 20 | 99.9 | 95.3 | 83.7 | 93.6 | 92.7 | 86.2 | 88.1 | 94.6 | 93.7 | 95.4 | 94.2 | 95.3 | 94.2 |
| 30 | 99.8 | 87.8 | 60.5 | 74.7 | 75.8 | 64.0 | 69.[illegible] | 80.6 | 83.0 | 85.5 | 82.8 | 82.9 | 84.8 |
| 40 | 99.6 | 80.0 | 35.2 | 42.1 | 44.3 | 34.1 | 42.3 | 53.2 | 60.3 | 63.5 | 59.5 | 56.7 | 68.2 |
| 50 | 98.2 | 72.5 | 15.0 | 14.2 | 15.6 | 11.6 | 19.1 | 26.5 | 28.3 | 26.8 | 23.3 | 20.8 | 40.4 |
| 100 | 84.7 | 51.1 | 4.5 | 2.4 | 2.3 | 2.2 | 3.3 | 3.5 | 2.5 | 2.7 | 2.0 | 2.3 | 6.5 |
| 200 | 31.7 | 17.8 | 1.7 | 0.8 | 0.7 | 0.6 | 1.1 | 0.6 | 0.6 | 0.7 | 0.5 | 0.7 | 2.3 |

* U.S.A. Sieve Series (ASTM E 11-81)

(Handwritten notes: "Sampled"; "28 ft"; 12.9, 11.9, 13.9, 14.0, 15.2, 16.1, 15.0; 4673, 3, 147, 485, 515, 484, 521, 458, 414, 334, 319, 347, 386, 260; "8 ft Pass Crush"; "6 ft Fail Crush"; "2 fail")

TABLE 3-6

GRADATION ANALYSES CONDUCTED ON SAND DEPOSITS
MISCELLANEOUS LOCATIONS

Total Percent Passing (By Mass)

| Location | West Bank Trench #4 | West Bank Dynamite Blast |
|---|---|---|
| Sieve Designation* | | |
| 8 | 100 | 100 |
| 10 | 99.2 | 100 |
| 16 | 95.8 | 99.9 |
| 20 | 85.8 | 99.9 |
| 30 | 69.1 | 99.8 |
| 40 | 53.0 | 99.8 |
| 50 | 30.2 | 99.7 |
| 100 | 3.5 | 94.5 |
| 200 | 0.9 | 18.3 |

(32)

* U.S.A. Sieve Series (ASTM E 11-81)

# TABLE 3-7

## FRAC SAND SPHERICITY AND ROUNDNESS

| Borehole No. | Sample No. | Depth (feet) | Average Sphericity* | Average Roundness** | Crush |
|---|---|---|---|---|---|
| E89-1 | 3 | 98-100 | 0.7 | (0.5) | |
| E89-3 | 9 | 124-126 | 0.7 | 0.6 | |
| E89-3 | 10 | 126-128 | 0.8 | 0.6 | 15.6 |
| E89-3 | 11 | 128-130 | 0.7 | 0.6 | |
| E89-3 | 13 | 138-140 | 0.7 | 0.6 | |
| E89-3 | 14 | 140-141 | 0.7 | 0.6 | |
| E89-3 | 18 | 150-150.5 | 0.7 | (0.5) | |
| E89-4 | 3 | 60-65 | 0.8 | (0.5) | |
| E89-4 | 4 | 65-67 | 0.7 | (0.5) | |
| E89-5 | 4 | 116-118 | 0.7 | 0.6 | |
| E89-5 | 5 | 118-120 | 0.7 | 0.6 | |
| E89-5 | 6 | 120-122 | 0.7 | 0.6 | |
| E89-5 | 7 | 122-124 | 0.7 | 0.6 | 14.0 |
| E89-5 | 8 | 124-126 | 0.8 | 0.7 | 15.2 |
| E89-5 | 9 | 126-128 | 0.8 | 0.7 | 14.8 |
| E89-5 | 10 | 128-130 | 0.7 | 0.7 | 16.7 |
| E89-5 | 12 | 132-134 | 0.7 | 0.7 | 15.0 |
| West Bank Trench #4 | | -- | 0.6 | 0.6 | 14.6 |

* API RP 56, First Edition, March, 1983, Section 5.2

** API RP 56, First Edition, March, 1983, Section 5.3

() Less than the recommended minimum value of 0.6

# TABLE 3-8

## SAND SOLUBILITY IN ACID

| Borehole No. | Sample No. | Depth (feet) | Solubility* (% by Weight) |
|---|---|---|---|
| E89-1 | 3 | 98-100 | 0.84 |
| E89-3 | 9 | 124-126 | 0.80 |
| E89-3 | 10 | 126-128 | 0.79 |
| E89-3 | 11 | 128-130 | 0.84 |
| E89-3 | 13 | 138-140 | 0.93 |
| E89-3 | 14 | 140-141 | 0.84 |
| E89-3 | 18 | 150-150.5 | 0.86 |
| E89-4 | 3 | 60-65 | 0.53 |
| E89-4 | 4 | 65-67 | 0.81 |
| E89-5 | 4 | 116-118 | 0.74 |
| E89-5 | 5 | 118-120 | 1.12 |
| E89-5 | 6 | 120-122 | 0.82 |
| E89-5 | 7 | 122-124 | 0.81 |
| E89-5 | 8 | 124-126 | 0.84 |
| E89-5 | 9 | 126-128 | 0.81 |
| E89-5 | 10 | 128-130 | 1.01 |
| E89-5 | 12 | 132-134 | 0.81 |

* API RP 56, First Edition, March, 1983, Section 6
() Greater than the recommended maximum value of 2.0 percent by weight

# TABLE 3-9

## TURBIDITY MEASUREMENT OF SILT AND CLAY SIZE PARTICULATE MATTER

| Borehole No. | Sample No. | Depth (feet) | Turbidity* (FTU) |
|---|---|---|---|
| E89-1 | 3 | 98-100 | 79 |
| E89-3 | 9 | 124-126 | 46 |
| E89-3 | 10 | 126-128 | 63 |
| E89-3 | 11 | 128-130 | 60 |
| E89-3 | 13 | 138-140 | 54 |
| E89-3 | 14 | 140-141 | 56 |
| E89-3 | 18 | 150-150.5 | 54 |
| E89-4 | 3 | 60-65 | 7 |
| E89-4 | 4 | 65-67 | 54 |
| E89-5 | 4 | 116-118 | 44 |
| E89-5 | 5 | 118-120 | 33 |
| E89-5 | 6 | 120-122 | 74 |
| E89-5 | 7 | 122-124 | 36 |
| E89-5 | 8 | 124-126 | 37 |
| E89-5 | 9 | 126-128 | 47 |
| E89-5 | 10 | 128-130 | 21 |
| E89-5 | 12 | 132-134 | 54 |

* API RP 56, First Edition, March, 1983, Section 7, Method I
() Greater than the recommended frac sand turbidity value of 250 FTU

# TABLE 3-10

## FRAC SAND CRUSH RESISTANCE

| Borehole No. | Sample No. | Depth (feet) | Crush Resistance* (% Fines by Weight) |
|---|---|---|---|
| E89-1 | 3 | 98-100 | 13.9 |
| E89-3 | 9 | 124-126 | 10.8 |
| E89-3 | 10 | 126-128 | (15.6) |
| E89-3 | 11 | 128-130 | 12.5 |
| E89-3 | 13 | 138-140 | 12.1 |
| E89-3 | 14 | 140-141 | 11.7 |
| E89-3 | 18 | 150-150.5 | 13.7 |
| E89-4 | 3 | 60-65 | 13.0 |
| E89-4 | 4 | 65-67 | (14.7) |
| E89-5 | 4 | 116-118 | 12.9 |
| E89-5 | 5 | 118-120 | 11.9 |
| E89-5 | 6 | 120-122 | 13.9 |
| E89-5 | 7 | 122-124 | (14.0) |
| E89-5 | 8 | 124-126 | (15.2) |
| E89-5 | 9 | 126-128 | (14.8) |
| E89-5 | 10 | 128-130 | (16.7) |
| E89-5 | 12 | 132-134 | (15.0) |
| West Bank Trench #4 | | -- | (14.6) |

* API RP 56, First Edition, March, 1983, Section 8

() Greater than or equal to the recommended maximum fines value of 14 percent by weight.

# "Recommended Practices for Testing Sand Used in Hydraulic Fracturing Operations" Evaluations on 10 Sand Samples For Winn Bay Sands Submitted December 17, 2009

**Prepared For**:
Mr. James Punt
Winn Bay Sand
Unit 75, 4100 Salish Drive
Vancouver BC, Canada V6N3M2
(306) 696-3447
(306) 668-0486 Fax

**Prepared By**:
Stim-Lab, Inc.
7406 North Hwy 81
Duncan, Oklahoma 73533-1644

[redacted]

Lisa O'Connell, Laboratory Supervisor

P.O. Number: Per Email

File Number: SL8686

December 2009



Stim-Lab
A CORE LABORATORIES COMPANY

Stim-Lab
A CORE LABORATORIES COMPANY

**STIM-LAB, Inc.**
7406 North HWY 81
Duncan, Oklahoma 73533
Phone: 580-252-4309
Fax: 580-252-6979
www.stimlab.com

December 30, 2009

Mr. James Punt
Winn Bay Sand
Unit 75, 4100 Salish Drive
Vancouver BC V6N 3M2
Canada

Dear Mr. Punt:

STIM-LAB, Inc. has completed the API RP-56 evaluations requested on the submitted sand samples labeled Larkin Valley 50/140, PR2 40/50, PR2 50/140, PR4 40/50, PR4 50/140, PR5 50/140, PR6 50/140, PR7 50/140, PR8 40/50, and PR8 50/140. The samples were received at Stim-Lab Inc. on December 17, 2009.

Tables 1through 10 provide the sphericity and roundness (Krumbein Shape Factor) evaluations for each of the samples. The samples identification is listed at the top of each table. Table 7 also includes the results for the crush resistance at 5000 psi as requested. Pictures of the samples are provided below each table for your review. The procedures followed are as stated in API RP-56.

Thank you for having STIM-LAB, Inc. to perform these analyses. We hope you will consider us for your future testing needs. If you have any questions regarding the testing or results, please do not hesitate to give me a call.

Sincerely,

[redacted]

Lisa O'Connell
Laboratory Supervisor
Conductivity Laboratory

Stim-Lab
A CORE LABORATORIES COMPANY

SL 8686

Table 1

**Frac Sand Samples, Submitted by Winn Bay Sand, LP**
**Sample: Larkin Valley 50/140**
**Arrived 12/17/09**
**Recommended Practices for Testing Frac Sand**
**used in Hydraulic Fracturing Operations**

**API RP-56, Section 5, "Frac Sand Sphericity and Roundness"**

* mean of a 20 count

| | |
|---|---|
| **Sphericity =** | **0.7** |
| **Roundness =** | **0.6** |
| **Clusters =** | **None Observed in Field of Count** |

Recommended Sphericity and Roundness for proppants = 0.6 or greater API RP-56

December 2009

SL 8686

## Table 2

**Frac Sand Samples, Submitted by Winn Bay Sand, LP**
**Sample: PR2 40/50**
**Arrived 12/17/09**
**Recommended Practices for Testing Frac Sand**
**used in Hydraulic Fracturing Operations**

**API RP-56, Section 5, "Frac Sand Sphericity and Roundness"**

* mean of a 20 count

| | |
|---|---|
| **Sphericity =** | **0.6** |
| **Roundness =** | **0.6** |
| **Clusters =** | **None Observed in Field of Count** |

Recommended Sphericity and Roundness for proppants = 0.6 or greater API RP-56

December 2009

Stim-Lab
A CORE LABORATORIES COMPANY

SL 8686

**Table 3**

**Frac Sand Samples, Submitted by Winn Bay Sand, LP**
**Sample: PR2 50/140**
**Arrived 12/17/09**
**Recommended Practices for Testing Frac Sand**
**used in Hydraulic Fracturing Operations**

**API RP-56, Section 5, "Frac Sand Sphericity and Roundness"**

* mean of a 20 count

| | |
|---|---|
| **Sphericity =** | **0.7** |
| **Roundness =** | **0.5** |
| **Clusters =** | **None Observed in Field of Count** |

Recommended Sphericity and Roundness for proppants = 0.6 or greater API RP-56

December 2009

Stim-Lab
A CORE LABORATORIES COMPANY

SL 8686

Table 4

**Frac Sand Samples, Submitted by Winn Bay Sand, LP**
**Sample: PR4 40/50**
**Arrived 12/17/09**
**Recommended Practices for Testing Frac Sand**
**used in Hydraulic Fracturing Operations**

**API RP-56, Section 5, "Frac Sand Sphericity and Roundness"**

* mean of a 20 count

| | |
|---|---|
| **Sphericity =** | **0.7** |
| **Roundness =** | **0.5** |
| **Clusters =** | **None Observed in Field of Count** |

Recommended Sphericity and Roundness for proppants = 0.6 or greater API RP-56

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## Table 5

**Frac Sand Samples, Submitted by Winn Bay Sand, LP**
**Sample: PR4 50/140**
**Arrived 12/17/09**
**Recommended Practices for Testing Frac Sand**
**used in Hydraulic Fracturing Operations**

**API RP-56, Section 5, "Frac Sand Sphericity and Roundness"**

* mean of a 20 count

| | |
|---|---|
| **Sphericity =** | **0.7** |
| **Roundness =** | **0.5** |
| **Clusters =** | **None Observed in Field of Count** |

Recommended Sphericity and Roundness for proppants = 0.6 or greater API RP-56

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## Table 6

**Frac Sand Samples, Submitted by Winn Bay Sand, LP**
**Sample: PR5 50/140**
**Arrived 12/17/09**
**Recommended Practices for Testing Frac Sand used in Hydraulic Fracturing Operations**

---

**API RP-56, Section 5, "Frac Sand Sphericity and Roundness"**

* mean of a 20 count

| | |
|---|---|
| **Sphericity =** | **0.7** |
| **Roundness =** | **0.5** |
| **Clusters =** | **Approx 1 of Every 100 Grains Contained Clusters** |

Recommended Sphericity and Roundness for proppants = 0.6 or greater API RP-56

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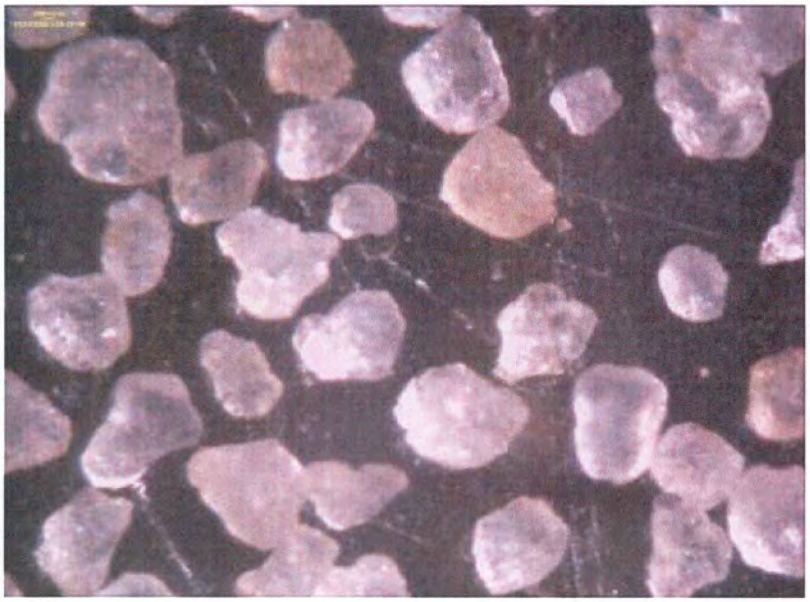

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**Table 7**

**Frac Sand Samples, Submitted by Winn Bay Sand, LP**
**Sample: PR6 50/140**
**Arrived 12/17/09**
**Recommended Practices for Testing Frac Sand**
**used in Hydraulic Fracturing Operations**

**API RP-56, Section 5, "Frac Sand Sphericity and Roundness"**

* mean of a 20 count

| | |
|---|---|
| **Sphericity =** | **0.7** |
| **Roundness =** | **0.6** |
| **Clusters =** | **None Observed in Field of Count** |

Recommended Sphericity and Roundness for proppants = 0.6 or greater API RP-56

**API RP 56, Section 8, "Recommended Frac Sand Crush Resistance Test"**

| ***PSI*** | ***% Fines -50+140 Crush Prep*** |
|---|---|
| **5000** | **6.1** |

Suggested maximum fines for 70/140 Frac Sand per API RP-56 = 6% @ 5000psi



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## Table 8

**Frac Sand Samples, Submitted by Winn Bay Sand, LP**
**Sample: PR7 50/140**
**Arrived 12/17/09**
**Recommended Practices for Testing Frac Sand**
**used in Hydraulic Fracturing Operations**

**API RP-56, Section 5, "Frac Sand Sphericity and Roundness"**

* mean of a 20 count

| | |
|---|---|
| **Sphericity =** | **0.7** |
| **Roundness =** | **0.5** |
| **Clusters =** | **Approx 1 of Every 100 Grains Contained Clusters** |

Recommended Sphericity and Roundness for proppants = 0.6 or greater API RP-56

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## Table 9

**Frac Sand Samples, Submitted by Winn Bay Sand, LP**
**Sample: PR8 40/50**
**Arrived 12/17/09**
**Recommended Practices for Testing Frac Sand**
**used in Hydraulic Fracturing Operations**

---

**API RP-56, Section 5, "Frac Sand Sphericity and Roundness"**

* mean of a 20 count

| | |
|---|---|
| **Sphericity =** | **0.7** |
| **Roundness =** | **0.6** |
| **Clusters =** | **None Observed in Field of Count** |

Recommended Sphericity and Roundness for proppants = 0.6 or greater API RP-56

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**Table 10**

**Frac Sand Samples, Submitted by Winn Bay Sand, LP**
**Sample: PR8 50/140**
**Arrived 12/17/09**
**Recommended Practices for Testing Frac Sand**
**used in Hydraulic Fracturing Operations**

**API RP-56, Section 5, "Frac Sand Sphericity and Roundness"**

* mean of a 20 count

| | |
|---|---|
| **Sphericity =** | **0.7** |
| **Roundness =** | **0.4** |
| **Clusters =** | **None Observed in Field of Count** |

Recommended Sphericity and Roundness for proppants = 0.6 or greater API RP-56

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