# KODIAK PETROLEUM ULC
# GRANDVIEW (LITTLE CHICAGO) 2007
# GRAVITY ON SEISMIC PROGRAM
# FINAL REPORT

**Little Chicago, Northwest Territories**
**March 2 to March 8, 2007**


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## UNDER SEPARATE 11” X 17” COVER

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1. Bouguer Gravity
2. 20km Regional Gravity Model
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# INTRODUCTION

The following report describes the gravity survey conducted by *Excel Geophysics Inc.* (*Excel*) for *Kodiak Petroleum ULC* (*Kodiak*) through *Synterra Technologies Ltd*. (*Synterra*) during the winter of 2007. The gravity survey was conducted in conjunction with the Grandview (Little Chicago) 2007 2D seismic program. The area of exploration was in the Northwest Territories, Canada, on the West side of the MacKenzie River near Little Chicago NT, 145 km north of Fort Good Hope, NT. Gravity data were collected along seven seismic lines, LC07-101 to LC07-107. Gravity and GPS data were also collected along the access route from the camp at Little Chicago to the start of seismic line LC07-105. The survey was conducted from March 2 to 8, 2007. Figure 1 shows the location of the program.

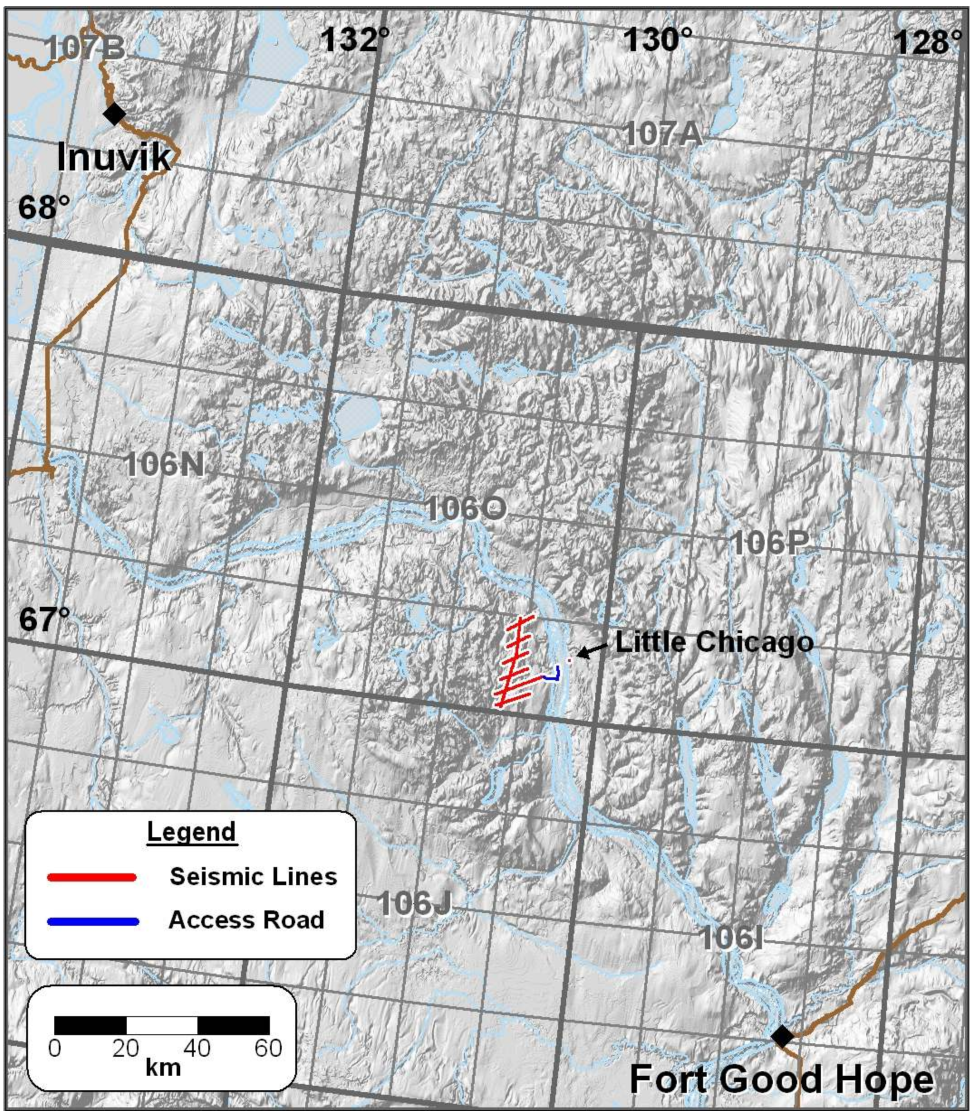



**Figure 1.** Little Chicago Survey Area

## SAFETY

Each crewmember held current safety certifications in Emergency First Aid, WHMIS and $H_2S$ awareness. An emergency response plan, containing contact numbers and emergency procedures, was distributed and explained to all staff members, and was posted in an accessible location. Safety meetings were held on a regular basis by the field staff to help identify any potential safety hazards.

*Excel* ensured that each member of the crew was equipped with appropriate outdoor wear, two-way radio, satellite phone, first-aid kit, and a safety vest. A medic was on site and monitoring radio calls for the duration of the project. *Excel* also followed safety procedures set forth by the site supervisor, Larry McEwen from *Kodiak*.

## GRAVITY SURVEY PARAMETERS

The following two tables outline the main details of the gravity survey as well as the people involved with this project.

**Table 1.** Gravity Survey Parameters

| Gravity Survey Parameters | |
|---|---|
| **General Survey Locations** | Little Chicago, Northwest Territories.<br>Latitude: 67° 06.251' N<br>Longitude: 130° 15.935' W |
| **Survey Duration** | March 2 to March 8, 2007 |
| **Gravity Station Spacing** | 240m |
| **Gravity Stations Acquired** | Total Gravity Stations: 378<br>On Seismic Lines: 347<br>On Access: 31 |
| **Terrain Corrections** | to 40 km |
| **Land Gravity Meters Used** | LaCoste and Romberg G-232<br>LaCoste and Romberg G-472<br>LaCoste and Romberg G-645 |

**Table 2.** Project Personnel

| Project Personnel | | |
|---|---|---|
| ***Kodiak* Project Manager** | Jim Trafford | |
| ***Kodiak* Site Supervisor** | Larry McEwen | |
| ***Synterra* Project Manager** | Larry Wellspring | |
| **Gravity Field Crew** | Jessica Pugh | Andrew Befus |
| **Data Processor** | Nicole Trenholm | Jessica Pugh |

# GENERAL PROCEDURES

The Little Chicago geophysical operations were project managed by *Synterra*. *Kodiak* also had a field supervisor on site at the Little Chicago camp for the duration of the project. The camp was located on the East side of the Mackenzie River and crews were flown into the project area on the west side of the river each day using a Bell 206 Longranger helicopter. Once on the project site the survey was conducted using snowmobiles and a sled rented from Wilfred Jackson. Mr. Jackson owns a cabin at Little Chicago and was also the monitor for the project. *Excel*'s two-man crew operated out of the camp along with the surveyors, slashers, cat operator's and drilling crew. *Excel* finished the gravity survey and was out of the camp by the time the seismic recording crew from Trace Energy arrived on the project. The rooms in the camp were roughly 9' x 11' and housed two people. Each room had power and access to wireless internet. The camp also included an office with satellite phone, recreation room, and kitchen. Figure 2 shows the camp at Little Chicago.

**Figure 2. Little Chicago Camp**

*Nehpets Holdings Ltd. (NHL)* was responsible for collecting the survey data along the seismic lines. The survey crew used Leica real-time GPS units, carried in a backpack on foot to locate and mark the shot points. The shot points were marked at a spacing of 80 m with a yellow tag tied to a tree and labeled with the station number. Receiver points were marked and labeled with red tags at a spacing of 20 m. Figure 3 shows a seismic line and shot point marked with a yellow tag.


**Figure 3. A typical seismic line**

## GRAVITY SURVEY PROCEDURE

The Gravity Survey crew consisted of two *Excel* geophysical operators/data processors. Jessica Pugh acted as the crew supervisor, and was on site for the duration of the project to coordinate all aspects of the operation including data quality control, environmental compliance and adherence to safety guidelines.

The area of exploration was surveyed using snowmobiles. LaCoste and Romberg gravity meters were used in this survey and were transported from station to station using backpacks. Gravity readings were taken at approximately 240 m intervals on the access route using the position function on the Leica GPS receivers and using every twelfth receiver point (240 m) along the seismic lines. The survey elevation data for the stations along the access road were collected by *Excel* operators using geodetic grade dual frequency Leica GPS receivers. This aspect of the survey is described in detail under GPS survey procedure and processing. The survey elevation data for the seismic lines was provided by *NHL* at the end of the project.

## GRAVITY BASE STATIONS

The Grandview (Little Chicago) Gravity Survey was tied to a local gravity base from the Canadian Gravity Standardization Network (CGSN). Prior to leaving Norman Wells, NT, the crew took a reading at CGSN base 1992-9002, which is located at the southeast corner inside the fire hall of the MOT multiple services building, and is shown in Figure 4. Two gravity meters were used for the base tie. Although not collected in a closed loop, the base tie agreement between the two meters was very good and facilitated the integration of GSC regional data. *Excel* set up a main base for this project at the Little Chicago Camp (Figure 5). The base in and base out gravity readings were recorded at the beginning and end of each day at the gravity base in the camp. Table 3 shows the coordinates and gravity values for the bases used on this project.


**Figure 4.** CGSN Gravity Base 9002-1992 , Norman Wells, Northwest Territories


**Figure 5.** *Excel* Gravity Base.

**Table 3. Project Gravity Bases**

| Base Name | WGS84 Latitude | WGS84 Longitude | Observed Gravity (mGal) |
|---|---|---|---|
| **CGSN 9002-1992; Norman Wells, NT** | 65° 16' 42" N | 126° 47' 17" W | 982229.001 |
| **Little Chicago Camp Control Base; 3711** | 67° 9' 9.38697" N | 130° 12' 40.75995" W | 982408.14 |

# GPS PROCEDURE

*Excel* tied into a control base established by *NHL's* survey crew. This control base was located on the existing cutline used to access LC07 – 105. Appendix C shows details of this control base. The coordinates for this base is shown in Table 4. This control base as well as two temporary field bases were used as the base network to solve the data from our roving GPS units. To ensure ample GPS coverage, the bases were positioned so that the distance to the roving units was no more than five kilometers.

**Table 4. Project GPS Bases**

| Base Name | Latitude NAD 83 | Longitude NAD 83 | Ellipsoidal Elevation (m) |
|---|---|---|---|
| **LC2B (371 03081)** | 67° 06' 14.2759" | 130° 21' 36.9653" | 85.98 |

*Excel's* operators were responsible for recording GPS readings with the Leica 500 GPS receiver at each gravity station along the access route to the seismic lines. The GPS units were set up on a tripod at each gravity station. At stations with significant snow depth, the crew dug through the snow to ground level to be sure that the GPS and gravity reading were both recorded on the ground. Due to differences in geoid models, there was a discrepancy between the orthometric elevations provided by *NHL* and the elevations along the access road collected by *Excel*. In order to integrate the gravity data collected along the access road with the seismic line gravity data, *Excel* shifted the elevations along the access road up by 0.836 m.

# GPS PROCESSING

The Leica 500 series GPS technology was chosen for this gravity application because of its reliability, fast satellite acquisition, ease of operation, and small size. GPS data was processed each evening using Leica Skipro post-processing software. All field bases were used to calculate solutions for the GPS rover units. Factors such as satellite position, signal strength and topography affect the results; only the highest quality solutions were selected for each station.

# GRAVITY DATA REDUCTION

The Lacoste and Romberg land gravity meter (G-series) is operated manually and is capable of reliable and repeatable gravity readings to an accuracy of 0.02 mGal by experienced operators. The operator must ensure that the meter is level and operated at the recommended regulated temperature during the reading.

The date, time, dial reading, inner terrain corrections, instrument height, and snow depth are recorded in a field notebook at each land gravity station. A gravity base is measured at the beginning and end of each day to correctly account for meter drift. Each evening the field data are entered into a portable notebook computer and corrected for sun/moon tidal effects instrument height, and instrument drift to obtain the observed gravity. Refer to *Observed Land Gravity Data Listing* (under separate cover) for the raw data, the observed gravity, and intermediate reduction values for each day.

GPS coordinates and elevation data for the survey were merged with the observed gravity for each station. See Table 5 for the formulae used to determine the intermediate corrections and Bouguer gravity values. The Bouguer gravity was calculated using variable density Bouguer and terrain corrections. The average elevation of the surveyed stations was 144 m above sea level. Based on this value, an elevation datum of 145 m was chosen to minimize the effects of the Variable Density Bouguer Correction. Refer to the *Bouguer Gravity Data Listing* (under separate cover) for the Bouguer values and all intermediate corrections.

**Table 5. Gravity Correction Formulae**

| Gravity Corrections | Description |
|---|---|
| **Latitude Correction** | Standard latitude correction adopted by the International Association of Geodesy, 1967. G=978031.85 * (1+0.005278895 $\sin^2$(latitude) + 0.000023462 $\sin^4$(latitude)) |
| **Free Air Correction** | (elevation (m) – datum (m)) * 0.3068 mGal/m [datum = 250m] |
| **Bouguer Correction** | (elevation (m) – datum (m))* density (g/$cm^3$) * (2.0 * pi * 0.006672) (note: density values vary depending on surface geology) |
| **Terrain Corrections** | Inner terrain corrections (2m to 175m) determined from field observations. |
| | Outer terrain corrections (175m to 40km) with variable densities computed with proprietary software. |
| **Final Bouguer Values** | Bouguer anomaly (mGal) = observed gravity – latitude correction + free air correction + Bouguer correction + terrain corrections |

## DATA QUALITY

*Excel* collected a total of 374 gravity stations on seismic lines and 31 gravity stations along the access route to the seismic lines. We found no reason to edit any of these stations from gridding. Overall, we have found the Observed Gravity values to be better than 0.02 mGal and the Bouguer Gravity values to be better than 0.05 mGal. 11 repeat data points were collected during this survey, and the data from these repeats falls well within the accuracy of the gravity meters.

## REFERENCES

Wheeler, J.O. and McFeely, P. (comp), 1991. Tectonic Assemblage Map of the Canadian Cordillera and adjacent parts of the United States of America. Geological Survey of Canada Map 1712A

# APPENDIX A - UTM Zone 9 Coordinate System Parameters

The coordinate system used for mapping purposes is UTM Zone 9 (NAD83). Parameters for this coordinate system are shown in Table 6.

**Table 6. UTM Zone 9 Mapping Parameters**

| Project Mapping System | |
|---|---|
| **Datum** | NAD 83 |
| **Ellipsoid** | WGS 84 |
| **Latitude of Origin** | Equator, $0^o$ |
| **Central Meridian** | $129^o$ W |
| **Grid Projection** | UTM Zone 9 |
| **Scale Factor** | 0.9996 |
| **False Easting** | 500,000.0 m |
| **False Northing** | 0.0 m |

| Ellipsoids: | WGS 84 |
|---|---|
| **Semi-major axis** | 6378137.0 m |
| **Semi-minor axis** | 6356752.3 m |

# APPENDIX B - Data Listing

## Observed Land Gravity Data

The *Observed Land Gravity Data Listing* (under separate cover) contains a listing of all land gravity data collected by the crew during the survey period. The data is presented in chronological order.

The LaCoste and Romberg G-series land gravity meter uses a zero length spring supporting a mass on a beam as is standard in all modern gravity meters. While the meter is level, a counter dial is turned to adjust the position of the beam until the force of gravity is balanced by the mechanical force of the zero length spring. A calibration table is used to convert the counter reading value to a value in mGal. While the zero length spring system is prone to drift during a day, this drift can be accurately identified and corrected by reoccupying a known gravity station one or more times during the day.

Each land gravity loop is separated by a blank row. For gravity stations collected along seismic lines, the line and shot point number is used for line and station values. Along the winter road and access roads, the date was used for the line value, and the gravity stations were numbered sequentially for the day. The date, time, Greenwich Mean offset, and project location (latitude and longitude) are used to compute the sun/moon gravity tide correction.

The relative gravity is computed by summing all of the terms:

Relgrav = calibrated counter reading + Instrument Height (HI) correction
+ tide correction - drift

Gravity base values can be seen in Table 3.

## Bouguer Gravity Data

The *Variable Density Bouguer Gravity Data Listing* (under separate cover) displays the observed gravity and coordinate data with intermediate corrections and variable density Bouguer gravity values. The table summarizes all of the collected data including the survey coordinates, elevation, and observed gravity at each station. Latitude and longitude values are given as well as UTM zone 9 coordinates in NAD 83. The elevations shown are orthometric height above mean sea level, as provided by *NHL*. The intermediate corrections include the latitude, free air, variable density Bouguer and variable density terrain corrections. The variable density Bouguer gravity values were computed using density values determined from surface geology which range from 2.40 $g/cm^3$ to 2.77 $g/cm^3$. Terrain corrections were calculated for all stations using the most accurate digital elevation data available in the area. For this gravity survey, the digital elevation grid was created by integrating Canadian Digital Elevation Data, Level 1 (CDED1) and National Topographic Data Base (NTDB) data from the Centre for Topographic Information (CTI) at Natural Resources Canada.

# APPENDIX C – GPS Control Base Information Sheet

**Nehpets Holdings Ltd.** *Seismic & G.P.S. Surveyors*

#128 - 5700 1 St. SW, Calgary, Alberta, Canada T2H-3A9 (403) 252-4860, Fax 253-3229

# GPS STATION INFORMATION SHEET

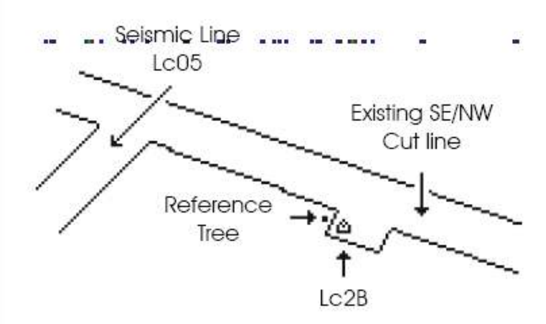
| Station | LC2B | Coordinate Values |
|---|---|---|
| Method : | Static GPS | W.G.S. 84 Geographic Values |
| Date : | Mar. 2007 | ϕ : 67° 06' 14.2759" N |
| Agency : | Nehpets Holdings Ltd | λ : 130° 21' 36.9653" W |
| Surveyor : | Rick Scopick | Height: 85.98 m |
| NTS Map Sheet: | 106 - 0 - 01 | W.G.S. 84 U.T.M. Values |
| Location : | Little Chicago Area | X : 7443615.78 |
| Province : | Northwest Territories | Y : 440946.25 |
| Country : | Canada | Elevation: 90.08 M |
| | | Geoid Separation: -4.10m (HTv2.0) |

**Legal Description:** Unit 37, Block B, 106 - 0 - 01.

**Monument**

| | | Condition | Monument Height |
|---|---|---|---|
| [x] Set | [ ] Recovered | | |
| Mon. type | 36" Steel Pin | [x] Good | Above Surf.: 15 cm |
| | | [ ] Disturbed | Below Surf: |
| | | [ ] Not Found | [ ] Flush |
| Mounted on | | | |

**General Area Diagram**




**Location Detail**

Located within a Burn area, in a clearing just off a SE/NW Cutline near 'Little Chicago', NWT. Marked with a 6 foot Tripod.

**References**

1.) 11m SW from Centerline of SE/NW Cutline.
2.) 7m SE of 23 ft. Dead Spruce Ref. Tree.
3.) 3.86km West of Wilfred Jackson's Cabin.
4.) 3.94km West of Mackenzie River.
5.) 3606m @ 272.56° fm 'LC01'. See Report.
6.) 10119m @ 122.74° fm 'LC03'. See Report.
7.) 9022m @ 64.95° fm 'LC04'. See Report.
8.) 3818m at 273.20° from Legal Lot pin 01060/1 – L1005. (near #3 cabin)

**Monument Detail**

N/A