# URANIUM EXPLORATION PLAN 2014

**Nunavut Water Board Licence No. 2BE-ANG1318**

**Submitted to: NWB**
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**Kivalliq Energy Corporation**
**August 19, 2014**

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## PROPERTY DESCRIPTION AND LOCATION

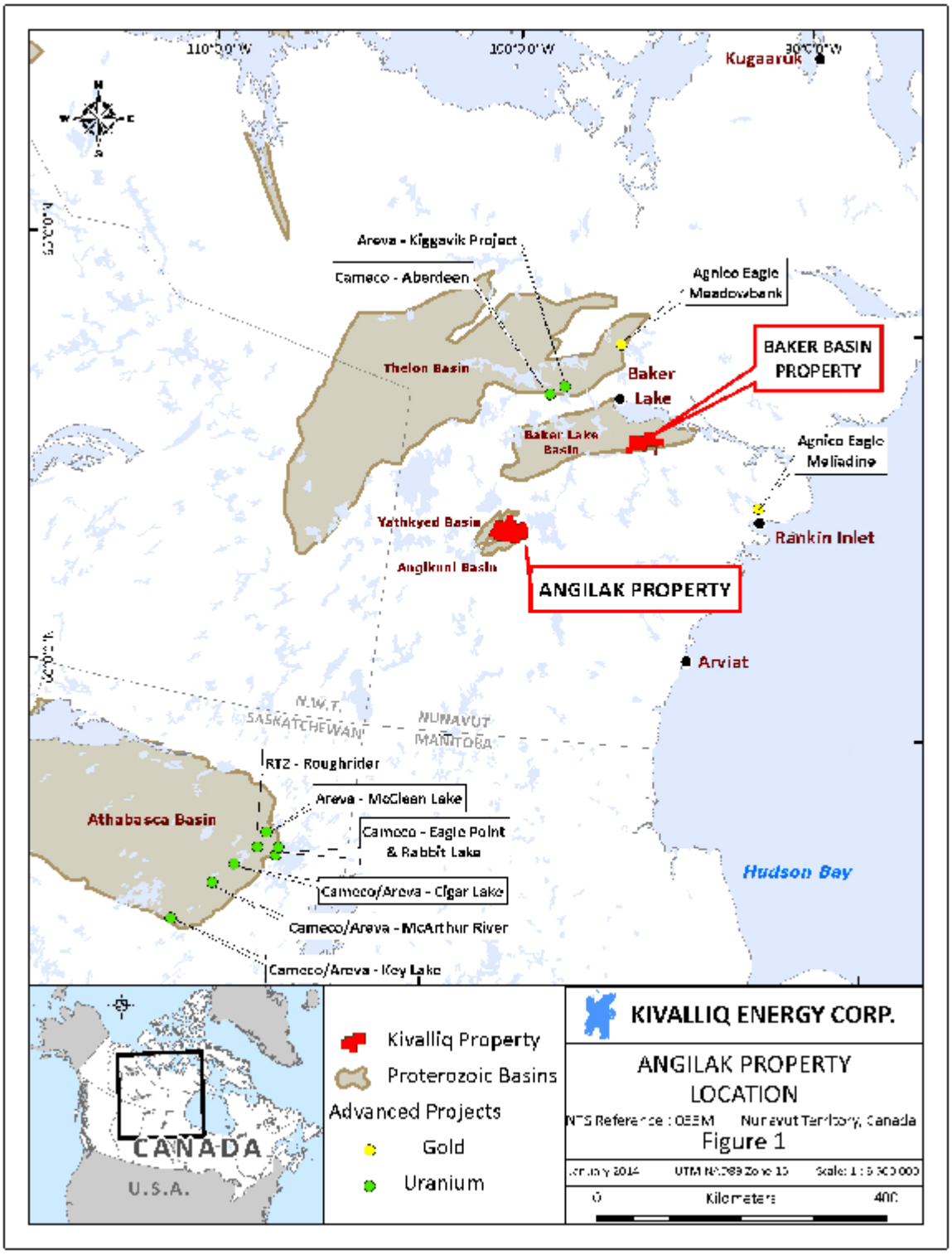
The Angilak Project property consists of 139 mineral claims and Inuit Owned Land Parcel RI-30 (IOL), comprising a total area of 340,268.3 acres (137,701.7 hectares) in the Kivalliq Region of southern Nunavut Territory. The property is located 350 kilometres west of Rankin Inlet and 225 kilometres southwest of Baker Lake (Figure 1). The property dimensions measure 55 kilometres in an east-west direction and approximately 35 kilometres north-south.

As indicated on Figure 2, all mineral claims and the IOL are contiguous and extend north, south, east and west between latitudes 62° 27' and 62°48' North and longitudes 98° 21' and 99°24' West in NTS map areas 65 J/06, 65 J/07, 65 J/09, 65 J/10, 65 J/11 and 65 J/15 (UTM coordinates: 6925500N to 6962000N and 479300E to 533000E, NAD83, Zone 14).

Land use permits, authorizing exploration work over the entire property area have been issued, renewed and amended by the Kivalliq Inuit Association (KIA) for parts of the property covering Inuit Owned Lands (IOL) and Aboriginal Affairs and Northern Development Canada (AANDC) for mineral claims on crown lands. Kivalliq Energy Corporation (Kivalliq Energy) also operates under the terms and conditions of a Nunavut Water Board (NWB) licence, covering activities on both the IOL and mineral claims. See Table 1 below for active permits and licences issued for lands that comprise the Angilak Property. Refer to **Appendix A** for the Angilak Project Uranium Exploration Nutaaq Camp Radiation Hazard Control Guidelines.

**Table 1: 2014 Land Use Permits and Licences**

| Issuing/Screening Agency | Date Issued | File Number |
|---|---|---|
| KIA | August 1, 2008 | KVL308C09 |
| NIRB | July 31, 2008 | 08EN052 |
| AANDC | August 7, 2013 | N2012C0030 |
| NWB | March 4, 2013 | 2BE-ANG1318 |


110°0'0"W
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Kugaaruk
Areva - Kiggavik Project
Cameco - Aberdeen
Agnico Eagle Meadowbank
BAKER BASIN PROPERTY
Thelon Basin
Baker Lake
Baker Lake Basin
Agnico Eagle Meliadine
Yathkyed Basin
Angikuni Basin
Rankin Inlet
ANGILAK PROPERTY
Arviat
N.W.T.
SASKATCHEWAN
NUNAVUT
MANITOBA
RTZ - Roughrider
Areva - McClean Lake
Athabasca Basin
Cameco - Eagle Point & Rabbit Lake
Cameco/Areva - Cigar Lake
Cameco/Areva - McArthur River
Cameco/Areva - Key Lake
Hudson Bay
CANADA
U.S.A.
Kivalliq Property
Proterozoic Basins
Advanced Projects
Gold
Uranium
KIVALLIQ ENERGY CORP.
ANGILAK PROPERTY
LOCATION
NTS Reference : 055M Nunavut Territory, Canada
Figure 1
January 2014 UTM NAD83 Zone 15 Scale: 1 : 5 000 000
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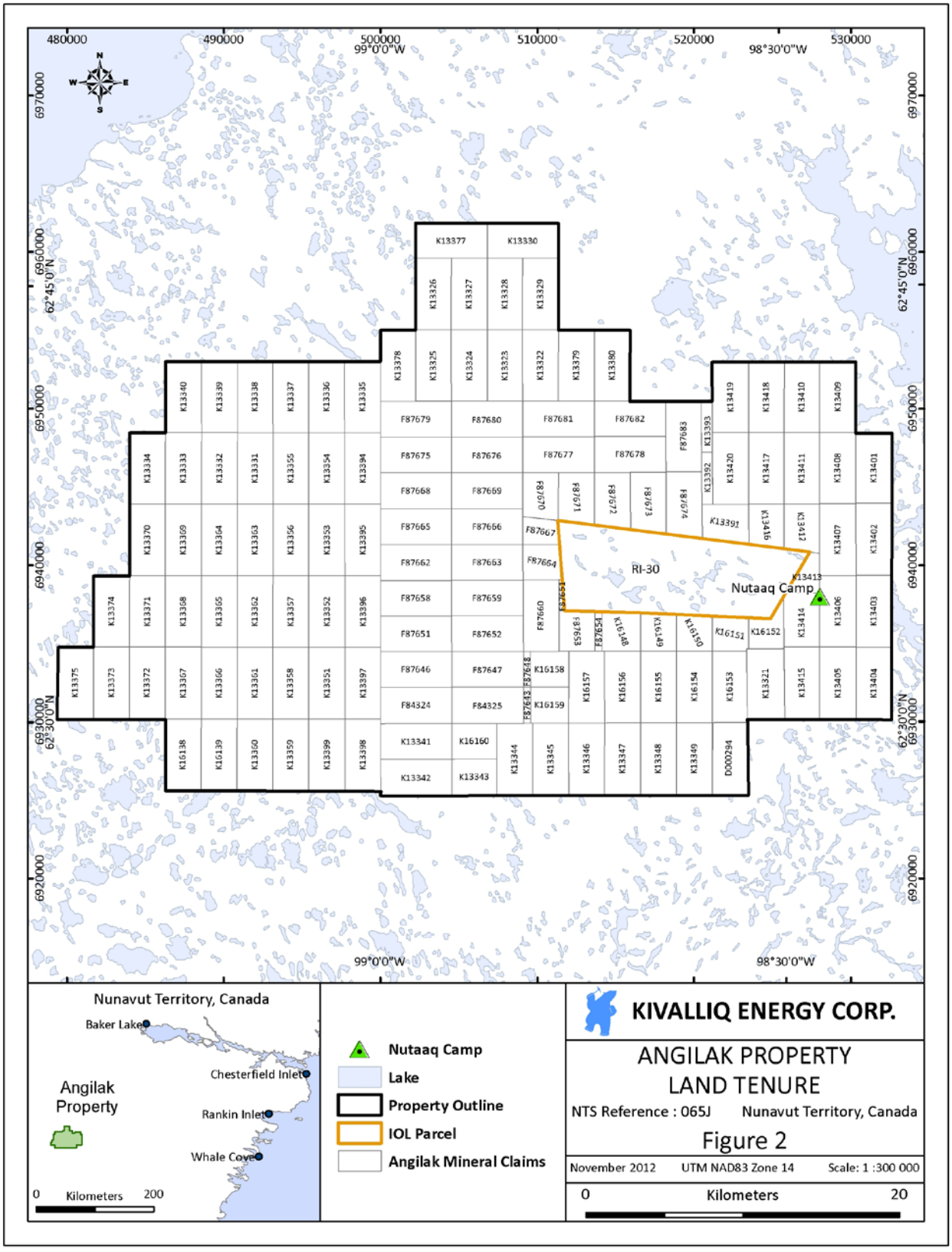
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RI-30
Nutaaq Camp
Nunavut Territory, Canada
Baker Lake
Chesterfield Inlet
Rankin Inlet
Whale Cove
Angilak Property
0 Kilometers 200
Nutaaq Camp
Lake
Property Outline
IOL Parcel
Angilak Mineral Claims
KIVALLIQ ENERGY CORP.
ANGILAK PROPERTY
LAND TENURE
NTS Reference : 065J Nunavut Territory, Canada
Figure 2
November 2012 UTM NAD83 Zone 14 Scale: 1 :300 000
0 Kilometers 20

## CORPORATE BACKGROUND AND PROJECT INFORMATION

Kivalliq Energy is a Vancouver-based uranium exploration company holding Canada's highest-grade uranium resource outside of Saskatchewan's Athabasca Basin. The company has been operating in Nunavut since 2008. Its flagship project is the Angilak Property.

Kivalliq Energy was the first company in Canada to have a comprehensive agreement to explore on Inuit Owned Land for uranium. As part of this landmark partnership, Kivalliq Energy must meet certain commitments and Nunavut Tunngavik Inc. (NTI) received shares in Kivalliq and upon a production decision NTI can elect to have a participating interest in the project, or collect royalties. Kivalliq Energy also makes advance royalty payments to NTI annually. The agreement not only applies to IOL RI-30, but also extends to 139 Crown issued mineral claims. The Angilak property totals 340,268.3 acres in all.

Kivalliq Energy was formed to focus on projects in Nunavut. Management has extensive background working in Canada's north. John Robins is Chairman of the Company's board of directors, Jim Paterson is the Chief Executive Officer and Jeff Ward serves as President. Mr. Jonathan Singh is the Chief Financial Officer and Mr. Andrew Berry is Chief Operating Officer. Bill Cronk is Exploration Manager, Jim Dawson, Garth Kirkham, Dale Wallster and Jim Malone serve as directors. The group is committed to the social and economic development of the north while maintaining a level of excellence in minimizing environmental impacts. Kivalliq Energy looks forward to conducting a fourth community tour this year to meet with community members and increase awareness about the company and its projects.

Since 1979, the property and surrounding area has been called various names (i.e. LGT, Yathkyed, and Lac Cinquante); however going forward, Kivalliq Energy collectively refers to all land holdings as the "Angilak Property". The Angilak Property hosts the high-grade Lac 50 uranium deposit and more than 150 mineral showings.

On January 15, 2013 the Company announced a revised NI 43-101 compliant Mineral Resource estimate for the Lac 50 Trend uranium deposits (Lac Cinquante Eastern Extension, Western Extension, Ray and J4) that describes an Inferred Mineral Resource Estimate of 2,831,000 tonnes grading 0.69% $U_3O_8$ (15.2 lbs $U_3O_8$/tonne), totalling 43.3 million lbs $U_3O_8$ at a 0.2% $U_3O_8$ cut-off grade.

## WORK COMPLETED TO DATE

### 2013 Program

Exploration work in 2013 included diamond drilling, prospecting, soil sampling, ground geophysical surveying and environmental baseline monitoring.

A total of 2,101 metres of diamond drilling in fourteen holes was completed from April 3 to May 17, 2013. Of the thirteen holes completed, six were on the newly discovered J1 Zone, one was a lake based target northwest of the J1 Zone, four tested the ML Conductor, two were drilled on the VGR Zone and one tested the J4W Zone conductor (Figure 3).

The 2013 soil sampling program collected 1647 samples over two weeks in July. Soil sample locations and prospecting traverses are shown on Figure 4. The goal of the geochemical survey was to classify and prioritize bedrock conductors for drilling by identifying those conductors which have associated surface geochemical anomalies.

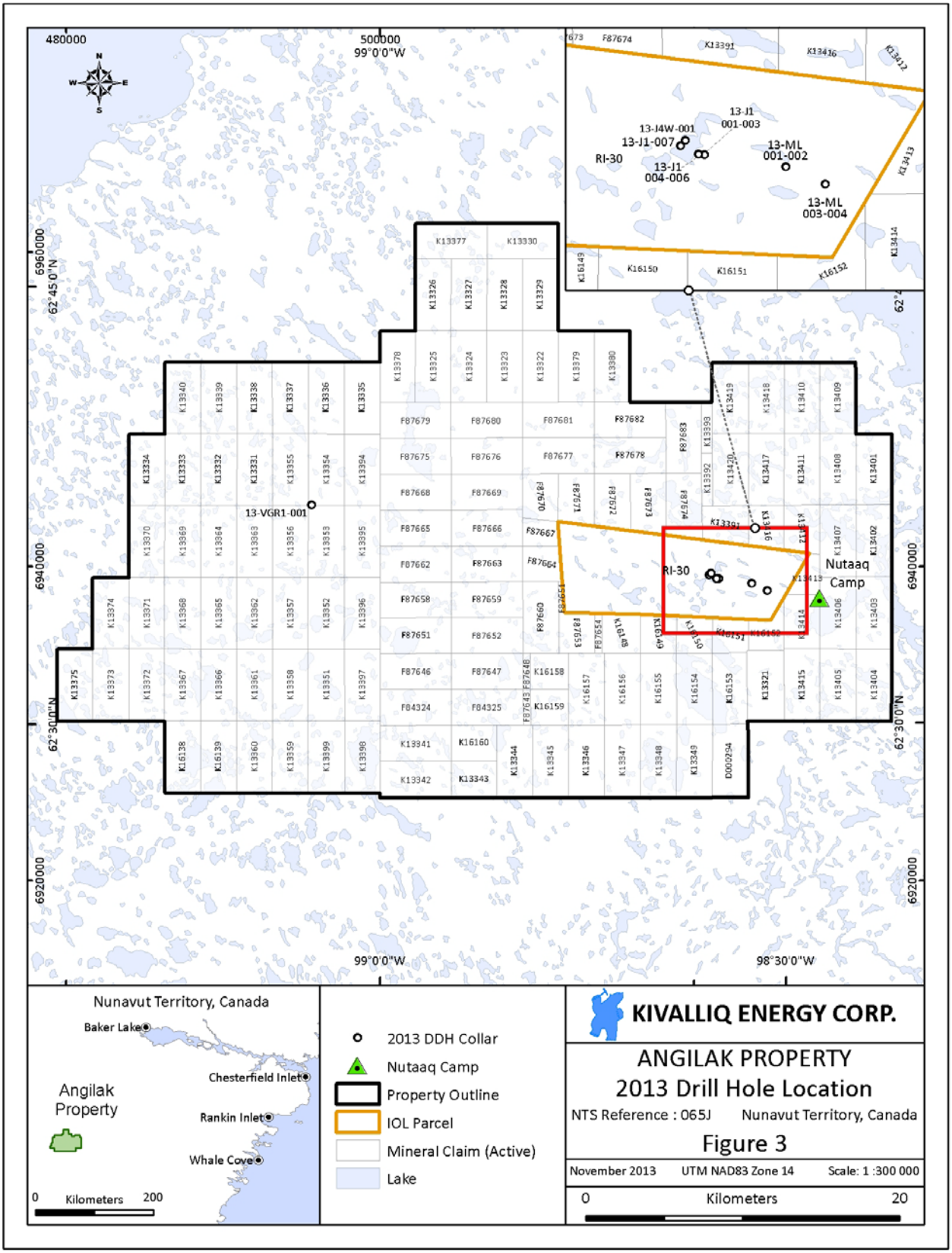
In 2013 Aurora Geosciences was contracted by Kivalliq Energy to conduct a variety of ground geophysical surveys. During the period March 18 to May 19, 2013, 591.6 line kilometres of OhmMapper survey, 300.9 line kilometres of combined Mag and VLF survey and 9.5 line kilometres of ELF survey were completed. The objective of these surveys was to overlap and extend previous ground geophysical data in order to explore potential conductive trends and to extend zones of interest.

### 2007- 2012 Program

Exploration work between 2007 to 2012 included constructing a new camp, infrastructure upgrades, diamond drilling, reverse circulation (RC) drilling, prospecting, airborne geophysical surveys, ground geophysical surveys and environmental baseline monitoring.

A total of 33,583 metres of diamond drilling in 173 holes was completed from March 18 to September 15, 2012. The RC drilling program completed 5,273 metres in 38 holes between May 1 and September 4. MEG Systems Ltd. conducted a two phase gravity surveying program which covered a total of 2,556 stations on the VGR and YAT Zones. Aurora Geosciences conducted Total Field magnetics, Very Low Frequency EM (VLF) and Capacitively Coupled Resistivity (OhmMapper) surveys over a number of target areas. A total of 309 line kilometres of data was collected on four separate areas between April and May, 2012.

Frontier Geosciences Inc. conducted a seismic survey over a two kilometre line on the VGR Zone between August and September, 2012. A radiometric survey was conducted by Kivalliq Energy covering eight grids on the Angilak Property and a total of 95 rock grab samples were collected during the 2012 prospecting program.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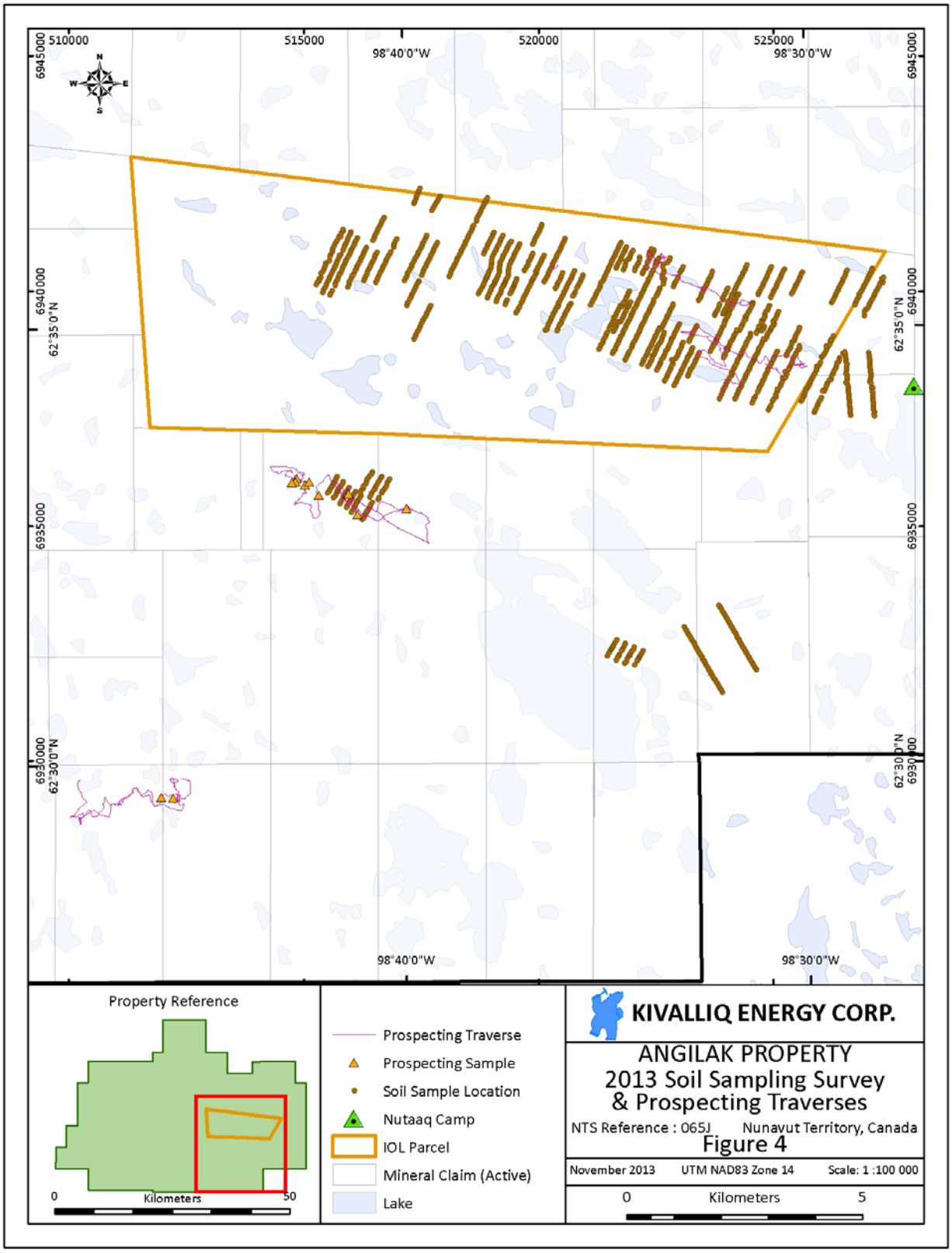
13-J1-007
RI-30
13-J1-004-006
13-J1-001-003
13-ML-001-002
13-ML-003-004
Nutaaq Camp
Nunavut Territory, Canada
Baker Lake
Chesterfield Inlet
Rankin Inlet
Whale Cove
Angilak Property
0 Kilometers 200
2013 DDH Collar
Nutaaq Camp
Property Outline
IOL Parcel
Mineral Claim (Active)
Lake
KIVALLIQ ENERGY CORP.
ANGILAK PROPERTY
2013 Drill Hole Location
NTS Reference : 065J
Nunavut Territory, Canada
Figure 3
November 2013
UTM NAD83 Zone 14
Scale: 1 :300 000
0 Kilometers 20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Property Reference
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Prospecting Traverse
Prospecting Sample
Soil Sample Location
Nutaaq Camp
IOL Parcel
Mineral Claim (Active)
Lake
KIVALLIQ ENERGY CORP.
ANGILAK PROPERTY
2013 Soil Sampling Survey
& Prospecting Traverses
NTS Reference : 065J
Nunavut Territory, Canada
Figure 4
November 2013
UTM NAD83 Zone 14
Scale: 1 :100 000
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Kilometers
5

The 2011 drill program totaled 23,849 metres in 153 holes of diamond drilling and 6,411 metres in 88 holes of RC drilling. The airborne geophysical survey flew a total of 5,470 line kilometres and ground geophysical surveys included 1,605 gravity stations and 1,597.47 kilometres of VLF/Mag surveys. The 2011 prospecting program collected 273 rock grab samples and 348 soil geochemical samples.

The 2010 drill program totaled 16,606 metres in 107 holes drilled. Under the 2010 prospecting program a total of 291 samples were collected for geochemical analysis. A new camp named Nutaaq, comprised of 15 structures, was constructed to accommodate exploration activities. Baseline environmental work was initiated in 2010 and the first year of studies was successfully completed.

In total, 600 line kilometers of ground geophysical surveying was completed in 2009. The drill program comprised 1,745 metres of NQ core drilled in 16 holes targeting the Lac 50 uranium deposit.

Exploration in 2008 included 5,753 line kilometres of airborne geophysical surveying, 140 line kilometres of ground geophysics, prospecting, sampling and re-logging / re-sampling of select core and showings. Work was undertaken by GeoVector Management Inc. based out of Ottawa Ontario. Work in 2008 was conducted from the former YAT Camp on the western side of the Angilak Property and from the Ferguson Lake Camp located 80 kilometres east-northeast of the project area.

## ACTIVITIES FOR 2014

### A) EXPLORATION

The 2014 exploration program will include diamond drilling, ground geophysical surveys, soil sampling, prospecting and continued environmental baseline monitoring.

### Sampling and Prospecting

The 2014 soil sampling program will be undertaken during the summer months and include the collection of up to 2,500 samples similar to the 2013 program. Soil sample grids will be placed over known geophysical trends and analyzed for the geochemical signatures characteristic of the anomalous mineralization. The geochemical surveys will be used to classify and prioritize bedrock conductors for drilling by identifying those conductors which have associated surface geochemical anomalies. Concurrently, soil sampling crews will map bedrock geology and collect prospecting samples where required.

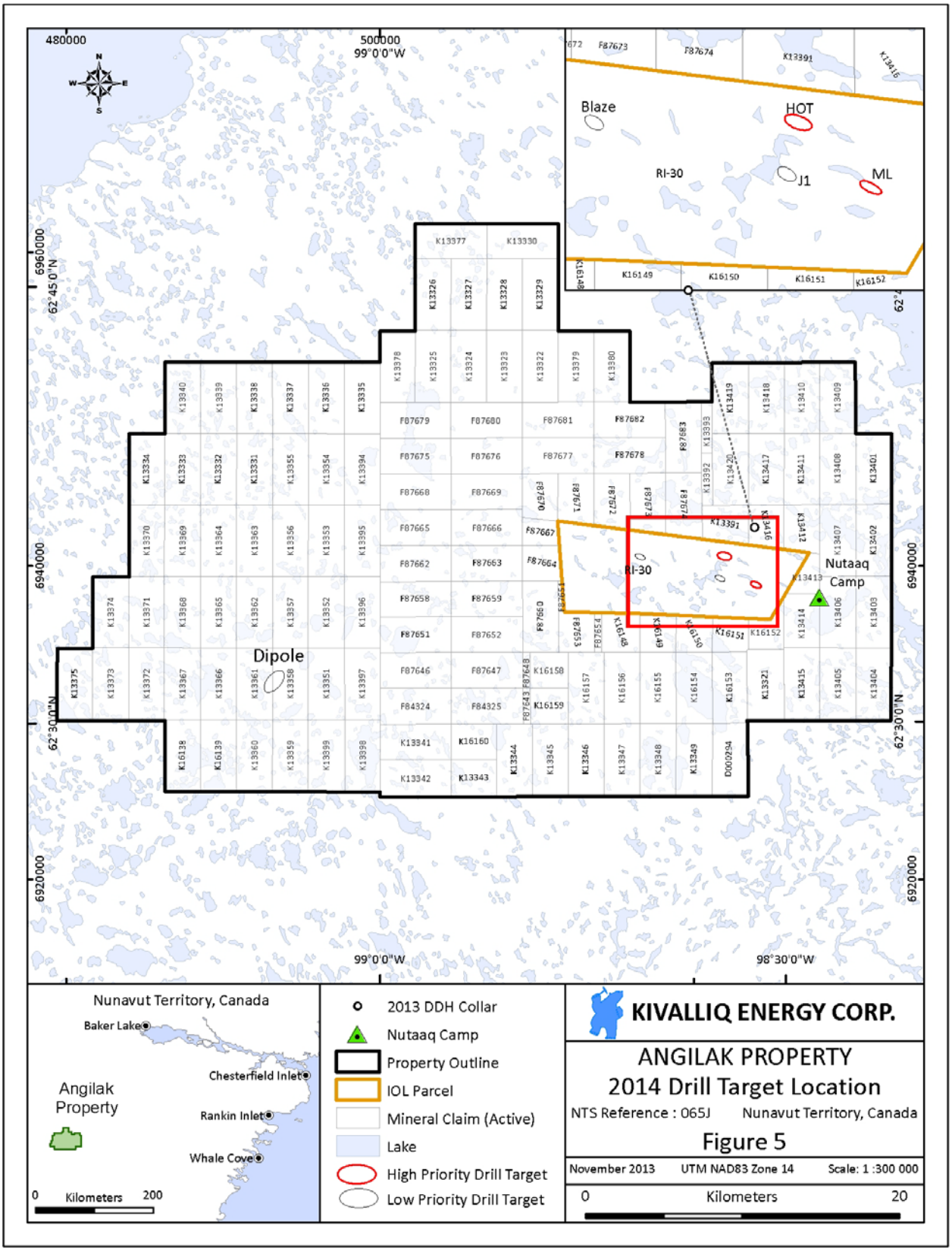
### Drilling

Pending market conditions, Kivalliq Energy may drill up to 10,000 metres in 2014 using two drill rigs contracted from Major Drilling International Inc. Three of these heli-portable Boyles 17 drill rigs are currently stored on the Angilak Property and were used on previous programs. Drill crews will mobilize to camp in the summer months and should finish drilling by September 1, 2014.

Drill operations will be supported from the camp via helicopter. Detail drilling would be conducted over the ML Zone and Hot Zone with early stage exploration drilling contemplated at the J1 Zone, Blaze Zone and potentially Dipole Target 27 kilometres southwest of Lac 50. Potential drill target areas for 2014 are shown on Figure 5.

#### Geophysics

Kivalliq Energy may continue with ground and/or air geophysical surveying in 2014. These surveys are done on foot or by air and may be conducted during the spring and summer months as directed by ongoing exploration and results. As on previous programs, this may comprise of several weeks of OhmMapper and MAG/VLF surveys. The ground geophysical surveys will investigate potential targets identified by the earlier airborne/ground geophysical surveys and the 2013/2014 sampling and prospecting programs.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Nutaaq Camp
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Baker Lake
Chesterfield Inlet
Rankin Inlet
Whale Cove
Angilak Property
0 Kilometers 200
2013 DDH Collar
Nutaaq Camp
Property Outline
IOL Parcel
Mineral Claim (Active)
Lake
High Priority Drill Target
Low Priority Drill Target
KIVALLIQ ENERGY CORP.
ANGILAK PROPERTY
2014 Drill Target Location
NTS Reference : 065J
Nunavut Territory, Canada
Figure 5
November 2013
UTM NAD83 Zone 14
Scale: 1 :300 000
0 Kilometers 20

## B) FUEL CACHES

Kivalliq Energy is permitted to store up to 3000 drums of fuel at the Nutaaq Camp fuel cache The main cache site is located approximately 200 metres northwest of the Nutaaq Camp at 527800mE 6938100mN NAD 83 Z14. All fuel is stored in secondary containment berms equipped with RainDrains and located a minimum of 31 metres from any water body. Fuel drums will be transported to camp via Ookpik Turbo Otter. All drums, secondary containment berms and fuel caches will be inspected daily. A record of these inspections will be kept on site and will be available for review by Inspectors upon request. Spill kits are flagged and located at each fuel cache and within the re-fueling wagon used to fill heating fuel drums located behind each tent.

At the end of the 2013 program the Nutaaq Camp fuel cache contained 354 drums of diesel, 402 drums of jet fuel, three drums of gasoline and nine propane cylinders. The majority of empty drums from the 2013 season were removed, however; approximately 100 drums were left on site to be removed by the Turbo Otter flights early in the 2014 season.

*2013 Fuel Berms*

## C) CAMP AND INFRASTRUCTURE UPGRADES

Kivalliq Energy established the Nutaaq Camp at its present location in March 2010. Infrastructure changes in 2013 included the removal of five sleeper tents and the installation of a solar-operated Bearwise electric bear fence around the Nutaaq Camp and the Sprung Tent. There are no significant camp infrastructure upgrades planned for 2014. See Figure 6.

### Airstrip

During the summer months a 350 metre long flat topped, gravel tundra strip located 1.5 kilometres west of the Nutaaq Camp, the Nutaaq Airstrip (526380mE 6938130mN NAD 83 Z14), will be used to support exploration on the Angilak property.

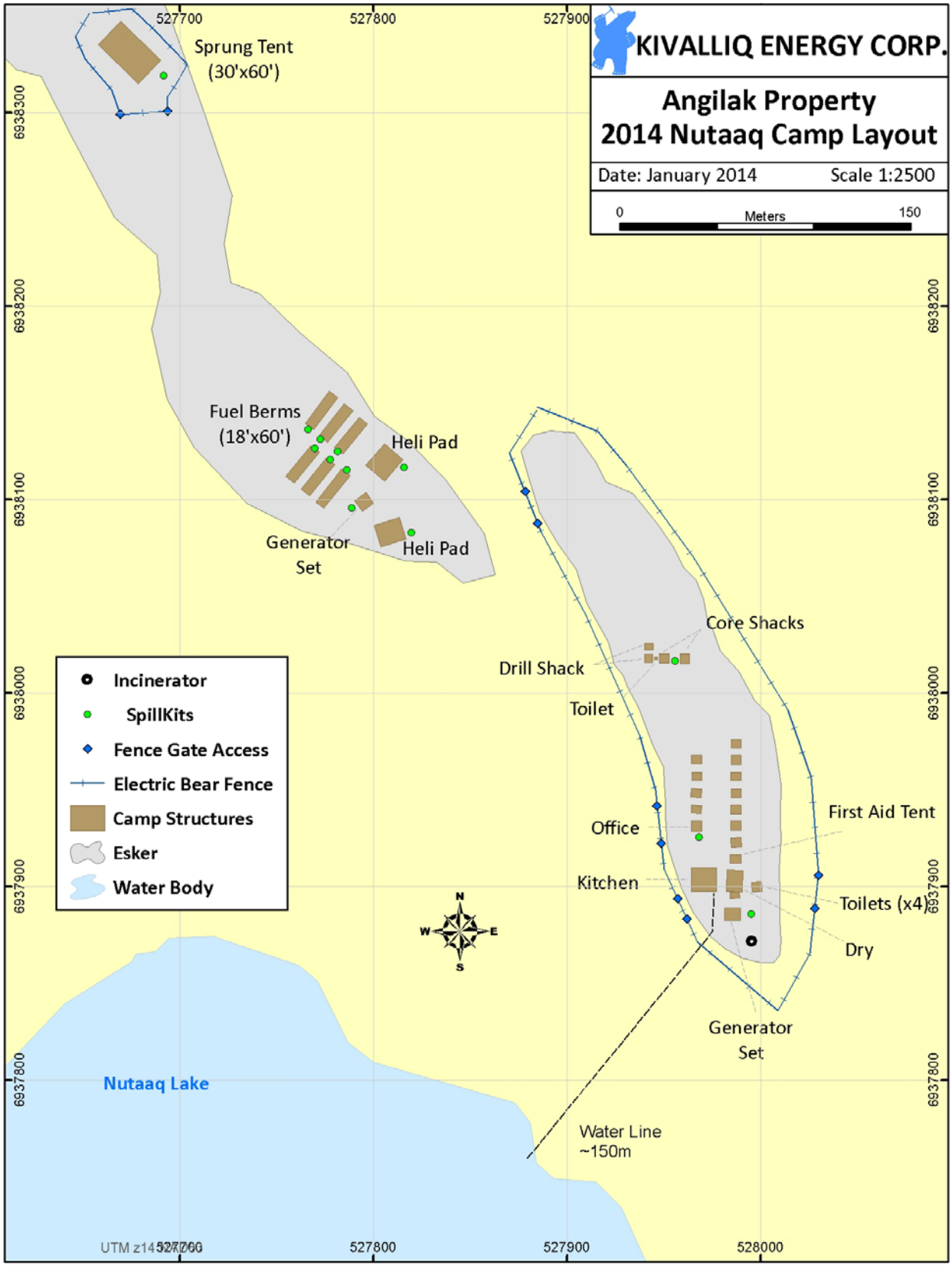

Figure 6: 2014 Nutaaq Camp Layout

## D) BASELINE MONITORING PROGRAM

The ongoing environmental baseline program is designed to build an understanding of local and regional environmental attributes, and increase in scope as work advances. The program was initiated in 2010 and has been conducted on an annual basis since that time. The environmental monitoring program results are compiled into a report and appended to the annual report sent to the KIA and other regulatory agencies. The following environmental baseline monitoring will be conducted in 2014:

### *Meteorology*

A fully automated climate station was installed near the camp in 2010. The parameters being recorded are: temperature, relative humidity, total precipitation, barometric pressure, wind speed and direction. The data is transmitted via satellite to a secure database every three hours. While camp was operational, manual weather information was also collected by trained Kivalliq Energy staff to corroborate the weather station data.

### *Water Quality*

In 2010, twenty water quality sites were established and five more were added in 2012. In 2013, two additional water quality sample sites were sampled in relation to drilling. In 2014, as Kivalliq's ongoing exploration program advances targets elsewhere on the property, additional water quality sites may be added to the existing program to monitor the influence Kivalliq's expanded work areas.

### *Wildlife Monitoring*

The overall objective of the wildlife program is to describe wildlife use of the study area, and produce coarse-scale population estimates for Project valued ecosystem components (VECs) occurring in the study area. As in the previous four years, the 2014 program will consist of logging incidental observations of all wildlife encountered and providing information to field staff to help them recognize high profile VECs and Species at Risk that could potentially occur within the project area.

## E) Environmental Considerations

All employees and contractors working for Kivalliq Energy are required to sign off on the company's internal environmental and wildlife policies and procedures (attached) which include the AANDC Caribou Protection Measures. All employees will be made familiar with the Terms and Conditions of the project's licences and permits. Every person arriving at the Angilak Project will undergo an orientation which will include information on health, safety and environmental responsibilities and stewardship.

The orientation and training will include, but not be limited to: spill response, bear safety, environmental policies (including waste management), wildlife mitigation measures and the caribou protection measures.

All wildlife sightings, whether occurring in the field or in camp, will be reported to a designated staff member for daily entry into a database. All employees and contractors will be required to report sightings.

Wildlife incidents will be reported immediately to the KIA and to the GN Wildlife Biologists. Contact information for emergency situations will be hung on the wall of the office.

Water and aquatic life will be protected. Waterlines for drilling and domestic use will be properly placed to minimize disturbance to the shoreline and substrate and will be screened in accordance with the “Freshwater Intake End-of-Pipe Screen Guideline” prepared by the Department of Fisheries and Oceans. A copy of these guidelines will also be kept in the office tent.

No wastes will enter any water bodies. This includes discharge from the camp and return effluents from diamond drilling. The Nutaaq camp grey water is filtered through a grease trap then drained through a weeping tile bed installed behind the dry. The area of the weeping bed is inspected daily for grey water release on surface. Return effluents from diamond drilling are captured at the casing and run through Kivalliq's drill cuttings settling circuit. The circuit is continuously monitored to separate drilling cuttings from effluent flows. Only cleared water with suspended solids removed is released to the ground. Drill sites are inspected prior to the drill being moved. Sites are remediated and reclaimed on an ongoing basis as drilling proceeds.

Daily inspections will be conducted around the camp and a record of these inspections will be kept in the office for review by the Inspector upon request while at the camp.

## F) Reclamation

Kivalliq Energy has a policy of progressive reclamation. Drill sites are reclaimed at the completion of each hole. When immediate or complete reclamation is not possible, these sites are recorded and re-visited at the earliest possible opportunity. Photos will be taken of all drill sites and will be submitted to the KIA, NWB and AANDC in the company’s annual report.

A cutting retrieval system is used during drill operations. Benign cuttings will be captured and stored in a natural depression as per land use permits. If uranium concentrations are greater than 0.05% (or eU equivalent), drill cuttings will be contained in sealed steel 205 liter drums and cached as short term storage on an elevated outcrop on the east side of the Lac 50 Main Zone drill area.

## G) Socio-Economic Impacts and Benefits

Kivalliq Energy is in the early stages of exploration and evaluation. The company and its management have demonstrated a strong commitment to Nunavut with the creation of Kivalliq Energy and its mandate to explore the Angilak Project in partnership with the Inuit. By entering into a uranium exploration agreement with NTI, Kivalliq Energy provides benefits to the Inuit as shareholders in the company, as well as to NTI having the option to participate directly in the project at a later date. Kivalliq Energy's agreement with NTI not only covers Inuit Owned Land, but extends the same benefits to a total 340,268.26 acres that includes Crown claims held by Kivalliq Energy.

Kivalliq Energy hires locally whenever possible and will utilize northern businesses and services wherever available. In 2013 Kivalliq had seven staff members sourced from local communities. Kivalliq representatives plan to visit Rankin Inlet, Arviat and Baker Lake in April 2014 to discuss results from the 2013 program and present the work program proposed for 2014. These visits represent an excellent opportunity to meet with community individuals and discuss future opportunities with interested individuals. Kivalliq Energy will be attending the Nunavut Mining Symposium in Iqaluit this year. As in previous years, Kivalliq Energy will present an update on the progress of work at Angilak.

## H) Archaeological, Traditional Knowledge

Any archaeological sites discovered during the course of exploration activities are handled with the utmost care. The location is recorded using a GPS and designated off limits to all workers. Disturbance is prohibited. Kivalliq Energy contracts Points West Heritage Consultants to document, survey and record, archaeological sites on the Angilak Property. As part of the Nunavut Archaeologist Permit, the final reports are submitted to the KIA and chief archaeologist at the Department of Culture, Language, Elders and Youth.

During community visits, Kivalliq Energy meets with elders to discuss work plans and proposed areas of interest. Any information that is shared regarding sites of historical significance, etc., will be incorporated in to the design of the program to ensure that these sites are protected for future generations.

# Appendix A

Angilak Project Uranium Exploration Nutaaq Camp
Radiation Hazard Control Guidelines


# ANGILAK PROJECT
# URANIUM EXPLORATION
# NUTAAQ CAMP
# RADIATION HAZARD
# CONTROL GUIDELINES

**MAY 2014**

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## 2014 PROJECT SUMMARY

The Angilak Project is a mid-stage exploration program with an inferred resource of 43.3 million pounds Uranium at a grade of 0.69% U3O8 per tonne (announced January 15, 2013). The primary objective of the 2014 Angilak Project Program is drilling focused on continued development of the Lac 50 Uranium Deposit (initially discovered in the late 1970's). In addition to the development of this historical deposit, work will also be completed on the commensurate Angilak Project land package to define and identify additional areas for potential economic resource development.

Procedures have been established to provide a safe workplace for employees while using best practices to minimize disturbance to the environment. These procedures are contained herein and will be reviewed and amended as needed if this program is successful in identifying a deposit warranting a more intensive drilling program.

All work on this program will be based out of the **Nutaaq Camp** located at:

- $62^{o}$ 34' 18" North Latitude
- $98^{o}$ 27' 19" West Longitude

The **Nutaaq Camp** was established in 2010 and designed to hold a maximum of 50 people. During the 2014 project season there is expected an average daily population of 20 to 30 people. The camp consists of insulated tents on plywood floors with a combination of wood and aluminum frames. A helicopter will be based in camp for the duration of the program and will be used for transportation to work sites.

All 2014 exploration activities will be helicopter-supported and will include diamond drilling, ground geophysical surveying, field mapping, prospecting and soil, water and till sampling. Approximately 10,000 metres of diamond drilling are planned for the season.

A Spill Contingency Plan, Abandonment and Reclamation Plan, and a Wildlife Mitigation Plan have been prepared and submitted as supplements in appropriate license and permit applications.

## REGULATORY SOURCES AND GUIDELINES

Information contained in this document is compiled from several sources: the Canadian Nuclear Safety Commission (CNSC), Health Canada Radiation Protection Committee, Canadian Centre for Occupational Health and Safety (CCOHS), Saskatchewan Labour Occupational Health and Safety, and Cameco Corporation (Cameco).

It should be noted that the CNSC no longer regulates uranium exploration properties.

Transport of mineralized core and samples is governed by the *Packaging and Transportation of Nuclear Substance Regulations*, administered by the CNSC.

Kivalliq Energy Corp. is registered with the National Dosimetry Services, Occupational Radiation Hazards Division of Health Canada (NDS).

# INTRODUCTION

All persons performing uranium exploration on the Angilak Project are required to follow the procedures, guidelines and best practice methods laid out herein in this Company document: "Kivalliq Energy Corporation, Angilak Project Uranium Exploration, Radiation Hazard Control Guidelines". The Project Manager will ensure that all Contractors and Employees receive copies of these Guidelines and that all personnel are adequately trained in the Safe Work Procedures outlined in the document.

# RADIATION

Health Canada recognizes that there are two sources of radiation:

- Radiation from Naturally Occurring Radioactive Materials
- Radiation from Artificially Produced Radionuclides and Nuclear Fuels

For the purposes of this document, only the Natural Radiation sources will be discussed. Ionizing radiation is often just referred to as radiation. The primary radioactive elements found in the earth's crust are uranium, thorium and potassium and their radioactive derivatives. There are basically three types of ionizing radiation that emerge from radioactive substances such as uranium ores, namely, alpha, beta and gamma radiation. Alpha particles are relatively heavy charged particles, i.e., helium nuclei that are readily stopped by material, such as a sheet of paper or layers of dead skin. Beta particles are lighter charged particles, i.e., electrons or positrons, with slightly more penetrating power, typically up to 10 mm of body tissue. Gamma rays are electromagnetic radiation with high penetrating ability, such as being able to pass through steel pipes and body tissues. Detailed descriptions of the three types of ionizing radiation follow:

## Alpha Particles

Alpha particles are energetic, positively charged particles (helium nuclei) that rapidly lose energy when passing through matter. They are commonly emitted in the radioactive decay of the heaviest radioactive elements such as uranium and radium as well as by some manmade elements. Alpha particles lose energy rapidly in matter and do not penetrate very far, however they can cause damage over their short path through tissue. These particles are usually completely absorbed by the outer dead layer of human skin and so, alpha emitting radioisotopes are not a hazard outside the body. However, they can be harmful if they are ingested or inhaled. Alpha particles can be stopped completely by a sheet of paper.

## Beta Particles

Beta particles are fast moving, positively or negatively charged electrons emitted from the nucleus during radioactive decay. Humans are exposed to beta particles from manmade and natural sources such as tritium, carbon-14 and strontium-90. Beta particles are more penetrating than alpha particles, but are less damaging over equally travelled distances. Some beta particles are capable of penetrating the skin and causing radiation damage, however, as with alpha emitters, beta emitters are generally more hazardous when they are inhaled or ingested. Beta particles travel appreciable distances in air, but can be reduced or stopped by a layer of clothing or by a few millimetres of a substance such as aluminum.

## Gamma Rays

Like visible light and x-rays, gamma rays are weightless packets of energy called photons. Gamma rays often accompany the emission of alpha or beta particles from a nucleus. They have neither a charge nor a mass and are very penetrating. One source of gamma rays in the environment is naturally occurring potassium-40. Manmade sources include plutonium-239 and cesium-137. Gamma rays can easily pass completely through the human body or be absorbed by tissue, thus constituting a radiation hazard for the entire body. Several feet of concrete or a few inches of lead may be required to stop the more energetic gamma rays.

## Internal and External Exposure

An external exposure to radiation occurs if a person is subjected to radiation originating outside the body. External exposures primarily arise from gamma radiation emitted from a radioactive material, for example a high-grade core sample. Though alpha and beta particles have limited penetration into body tissues, beta radiation can result in exposures to both skin and eyes. An internal exposure to radiation occurs if a person is subjected to radiation arising from a radioactive material that has entered the body. Intake routes for radioactive materials are by inhalation of dusts and gases, ingestion of particles, or through an open wound, for example dust from cuttings or radon progeny in an enclosed space with ore present. The internal exposure arises from alpha and beta particles that penetrate into sensitive body tissue before being stopped.

# RADIATION PROTECTION BASICS

The greatest potential of an external exposure to radiation during uranium exploration is from uranium mineralization. Simple radiation protection is achieved by adhering to the three principles of Time, Distance, and Shielding:

> **Time** - radiation exposure is reduced by minimizing your time spent close to a radioactive material;

**Distance** - radiation exposure falls off drastically as the distance between you and the radioactive material is increased; and

**Shielding** - radiation is absorbed by materials. External exposure is reduced by introducing thick steel sheeting, or concrete structures, between you and the radioactive material.

Good radiation protection practice during uranium exploration is not to loiter in the vicinity of uranium mineralization and radioactive sources. Uranium mineralization and radioactive sources should be stored 30 metres or more away from active work areas. When there is cause for an employee to approach uranium mineralization while undertaking core drilling, core inspection, core stacking, labeling, packing, or transporting, work should be planned standing at least 2 metres away from the material. The task should be carried out in close proximity to the material in minimum time. The employee should then withdraw 2 metres away to plan the next task. Always minimize time in close proximity to, and maintain distance from, radioactive material.

## RADIATION IN URANIUM EXPLORATION

Uranium exploration personnel are potentially exposed to radiation from uranium and its associated radioactive decay products in naturally occurring mineralized outcrop, boulder float, drill core and drill cuttings. These radiation exposures will normally be quite small. Since the potential for significant radiation exposures is low and because they are working with naturally occurring radioactive material, exploration crews are classified as “incidentally exposed workers” and are regulated provincially and territorially. This is in contrast to workers in uranium mines who are usually classified as “nuclear energy workers” (NEW) and whose radiation exposures are regulated under the federal *Nuclear Safety and Control Act.*

The definitive document on radiation protection requirements for incidentally exposed workers is the *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM*), published by Health Canada. This document was developed by the Federal Provincial Territorial Radiation Protection Committee and has been endorsed by all provinces and territories as well as the federal government.

The NORM Guidelines define four categories for annual worker radiation exposures in order of increasing radiological concern. The radiation protection requirements for the different annual doses are summarized in the table below;

## Annual Worker Radiation Exposure Categories

| Annual Dose (mSv/y) | Radiation Protection Program |
|---|---|
| Dose < 0.3 | **None - Unrestricted**<br>*No requirements for dose management.* |
| 0.3 < Dose < 1.0 | **NORM Management**<br>*Radiation Surveys of work areas.* |
| 1.0 < Dose < 5.0 | **Dose Management**<br>*Dose estimates via radiation surveys and worker occupancy times*. Worker dose to be reported to National Dose Registry.*<br>*Expert advice recommended.* |
| Dose > 5.0 | **Radiation Management**<br>*Formal radiation protection program and the use of Thermoluminescent Dosimeters (TLDs) for worker dose measurement. Expert advice will be necessary.* |

## Exposure limits for Nuclear Energy Workers (New)

The maximum amount of radiation people are allowed to receive in the workplace is regulated. For a Nuclear Energy Worker (NEW)(a special designation for those working in a Nuclear power plant or uranium mine requires specific controls on the worker) the Canadian Nuclear Safety Commission (CNSC) sets a limit of 50 mSv in a single year and 100 mSv over 5 years (a 20 mSv per year average). The limit for a pregnant worker, once pregnancy has been declared, is 4 mSv for the remainder of the pregnancy. While exposure levels vary by job, the average yearly radiation exposure of a monitored NEW is about 0.3 mSv.

The radiation exposure limit designated for persons working in uranium exploration is the same as that of the general public.

## Exposure limits for general public (including workers in uranium exploration)

For members of the general public (including persons involved in uranium exploration), the exposure limit is 1mSv above normal background radiation. Generally, the CNSC and other provincial regulatory authorities use the same exposure limit for workplace radiation protection as that for a member of the public.

The annual exposure limit from both internal and external radiation for a uranium exploration worker is *1 mSv.*

# RADIATION SAFETY

Kivalliq Energy Corp. is committed to providing a safe workplace. The goal on the Angilak Project is to advance the historic Lac Cinquante Uranium Deposit however, as part of that mandate it is important to protect all associated personnel and minimize any impact to the environment. Radiation exposure can be controlled and minimized by reducing the time spent in contact with radioactive material, maintaining safe and approved distances and monitoring.

Exposure to alpha and beta particles can be controlled by wearing proper clothing and ensuring that it is cleaned appropriately. Hand washing is extremely important and eating, drinking and smoking is to be avoided while working around radioactive material. Exposure to gamma rays is controlled by maintaining a safe distance and limiting the time spent in contact with any radioactive source. Monitoring exposure with a Dosimeter badge (TLD badge) is an effective method of measuring exposure. In addition to the TLD badge, Kivalliq will also be using 25-IS-1 Personal Radiation Monitors (PRM) from Ludlum Measurements Inc. These monitoring devices will be used on all drill sites and in the core logging and core splitting shacks. The PRM's provide staff with real time dose measurements and a warning system should staff members encounter high levels of radiation.

## Potential Sources of Radiation Exposure for Exploration Crews

Exploration crews working with uranium may receive radiation exposures from:

- Gamma radiation emitted from the uranium mineralization
- The inhalation of radon (and the resulting radon progeny decay products) emanating from the drill core and drill cuttings
- The inhalation of radioactive dust
- The ingestion of radioactive dust

The primary source of worker radiation exposure will be from external gamma radiation. The external gamma radiation dose received by exploration crews will depend on:

- The grade of the mineralization
- The amount of time spent by workers close to mineralized drill core and cuttings
- The amount of mineralized drill core and cuttings in the vicinity
- The distance between workers and the drill core and cuttings

Worker radiation exposures from the inhalation or ingestion of radioactive dust (or dirt) should not be a concern since enclosed areas such as core shacks are suitably ventilated and all work areas will be kept clean. Workers should wash their hands after handling radioactive drill core and cuttings and before eating or smoking.

## Radiation Protection (RP) Controls

Uranium exploration and drilling program involves various grades of uranium ore and various levels of potential radiological hazards. A radiation level has been determined above which Radiation Protection (RP) controls are initiated and all the elements of the Radiation Protection Guidelines described below come into effect. If the ore being handled is below this action level, normal Health and Safety related practices will be in effect.

The RP level has been determined on the basis of available Federal and Provincial guidelines that address uranium exploration and radiological safety controls in mining areas. This indicates that areas with exposure rates that are less than 1 µSv/h don't require controls.

An exposure rate greater than **1 µSv/h** corresponds to a reading of **1000 cps at one metre** on an exploration scintillometer and initiates Radiation Protection (RP) controls.

## Radiation Protection Guidelines

The most important factor to consider when handling Naturally Occurring Radioactive Materials is personal hygiene. Wear Personal Protective Equipment, minimize time handling radioactive materials and maximize your distance from radioactive materials. Radioactive particles are easily transported from contamination control zones on a Worker's clothing or skin. Do not wear work clothes in non work settings (kitchen tent, sleep tent, etc.) Wash hands frequently.

The best way to prevent ingestion of potentially radioactive dust particles is through frequent hand-washing and good personal hygiene.

The following safety measures are mandatory when working directly with or in an environment that may contain radioactive materials and will be provided to all employees on site:

- Minimize time handling radioactive material
- Maximize distance from radioactive material
- Wash hands regularly
- Wear personal protective equipment
- Don't wear work clothes in non-work settings (kitchen tent, sleep tent, common areas, etc.)
- Wear gloves, such as cotton gloves, when handling soil, silt, rock or taking chip samples.
- Wash hands, hair daily and clothes regularly
- Do not lick any rock
- Bandage open wounds
- Wash hands after handling rock and before eating or smoking
- Do not eat, drink or smoke in core shacks, splitting shacks, drys, on the drill platform or any other location with elevated radiation levels
- When working with drill core, coveralls, rubber gloves, and safety glasses must be worn at all times. Boot covers may also be necessary

- Safety glasses are mandatory when working with drill core to protect the eyes from beta radiation
- Use a ½ face particulate respirator when core splitting. Store respirator in a clean plastic bag away from the work area when not in use
- Reduce dust by wetting the area with water on a regular basis
- Check field clothes periodically with a scintillometer. Rinse clothes at site if reading is greater than 100 CPS and continue rinsing until readings fall below the acceptable level
- Always work in well-ventilated environment, monitor work areas on a regular basis with contamination metres
- Control the spread of contamination at all times by following field protocols.
- TLDs (thermoluminescent radiation dosimeters) must be worn by all field workers

## TRAINING

All employees entering the Angilak Project will be provided with an orientation program that includes Radiation Protection Training. Safety meetings in which Radiation Protection is reviewed and Radiation Hazards are discussed will be held on a weekly basis. Daily toolbox sessions are used as important daily reminders about Radiation Hazards in the work place. A radiation safety consultant from ALARA Consultants Inc. will oversee radiation safety training and will be onsite regularly to provide radiation training to all personnel.

## WORKER RESPONSIBILITIES

All employees and contractors active on the Angilak Project must:

- attend all required training, safety meetings and briefing sessions
- be familiar with and adhere to the Radiation Protection Guidelines
- perform only those tasks that can be performed safely
- report any unsafe conditions to the supervisor or Project Manager
- wear a TLD (dosimeter) badge

## ALARA

The objective of the Radiation Safety Program is to minimize personal and environmental radiation exposures to levels that are As Low As Reasonably Achievable (ALARA), economic and social factors considered. This is accomplished by the implementation of personal and area monitoring procedures and, where applicable, the use of personal protective equipment.

Kivalliq is committed to the ALARA principle for Radiation Hazard Control.

## WORK SITE MITIGATION AND PERSONAL HYGIENE

As internal exposure to radiation can occur from the inhalation or ingestion of radioactive materials, work practices should be adopted that restricts the amount of airborne dust and the potential for cross contamination of the hands, nose and mouth. This is best achieved by handling materials in the wet state. When the radioactive material cannot be made damp, and airborne dusts occurs, wear respiratory protection. However, respiratory protection cannot filter out radon gas, and the best method of avoiding a radon intake when handling uranium mineralization is to work in a well ventilated area. Extractor fans are used in areas where radioactive dust can be generated i.e. core splitting bench

Radiation protection involves minimizing the external and internal exposures to radiation. It is important that the uranium mineralization is kept in its correct storage locations. Any spillage or accumulation of the materials should be cleaned up immediately. A gamma radiation exposure will arise from small piles of materials. Internal exposure will occur from inhalation of airborne dusts. Prevention of ingestion of radioactive bearing material can be achieved by washing hands prior to smoking and eating.

## PERSONAL PROTECTIVE EQUIPMENT – PPE's

While working with mineralization, there are a number of actions that each worker can take to protect themselves. To limit the spread of contamination when working with NORM in rock or core samples, workers should wear coveralls and gloves to keep mineralized dust from their hand and clothes. Safety glasses are mandatory when working with mineralized drill core to protect the eyes from beta radiation. Respiratory protection is vital for limiting exposure from dust and radon progeny, particularly when working in an enclosed area.

Workers will change from their work clothes into clean clothes at the end of each shift in the camp dry.

### Decontamination

Personnel decontamination will be done by washing if necessary. Work clothing will be washed and rinsed in water. Contaminated PPE's will be washed or disposed of accordingly.

## DRILLING AND HANDLING RADIOACTIVE DRILL CORE AND ROCK CHIPS

The following procedure for handling and logging of radioactive rocks (drill core, hand samples, chips etc.) have been developed by the Health and Safety Committee of Prospectors and Developers Association of Canada (PDAC). Kivalliq Energy Corp. is adopting this procedure for their uranium exploration camps. In addition to the Radiation Protection Guidelines the Project Manager will ensure that all personnel are made familiar with the following procedures, and ensure the updating and implementation of this procedure.

1. All employees who work with radioactive rocks or drill core must wear TLD badges. TLD badges are mandatory at the drill rigs and in the core tents.

2. Workers must be aware when working with radioactive materials. Safety glasses, work gloves and coveralls must be worn. ½ face respirators are required when working with radioactive dust. When not in use respirators should be stored in a clean plastic bag and removed from the work site. Gloves and coveralls should be laundered and/or replaced regularly. Gloves, coveralls and other exposed outerwear PPE will not be worn into the kitchen area.

3. Wash hands well with soap and water after handling radioactive material.

4. Do not eat, drink or smoke when handling or working near radioactive material.

5. Ensure that all work stations with exposure to radioactive materials have proper ventilation to ensure constant air turnover. Ventilation fans are installed in the core tent. Ventilation fans and extractor fans are installed at the core splitting station. A dust collecting extraction unit is attached to the cyclone on the RC rig.

6. Store radioactive core at least 30 metres away from the drill shack and the core logging tent.

7. Post storage areas and the logging / splitting shacks as radioactive areas.

8. Radioactive core must be logged into and out of the core logging tent. Date, time and the gamma level at 1 metre intervals are also recorded. A radiation warning sign must be placed on the core shack door when while radioactive core is inside.

9. Do not move or store radioactive core unless in core boxes secured with wood or Plexiglas lids.

10. Do not loiter in the vicinity of mineralized drill core, mineralized drill cuttings or mineralized drill chips

11. Do not wear work clothes in the kitchen, common areas or sleep tents

12. Drillers/helpers/others when drilling or handling radioactive drill core or drill chips will change out of their contaminated clothes and leave them at the drill site to avoid contaminating the helicopter.

13. Follow all regulations and procedures regarding the shipment of radioactive materials.

The above information, entitled “Drilling and Handling Radioactive Core and Rock Chips” will be posted prominently at the camp and in the core shack.

## Drilling

Before building a drill setup on a drill site, orientation tests will be performed to determine Natural Background Radiation levels at the drill site. Upon commencement of the drill hole, drillers need to be instructed on where to expect mineralization, the identifying characteristics of that mineralization and how to minimize contact with the drill core and cuttings when the mineralized intersection is drilled. Mineralized core should be stored 30 metres from the drill shack prior to being transported to the core logging tent. A placard noting radiation should be posted at the drill site core storage area.

Where uranium mineralization is encountered in a drill hole, the drill mud solids or cuttings with a uranium concentration greater than 0.05 per cent will be collected and pumped back down the hole or will be collected in appropriate containers and stored in the long-term core storage area.

Any drill hole that encounters mineralization with a uranium content greater than 1 .0 percent over a length of > 1.0 metre, and with a metre-per-cent concentration > 5.0, will be sealed by grouting over the entire length of the mineralization zone and not less than 10 metres above or below each mineralization zone. The top 30 metres of the hole within bedrock will also be sealed by grouting once drilling is complete.

As with all drilling procedures, at each drill site a suitable natural depression will be used to serve as a sump for the disposal of cuttings, sludge and return water that cannot be recirculated during the drilling process. The sump will be located at a minimum of 31 metres from the ordinary high water mark of any adjacent water body, where direct flow into a water body is not possible and no additional impacts are created. Upon completion of the hole, the sump will be restored as required to the pre-existing natural contour of the land. Reclaimed drill sites will be inspected and tested for radiation.

## Core Storage

Once the uranium content has been established by assaying, a decision will be made on the long range storage of the core. If stored on the property, it will be located in the long term core storage area for radioactive rocks. This core storage area will be located at a minimum of 31 metres from other working structures. Radiation levels must be reduced to less than 1.0 µSv measured at 1 metre from the surface and in no instance will be allowed to exceed 2.5 µSv.

## ENVIRONMENTAL CONSIDERATIONS

Kivalliq Energy Corp. will establish, in cooperation with the KIA and AANDC, a suitable long-term core storage area for radioactive rocks, separate from the non-radioactive rocks. This area will have the appropriate containment systems in place, will be located at a minimum of 100 metres from the normal high water mark of any water body and will have appropriate signs. Additional measures may be required dependent on the uranium concentration of the rocks. These will be discussed with the regulatory agencies.

## ADDITIONAL INFORMATION

Workers are encouraged to consult regulatory guidelines for additional Radiation Safety information. Copies of the Canadian Guideline for the Management of Naturally Occurring Radioactive Materials (NORM) from Health Canada, the Radiation Protection Guidelines for Uranium Exploration from Saskatchewan Labour, Occupational Health and Safety, the CNSC Radiation Protection Regulations and the CNSC Packaging and Transport of Nuclear Substance Regulations are available for review from the Project Manager

## SHIPPING AND TRANSPORT

The shipping of radioactive materials (Class 7) from the Project site is controlled by the CNSC *Packaging and Transport of Nuclear Substances Regulations (PTNSR)* and Transport Canada's *Transportation of Dangerous Goods Act* and *Regulations*.

The Project Manager will supervise shipping radioactive materials and is certified to the standards required by the Transport of Dangerous Goods Regulations

The *Regulations* stipulate that Low Specific Activity consignments will be shipped as Excepted Packages if the radiation on the external surface does not exceed 5µSv/hr. The container must bear the UN Number as per PTNSR 17(2) and contain a marking of "radioactive" on an internal surface that is visible upon opening the package.

The transportation of uranium mineralization and ores that have an average specific activity in excess of 70 kBq/kg conform to the requirements of the Packaging and Transport of Nuclear Substances Regulations.

Exploration camps have one exemption to the Transport of Dangerous Goods Regulations. Due to remoteness, exploration camps are permitted to transport core samples by air, providing they are less than 100 mm in diameter and are packaged in accordance with the Packaging and Transport of Nuclear Substances Regulations

Kivalliq has an 'INSPECTOR' radiation meter built by Canadawide Scientific Ltd to determine radiation levels in Sieverts and a RS 230 spectrometer to differentiate radiation by mineral type.

## Requirements for an Excepted Package

If the radiation intensity is < 5 µSv/hr, then the shipment may be considered an "Excepted Package" under CNSC regulations and the TDG regulations do not apply. Therefore if the dose rate on the exterior of the package is <5 µSv/hr, it can be shipped under routine conditions of transportation – it can be considered a non-dangerous good. The following procedures must be followed when shipping an Excepted Package:

- A label marked "Radioactive Samples" must be placed inside the package in such a manner that the label is visible to the person opening the package.
- Removable radioactive contamination on the outside of the package must not exceed 0.4 Bq/cm2 averaged over 300 cm2
- The United Nations Number "UN2910" is attached to one vertical side of the container
- Both the Consignor and Consignee addresses are to be displayed on the exterior of the package
- The weight must be shown on the exterior of the package if it exceeds 50 kilograms
- The way bill requires the shipping name (Radioactive material, Excepted Package – Limited Quantity of Material) and the UN number
- 3 copies of the documentation is required; one for the shipper, the carrier and the receiver

## Requirements for Shipping Low Specific Activity – (LSA-1) Packages

If the dose rate on the exterior of the package is **>** 5 µSv/hr then the package will be shipped as a Low Specific Activity – (LSA-1) shipment. The following procedures must be followed when shipping any Low Specific Activity Package:

- Both the Consignor and Consignee addresses are to be displayed on the exterior of the package
- The weight must be shown on the exterior of the package if it exceeds 50 kilograms
- The Shipping Name (Radioactive Material, Low Specific Activity) and the UN Number

"UN2912" is attached to two (2) vertical and opposite sides of the shipping container

- Three copies of the documentation is required; one for the shipper, the carrier and the receiver

- An LSA-1 shipment will require a shipper's document identifying the shipment as a Class 7 dangerous good
- Radioactive Yellow II labels are attached next to the shipping name and UN number labels
- On the Radioactive Yellow II Labels the following must be written:
    - Radioactive contents section write "LSA – 1"
    - Transportation Index - Estimate the activity in the package in Bq (this number must be in Bq units)
    - The Transportation Index is the gamma radiation intensity in µSv/hr at a distance of 1 metre from the exterior of the package divided by 10. For example the Transport Index for 4.5 µSv/hr will be 0.5 The package for an LSA-I Shipment must satisfy the IAEA Requirements for Type 1 Industrial Packages (Type IP-1) which are the same as for an Excepted Package plus :
    - The smallest external dimension of the package cannot be less than 10 centimetres
    - The container must be durable and legally marked on the outside "Type IP-1"

## Standard Units of Measure

The standard unit of measure of the activity (number of atoms decaying per second) is the becquerel (Bq). Since 1 Bq is a very small quantity, larger multiples are used as follows:

| | | | |
|---|---|---|---|
| 1kBq | = kilobecquerel | = 1000 Bq | = 1 x 103 Bq |
| 1MBq | = megabecquerel | = 1,000,000 Bq | = 1 x 106 Bq |
| 1GBq | = gigabecquerel | = 1,000,000,000 Bq | = 1 x 109 Bq |
| 1TBq | = terabecquerel | = 1,000,000,000,000 Bq | = 1 x 1012 Bq |

Becquerels replace the curie (Ci) as the unit of measure of activity. The radiation dose-equivalent is

expressed in units of sieverts (Sv). Smaller fractions are often used as follows:

1 mSv = millisievert = 0.001 Sv = 1 x 10-3 Sv

1 µSv = microsievert = 0.000001 Sv = 1 x 10-6 Sv

The sievert replaces the older unit for dose-equivalent, the "rem".

# REFERENCES AND RESOURCES

**Associations**

Prospectors and Developers Association

**Federal Government**

Canadian Guidelines for Management of Naturally Occurring Radioactive Materials (NORM)

Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines

Canadian Nuclear Safety Commission Occupational Exposure to Radiation

National Dosimetry Services (NDS)

**Provincial Governments**

Saskatchewan Labour - Occupational Health and Safety

Saskatchewan Environment – Mineral Exploration Guidelines for Saskatchewan

**Other**

Cameco Corporation

Aurora Energy Resources Inc.

Saskatchewan Research Council (SRC)