Future sampling at N-1and the relocated N-2 will be conducted for a 12-month period beginning in September 2013. Preoperational monthly sampling and analysis will be conducted for suspended and dissolved natural uranium, radium-226, and thorium-230, with semi-annual sampling for suspended and dissolved lead-210 and polonium-210.

USBR Box Butte Reservoir Storage Content

The USBR monitors the contents of the Box Butte Reservoir daily (USBR 2013). Measurements (acre-feet) for the reservoir from 2003 through September 2013 are shown in **Table 2.9-34.** The average values for the content of the reservoir was 9, 627 acre-feet between 2003 and September 2013. The minimum and maximum values were 2,352 and 24,942 acre-feet, respectively (see summary values in **Table 2.9-35**). Since the 1950s, groundwater depletions of base flow and numerous farm conservation practices have greatly reduced inflow into the reservoir (USBR 2008).

Box Butte Reservoir is used as a source of irrigation water; consequently, the reservoir storage content (in acre-feet) can vary considerably annually due to the use of the water for irrigation purposes downstream of the reservoir dam. Historically, the reservoir has experienced the highest reservoir elevations during the months of May and June, while September and October exhibit the lowest reservoir elevations following irrigation releases (USBR 2008). As seen in **Table 2.9-34**, the reservoir contained an average of 12,336 and 12,965 acre-feet in May and June 2013, respectively, whereas in August and September, 2013, the reservoir contained an average of 6,541 and 5,295 acre-feet, respectively.

Under an agreement among the Mirage Flats Irrigation District, the NGPC, and the USBR, a minimum pool elevation is maintained at 3,978 acre-feet to support and maintain a viable fishery resource in the reservoir (USBR 2008).

Quality of Surface Water Measurements

The accuracy of monitoring data is critical to ensure that the water monitoring program precisely reflects water quality. See discussions in Section 2.9.3.4 that address surface and groundwater analytical quality requirements.

2.9.5 Baseline Vegetation, Food, and Fish Monitoring

Reference is made in this section to "milling" or "mill site" as it applies to RG 4.14. Milling or mill site typically refer to a primary recovery method or facility used to extract uranium from mined operations, e.g., conventional milling. ISR facilities perform uranium "milling" under an expanded NRC definition of by-product material that includes discrete surface wastes resulting from uranium solution extraction processes. Therefore, references to milling or mill site -in this section can be extrapolated to uranium *in-situ* operations.

2.9.5.1 Vegetation

RG 4.14 recommends sampling of grazing areas near the site in different sectors that will exhibit the highest predicted air particulate concentrations during the milling operations.

Forage Vvegetation will bewas sampled as described in **Table 2.9-36 41** following guidance in RG 4.14. The factors used to select the vegetation sampling locations within the MEA were; the three dominate wind directions, the grazing area availability and private landowner access. ~~Using the recently acquired meteorological data and completed MILDOS calculations,~~The forage vegetation sampling locations~~es~~ are shown on **Figure 2.7-4.** ~~will be collected in grazing areas located downwind of the Marsland satellite facility in sectors having the highest predicted air particulate concentrations during operations. A minimum of t~~Three samples ~~will be~~were collected three times during the grazing season and analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Results from the vegetation sampling are shown in **Table 2.9-44**. The analytical data sheets for vegetation sampling are provided in **Appendix Q.**

2.9.5.2 Food

Crops

RG 4.14 recommends that crops raised within ~1.86 miles (3 km) of the mill site be sampled at the time of harvest. The NRC has indicated that other food sources should be explored for sampling, such as private gardens in the area (e.g., sampling a variety of available garden plants). Grab samples should be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210.

~~Cameco is proposing a~~An alternative approach to estimating baseline radionuclide concentrations in vegetables was selected to protect the private owner's crops. ~~–~~B~~b~~ecause the quantity of vegetables required to meet LLDs is very large, and in many instances would~~will~~ decimate a~~the~~ private garden owner's~~homeowner's~~ crop, an alternative approach to estimating baseline radionuclide concentrations in vegetables was used. ~~.~~Thi~~se~~ ~~proposal~~ approach relies heavily on the approach developed by Powertech for use at the Dewey Burdock site (ML11208B714).

The PPMP baseline plan employed a ~1.86-mile (3 km) area around the license boundary to identify gardens for soil sampling. Seven garden/crop locations were selected **(Figure 2.7-4)** and~~Cameco will sample the~~ soil samples were taken from ~~in~~ the vegetable gardens rather than the vegetables. To estimate the radionuclide concentrations, ~~CBR will use~~ Equation 1, Section 5 (Equation 5.5) of NUREG-5512 was used to calculate the vegetable concentration factors.

$$Csvhj = 1000\,(MLv + Bjv)\,Wv\ \{ACsj, tgv\}/Csj \quad \text{(Equation 1)}$$

Where:

- Csvhj = concentration factor for radionuclide j in plant v at harvest from an initial unit concentration of parent radionuclide i in soil (pCi/kg wet-weight plant per pCi/g dry-weight soil)
- Bjv = concentration factor for uptake of radionuclide j from the soil in plant v (pCi/kg dry-weight plant per pCi/g dry-weight soil)
- MLv = plant soil mass-loading factor for re-suspension of soil to plant v (pCi/kg dry-weight plant per pCi/g dry-weight soil)
- Wv = dry to wet-weight conversion factor (unitless)
- {ACsj, tgv} = decay operator notation used to develop the concentration of radionuclide j in soil at the end of the crop growing period t0' (pCi/g dry-weight)

C'j = concentration of radionuclide j in soil during the growing period (pCi/g dry-weight)

C'j(O) = initial concentration of radio nuclide j in soil during the growing period (pCi/g dry-weight)

tgv = growing period for food crop (days)

1000 = unit conversion factor (g/kg)

RG 4.14 specifies analysis of natural uranium, thorium-230, radium-226, lead-210, and polonium-210 in vegetables. With the exception of polonium-210, these radionuclides have long half–lives when compared to the growing season. For that reason, the decay correction can be ignored. For polonium-210, CBR will assume that the initial soil concentration and the soil concentration during the growing season remain identical. Thus, Equation 1 is simplified to Equation 2:

$$Csvhj = 1000\ (MLv + Bjv)\ Wv \qquad (Equation\ 2)$$

Based upon Equation 2, **Table 2.9-36** presents both the parameters that will be used to estimate wet-weight vegetable concentrations from dry-weight soil concentrations and the average value for each plant type and each radionuclide in pCi/kg wet-plant weight from the seven gardens sampled. The locations of the gardens are shown in **Figure 2.7-4**. The Garden Soil Analysis in **Appendix CC** contains a table that compiles the analytical data, the laboratory data, the laboratory reports, and a Polonium LLD evaluation for soil.

~~The PPMP baseline plan employed a ~1.86-mile (3 km) area around the license boundary to identifycenterpoint of the satellite facility to determine the locations of the gardens~~.

~~CBR will seek approval from the garden owner to collect soil samples. A schedule for remaining baseline sampling is provided on **Figure 2.9-1**.~~

Vegetation samples ~~will be~~were collected in accordance with the Safety Health Environment and Quality Management System (SHEQMS) Volume VI Environmental Manual (CBR 2010).

Livestock

NRC RG 4.14 recommends sampling and analysis of the edible portions of livestock raised within 3 km of the site ~~that livestock raised within ~1.86 miles (3 km) of the mill site be sampled~~ at the time of slaughter. Grab samples should be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. ~~Cattle are the livestock present in the area. Samples will be collected from three locally fed cattle.~~

With the cooperation of a local landowner in March of 2014, animal tissue samples were collected from locally raised beef cattle at the time of slaughter within 3 km of the MEA. The location of livestock samples are shown on **Figure 2.7-4.** Samples were~~ill be~~ analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. **Table 2.9-45** presents the radionuclide analysis for beef samples collected in the MEA. The individual analytical data sheets, analytical QA/QC summary report, and chain of custody record are found in **Appendix DD.** ~~A schedule for remaining baseline sampling is provided on **Figure 2.9-1**.~~

Game Animals

No preoperational samples of game animals were collected due to the following considerations:

- Hunting access is limited by private landowners.
- There are a limited number of game animals in the licensed area.
- Due to the migratory nature of game animals, it would be difficult to attribute any radionuclide concentration origins to the site.

Livestock is the primary food source in the MEA and more likely to be in the pathway-to-man. Therefore, livestock was determined to be a better food sample.

2.9.5.3 Fish

RG 4.14 requires that fish be collected, if available, from lakes and streams in the project site area that may be subject to seepage or direct surface runoff from potentially contaminated areas or that could be affected by a tailings impoundment failure. Fish should be collected, sampled, and analyzed semiannually for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. There are no streams or water impoundments located within the MEA license boundary. There are only two dry drainages that cross the license area. Therefore, fish sampling within the MEA license boundary is not feasible.

The nearest permanent stream is the Niobrara River located just to the south of MEA license boundary which flows into Box Butte Reservoir. Given the large sample size required to attain LLDs (14 pounds) and the limited fish population present in the stream, the fish sampling focused on northern pike in the inlet of Box Butte Reservoir. Box Butte Reservoir is overpopulated with northern pike, which allows for a larger bag limit than elsewhere in Nebraska. As the most prevalent species, a popular gamefish and known human food source, sampling the meat of the northern pike is the only feasible approach to assessing potential dietary contribution to humans. Northern pike fish tissue samples were collected from the inlet of the Box Butte Reservoir on May 25, 2014 and September 26, 2014. The samples were analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210 (**Table 2.9-37**).

Collection of fish tissue at N-1 and N-2 **(Figure 2.7-4)** was~~is~~ not feasible due to the small fish population with insufficient fish biomass. Attempting to collect the required amount of fish tissue needed for the analytical laboratory to obtain the required LLD would decimate the limited fish population.

~~Tissue samples were collected from northern pike on August 22, 2011 and May 25, 2012, and analyzed for lead-210, polonium-210, radium-226, thorium-230, uranium and uranium activity (**Table 2.9-37**). The analytical results were considered low. The sampling results are reported on a wet weight basis (as received). Sampling results for lead-210 were classified as "U" or undetected at minimum detectable concentration (<1.0E-06 and 7.9E-07 microcuries per kilogram [µCi/kg], respectively). One analytical result for polonium-210 was at the RL limit of 5.0E-07 µCi/kg, with the other value not detected at the RL of 2.8E-07 uCi/kg. For radium-226, the sampling results were at or below the RL of 2.0E-07 and 2.2E-07 uCi/kg. The thorium-230 concentration was 1.0E-5 µCi/kg versus the RL of 8.0E-06 uCi/kg for one sampling event, and~~

~~not detected at the RL of 6.7E-08 uCi/kg for the other sampling event.. The uranium and uranium activity values were below the RLs of <0.0003 mg/kg and <2E-07 µCi/kg, respectively, for one sampling event, while for the other sampling event, levels of 0.00099 mg/kg and 6.7E-07 uCi/kg were reported, respectively.~~

The analytical data sheets and the QA/QC summary reports for the fish tissue samples are shown in **Appendix X**.

As of May 2010, the Nebraska Department of Human and Health Services (NDHHS) with the NDEQ, the NGPC and the Nebraska Department of Agriculture (NDA), have issued fish consumption advisories for warning to limit the consumption of northern pike in Box Butte Reservoir due to elevated mercury concentrations (NDEQ 2011a).

Due to the lack of background data from the study area with which to compare the current findings, radionuclide data interpretation is impracticable at this time, other than that the concentrations are considered low. The radiological results will serve as background information for future sampling events and the development of long-term trends.

~~2.9.5.4 Quality of Food, Vegetation, and Fish (wet) Measurements~~

~~As noted above, CBR proposes to use an alternative approach to estimate baseline radionuclide concentrations in food crops. CBR will estimate wet-weight vegetable concentrations from dry-weight soil concentrations and will use the MDC/LLDs provided in RG 4.14 for dry soil and sediment. Specifically:~~

~~2 10^{-7} uCi/g for uranium-natural, thorium-230, radium-226, and lead-210~~

~~RG 4.14 does not provide an LLD for polonium-210 in dry soil. CBR will work with laboratories to justify an appropriate LLD when the data are submitted to NRC. A schedule for remaining baseline sampling is provide on **Figure 2.9-1**.~~

~~The private laboratory employed by CBR, ELI, reported the lower limits of detection for fish tissue as MDC/LLD values. ELI stated in a letter dated April 23, 2012 (ELI 2012, **Appendix Q**) that the reported MDC/LLD values for the MEA fish samples were in compliance with RG 4.14, Section 5 "LLD". The LLD levels specified in RG 4.14 will be met for future fish and vegetation sample analyses.~~

Radionuclide	MDC/LLD for Vegetation, Food and Fish (wet)	
	µCi/kg	pCi/g
Natural Uranium	2 x 10^{-7}	0.2 pCi/g
Thorium-230	2 x 10^{-7}	0.2 pCi/g
Radium-226	5 x 10^{-8}	0.05 pCi/g
Polonium-210	1 x 10^{-6}	1.0 pCi/g
Lead-210	1 x 10^{-6}	1.0 pCi/g

Source: ELI 2012 (Appendix Q)

Note: For analytes reported in two significant figures. MDC/LLD values rounded off to only one significant figure (e.g., 1.3 pCi/g = 1 pCi/g).

ELI met the criteria of the guidance suggested by the NRC when reasonably achievable by available conventional laboratory methodology. If for some reason the MDC/LLD was not met on the original analysis, the samples were recounted ore re-analyzed until RG 4.14 MDC/LLDs were achieved. See **Appendix Q** for additional discussions by ELI of MDC/LLD reporting.

MDC levels for fish tissue radiological analytes are presented in **Table 2.9-37.**

2.9.6 Baseline Soil Monitoring

RG 4.14 recommends soil samples be collected as follows:

- Up to 40 surface soil samples would be collected at 300-meter intervals to a distance of 1,500 meters in each of eight directions from the center of the milling area. Surface soil samples would be collected to a depth of 5 cm using consistent sampling methods. Sampling would be conducted once prior to construction and repeated for locations disturbed by excavation, leveling, or contouring. All samples would be analyzed for radium-226, and 10 percent of the samples analyzed for natural uranium, thorium-230, and lead-210.
- Five or more surface soil samples (to a depth of 5 cm) would be collected at the same locations used for air particulate samples. Samples would be collected once prior to construction. Samples would be analyzed for natural uranium, radium-226, thorium-230, and lead-210.
- Five subsurface samples would be collected at the center point location and distances of 750 meters in each of four directions. Subsurface soil samples would be collected to a depth of 1 meter and divided into three equal sections for analysis. Samples would be collected once prior to construction and repeated for locations disturbed by construction. All samples would be analyzed for radium-226, and one set of the samples would be analyzed for natural uranium, thorium-230, and lead-210.