ENERGYSOLUTIONS

June 18, 2014 CD14-0136

Mr. Helge Gabert
Project Manager, DU Contract
Utah Division of Solid and Hazardous Waste
P.O. Box 144880
Salt Lake City, UT, 84114-4880

Subject: License No: UT2300249; RML #UT 2300249 –Condition 35 Compliance Report, Revision 1; **Revised Response to May 2014 Round 2 Interrogatory #182**

Dear Mr. Gabert:

On June 17, 2014, Energy*Solutions* provided responses to the Utah Department of Environmental Quality "Round 2 Interrogatories" (dated May 27, 2014). As a result of subsequent dialogue with the Department, Energy*Solutions* hereby submits a revised response to May 2014 Round 2 Interrogatory #182.

182. INTERROGATORY CR R313-25-19-182/2: GROUNDWATER EXPOSURE PATHWAYS

As discussed elsewhere (see, for example, Interrogatory CR R313-25-8(4)(a)-96/2 and Interrogatory CR R313-25-8(4)(a)-97/2: Need for Potable and/or Industrial Water), SC&A believes that additional information must be provided to demonstrate the groundwater at Clive is not a potential dose pathway. Under Interrogatory CR R313-25-8(4)(a)-96/2, SC&A indicates that ES needs to examine the possibility that the lower confined aquifer at Clive could become contaminated and thus become a source of exposure, either to an inadvertent intruder or to a member of the public. If the water from this aquifer were used for domestic uses but did not meet the test of a public water system, regulation would be left to Tooele County. It is our understanding that the County does not require testing for uranium or other radioactive contaminants.

EnergySolutions' Response: As is reflected in Energy*Solutions* (2013), both the upper unconfined and lower confined aquifers have been classified as Class IV, "*non-potable, saline ground water*" due to total dissolved solids and other naturally-present constituents. As such, consideration of a groundwater ingestion scenario as an exposure or dose pathway is not representative of "*current local well-drilling techniques and/or water use practices*," (NRC, 2000). Even so, Energy*Solutions* recognizes current local groundwater practices involve pumping of water as a limited source of non-ingestible industrial water (such as for dust suppression). While of comparably poor water quality, similar local wells installed for the production of industrial water have been screened into the deeper confined aquifer as production sources for industrial water (due to the relatively low yield of the upper, unconfined aquifer).

In fact, Energy*Solutions* requested permission from the Division to install such a well in Section 29 (immediately north of the area licensed for radioactive waste management), (Envirocare, 2005; included as Section 6 to this Response Report). Analyses and representative well characteristics from Envirocare (2005) have been used to model potential doses for an inadvertent industrial intruder well scenario in support of the response to this Interrogatory. Since a cost-benefit/business analysis is implied in Envirocare's 2005 decision to seek approval to install a well in the northwest corner of Section 29 (as opposed to continuing to truck water), repeating such an activity as part of this response is unnecessary. Envirocare deemed pumping water from a local well financially feasible and commissioned the study (attached as Section 6 to the Round 2 Response Report). Envirocare abandoned its pursuit of the Section 29 well when it became apparent that burdensome regulatory requirements would make it more expensive than continuing to truck water from another source. It is assumed that these same regulatory hurdles will not be present in the Inadvertent Industrial Well scenario considered below.

However, it is important to note that Envirocare's 2005 petition to install the well was that of an "*informed*" or "*advertent*" intruder. Envirocare knew what quality of water was being sought and, as such, the limited uses to which it could be applied. Conversely, if someone were to explore for water in the valley in the future, after the loss of institutional control, without knowledge of water quality, they would most likely install a well nearer to the foothills – where water quantity is more abundant and of higher quality. Water quality continues to degrade as it migrates to the center of the valley – this is the conceptual model for the entire Basin and Range Province. It is extremely unlikely that an industrial user without any knowledge of the valley would select the middle of the valley as their well installation site of primary interest. Additionally, for any industrial use other than dust suppression, the inadvertent intruder will quickly realize the poor quality of the groundwater – when their associated pumps and other industrial equipment become corroded and unusable. This poor quality water naturally contains high concentrations of Uranium and other NORM isotopes. Once an industrial user becomes aware that the water (even in its natural form) must be treated before its possible uses can be expanded – that individual no longer is "*inadvertent*" in its knowledge or intended groundwater uses.

As for the Division's insistence on including a groundwater ingestion dose pathway in the model, the quality of water from the deeper aquifer is of similar classification to that from the shallow aquifer (very high TDS, brackish, and of extremely poor taste and smell). An assumption that there is any possible or reasonable chance to drink it is as unlikely as an assumption that the shallow aquifer is ingested. Therefore, no ingestion was considered credible or representative of current practice.

While highly improbable, it is assumed that an inadvertent industrial intruder driller uses a mud rotary system (which is common in the Clive area) to drill a well (similar in physical characteristics to that proposed in 2005) 90 feet from the design toe of the DU waste within the Federal Cell. For the purposed of this analysis, it is assumed that this occurs sometime after site closure/ institutional control. As is justified in the response to Interrogatory CR R313-25-20-92/2: Inadvertent Intruder Dose Standard and Scenarios, all exposure scenarios (whether acute or chronic) are subject to a dose limit of 500 mrem/year.

These are the known uses of groundwater in the valley. Since this scenario considers direct application of contaminated water onto a broad industrial land surface as dust suppression, any resulting external exposure pathway bounds that of a volumetrically-limited imaginary R/O brine impoundment (as included in the Division's interrogatory basis). In fact, the current users use R/O to treat groundwater pulled from the mountain front, which has much lower TDS (yet, still requires R/O treatment) and a higher yield. These current users are also several miles upgradient of Energy*Solutions'* proposed Federal Cell and will not be impacted by its construction and operation. Envirocare's 2005 analysis modeled what Envirocare intended to do, which was to install a deep well near the licensed area (also upgradient) for direct use in dust control.

Finally, it is important to note that Energy*Solutions* (even in support of its 2005 analysis) has never considered the use of an R/O system down-gradient of its licensed areas. This is because the poor native groundwater condition (i.e., extremely high TDS) downgradient of Energy*Solutions'* licensed areas prevents effective use of R/O systems. In fact, the reason the only R/O system currently in use in that valley is located at the foothills – is that the TDS for the groundwater from that foothill location is approximately half that naturally beneath Energy*Solutions'* embankments. R/O systems will not work effectively on groundwater with TDS levels significantly higher than those at Aragonite.

<u>ACUTE INADVERTENT WELL DRILLER INTRUDER SCENARIO DEFINITION</u>: A distinct acute exposure scenario to an inadvertent intruder considered in this analysis is referred to as the "*acute well drilling scenario*". The acute well drilling scenario is based on the assumption that after active institutional control ceases, an intruder drills a well within the licensed buffer zone (90 feet from the toe of the disposed depleted uranium). The acute well drilling scenario considers exposures during the short period of time required for

drilling and construction of the well. During well drilling, the following relevant exposure pathways are assumed:

- External exposure photon-emitting radionuclides in the unshielded cuttings pile containing waste, and
- Inhalation of radionuclides suspended in air from the uncovered cuttings pile containing waste.

The importance of the acute well drilling scenario arises primarily from the assumption that an inadvertent intruder could be located near an unshielded cutting pile for a substantial period of time. Probabilistic isotopic concentrations in the unconfined aquifer (as projected in version 1.2 of the Modeling Report) are used to calculate the associated acute well drilling scenario isotopic dose [$D_{wd}(i,t)$] for each isotope, i, at the unique time, t, corresponding to that isotopic concentration in the unconfined aquifer.

$$D_{wd}(i,t) = DC_{wd}(i) \times C_{pit}(i,t)$$

where

$D_{wd}(i,t)$	=	The acute dose to the well driller for isotope, i, at the time of its peak shallow aquifer concentration (as projected in version 1.2 of the Modeling Report), (mrem/year).
$DC_{wd}(i)$	=	Acute well drilling scenario dose coefficient for radionuclide, i, (mrem/year per uCi/m^3).
$C_{shallow}(i,t)$	=	Isotopic, i, concentration of the waste in the shallow aquifer, (uCi/m^3).

The acute well drilling scenario dose coefficient for isotope, i, [$DC_{wd}(i)$] is estimated by summing the exposure pathway dose coefficients:

$$DC_{wd}(i) = DC_{ext}(i) + DC_{inh}(i)$$

where

$DC_{ext}(i)$	=	Acute well drilling scenario external exposure dose coefficient for radionuclide, i, (mrem/year per uCi/m^3).

$DC_{inh}(i)$	=	Acute well drilling scenario inhalation exposure dose coefficient for radionuclide, *i*, (mrem/year per uCi/m^3).

The acute well drilling external exposure dose coefficient for isotope, *i*, [$DC_{ext}(i)$] is estimated by:

$$DC_{ext}(i) = f_c \times U_y(wd) \times DCF_{ie15}$$

where

f_c	=	Dilution factor for mixture of upper aquifer waste water, deep aquifer clean water, geologic cuttings, and well drilling mud, (unitless).
$U_y(wd)$	=	Fraction of a year well driller is exposed to cuttings and mud management pit while drilling the well, (unitless).
DCF_{ie15}	=	Dose conversion factor for external exposure to 15 cm of soil and mud uniformly contaminated with radionuclide, *i*, (mrem/year per uCi/m^3).

The acute well drilling inhalation exposure dose coefficient for isotope, *i*, [$DC_{inh}(i)$] is estimated by:

$$DC_{inh}(i) = \left(\frac{f_c \times U_y(wd) \times I_{aw} \times L_a(wd) \times DCF_{inh}}{\rho_{mud}} \right)$$

where

I_{aw}	=	Annual air intake for driller (m^3/year)
$L_a(wd)$	=	Air mass loading during drilling (kg/m^3)
DCF_{inh}	=	Dose conversion factor for inhalation of radionuclide, *i*, (mrem per uCi).
ρ_{mud}	=	Average bulk density of geologic cuttings (kg/m^3)

The dilution factor, f_c, that accounts for the mixture of upper aquifer waste water, deep aquifer clean water, geologic cuttings, and well drilling mud is computed as:

$$f_c = \left(\frac{V_{shallow}}{V_{shallow} + V_{deep} + V_{mud} + V_{cuttings}}\right)$$

where

$V_{shallow}$	=	Volume of contaminated water from the shallow aquifer brought up as part of the well excavation process, (m^3).
V_{deep}	=	Volume of clean water from the deep aquifer brought up as part of the well excavation process, (m^3).
V_{mud}	=	Volume of drill mud used up as part of the well excavation process, (m^3).
$V_{cuttings}$	=	Volume of drill cuttings excavated from the well drilling process, (m^3).

The volume of drill cuttings, $V_{cuttings}$, brought up as part of the excavation process is computed as:

$$V_{cuttings} = \pi z_{excavation}\left(\frac{DIA_{excavation}}{2}\right)^2$$

where

$z_{excavation}$	=	Total depth of excavation, (m).
$DIA_{excavation}$	=	Total diameter of excavation, (m).

The volume of water from the confined aquifer, V_{deep}, brought up as part of the excavation process (assumed to be from the region of 2 times the excavation diameter) is computed as:

$$V_{deep} = \pi n_{deep} z_{deep} (DIA_{excavation})^2$$

where

z_{deep}	=	Depth of excavation in unit 1 (deep aquifer hosting zone), (m).

n_{deep} = Effective porosity of unit 1 (deep aquifer hosting zone), (unitless).

The volume of water from the unconfined aquifer, $V_{shallow}$, brought up as part of the excavation process (assumed to be from the region of 2 times the excavation diameter) is computed as:

$$V_{shallow} = \pi(n_{uncon}z_4 + n_{uncon}z_3)(DIA_{excavation})^2$$

where

z_4 = Thickness of excavation in unit 4 between water table and lower layer boundary (unconfined aquifer hosting zone), (m).

z_3 = Thickness of unit 3, (m).

n_{uncon} = Effective porosity of unconfined aquifer, (unitless).

CHRONIC INADVERTENT INDUSTRIAL INTRUDER SCENARIO DEFINITION: A distinct chronic exposure scenario to an inadvertent intruder considered in this analysis is referred to as the chronic post- drilling scenario. The chronic post- drilling scenario is based on the assumption that after active institutional control ceases, an inadvertent intruder who works near the Federal Cell, uses water produced from the intruder well for industrial purposes (such as dust suppression). While it is recognized that this industrial individual did not conduct activities that actually intruded into the waste, it is assumed that any associated industrial activities are conducted within the buffer area. Additionally, it is assumed that the industrial intruder is unaware of any possible depleted uranium-related contaminants that may have leached into the unconfined aquifer. Under this condition, NRC still characterizes the inadvertent industrial user as an inadvertent intruder, since:

> "*Finally, the disruptive actions of an inadvertent intruder do not need to be considered when assessing releases of radioactivity offsite* [that may result in subsequent exposure to members of the general public]." (NUREG-1573, pg. 3-11).

The following relevant exposure pathways involving the contaminated material sprayed onto the surface are then assumed to occur:

- External exposure photon-emitting radionuclides in the unshielded surface-sprayed wastewater, and

- Inhalation of radionuclides suspended in air from the unshielded surface-sprayed wastewater.

The importance of the chronic post-drilling scenario arises primarily from the assumption that an intruder could inadvertently use contaminated water for dust suppression for a substantial period of time. It is assumed that water extracted from the production well consists of contaminated wastewater from the unconfined aquifer (not within the well screen depth) that has leaked down into the uncontaminated deep aquifer (where the well casing is screened). The chronic post-drilling scenario isotopic dose [$D_{pd}(i,t)$] is estimated for each isotope, i, at its unique time of peak concentration, t, in the unconfined aquifer.

$$D_{pd}(i,t) = DC_{pd}(i) \times C_{shallow}(i,t)$$

where

$D_{pd}(i,t)$	=	The chronic dose to the post driller for isotope, i, at the time of its peak shallow aquifer concentration (as projected in version 1.2 of the Modeling Report), (mrem/year).
$DC_{pd}(i)$	=	Chronic post-drilling scenario dose coefficient for radionuclide, i, (mrem/year per uCi/m^3).

The chronic post-drilling scenario dose coefficient for isotope, i, [$DC_{pd}(i)$] is estimated by summing the exposure pathway dose coefficients:

$$DC_{pd}(i) = DC_{pd\text{-}ext}(i) + DC_{pd\text{-}inh}(i)$$

where

$DC_{pd\text{-}ext}(i)$	=	Chronic post-drilling scenario external exposure dose coefficient for radionuclide, i, (mrem/year per uCi/m^3).
$DC_{pd\text{-}inh}(i)$	=	Chronic post-drilling scenario inhalation exposure dose coefficient for radionuclide, i, (mrem/year per uCi/m^3).

The chronic post-drilling scenario external exposure dose coefficient for isotope, i, [$DC_{pd\text{-}ext}(i)$] is estimated by:

$$DC_{pd\text{-}ext}(i) = f_{pdc} \text{ x } U_y(pd) \text{ x } DCF_{ie15}$$

where

f_{pdc}	=	Dilution factor for mixture of upper aquifer waste water and deep aquifer clean water, (unitless).
$U_y(pd)$	=	Fraction of a year inadvertent industrial worker is exposed to ground surface contaminated by dust suppression spray, (unitless).

The chronic post-drilling inhalation exposure dose coefficient for isotope, i, [$DC_{pd\text{-}inh}(i)$] is estimated by:

$$DC_{pd-inh}(i) = \left(\frac{f_{pdc} \text{ x } U_y(pd) \text{ x } I_{aw} \text{ x } L_a(wd) \text{ x } DCF_{inh}}{\rho_s}\right)$$

where

ρ_s	=	Average bulk density of surface soils (kg/m^3)

The well water dilution factor, f_{pdc}, that accounts for the mixture of upper aquifer waste water that has been allowed to leak downward into the confined aquifer and the deep aquifer clean water is computed as:

$$f_{pdc} = \left(\frac{Q_{shallow}}{Q_{produced}}\right)$$

where

$Q_{shallow}$	=	Shallow aquifer water downward leakage rate, (m^3/year).
$Q_{produced}$	=	Total rate of water produced from the well (including from the deep, confined aquifer and any water leaked from the upper confined aquifer) for industrial uses, (m^3/year).

The volume of contaminated wastewater transported from the upper unconfined aquifer, through the leaking well casing, and downward to the deep, confined aquifer, $Q_{shallow}$, is computed using the Thiem-Dupuit's method (Freeze, R.A. and J.A. Cherry, 1979) as the volume of water producible from the unconfined aquifer, under steady-state pumping, that would result in the localized waste table drop (i.e., cone of depression), projected in Envirocare (2005), as:

$$Q_{shallow} = 2\pi K_{shallow} D \left(\frac{s'_{m1} - s'_{m2}}{ln(^{r_2}/_{r_1})} \right)$$

where the parameters are illustrated in the following:

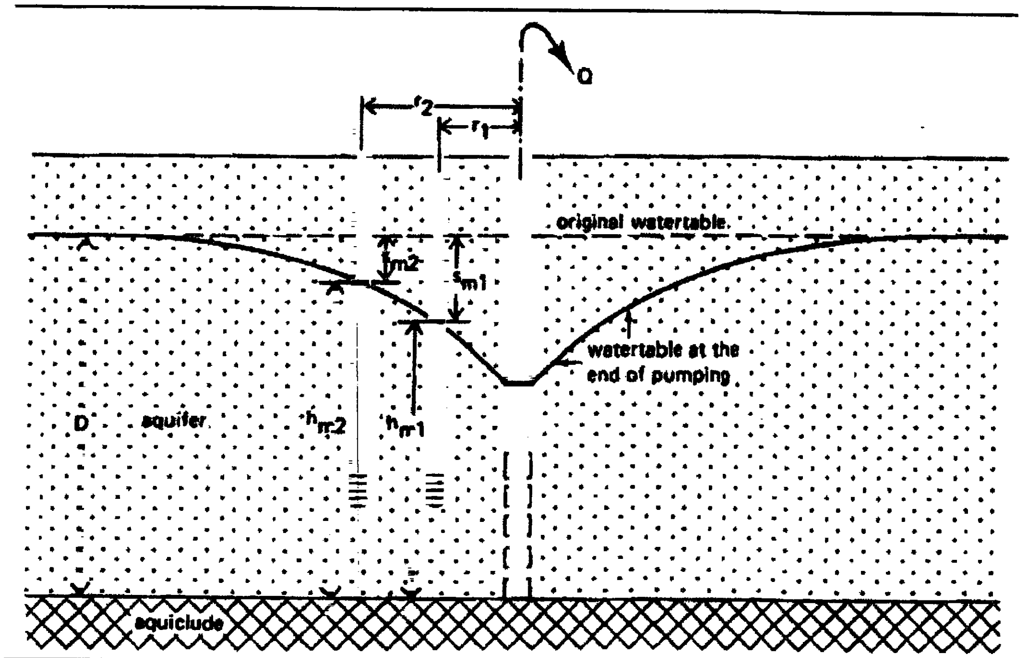

Figure - Thiem-Dupuit's method scenario parameter layout

INADVERTENT INTRUDER WELL DOSE CALCULATIONS:

Doses in the inadvertent intruder groundwater analysis were estimated by using the isotopic concentrations projected in the upper unconfined aquifer in version 1.2 of the Modeling Report and well characteristics similar to that proposed in Envirocare (2005). For each exposure pathway in a scenario of interest, an effective dose equivalent (EDE) in mrem/year for each isotope of interest is calculated.

TABLE – Inadvertent Intruder Well Model Input Parameters

INPUT PARAMETER	DESCRIPTION	VALUE	UNIT	REFERENCE
$Q_{produced}$	Total rate of water produced from the well (including from the deep, confined aquifer and any water leaked from the upper confined aquifer) for industrial uses	1.33E+05	m^3/year	Envirocare, 2005
z_{deep}	Depth of excavation in unit 1 (deep aquifer hosting zone)	1.71E+02	m	Envirocare, 2005
n_{deep}	Effective porosity of unit 1 (deep aquifer hosting zone)	1.30E-01	unitless	Envirocare, 2005
$U_y(wd)$	Fraction of a year well driller is exposed to cuttings and mud management pit while drilling the well	4.57E-03	unitless	EPA, 2011
I_{aw}	Annual air intake for driller	2.19E+04	m^3/year	EPA, 2011
$L_a(wd)$	Air mass loading during drilling	1.00E-06	kg/m^3	EPA, 2011
ρ_{mud}	Average bulk density of geologic cuttings	1.00E+03	kg/m^3	Envirocare, 2005
$z_{excavation}$	Total depth of excavation	1.83E+02	m	Envirocare, 2005
$DIA_{excavation}$	Total diameter of excavation	2.41E-01	m	Envirocare, 2005
z_4	Average thickness of unit 4	3.05E+00	m	Envirocare, 2005
z_3	Average thickness of unit 3	4.57E+00	m	Envirocare, 2005
n_{uncon}	Effective porosity of saturated regions of units 4 and 3	2.90E-01	unitless	Envirocare, 2005
$U_y(pd)$	Fraction of a year inadvertent industrial worker is exposed to ground surface contaminated by dust suppression spray	2.28E-01	unitless	EPA, 2011
ρ_s	Average bulk density of surface soils	1.60E+03	kg/m^3	Envirocare, 2005
D_{wt}	Average depth from ground surface to unconfined aquifer (water table)	5.18E+00	m	Envirocare, 2005
D	Average thickness of unconfined aquifer	6.10E+00	m	Envirocare, 2005
$K_{shallow}$	Effective hydraulic Conductivity of saturated regions of units 4 and 3	1.06E+02	m/yr	Envirocare, 2005
r_1	Radial distance to 1st unconfined aquifer drawdown reading	9.14E+02	m	Envirocare, 2005
r_2	Radial distance to 2nd unconfined aquifer drawdown reading	2.13E+03	m	Envirocare, 2005
s'_1	Steady-state draw down in unconfined aquifer at 1st location	2.13E-01	m	Envirocare, 2005
s'_2	Steady-state draw down in unconfined aquifer at 2nd location	1.22E-01	m	Envirocare, 2005

INPUT PARAMETER	DESCRIPTION	VALUE	UNIT	REFERENCE
V_{mud}	Volume of drilling mud	1.69E+02	m^3	Fleming, et. al 2012
Sr-90	Peak unconfined shallow aquifer concentration - mean	0.00E+00	uCi/m^3	Table 2 Modeling Report (v1.2)
Tc-99	Peak unconfined shallow aquifer concentration - mean	7.40E-01	uCi/m^3	Table 2 Modeling Report (v1.2)
I-129	Peak unconfined shallow aquifer concentration - mean	4.82E-04	uCi/m^3	Table 2 Modeling Report (v1.2)
Th-230	Peak unconfined shallow aquifer concentration - mean	1.85E-29	uCi/m^3	Table 2 Modeling Report (v1.2)
Th-232	Peak unconfined shallow aquifer concentration - mean	1.44E-35	uCi/m^3	Table 2 Modeling Report (v1.2)
Np-237	Peak unconfined shallow aquifer concentration - mean	9.75E-21	uCi/m^3	Table 2 Modeling Report (v1.2)
U-233	Peak unconfined shallow aquifer concentration - mean	3.86E-25	uCi/m^3	Table 2 Modeling Report (v1.2)
U-234	Peak unconfined shallow aquifer concentration - mean	1.51E-24	uCi/m^3	Table 2 Modeling Report (v1.2)
U-235	Peak unconfined shallow aquifer concentration - mean	1.10E-25	uCi/m^3	Table 2 Modeling Report (v1.2)
U-236	Peak unconfined shallow aquifer concentration - mean	2.24E-25	uCi/m^3	Table 2 Modeling Report (v1.2)
U-238	Peak unconfined shallow aquifer concentration - mean	1.12E-23	uCi/m^3	Table 2 Modeling Report (v1.2)
Sr-90	Peak unconfined shallow aquifer concentration - median	0.00E+00	uCi/m^3	Table 2 Modeling Report (v1.2)
Tc-99	Peak unconfined shallow aquifer concentration - median	1.95E-02	uCi/m^3	Table 2 Modeling Report (v1.2)
I-129	Peak unconfined shallow aquifer concentration - median	6.76E-10	uCi/m^3	Table 2 Modeling Report (v1.2)
Th-230	Peak unconfined shallow aquifer concentration - median	0.00E+00	uCi/m^3	Table 2 Modeling Report (v1.2)
Th-232	Peak unconfined shallow aquifer concentration - median	0.00E+00	uCi/m^3	Table 2 Modeling Report (v1.2)

INPUT PARAMETER	DESCRIPTION	VALUE	UNIT	REFERENCE
Np-237	Peak unconfined shallow aquifer concentration - median	0.00E+00	uCi/m^3	Table 2 Modeling Report (v1.2)
U-233	Peak unconfined shallow aquifer concentration - median	0.00E+00	uCi/m^3	Table 2 Modeling Report (v1.2)
U-234	Peak unconfined shallow aquifer concentration - median	0.00E+00	uCi/m^3	Table 2 Modeling Report (v1.2)
U-235	Peak unconfined shallow aquifer concentration - median	0.00E+00	uCi/m^3	Table 2 Modeling Report (v1.2)
U-236	Peak unconfined shallow aquifer concentration - median	0.00E+00	uCi/m^3	Table 2 Modeling Report (v1.2)
U-238	Peak unconfined shallow aquifer concentration - median	2.21E-39	uCi/m^3	Table 2 Modeling Report (v1.2)
Sr-90	Peak unconfined shallow aquifer concentration - 95th %ile	0.00E+00	uCi/m^3	Table 2 Modeling Report (v1.2)
Tc-99	Peak unconfined shallow aquifer concentration - 95th %ile	4.46E+00	uCi/m^3	Table 2 Modeling Report (v1.2)
I-129	Peak unconfined shallow aquifer concentration - 95th %ile	3.39E-03	uCi/m^3	Table 2 Modeling Report (v1.2)
Th-230	Peak unconfined shallow aquifer concentration - 95th %ile	3.35E-34	uCi/m^3	Table 2 Modeling Report (v1.2)
Th-232	Peak unconfined shallow aquifer concentration - 95th %ile	2.09E-40	uCi/m^3	Table 2 Modeling Report (v1.2)
Np-237	Peak unconfined shallow aquifer concentration - 95th %ile	1.32E-27	uCi/m^3	Table 2 Modeling Report (v1.2)
U-233	Peak unconfined shallow aquifer concentration - 95th %ile	1.00E-28	uCi/m^3	Table 2 Modeling Report (v1.2)
U-234	Peak unconfined shallow aquifer concentration - 95th %ile	8.10E-29	uCi/m^3	Table 2 Modeling Report (v1.2)
U-235	Peak unconfined shallow aquifer concentration - 95th %ile	6.77E-30	uCi/m^3	Table 2 Modeling Report (v1.2)
U-236	Peak unconfined shallow aquifer concentration - 95th %ile	1.08E-29	uCi/m^3	Table 2 Modeling Report (v1.2)

INPUT PARAMETER	DESCRIPTION	VALUE	UNIT	REFERENCE
U-238	Peak unconfined shallow aquifer concentration - 95th %ile	6.35E-28	uCi/m^3	Table 2 Modeling Report (v1.2)
Sr-90	Mean Dose Conversion Factor (inhalation)	5.92E+02	mrem per uCi	Appendix 11, Modeling Report (v1.2)
Tc-99	Mean Dose Conversion Factor (inhalation)	4.81E+01	mrem per uCi	Appendix 11, Modeling Report (v1.2)
I-129	Mean Dose Conversion Factor (inhalation)	3.55E+02	mrem per uCi	Appendix 11, Modeling Report (v1.2)
Th-230	Mean Dose Conversion Factor (inhalation)	3.70E+05	mrem per uCi	Appendix 11, Modeling Report (v1.2)
Th-232	Mean Dose Conversion Factor (inhalation)	4.07E+05	mrem per uCi	Appendix 11, Modeling Report (v1.2)
Np-237	Mean Dose Conversion Factor (inhalation)	1.85E+05	mrem per uCi	Appendix 11, Modeling Report (v1.2)
U-233	Mean Dose Conversion Factor (inhalation)	3.55E+04	mrem per uCi	Appendix 11, Modeling Report (v1.2)
U-234	Mean Dose Conversion Factor (inhalation)	3.48E+04	mrem per uCi	Appendix 11, Modeling Report (v1.2)
U-235	Mean Dose Conversion Factor (inhalation)	3.15E+04	mrem per uCi	Appendix 11, Modeling Report (v1.2)
U-236	Mean Dose Conversion Factor (inhalation)	3.22E+04	mrem per uCi	Appendix 11, Modeling Report (v1.2)
U-238	Mean Dose Conversion Factor (inhalation)	2.96E+04	mrem per uCi	Appendix 11, Modeling Report (v1.2)
Sr-90	Mean Dose Conversion Factor ext - 15cm)	4.40E-04	mrem/year per uCi/m^3	Appendix 11, Modeling Report (v1.2)
Tc-99	Mean Dose Conversion Factor ext - 15cm)	7.84E-05	mrem/year per uCi/m^3	Appendix 11, Modeling Report (v1.2)
I-129	Mean Dose Conversion Factor ext - 15cm)	8.09E-03	mrem/year per uCi/m^3	Appendix 11, Modeling Report (v1.2)
Th-230	Mean Dose Conversion Factor ext - 15cm)	7.56E-04	mrem/year per uCi/m^3	Appendix 11, Modeling Report (v1.2)
Th-232	Mean Dose Conversion Factor ext - 15cm)	3.26E-04	mrem/year per	Appendix 11, Modeling

INPUT PARAMETER	DESCRIPTION	VALUE	UNIT	REFERENCE
			uCi/m^3	Report (v1.2)
Np-237	Mean Dose Conversion Factor ext - 15cm)	4.87E-02	mrem/year per uCi/m^3	Appendix 11, Modeling Report (v1.2)
U-233	Mean Dose Conversion Factor ext - 15cm)	8.73E-04	mrem/year per uCi/m^3	Appendix 11, Modeling Report (v1.2)
U-234	Mean Dose Conversion Factor ext - 15cm)	2.51E-04	mrem/year per uCi/m^3	Appendix 11, Modeling Report (v1.2)
U-235	Mean Dose Conversion Factor ext - 15cm)	4.51E-01	mrem/year per uCi/m^3	Appendix 11, Modeling Report (v1.2)
U-236	Mean Dose Conversion Factor ext - 15cm)	1.34E-04	mrem/year per uCi/m^3	Appendix 11, Modeling Report (v1.2)
U-238	Mean Dose Conversion Factor ext - 15cm)	6.44E-05	mrem/year per uCi/m^3	Appendix 11, Modeling Report (v1.2)

Using these input parameters, there are several factors (independent of isotope) that are calculated according to the approach summarized above.

TABLE – Inadvertent Intruder Well Model Calculated Parameters

CALCULATED PARAMETER	DESCRIPTION	VALUE	UNIT
$Q_{shallow}$	Shallow aquifer water downward leakage rate	4.37E+02	m^3/year
f_{pdc}	Dilution factor for mixture of upper aquifer waste water and deep aquifer clean water	3.28E-03	unitless
$V_{shallow}$	Volume of contaminated water from the shallow aquifer brought up as part of the well excavation process	4.04E-01	m^3
V_{deep}	Volume of clean water from the deep aquifer brought up as part of the well excavation process	4.06E+00	m^3
$V_{cuttings}$	Volume of drill cuttings excavated from the well drilling process	8.36E+00	m^3
f_c	Mud driller dilution factor	2.22E-03	unitless
$DC_{inh}(i)$ / DCF_{inh}	Intermediate ratio (isotope independent)	2.22E-10	m^3/year
$DC_{ext}(i)$ / DCF_{ie15}	Intermediate ratio (isotope independent)	1.02E-05	m^3/year
$DC_{pd\text{-}inh}(i)$ / DCF_{inh}	Intermediate ratio (isotope independent)	1.03E-08	m^3/year
$DC_{pd\text{-}ext}(i)$ / DCF_{ie15}	Intermediate ratio (isotope independent)	7.50E-04	m^3/year

These calculated factors can then be used to estimate inadvertent intruder well doses from isotopic unconfined aquifer concentrations projected in version 1.2 of the Modeling Report. As such, isotopic doses are to the acute Intruder Driller from unconfined shallow aquifer concentrations output from version 1.2 of the Modeling Report as calculated below.

TABLE – Acute Well Driller Isotopic Doses

ISOTOPE	ACUTE DOSE FROM MEAN SHALLOW AQUIFER CONCENTRATION (mrem/year)	ACUTE DOSE FROM MEDIAN SHALLOW AQUIFER CONCENTRATION (mrem/year)	ACUTE DOSE FROM 95% ILE SHALLOW AQUIFER CONCENTRATION (mrem/year)
Sr-90	0.00E+00	0.00E+00	0.00E+00
Tc-99	8.51E-09	2.24E-10	5.13E-08
I-129	7.77E-11	1.09E-16	5.47E-10
Th-230	1.52E-33	0.00E+00	2.76E-38
Th-232	1.30E-39	0.00E+00	1.89E-44
Np-237	4.06E-25	0.00E+00	5.50E-32
U-233	3.05E-30	0.00E+00	7.91E-34
U-234	1.17E-29	0.00E+00	6.27E-34
U-235	1.27E-30	0.00E+00	7.84E-35
U-236	1.60E-30	0.00E+00	7.74E-35
U-238	7.38E-29	1.46E-44	4.18E-33

Since the version 1.2 Model Report-projected isotopic mean, median, and 95-percentile concentrations do not occur at the same point in time, it is inappropriate to estimate a total effective dose equivalent by summing over all isotopes. However, doing so does create a bounding estimate, above which the total dose estimated to the acute well driller will not exceed (upper dose limit from mean shallow aquifer concentrations = 8.6E-09 mrem/year, upper dose limit from median shallow aquifer concentrations = 2.2E-10 mrem/year, and upper dose limit from 95-percentile shallow aquifer concentrations = 5.2E-08 mrem/year), all of which are significantly lower than the 500 mrem/year intruder limit.

Application of the calculated factors can also be used to estimate isotopic doses to the chronic Industrial Intruder from isotopic unconfined aquifer concentrations projected in version 1.2 of the Modeling Report.

TABLE – Chronic Well User Isotopic Doses

ISOTOPE	CHRONIC DOSE FROM MEAN SHALLOW AQUIFER CONCENTRATION (mrem/year)	CHRONIC DOSE FROM MEDIAN SHALLOW AQUIFER CONCENTRATION (mrem/year)	CHRONIC DOSE FROM 95% ILE SHALLOW AQUIFER CONCENTRATION (mrem/year)
Sr-90	0.00E+00	0.00E+00	0.00E+00
Tc-99	4.09E-07	1.08E-08	2.46E-06
I-129	4.68E-09	6.56E-15	3.29E-08
Th-230	7.02E-32	0.00E+00	1.27E-36
Th-232	6.01E-38	0.00E+00	8.73E-43
Np-237	1.89E-23	0.00E+00	2.55E-30
U-233	1.41E-28	0.00E+00	3.65E-32
U-234	5.39E-28	0.00E+00	2.89E-32
U-235	7.26E-29	0.00E+00	4.47E-33
U-236	7.40E-29	0.00E+00	3.57E-33
U-238	3.40E-27	6.71E-43	1.93E-31

Since the version 1.2 Model Report-projected isotopic mean, median, and 95-percentile concentrations do not occur at the same point in time, it is inappropriate to estimate a total effective dose equivalent by summing over all isotopes. However, doing so does create a bounding estimate, above which the total dose estimated to the chronic inadvertent industrial well user will not exceed (upper dose limit from mean shallow aquifer concentrations = 4.2E-07 mrem/year, upper dose limit from median shallow aquifer concentrations = 1.1E-08 mrem/year, and upper dose limit from 95-percentile shallow aquifer concentrations = 2.6E-06 mrem/year), all of which are significantly lower than the 500 mrem/year intruder limit.

By using this same methodology and setting the dose to the inadvertent chronic industrial well user at 500 mrem/year, upper bounding equivalent depleted uranium isotopic concentrations can be reverse-calculated for SRS waste, assuming only the SRS depleted uranium wastes were disposed of in the Federal Cell (as are reported in Table 5 and 6 of Appendix 4 from version 1.2 of the Modeling Report).

TABLE – SRS Depleted Uranium Concentrations Equivalent to 500 mrem/year Chronic Well Isotopic Doses

ISOTOPE	ACTUAL MEAN SRS ACTIVITY FROM TABLES 5 AND 6 OF APPENDIX 4 (pCi/g)	NECESSARY SRS ACTIVITY TO CREATE AN ISOTOPIC-SPECIFIC 500 MREM/YEAR CHRONIC DOSE TO THE INADVERTENT INDUSTRIAL WELL USER (pCi/g)
Sr-90	47	5.69E+10
Tc-99	23800	2.88E+13
I-129	18.6	2.25E+10
Np-237	5.68	6.87E+09
U-233	478	5.78E+11
U-234	2170	2.62E+12
U-235	750	9.07E+11
U-236	1170	1.42E+12
U-238	6640	8.03E+12

When compared to the doses projected in Appendix 11 – Dose Assessment from version 1.2 of the Modeling Report, it is clear that doses from neither the proposed acute well driller inadvertent intruder nor the chronic industrial well user inadvertent intruder limit the analysis.

See also the response to Interrogatories CR R313-25-8(4)(B)-07/2: APPLICABILITY OF NRC HUMAN INTRUSION SCENARIOS.

Please contact me or Sean McCandless at 801-649-2000 if there are any comments or questions regarding this submittal.

Sincerely,

Vern C. Rogers
Environmental Manager

cc Rusty Lundberg, DRC
Don Verbica, DSHW
Enclosures

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.