URANIUM AND URANIUM PROGENY IN GROUNDWATER ASSOCIATED WITH URANIUM ORE BEARING FORMATIONS

Mark S. Pelizza, P.G.
Matt Hartmann, P.G.

Uranium Resources, Inc.
Centennial, Colorado
URANIUM - A NATURALLY OCCURRING RADIOACTIVE ELEMENT

• Geoscientists have historically sampled and analyzed groundwater for uranium from existing springs and wells as a exploration method.

• In 1973 the Atomic Energy Commission initiated the National Uranium Resource Evaluation (NURE) program to identify uranium resources in the United States.

• NURE investigators systematically sampled and analyzed groundwater across the United States to determine the presence and levels of uranium.

• Analysis of the NURE data shows where uranium is found above EPA’s MCLs in aquifers in the US.
Historic Water Wells Showing Uranium Above the EPA Standard

Legend
- Sampled Uranium Levels over 30 μg/L
- Sample Date (1975-1980)
- State Borders

- Montana 1,166 wells
- South Dakota 204 wells
- Wyoming 74 wells
- Idaho 4 wells
- Nebraska 171 wells
- Colorado 161 wells
- Kansas 71 wells
- New Mexico 126 wells
- Oklahoma 195
- Texas 435 wells
- Utah
- Nevada
- California 1 well
- Arizona 4 wells
- Mexico


Published April 19, 2000 by NURE West
IN SITU URANIUM RECOVERY “ISR”

- Uranium recovery via ISR has been widely practiced in the United States for about 40 years.

- ISR is conducted in aquifers.

- ISR is post NEPA; even early operations were regulated.

- A large amount of baseline ground water quality data is required before mining can begin which must be provided to regulatory agencies.

- This groundwater data is available and provides good documentation of background water quality at ISR facilities.
NURE West w/ISR facilities
NURE Texas w/ISR facilities
BACKGROUND SAMPLING PROTOCOL

• Baseline wells are completed in the mineralized sand within the production area or mine unit.

• Generally regulatory agencies require at least of five baseline wells or one baseline well for every four acres of production area which ever is more.

• ISR operators often obtain more samples than are required by regulatory agencies.

• Many operators take multiple (seasonal) samples per well.

• Samples are collected, preserved and controlled according to accepted methods using outside labs.

• Data from these multiple baseline wells samples are averaged for each production area or mine unit to establish background for restoration purposes.
**Pre-Mining Uranium and U Related Elements in ISL Wellfields**

(highlighted where the drinking MCL is exceeded)

<table>
<thead>
<tr>
<th>State:</th>
<th>Wyoming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mine:</td>
<td>Nichols Ranch</td>
</tr>
<tr>
<td>Wellfield Designation:</td>
<td>PA#1</td>
</tr>
<tr>
<td>Number of Wells Sampled:</td>
<td>52 (PA#1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>High Value</th>
<th>Average</th>
<th>MCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uranium (ug/l)</td>
<td>136</td>
<td>31.7</td>
<td>30</td>
</tr>
<tr>
<td>Radium (pCi/l)</td>
<td>254</td>
<td>56.4</td>
<td>5</td>
</tr>
<tr>
<td>Radon (pCi/l)</td>
<td>N/A</td>
<td>N/A</td>
<td>300</td>
</tr>
<tr>
<td>G. Alpha Radiation (pCi/l)</td>
<td>1080</td>
<td>239</td>
<td>15</td>
</tr>
<tr>
<td>G. Beta Radiation (pCi/l)</td>
<td>706</td>
<td>170</td>
<td>50</td>
</tr>
</tbody>
</table>

**Production Area Baseline Wells**

<table>
<thead>
<tr>
<th>Element</th>
<th>High Value</th>
<th>Average</th>
<th>MCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uranium (ug/l)</td>
<td>34.4</td>
<td>12.9</td>
<td>30</td>
</tr>
<tr>
<td>Radium (pCi/l)</td>
<td>12.1</td>
<td>1.09</td>
<td>5</td>
</tr>
<tr>
<td>Radon (pCi/l)</td>
<td>N/A</td>
<td>N/A</td>
<td>300</td>
</tr>
<tr>
<td>G. Alpha Radiation (pCi/l)</td>
<td>90.2</td>
<td>21.05</td>
<td>15</td>
</tr>
<tr>
<td>G. Beta Radiation (pCi/l)</td>
<td>80.1</td>
<td>8.33</td>
<td>50</td>
</tr>
</tbody>
</table>

**Monitor Well Ring**

<table>
<thead>
<tr>
<th>Element</th>
<th>High Value</th>
<th>Average</th>
<th>MCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uranium (ug/l)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radium (pCi/l)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radon (pCi/l)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Alpha Radiation (pCi/l)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Beta Radiation (pCi/l)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Uranerz
BACKGROUND URANIUM AT ISRs

Average Uranium Exceeds 30 PPB MCL at 129 of 155 Mine Units
BACKGROUND RA-226 AT ISRs

Average Radium Exceeds 5 pCi/L MCL at 154 of 155 Mine Units

- Radium 226
- EPA MCL
BACKGROUND RN-222 AT ISRs

Average Radon Exceeds 300 pCiL at 9 of 9 Mine Units Tested

- Kingsville Dome
- Highland
- Mobil Southtrend
- Smith Ranch
- Vasquez
- Smith Ranch
- Smith Ranch
- Highland
- Highland

Radon

300 pCiL
BACKGROUND GROSS ALPHA AT ISRs

Average Gross Alpha Radiation Exceeds 15 pCi/L MCL at 7 of 7 Mine Units Tested

- Gross Alpha Radiation
- 15 pCi/L MCL
ISR COMPILATION SUMMARY

• Data compiled from 4 states, 48 mines 155 mine units show that none meet MCLs for uranium and/or radium-226 together.

• Average uranium exceeds 30 µg/L MCL in 129 of 155 mine units or by 83.2%.

• Average radium-226 exceeds 5 pCi/L MCL in 154 of 155 mine units or by 99.3 %.

• Average radon-222 exceeds 300 pCi/L in 9 of 9 mine units or by 100 %.

• Average gross α radiation exceeds 15 pCi/L MCL in 6 of 6 mine units or by 100 %.
AQUIFER EXEMPTION - 40CFR146.4

Results show that exempted aquifer criteria is well founded

A USDW may be determined to be an exempted aquifer if:

(a) It does not currently serve as a source of drinking water; and
(b) It cannot now and will not in the future serve as a source of drinking water because:

(1) It is mineral, hydrocarbon or geothermal energy producing, or can be demonstrated...as part of a permit application...that considering their quantity and location are expected to be commercially producible....

(3) It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption...
AQUIFER EXEMPTION
A Regulatory Consideration ISR or Not?

The mission of EPA is to protect human health and the environment.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>MCL†</th>
<th>Potential Health Effects from Ingestion of Water</th>
<th>Sources of Contaminant</th>
</tr>
</thead>
<tbody>
<tr>
<td>226Ra and 228Ra</td>
<td>5 pCi/L</td>
<td>Increased risk of cancer</td>
<td>Erosion of natural deposits</td>
</tr>
<tr>
<td>Uranium</td>
<td>0.03 mg/L</td>
<td>Increased risk of cancer, kidney toxicity</td>
<td>Erosion of natural deposits</td>
</tr>
<tr>
<td>Gross α Radiation</td>
<td>15 pCi/L</td>
<td>Increased risk of cancer</td>
<td>Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation</td>
</tr>
<tr>
<td>222Rn</td>
<td>300-4000 pCi/L</td>
<td>Increased risk of cancer</td>
<td>Radioactive decay of 226Ra and 228Ra</td>
</tr>
</tbody>
</table>