NEBRASKA

DEPT. OF ENVIRONMENTAL QUALITY

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10-015 November, 2016

Frequently Asked Questions About In-Situ Recovery Mining in Nebraska

A Sandhills Sunrise, Garden County, Nebraska

What is ISR mining and how does it work?

In-Situ Recovery (ISR) mining techniques, also called in-situ leach (ISL), can be used to extract uranium, sulfur, potash, salts, and metals such as gold and copper from underground ore bodies without the use of conventional open-pit mining techniques. The U.S. Nuclear Regulatory Commission (NRC) defines ISR uranium mining as a process using a leaching solution to extract uranium from underground ore bodies in place (in other words, in-situ). The leaching agent, called lixiviant, contains an oxidant such as oxygen with sodium bicarbonate (baking soda). The uranium in the aquifer is in an environment that lacks oxygen. This type of environment allows the uranium to be attached to the sand grains that compose the aquifer. The lixiviant is injected through wells into the ore body to bring oxygen into that environment. The solution causes the uranium to detach from the sand grains, and it can then be pumped out of the aquifer through a series of wells (Figure 1).

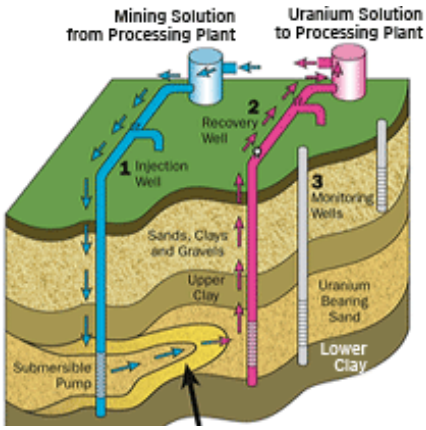


Figure 1. *In the in-situ recovery (ISR) process,* ***injection wells*** *(1) pump a chemical solution – typically sodium bicarbonate and oxygen – into the layer of earth containing uranium ore. The solution dissolves the uranium from the deposit in the ground, and is then pumped back to the surface through* ***recovery wells*** *(2) and sent to the processing plant to be converted into uranium yellowcake.* ***Monitoring wells*** *(3) are checked regularly to ensure that uranium and chemicals are not escaping from the mining area. From U.S. NRC. Accessed on the web 6/7/2010 http://www.nrc.gov/materials/uranium-recovery/extraction-methods/isl-recovery-facilities.html*

What is an aquifer?

An aquifer is a geologic formation, group of formations, or part of a formation that is capable of yielding usable amounts of water to a well, spring, or other point of discharge (Title 118, Ch. 1 §001). There are two basic types of aquifers: unconfined and confined. In unconfined aquifers, the groundwater only partially fills the aquifer and the upper surface of the groundwater (the water table) is free to rise and decline (Figure 2). A confined aquifer (Figure 2) is sandwiched between two confining beds (layers of impermeable materials such as clay which impede the movement of water into and out of the aquifer). Because of the confining beds, groundwater in these aquifers is under high pressure. The high pressure causes the water level in a well to rise to a level higher than the top of the confined aquifer. In the U.S., ISR mining oc

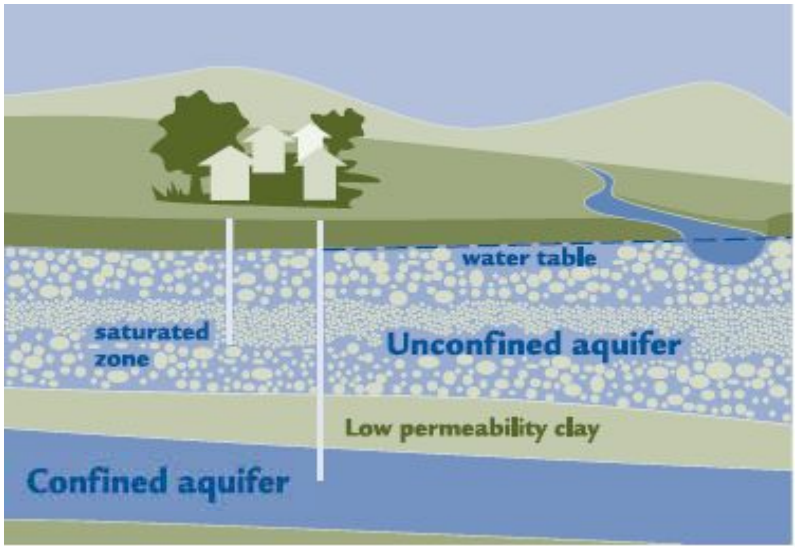


Figure 2. *Schematic of confined and unconfined aquifers. Accessed on the web 6/8/2010 (Modified from http://www.tol.ca/index.php?option=com_content&view=article&id=1063&Itemid=900)*

Where did the uranium in the aquifer cor

Uranium is one of the most abundant elements found in Earth's crust, and it can be found almost everywhere – from soils and rocks to rivers and oceans. It is slightly more abundant than tin and 40 times more abundant than silver. The table below gives an estimated concentration of uranium in different types of materials.

Granite	4 ppm Uranium
Sedimentary Rock	2 ppm Uranium
Average in Earth's continental crust	2.8 ppm Uranium
Seawater	0.013 ppm Uranium
*ppm = parts per million	

Source: World Nuclear Association

The uranium that is found in Nebraska was once part of volcanic ash in Wyoming, southern South Dakota, and western Nebraska. The ash was eroded by water and altered to clays. During this process, the uranium was released from the ash and incorporated into the groundwater. Over the course of thousands of years, the uranium traveled in groundwater through aquifers to a low oxygen zone. When the oxygen was depleted from the groundwater, the uranium attached to sand grains, creating what is called a roll-front deposit of uranium (Figure 3).

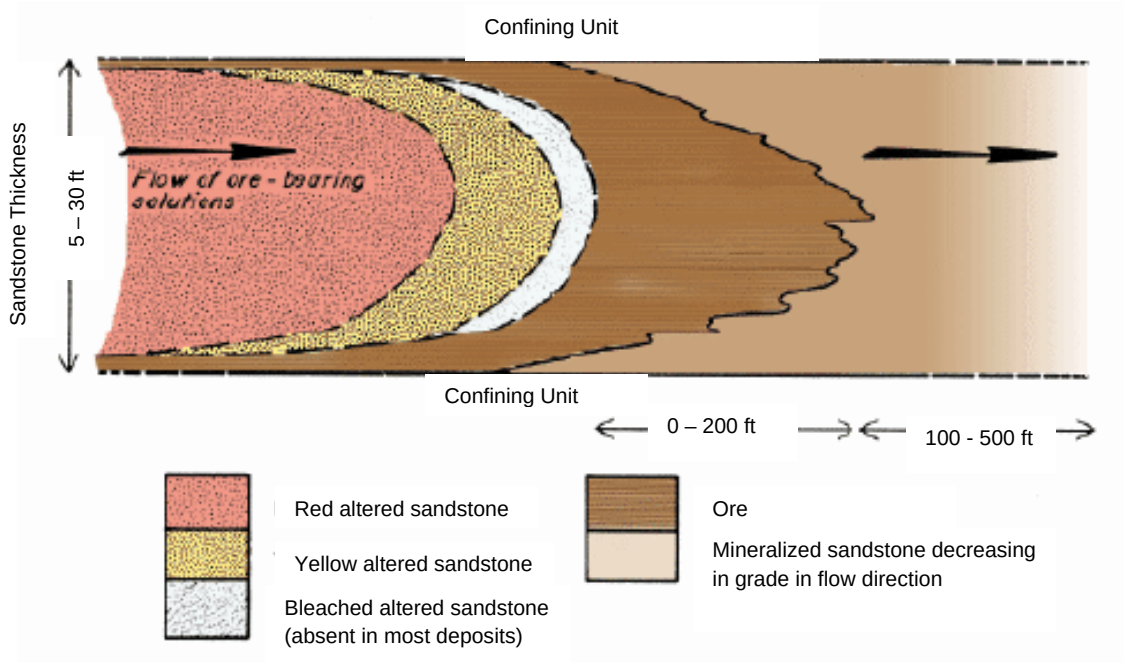


Figure 3. *Simplified diagram of roll-front uranium deposit. Modified from Heylmun, E.B. (2003), Roll-front Uranium Deposits, ICMJ Prospecting and Mining Journal. Accessed on the web 6/7/2010* *http://www.icmj2.com/03Oct/03OctFeature.htm*

Where can ISR uranium mining techniques be used?

The goal of the mining process is to remove uranium from the aquifer and bring it to the surface for processing. The mining fluids must be kept in a confined area to prevent contamination of

drinking water. Therefore, a confined aquifer is necessary to keep the fluids from migrating vertically. The facility must also demonstrate that it maintains hydraulic control on its wellfields to keep the mining fluids from migrating horizontally. To do this, facilities operate on a 1% - 2% "bleed"; that is, they are pumping out more fluid than they are injecting, so as to create a cone of depression around the mining area. A cone of depression is created when groundwater is pumped from an aquifer (Figure 4). Groundwater flow changes direction in a portion of the aquifer. Instead of moving in the natural direction of groundwater flow, water under the influence of the pumping well flows radially, toward the well from every direction. The pumping well creates an artificial discharge area by drawing down, or lowering, the water level around the well. This area of drawdown is called the cone of depression. In the cone of depression, radial flow ensures that water is flowing toward the mining area and not outside of the permitted boundary.

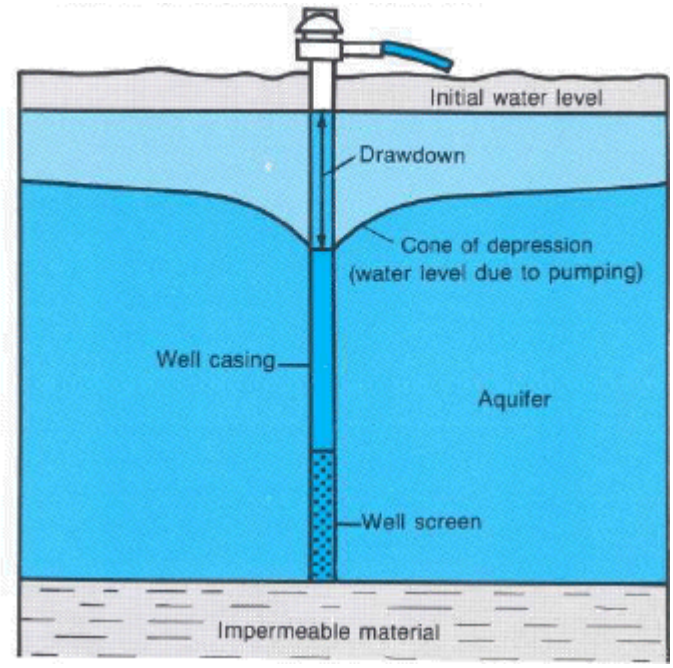


Figure 4. *Illustration of a cone of depression around a pumping well. From USGS. Accessed on the web 6/7/2010* *http://pubs.usgs.gov/gip/gw_ruralhomeowner/gw_ruralhomeowner_new.html*

How many ISR facilities are there in Nebraska?

Nebraska has only one permitted ISR mining facilities. This facility is a uranium mining facility owned by Cameco Resources, Inc. and operated by Crow Butte Resources, Inc. near Crawford, Nebraska.

What kinds of permits are necessary to operate an ISR uranium facility in Nebraska?

The Nebraska Department of Environmental Quality (NDEQ) requires an applicant to obtain an Underground Injection Control (UIC) Permit for a Class III injection well(s). The UIC program is delegated to states from the U.S. Environmental Protection Agency (EPA). Authority for this program comes from the federal Safe Drinking Water Act. Nebraska gained primacy over the state's UIC programs in 1984, and is therefore authorized by the EPA to issue permits for injection wells.

NDEQ also regulates and may require permits for: air quality, storm water runoff, and onsite domestic waste disposal systems located on a proposed facility's property.

An aquifer exemption is required if the proposed injection zone is an underground source of drinking water. Applicants submit a Petition for Aquifer Exemption to the State for review. Although the state reviews the aquifer exemption petition, it cannot grant the final aquifer exemption. After the state makes a decision on the aquifer exemption petition and it is duly public noticed, NDEQ makes a recommendation of the decision to EPA. EPA makes the final decision regarding aquifer exemptions.

A source license agreement must be obtained through the U.S. Nuclear Regulatory Commission (NRC). The NRC requires all facilities proposing to work with source materials to obtain a Source Material Facilities License. The application for a Source Material Facilities License is separate from the application for a Class III well. The Source Material Facilities License encompasses many facets of the operation. This license regulates the amount of radionuclide exposure to which each employee can be subjected. It also regulates fugitive dust; waste disposal via evaporation; and the packaging, handling, and shipping of the final uranium product, yellowcake. The NRC plays no role in the permitting process of the NDEQ; however, the agencies work cooperatively, since some of the information for the Source Materials Facilities License overlaps with information required for the Class III permit. Once mining has ceased at the site, however, the NRC and the NDEQ work together to ensure restoration of the aquifer.

The Department of Transportation (DOT) issues various permits and licenses for monitoring shipments of yellowcake. The yellowcake must be shipped by a company specifically trained to carry radioactive materials. Trucks are equipped with a global positioning system (GPS) for tracking purposes, and drivers must follow specified routes and pass checkpoints determined by the DOT.

The Natural Resources Districts (NRDs) across the state have developed sets of rules and regulations regarding permitting requirements and the installation of wells based on specific Groundwater Management Plans.

All wells installed in the State of Nebraska must be registered with the Nebraska Department of Natural Resources (NDNR). Additionally, the NDNR is charged with issuing permits for industrial use of groundwater.

The Nebraska Department of Health and Human Services (DHHS) requires that all wells in the State of Nebraska be installed by a licensed well driller Additionally, all groundwater samples must be collected by a certified water well monitoring technician or pump installer licensed in the State of Nebraska through DHHS. The Nebraska DHHS also requires that a public water supply serve facilities with more than 25 employees. These facilities must obtain a permit to operate a public water supply well. The well must also be operated by a person licensed to do so in the State of Nebraska.

What must an applicant demonstrate to NDEQ to obtain a permit for an ISR uranium facility?

Applicants must prove to NDEQ that they are taking the appropriate measures to:

- Protect drinking water;
- Maintain hydraulic control of the wellfield to prevent mining fluids from leaving the permitted area;
- Be financially capable of restoring the aquifer to its pre-mining class of use; and
- Not otherwise endanger human health and safety.

Applicants must also comply with the siting and construction standards, monitoring requirements, financial responsibility requirements, and other compliance requirements outlined in Nebraska Administrative Code Title 122 – *Rules and Regulations for Underground Injection and Mineral Production Wells*.

What must an applicant demonstrate to NDEQ & EPA to obtain an aquifer exemption?

In order to mine in an aquifer that could potentially serve as a source of drinking water, an aquifer exemption must be granted. The applicant must demonstrate:

- The aquifer does not currently serve as a source of drinking water; and
- The aquifer cannot now and will not in the future serve as a source of drinking water because:
    - It is mineral, hydrocarbon or geothermal energy bearing with production capability;
    - It is situated at a depth or location which makes recovery of water for drinking purposes economically or technically impractical;
    - It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or
    - It is located above an area that is subject to subsidence of catastrophic collapse.

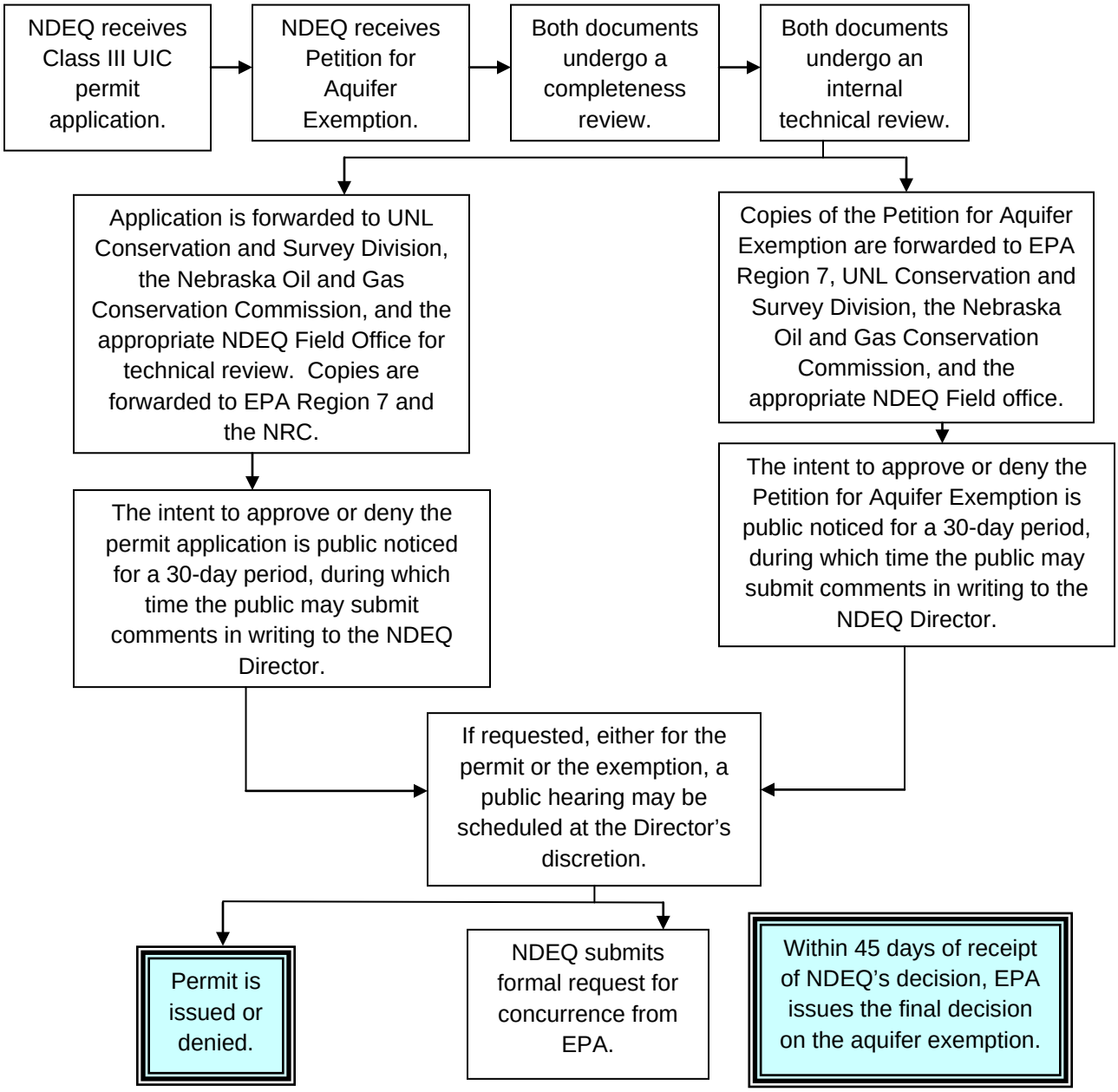
What is NDEQ's process for reviewing an ISR application?

The NDEQ must receive a Class III injection well application before a Petition for Aquifer Exemption. The Department, in consultation with the University of Nebraska – Lincoln, Conservation and Survey Division and the Nebraska Oil and Gas Conservation Commission, performs a technical review of the application. Comments from this review are incorporated into NDEQ's requests for additional information from the applicant.

Applicants for aquifer exemptions must submit narrative descriptions, illustrations, maps, and groundwater quality data to prove the above statements apply to the aquifer in question. A Petition for Aquifer Exemption is simultaneously reviewed with an application for a Class III permit. The petition is reviewed by NDEQ; the University of Nebraska – Lincoln, Conservation and Survey Division; the Nebraska Oil and Gas Conservation Commission; and the U.S. EPA as part of the technical review process. Comments from this review are incorporated into NDEQ's requests for additional information from the applicant.

After NDEQ makes a decision on the aquifer exemption petition and it is duly public noticed, NDEQ makes a recommendation of the decision to EPA. EPA makes the final decision regarding aquifer exemptions.

The flow chart below graphically describes the process of obtaining a permit from the State of Nebraska for an ISR uranium facility and an aquifer exemption.



How can the public review submitted documents?

All Class III injection permit applications and associated petitions for aquifer exemptions submitted to the Nebraska Department of Environmental Quality are kept on file for public review. To request a copy of an application or aquifer exemption petition, or to set up a time to view the files, contact NDEQ Records Management at (402) 471-3557. During the public comment period, documents related to the decision will be available for viewing at NDEQ offices or the local library nearest the proposed facility. Locations of these documents will be identified in the Public Notice, published in local newspapers.

How does the public participate?

During the public comment period, anyone may submit comments on the proposed decision as described in the Public Notice. Interested persons may request a public hearing, if one has not already been scheduled. A request for a public hearing must be in writing and must state the nature of the issues proposed to be raised in the public hearing. All relevant comments will be considered in the final decision. Additionally, a response to comments will be prepared by NDEQ. Written comments can be sent to the Director, Nebraska Department of Environmental Quality, P.O. Box 98922, Lincoln, Nebraska, 68509-8922.

More information regarding State regulation of Class III injection wells can be found in Title 122 – *Rules and Regulations for Underground Injection and Mineral Production Wells*, located on the NDEQ website (http://deq.ne.gov). The Nebraska Department of Environmental Quality can also be contacted by telephone at (402) 471-2186, or through e-mail at NDEQ.moreinfo@nebraska.gov.