This document is for use only as an overview of that part of the KDHE UIC program addressing Class I disposal wells. It is not intended to be an all inclusive listing of requirements or conditions for Class I Industrial Wastewater Disposal wells. This document may not be used in a court of law. Many of the requirements listed have been taken from the official Kansas Administrative Regulations publication. The permit application, permits, policies, guidance, statutes and rules and regulations establish the specific requirements for Class I disposal wells and are available from KDHE.

**INTRODUCTION**

Class I disposal wells inject hazardous or non-hazardous wastes into deep rock formations that are separated vertically from the lowermost usable water zone by many alternating layers of impermeable shale and limestone rocks.

**KDHE REGULATORY HISTORY**

After several incidents nationwide involving pollution traced to the use of injection wells, it was realized that injection activities could contaminate groundwater if not conducted under strict controls. This realization promoted Congress to develop the Federal UIC program as a part of the Safe Drinking Water Act (SDWA) of 1974. It should be noted the State of Kansas has regulated the injection of oil field brines since 1930’s and industrial wastes since 1950’s. The Environmental Protection Agency (EPA) has delegated primary, regulatory authority for the federal program to those state agencies that have demonstrated an ability to implement a UIC program that meets EPA requirements promulgated under the SDWA. These states are referred to as Primacy States.

The Kansas Department of Health and Environment (KDHE) received primacy from EPA in December 1983 to administer the UIC program in Kansas for Class I, III, IV, and V wells. Kansas Administrative Regulations (K.A.R.) 28-46-1 through 28-46-45 governs these classes of UIC wells in Kansas. These regulations can be found at:


The purpose of the UIC program is to prevent contamination of fresh and usable groundwater supplies by injection activities and to conserve water resources. In Kansas, approximately 90% of the water used is supplied from groundwater. The major contamination problems in Kansas are from sources associated with human activity. The groundwater supply can be lost for use if not adequately protected from contamination. The most effective method of protection groundwater supplies is to prevent contamination. Prevention is much more cost effective, and has better results than cleanup activities.

**CLASS I DISPOSAL WELL DESIGN AND OPERATION**

The main design criteria for all Class I wells is to deliver the wastewater to the permitted injection zone and keep it isolated without contaminating any fresh or usable water zones or contaminating the soils.
Construction of a typical Class I injection well is illustrated in Figure 1. The casing seals off formations above the injection zone. In some areas where bedrock is covered by thick unconsolidated deposits, a large-diameter conductor pipe is installed through these deposits into bedrock. A large-diameter hole is then drilled to a depth below the base of the deepest USDW. Steel surface casing is run to the bottom of the hole, centered, and cemented in place.

Figure 1

TYPICAL CLASS I WELL CONFIGURATION
The "long string" casing is lowered through the surface casing to the prescribed depth in the hole, centered, cemented from the bottom to the surface, and tested.

An injection tubing is then placed inside the long string casing and sealed at the top of the well and by a packer at the base of the casing. The space between the injection tubing and the inner wall of the long string casing is called the annulus. The annulus is filled with an inert fluid such as mineral oil and pressurized. The operator is required to constantly monitor the annulus pressure and report it to KDHE. Leakage from the tubing to the casing or from the casing to the surrounding rocks will cause a pressure decrease and liquid loss. The actual injection pressure also is monitored constantly. A fluctuation in either of these monitored pressures will automatically set off alarms. The well operators are required to file monthly reports of their injection activities listing monitored pressures, injectate volumes, and injection rates.

KDHE allows only “gravity” injection and does not allow the use of pump injection pressure. This reduces the stress on well components, prevents undesirable pressure buildup in the disposal zone and significantly limits the potential for induced seismic activity. Gravity injection allows only the amount of fluid that the formation can naturally accept.

**DEFINITIONS**

A **well** means a dug hole or bored, drilled or driven shaft whose depth is greater than it largest surface dimension or an improved sinkhole, or a subsurface fluid distribution system.

**Well Injection** means the subsurface emplacement of fluids through a well.

**Injection well** is a well into which fluids are injected.

A **fluid** is defined as any material that flow or moves, whether it is semisolid, liquid, sludge or gas.

As mentioned previously, the UIC program categorizes injection wells into five classes of wells. These are:

**Class I:** Wells used to inject hazardous wastes or dispose of industrial and municipal fluids beneath the lowermost formation containing, within one quarter (1/4) mile of the well bore, a source of fresh or usable water.

**Class II:** Wells used to inject fluids associated with the production of oil and natural gas or fluids/compounds used for enhanced hydrocarbon recovery. These wells normally inject below the lowermost fresh or usable water bearing zone into zones of former hydrocarbon production. These wells are regulated by the Kansas Corporation Commission. The contact for the KCC is (316) 337-6197.

**Class III:** Wells which inject fluids for the extraction of minerals.

**Class IV: Prohibited:** Wells which dispose of hazardous or radioactive wastes into or above a fresh or usable water bearing zone. These wells are prohibited by KDHE regulation K.A.R. 28-46-4.
**Class V:** Wells not included in other classes. Typically Class V injection wells are shallow wells used to place a variety of fluids below the land surface.

**Class VI:** These wells inject carbon dioxide (CO₂) for long term storage, also known as Geologic Sequestration or Co₂. These wells are regulated by EPA.

Class I, III and certain types of Class V wells require obtaining a permit from KDHE prior to construction. The injection of hazardous waste into a Class I disposal well also requires submittal of a petition to the U.S. Environmental Protection Agency seeking an exemption from the EPA prohibition of the injection of hazardous waste and obtaining an approved petition from EPA. Some types of endangering Class V wells are not allowed by KDHE. As stated previously, Class IV wells are prohibited in Kansas. A Class II well requires obtaining a permit from the Kansas Corporation Commission (KCC).

### INVENTORY

The number of Class I disposal wells currently carried on KDHE’s inventory as of March 2013, are shown in Table 1. The inventory includes active wells, wells permitted but not yet constructed, plugged, wells converted to other uses and wells reclassified as a different Class of injection well. Forty-five of the active wells inject nonhazardous waste and five wells inject hazardous waste. The five wells receiving hazardous waste are at one facility located a few miles southwest of Wichita, Kansas. Twelve of the wells permitted but not constructed are nonhazardous waste disposal wells and two are hazardous waste disposal wells.

<table>
<thead>
<tr>
<th>Class</th>
<th>Active</th>
<th>Permitted but not Constructed</th>
<th>Plugged</th>
<th>Converted-Other Uses</th>
<th>Converted-Other Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>50</td>
<td>14</td>
<td>27</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

The inventory of Class I disposal wells in Kansas varies greatly in total depth of installation and dates of installation. The wells were installed over a span of years from 1943-2010. The depths range from approximately 1,300 feet bgs to more than 7,000 feet bgs. Table 2 gives a general picture of the depth variation of the active disposal wells.

<table>
<thead>
<tr>
<th>Total Drilled Depth of Active Class I Disposal Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000-2000 bgs</td>
</tr>
<tr>
<td>2001-4000 bgs</td>
</tr>
<tr>
<td>4001-6000 bgs</td>
</tr>
<tr>
<td>6001-8000 bgs</td>
</tr>
</tbody>
</table>
Table 3

Total Number of Active Wells by Date of Construction

<table>
<thead>
<tr>
<th>Period</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940-1960</td>
<td>5</td>
</tr>
<tr>
<td>1961-1980</td>
<td>19</td>
</tr>
<tr>
<td>1981-2000</td>
<td>12</td>
</tr>
<tr>
<td>2001-2012</td>
<td>14</td>
</tr>
</tbody>
</table>

A Class I disposal well located in McPherson County was constructed in 1943 and is still operating today. A properly completed, operated, tested and maintained well should remain operational for many years.

LOCATION OF CLASS I DISPOSAL WELL FACILITIES

There are currently 27 industrial facilities located in Kansas which utilize a total of 50 Class I disposal wells. Counties with active Class I disposal wells are indicated by blue shading on Figure 2.

Figure 2
Location of Active Class I Disposal Wells

DESCRIPTION OF WASTE DISPOSED

The use of Class I disposal wells are considered by KDHE only for those wastes that cannot feasibly be treated, stored or disposed by other methods. The KDHE Bureau of Water Policy Memorandum #91-1 outlines the policy for determining the types of waste that are eligible for disposal through Class I disposal wells. A copy of this policy memorandum can be obtained by contacting KDHE.

Class I disposal wells in Kansas are used at the following types of facilities: hydrocarbon storage in solutioned salt cavities; meat packing plants using hide curing and/or tanning
processes; chemical manufacturing plants; salt solution mining facilities; solid waste landfill for disposal of leachate; natural gas compressor stations and natural gas fractionation plants. Some common wastes disposed include cooling tower blowdown; boiler blowdown; contaminated stormwater runoff; contaminated groundwater; waste brines from hydrocarbon storage well, hide curing and salt solution mining operations and chemical process wastes.

The total volumes of wastewater injected into all Class I disposal wells combined by calendar year for years 2000-2012 are shown in Table 4. Figure 3 shows these data graphically.

Table 4

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Volume Injected (Gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>3,015,141,926</td>
</tr>
<tr>
<td>2001</td>
<td>2,221,104,641</td>
</tr>
<tr>
<td>2002</td>
<td>1,762,151,510</td>
</tr>
<tr>
<td>2003</td>
<td>1,827,869,019</td>
</tr>
<tr>
<td>2004</td>
<td>2,597,442,187</td>
</tr>
<tr>
<td>2005</td>
<td>2,699,699,276</td>
</tr>
<tr>
<td>2006</td>
<td>2,937,564,119</td>
</tr>
<tr>
<td>2007</td>
<td>2,699,687,922</td>
</tr>
<tr>
<td>2008</td>
<td>2,757,265,537</td>
</tr>
<tr>
<td>2009</td>
<td>2,888,316,849</td>
</tr>
<tr>
<td>2010</td>
<td>2,917,495,119</td>
</tr>
<tr>
<td>2011</td>
<td>3,063,966,984</td>
</tr>
<tr>
<td>2012</td>
<td>3,167,505,339</td>
</tr>
</tbody>
</table>

Figure 3

Total Volume Injected Into Class I Disposal Wells

![Graph showing total volume injected into Class I disposal wells from 2000 to 2012](image-url)
Total wastewater volume injected per year has remained fairly steady over time. Occasionally new wells are installed while some wells are idle or plugged, resulting in fairly steady injection volumes from year to year.

**SITE CHARACTERISTICS NECESSARY FOR A CLASS I DISPOSAL WELL TO PREVENT ENDANGERMENT OF PUBLIC HEALTH AND ENVIRONMENT**

The proposed site for location of a Class I disposal well should, at a minimum, have the following characteristics to be suitable for the injection of wastewater. **The injection of wastewater shall not endanger public health or the fresh and usable waters, soils or mineral resources.**

- Injection interval sufficiently thick, with adequate porosity and permeability to accept waste at the proposed injection rate without necessitating excessive injection pressures.
- Injection interval of large enough areal extent so that injection pressure is minimized and so that injection waste will not reach discharge areas.
- Injection interval preferably “homogeneous” (without high-permeability lenses or streaks), to prevent extensive fingering of the waste-vs-formation water contact, which would make adequate monitoring of the waste movement extremely difficult or impossible.
- Overlying and underlying strata (confining beds) sufficiently thick and impermeable to confine waste to the injection interval.
- Structural geologic conditions generally simple; that is, a site reasonably free of complex faulting and folding.
- Site is an area of minor to moderate earthquake damage and low seismic activity so that the hazard of earthquake damage or triggering seismic events is minimized.
- Slow lateral movement of fluid in the injection interval, under natural conditions, to prevent rapid movement of waste away from the injection site, possible to a discharge area.
- Formation-fluid pressure normal to low so that excessive fluid pressure is not needed for injection. Accept fluid without the use of pump pressure.
- Formation temperature normal to low so that the rates of undesirable reactions are minimized, including corrosion.
- Wastewater compatible with formation fluids and minerals or can be made compatible by treatment, emplacement of a buffer zone or other means.
- Formation water in the disposal formation of no apparent value, i.e., not potable, unfit for industrial or agricultural use, and not containing minerals in economically recoverable quantities.
Injection interval adequately separated from fresh and usable water zones, both horizontally and vertically.

Waste injection does not endanger present or future use of mineral resources (coal, oil, gas, brine or others).

Waste injection does affect existing or planned gas-storage or freshwater-storage projects.

No unplugged or improperly abandoned wells penetrating the disposal formation in the vicinity of the disposal site, which could lead to contamination of other resources.

**DESCRIPTION OF DISPOSAL FORMATION IN KANSAS**

For most areas of Kansas, except in the southeast part of the state, the formation most suitable for the disposal of wastewater is the Arbuckle Group. There are areas of the northeast part of the state where the Arbuckle Formation is not present. The Arbuckle rocks are Ordovician in age (approximately 440 – 500 million years old) and originally consisted of limestone. The Arbuckle now consists generally of dolomite. Over time, diagenetic alteration from limestone to dolomite has occurred. Dolomitization has resulted in increased porosity. This dolomite has also undergone dissolution during cycles of uplifting and erosion. Walters (1958) indicated basement tectonics probably controlled development of an extensive joint system in the Arbuckle dolomite. Circulation of meteoric water through the fractures ultimately developed a cavernous porosity. The Arbuckle in most areas is capable of accepting significant volumes of liquid under “gravity” flow (500+ gpm). Forty-nine of the 50 active Class I disposal wells utilize the Arbuckle Formation as the disposal zone.

Another formation currently used for Class I disposal in Kansas is the Shawnee Group. There is only one Class I well disposing into the Shawnee Group.

The Cedar Hills Formation was utilized for disposal in past years, but there are now no Class I wells disposing into the Cedar Hills Formation. The Cedar Hills is not permitted for new Class I disposal wells per KDHE, Bureau of Water, Policy #90-3 because of the potential for an undesirable pressure build-up in the formation and questionable confining units in many areas of the state. A copy of this policy memorandum can be found at:


The Shawnee Group and Cedar Hills Formations generally have low permeability and accept only limited volumes of liquid under gravity flow. The Shawnee is a limestone and the Cedar Hills is a sandstone.

Attached Figures 4 – 12 depict the general geology relevant to Class I disposal wells in Kansas utilizing the Arbuckle Formation as the disposal zone.
PLUGGING AND CLOSURE

At the end of the useful life of the well or when determined necessary by KDHE to protect public health or the environment, the well shall be properly plugged. The well shall be plugged in a manner that is protective of public health and the environment. A plan for plugging the well shall be maintained on file with KDHE. Prior to commencing plugging, an updated plugging plan shall be submitted to KDHE for review and approval. No plugging work shall commence until plan approval has been obtained from KDHE. Detailed guidelines and requirements for developing a plugging plan and for procedures can be obtained by contacting KDHE.
Figure 4 – Generalized Geologic Section

Source: Arbuckle Reservoirs in Central Kansas: Relative Importance of Depositional Facies, Early Diagenesis and Unconformity Karst Processes on Reservoir Properties – KGS
Figure 5 is a generalized geologic map of Kansas

Source: Kansas Geologic Survey Postcard

Figure 6 is an east-west geologic cross-section

Source: KGS “Geologic History of Kansas”
Figure 7 (top) depicts the major structural features in Kansas and Figure 8 (bottom) is a cross-section depicting the Arbuckle Formation from KGS Open File Report 2003-59.
Figure 9 - Principal Aquifers of Kansas

Figure 10 depicts the thickness and extent of the Arbuckle in Kansas.
(From USGS Open-File Report 86-491)
Figure 11 - Depicts permeability values expressed in millidarcies for various locations as determined by formation pressure fall-off test conducted on Class I disposal wells.

Figure 12 depicts the distribution of chloride concentration in the Arbuckle. Figure 12: Distribution of chloride concentration in water from the Arbuckle aquifer. (From USGS Open-File Report 86-491)