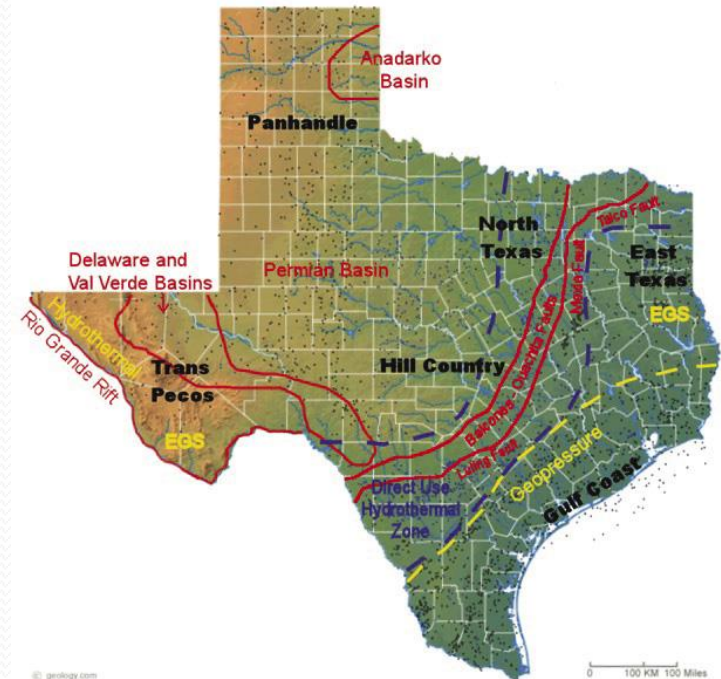


An Evaluation of ^{226}Ra and ^{228}Ra in Drinking Water in Several Counties in Texas, USA

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Introduction

- NORM and TENORM can be a potential health risk.
- Many parts of Texas have given rise to levels of ^{226}Ra and ^{228}Ra that often exceed the limits set by the US Environmental Protection Agency.
- A detailed literature search was undertaken to assess the levels of ^{226}Ra and ^{228}Ra in all of the Texas counties.



Enviroklean Product Development Inc. (EPDI)

- EPDI is a State of Texas licensed "NORM" decontamination company and chemical manufacturer
- Decontamination of pipe, land, buildings, equipment and materials.
- Transportation and disposal of NORM.
- Radium mixes with barium, strontium, or calcium, hard and insoluble deposits form on the inside of pipes



Texas Aquifers With a History of Naturally Occurring Radionuclides

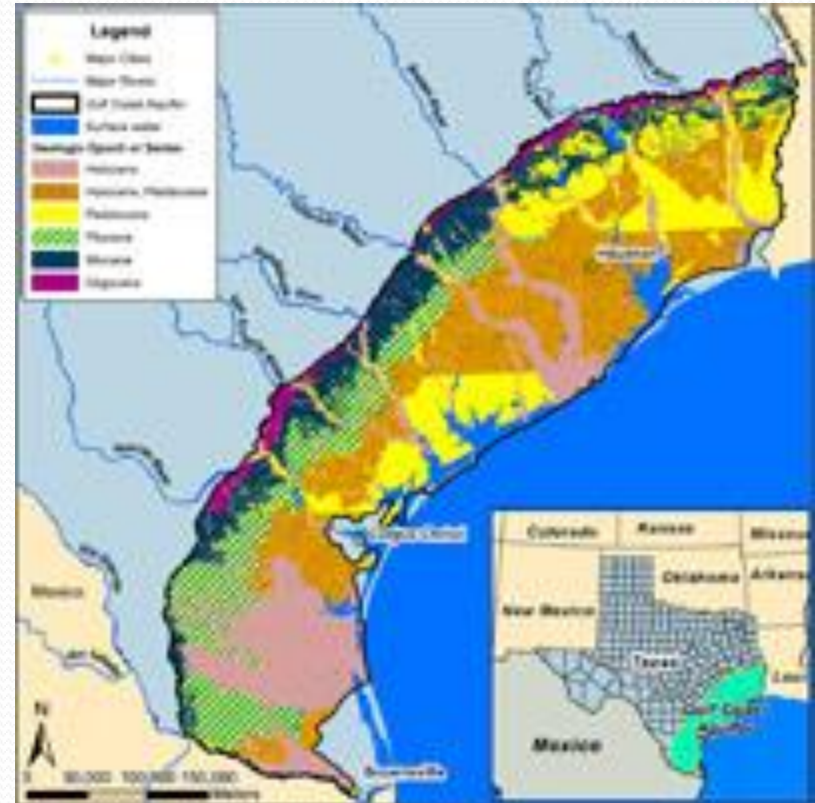
- Gulf Coast Aquifer
- Ogallala Aquifer
- Edwards-Trinity Aquifer
- Hickory Aquifer
- Dockum Aquifer

Hickory Aquifer

- Located in the Llano Uplift Region of central Texas
- Characterized by Precambrian igneous and metamorphic rocks which are exposed at the earth's surface
- There are no indications of uranium deposits in the geology surrounding the aquifer
- There are elevated levels of uranium within the area
- <http://watrnews.com/2012/05/hickory-aquifer-seven-times-amount-allowed-radiation/>
- May 23, 2012
- Seven times the legal limit
- Brady and San Angelo affected cities

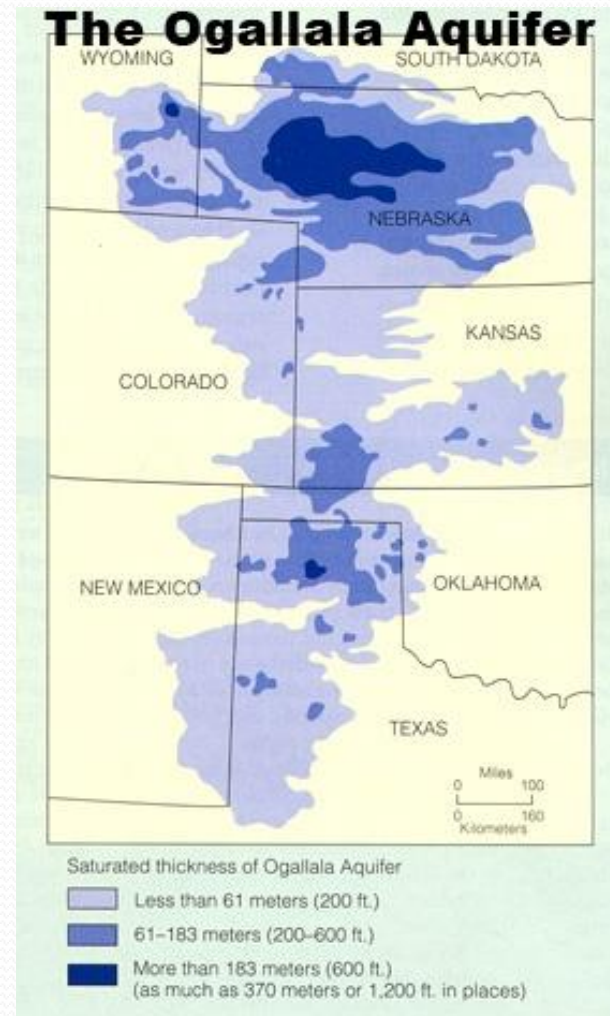
Gulf Coast Aquifer

- A major aquifer that spreads down in Mexico and with a small portion also in Louisiana
- There are high uranium deposits within the aquifer and a history of uranium mining
- Most the mines have been closed but there are several counties with active mines



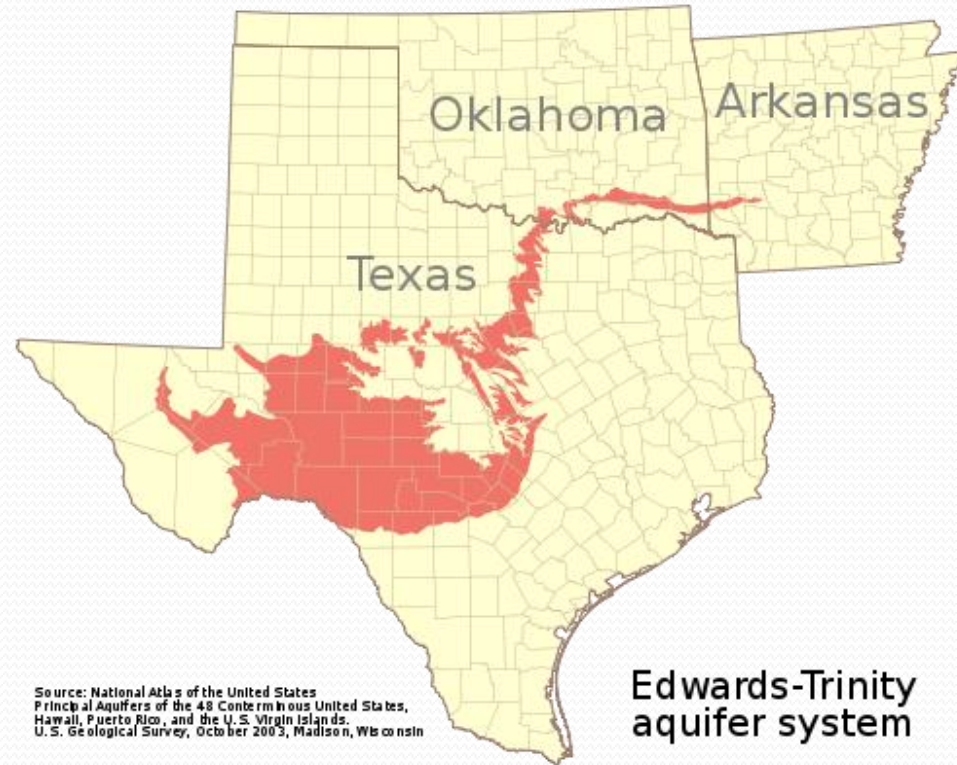
Dockum and Ogallala Aquifer

- Dockum is a minor aquifer of Texas while the Ogalla system spreads through at Texas an in the western United States
- Both aquifers are in West Texas and the Panhandle region
- Both aquifers have uranium deposits within the aquifer's outlying geology



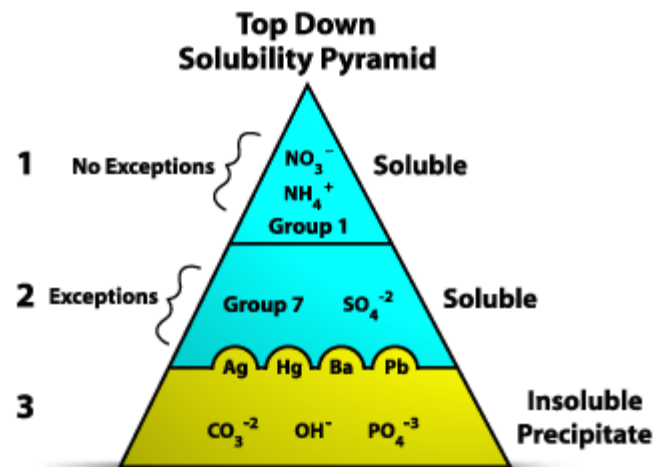
Edwards Trinity Aquifer

- Major aquifer that contains three interconnecting bodies of water
- There are no indication of uranium deposits or high levels within the carbonate and clastic rocks (particles of pre-existing rocks and minerals) that surround the aquifer



Solubility of Ra-226 and Ra-228

- Unlike their parent products uranium and thorium the radium daughters are quite soluble
- Become mobilized within the aquifer allowing them to travel great distances especially Ra-226 due to its long half-life
- Presumably Ra-228 will have to be closer to the parent product thorium since it has a much shorter half life

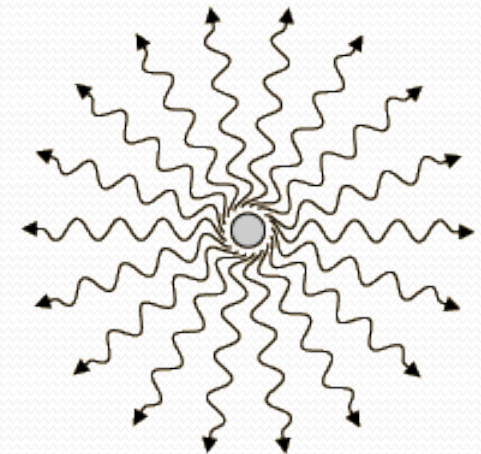


EPA Rules and Regulations

- Combined Ra-226 and Ra-228 is 0.185 Bq/L (5 pCi/L)
- The rules and regulations were set forth to ensure that the communities could meet national standards without creating much financial burden and at the same time minimizing the health risk to those drinking the water



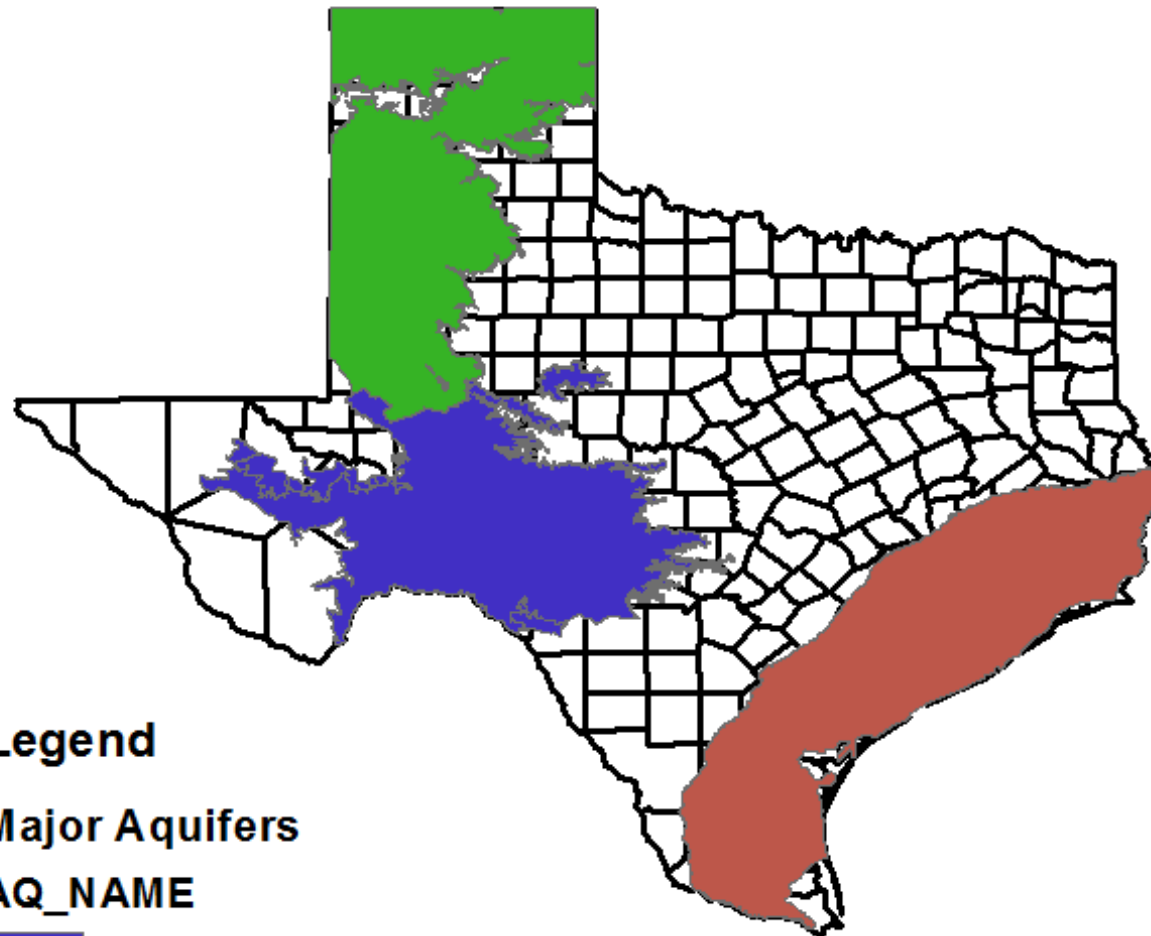
Activity of radioactive source measured in **becquerels** or **curies**



Combined Radium Violations

- Data was collected by going through the Texas Commission of Environmental Quality (TCEQ) and the New York Times Toxic Water Report database
- Each time a there was a TCEQ combined radium or RAD (radionuclide violations) it was noted
- The New York Times database split Ra-226 and Ra-228 into separate entities so the cumulative amount were added to ascertain if there was a combined radium violations




Major Aquifers with a History of Radionuclides



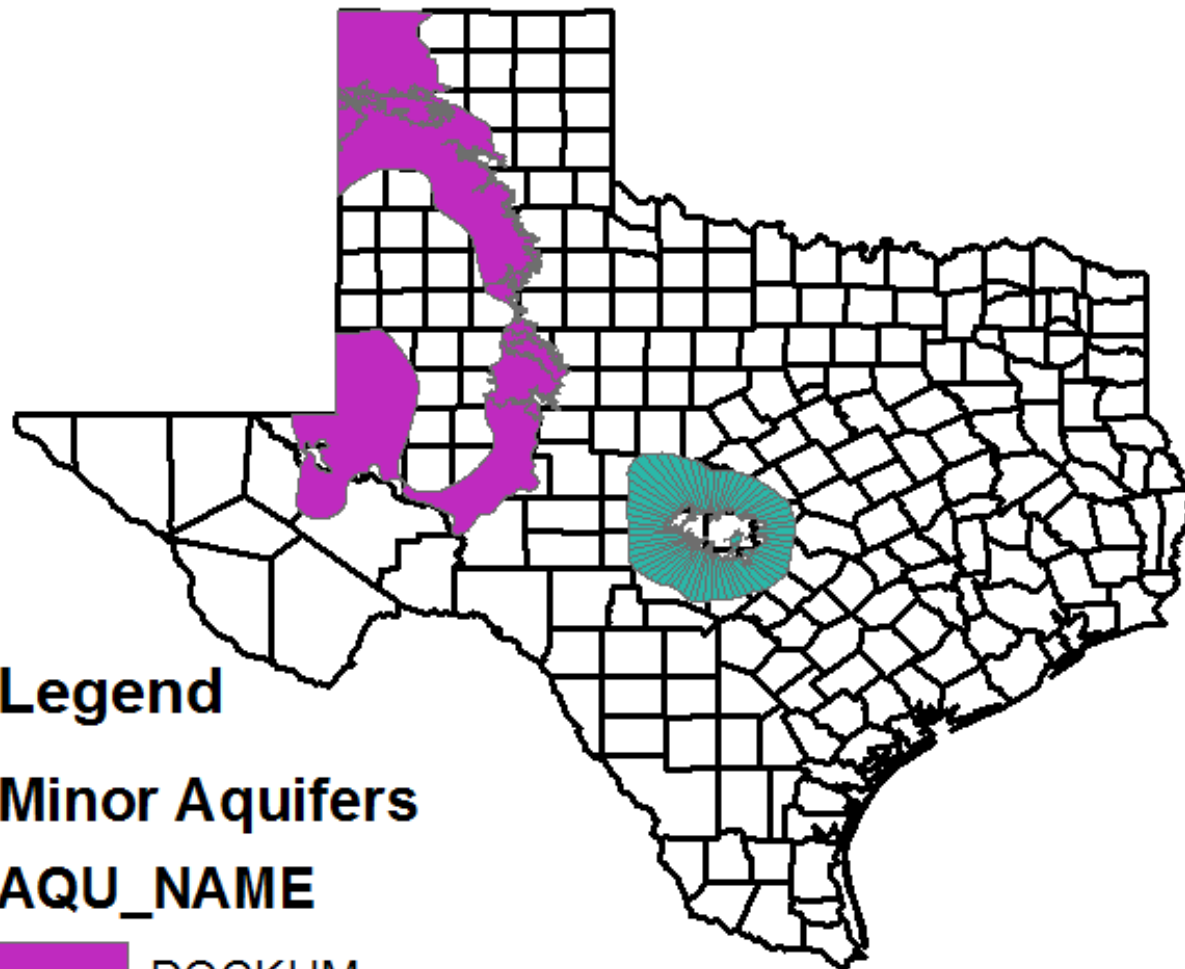
Legend

Major Aquifers

AQ_NAME

-  EDWARDS-TRINITY
-  GULF_COAST
-  OGALLALA


Minor Aquifers with a History of Radionuclides




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Minor Aquifers

AQU_NAME

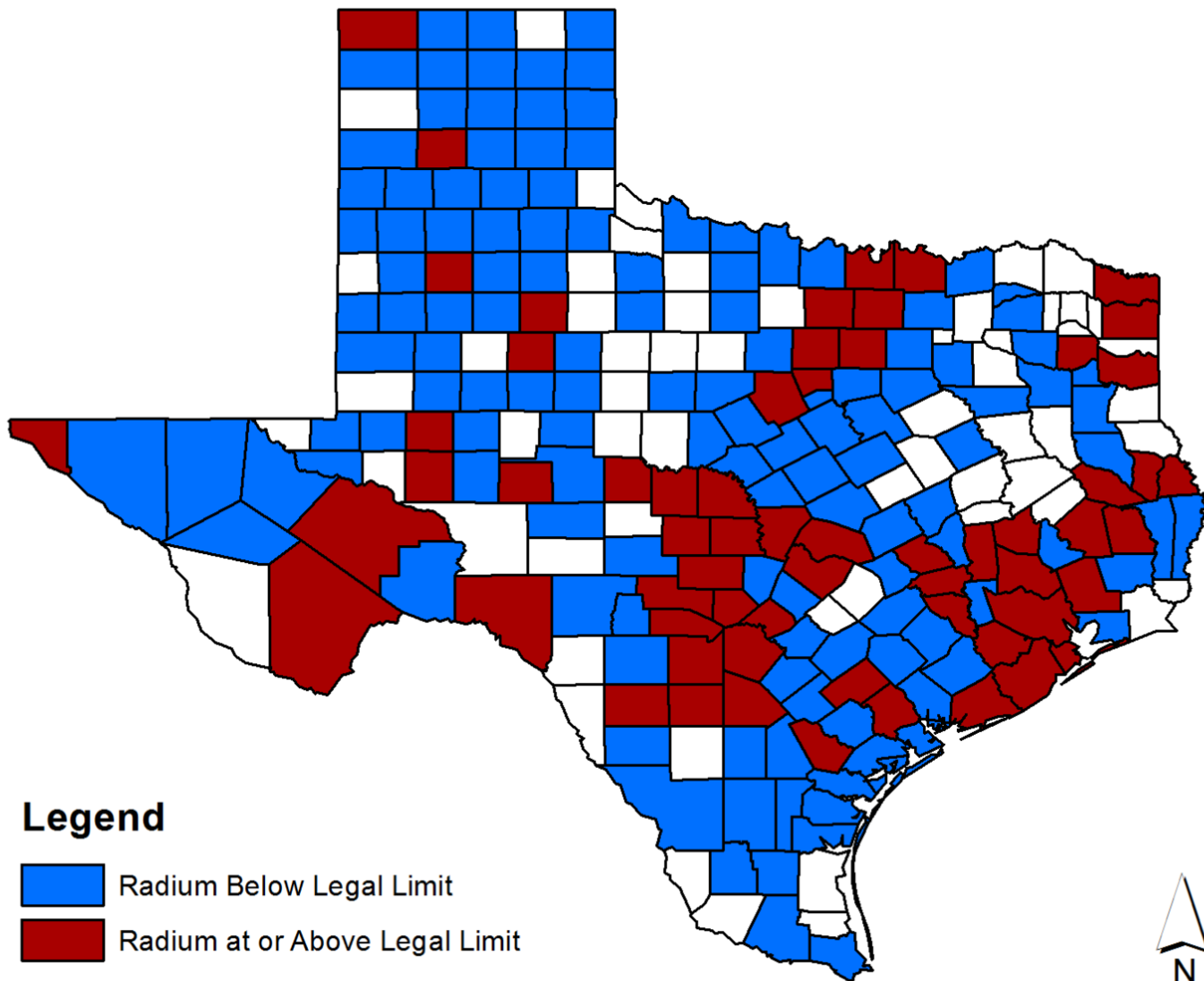
 DOCKUM

 HICKORY

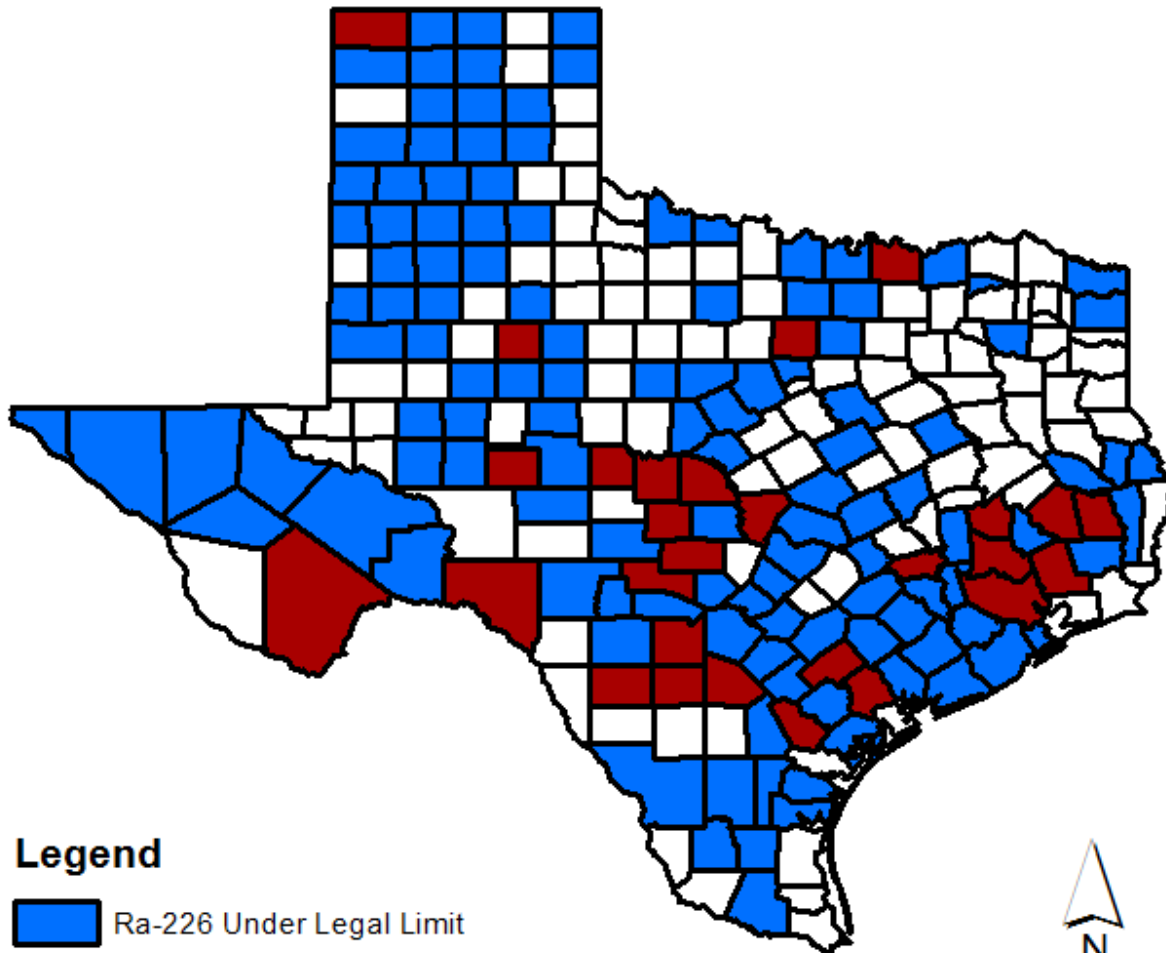
Results

- 62 out of 254 Counties have had at least 1 violations for combined Ra-226 and Ra-228
 - 24.4% of the Counties in Texas
 - 48.8% have a low levels of combined Ra-226 and Ra-228

Counties with Combined Ra-226 and Ra-228



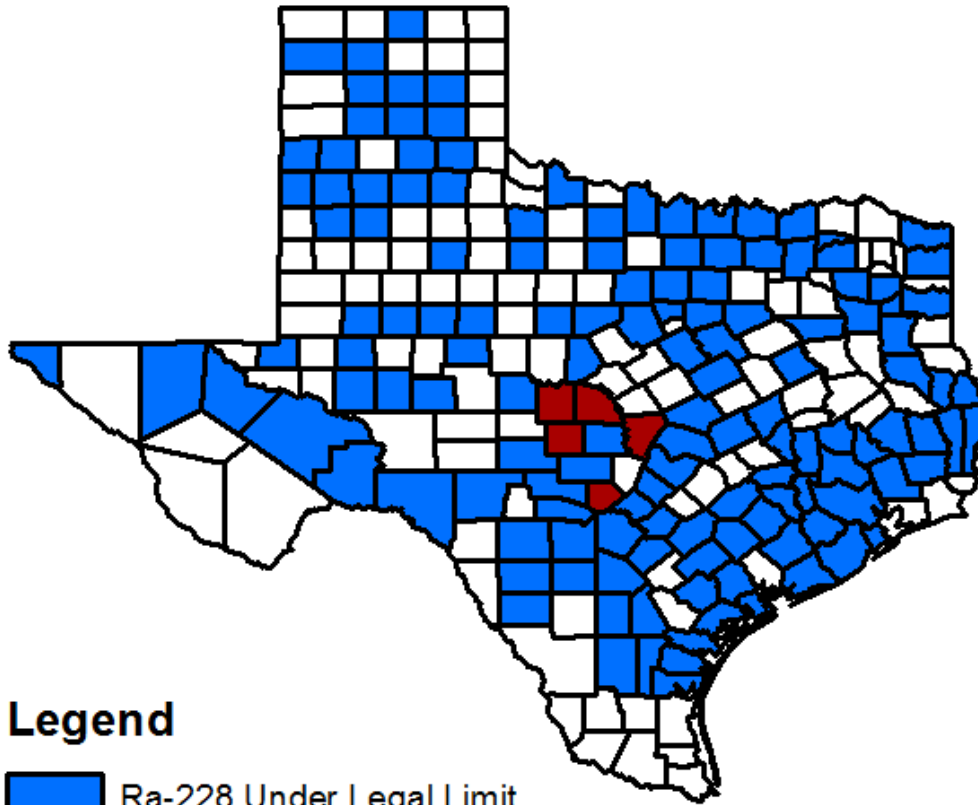
Counties with Ra-226





Legend

- Ra-226 Under Legal Limit
- Ra-226 at or Above Legal Limit

Counties with Ra-228



Legend

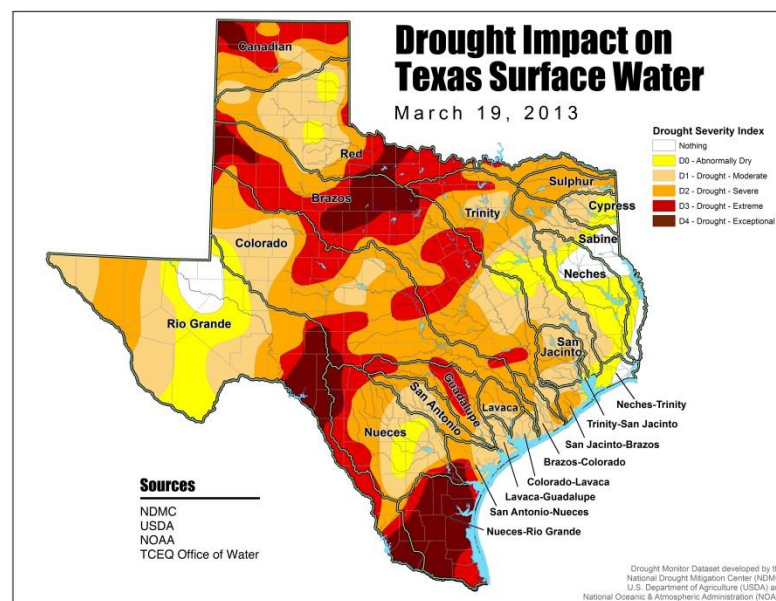
-  Ra-228 Under Legal Limit
-  Ra-228 at or Above Legal Limit

Discussion

- The maps show that the highest concentrations of elevated radium are over the areas where there have been known radionuclides in the drinking water the exception of North Texas
- It also shows that in most areas Ra-226 is higher with the exception of the Hickory aquifer where Ra-228 by itself is over the legal limit

Discussion Continued

- Majority of the effected water supplies are small communities and towns with little resources to change their water supply, clean or replace the pipes or add improve water filtration systems to their water supply
- Access to an alternative water reservoir may be difficult to acquire since there is a lack of natural lakes (surface water in Texas) and the current severe drought conditions

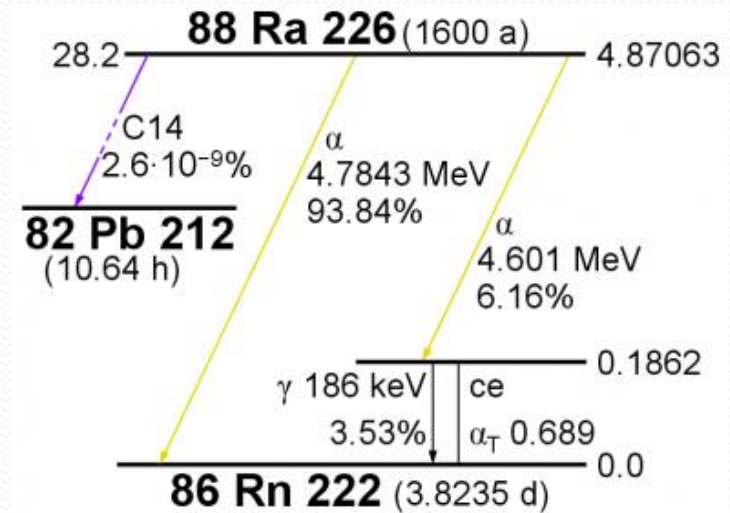


Range and Averages of Radionuclides in Texas Drinking Water

- Ra-226 ranged from 0.044-0.42 Bq/L (1.2-11.4 pCi/L)
- Ra-228 ranged from 0.0074-0.44 Bq/L (0.2-11.9 pCi/L)
- The average combined Ra-226 and Ra-228 maximum concentration was 0.39 Bq/L (10.5 pCi/L)

Radionuclides Analysis

- The statistical analysis showed no correlation between Ra-226 and Ra-228 levels
- The concentration of ^{226}Ra above the legal US EPA limits as compared to the concentration of the total alpha particle activity (had an average ratio of 0.29)



Hickory Aquifer-Llano Uplift Area

- This particular area of Texas has the highest documented levels of Ra-226
- Also has high levels of Ra-228
- This has some of the highest concentration of radionuclides including alpha and beta particles
- Reports go back over 40 years documenting elevated Ra-226 in the drinking water

Other Considerations

- The State of California did a study on the link to cancer and radium in the drinking water to cancer
- They concluded that the limits set by the US EPA should be significantly reduced by an order of magnitude
- They felt the risk of cancer is too great with the current legal limits

Economic Impact

- Economic impact of reducing the levels of $^{226}, ^{228}\text{Ra}$ can be very expensive.
- Larger cities can absorb the costs
- Smaller communities as in many parts of rural Texas generally do not have the needed resources
- Brady, Texas \$9 million was recently spent on a new water filtration system yet the population served is approximately 5,500 people (The Brady Standard, 2012).
- The city of Brady has also received a \$22 million grant to clean up the pipes for the drinking water.
- An alternative solution is to buy various household water systems such as reverse osmosis, ion exchange, or nanofiltration (Water Research Foundation, 2012) with these systems typically cost several hundred US dollars.

Conclusions

- A more in-depth study should be done on the counties with the highest radium levels in the drinking water
- Temporary and permanent solutions to the problem should be put in order
- New water sources, cleaning the pipes, to adding better water filtration systems
- The citizens should also be better informed of the health risks and dangers and have it explained to them so they understand the health risks from drinking the tap water
- Further research including animal studies should be done for low levels of radium