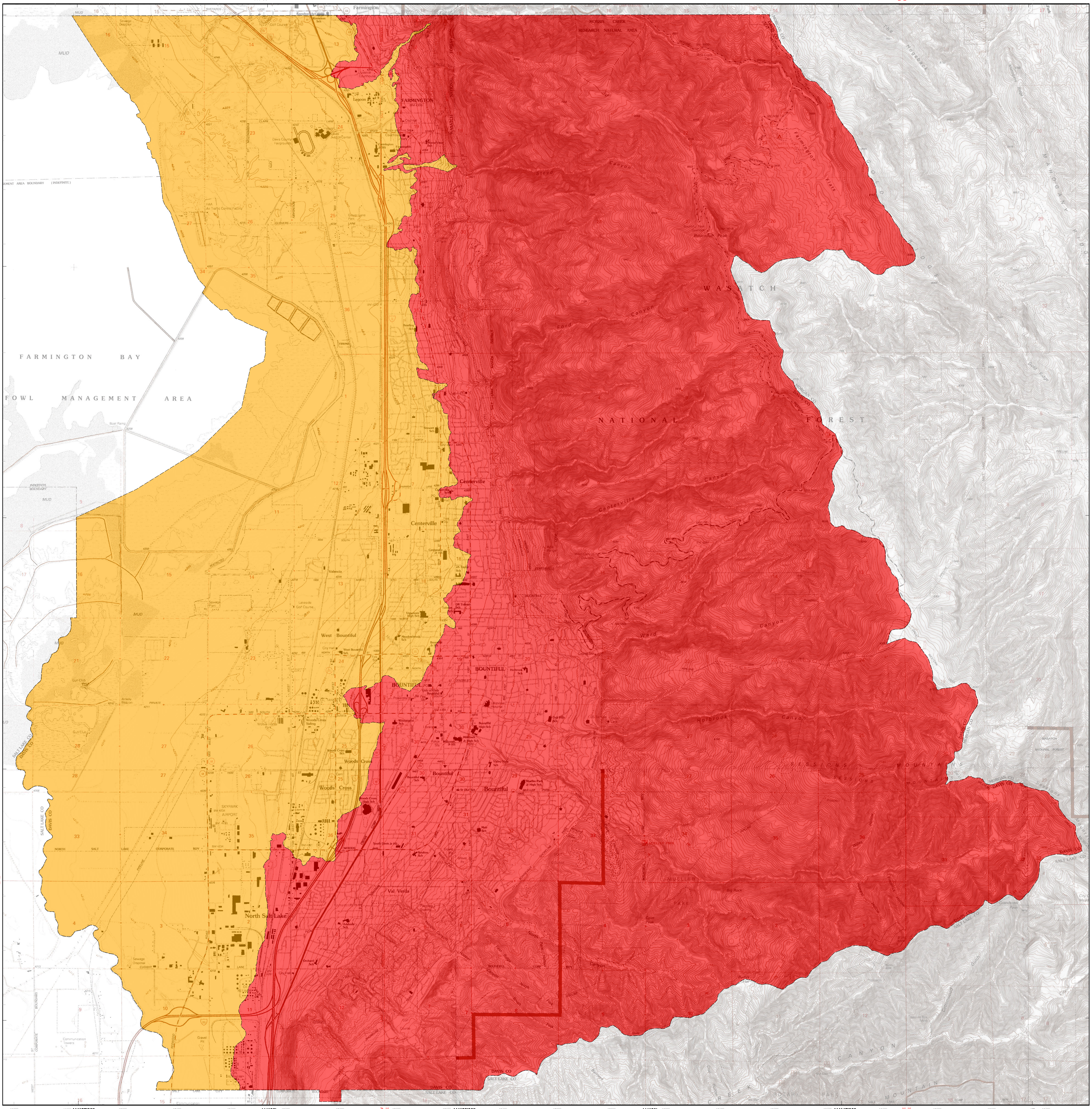
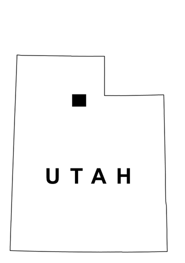
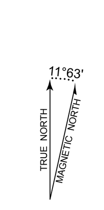




MAP LOCATION



APPROXIMATE MEAN DECLINATION, 2016

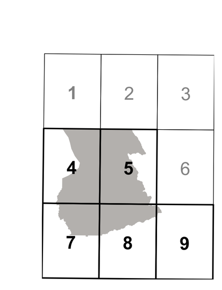
SCALE 1:24,000

1 0.5 0 1 MILE

5000 2500 0 5000 FEET

1 0.5 0 1 KILOMETER

CONTOUR INTERVAL 20 or 40 FEET



1. Kaysville
2. Peterson
3. Morgan
4. **Farmington**
5. **Bountiful Peak**
6. Porterville
7. **Salt Lake City North**
8. **Fort Douglas**
9. **Mountain Dell**

7.5' QUADRANGLE INDEX

Base from U.S. Geological Survey Kaysville (1998), Peterson (1998), Morgan (1997), Farmington (1998), Bountiful Peak (1998), Porterville (1998), Salt Lake City North (1998), Fort Douglas (1998), and Mountain Dell (1998) 7.5' topographic quadrangles. Hillshade derived from 10-meter National Elevation Dataset (NED) data from the Utah Automated Geographic Reference Center State Geographic Information Database.
Datum: NAD 1983
Spheroid: Clarke 1866

GIS and Cartography: Jessica J. Castleton, Ben A. Erickson and Jay C. Hill

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RADON HAZARD POTENTIAL MAP OF SOUTHERN DAVIS COUNTY, UTAH

by

Jessica J. Castleton, Ben A. Erickson, and Emily J. Kleber

2016

EXPLANATION

- - - - Mapped area boundary

Area not mapped

RADON HAZARD POTENTIAL CATEGORIES

High: Area where probable soil uranium concentrations are greater than 3 parts per million (ppm); indoor radon levels are likely to be >4 picocuries per liter (pCi/L); groundwater depth is greater than 10 feet below the surface and soil is highly permeable to moderately permeable. Boundary is dashed where approximate due to fluctuating groundwater levels.

Moderate: Area where probable soil uranium concentrations range from 2-3 ppm; indoor radon levels are likely to be 2-4 pCi/L; groundwater depth is less than 10 feet below the surface and soil permeability is low to moderate. Due to fluctuating groundwater levels and variable subsurface geology, indoor radon levels >4 pCi/L are possible in moderate zones.

USING THIS MAP

This map is intended to provide an estimate of the underlying geologic conditions that may contribute to the indoor radon hazard potential. This map is not intended to indicate indoor radon levels in specific structures. Although certain geologic factors are conducive to elevated indoor radon hazard potential, other highly variable factors affect indoor radon levels, such as building materials and foundation openings; therefore, indoor radon levels can vary greatly between structures located in the same hazard category. Indoor radon levels in the moderate category may be >4 pCi/L due to variable subsurface geology and construction techniques. This map is not intended for use at scales other than 1:24,000, and is intended for use in general planning to indicate the need for site-specific indoor-radon-level testing. Indoor radon testing is important in all hazard categories and we recommend testing be completed in all existing structures.

RADON HAZARD

Radon is an odorless, tasteless, and colorless radioactive gas that is highly mobile and can enter buildings through small foundation cracks and other openings such as utility pipes. The most common type of radon is naturally occurring and results from the radioactive decay of uranium, which is found in small concentrations in nearly all soil and rock. Although outdoor radon concentrations never reach dangerous levels because air movement and open space dissipate the gas, indoor radon concentrations may reach hazardous levels because of confinement and poor air circulation in buildings.

Breathing any level of radon over time increases the risk of lung cancer, but long-term exposure to low radon levels is generally considered a small health risk. Smoking greatly increases the health risk due to radon because radon decay products attach to smoke particles and are inhaled into the lungs, greatly increasing the risk of lung cancer. The U.S. Environmental Protection Agency (EPA, 2009) recommends that action be taken to reduce indoor radon levels exceeding 4 picocuries per liter of air (pCi/L), and cautions that indoor radon levels less than 4 pCi/L still pose a health risk, and in many cases can be reduced. Indoor radon levels are primarily a result of the design and construction methods used for a structure, along with several geologic factors including uranium content in soil and rock, soil permeability, and groundwater. Granite, metamorphic rocks, some volcanic rocks and shale, and soils derived from these rocks are generally associated with elevated uranium content that contributes to high indoor radon levels.

To evaluate the radon hazard potential, we used four main sources of data to identify areas where underlying geologic conditions may contribute to elevated radon levels: (1) soil permeability data from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) Database for Davis County Area, Davis County, Utah, and Salt Lake Area, Salt Lake County, Utah (NRCS, 2006, 2013), (2) depth-to-groundwater mapping, completed for this study, (3) available geologic mapping (Bryant, 2003; Lowe and others, in preparation, McKean, in preparation), and (4) U.S. Geological Survey (USGS) National Uranium Resource Evaluation (NURE) Hydrogeochemical and Stream Sediment Reconnaissance Data (USGS, 2004). Incorporating soil permeability, depth to groundwater, and geologic factors contributing to uranium content, we classified soil and rock units into high, moderate, and low hazard categories (after Solomon, 1992, and Black and Solomon, 1996; tables 1 and 2). This classification methodology is based on the potential of the underlying geologic units to generate radon gas and the ability of the gas to migrate upward through the overlying soil and rock. NURE uranium levels in lake sediment derived from high-uranium geologic material to the east is >3 ppm. Shallow groundwater is present in the investigation area; however, no areas were assigned a point value below 5 (table 2), due to high uranium levels in soils throughout the investigation area.

Soil permeability and groundwater affect the mobility of radon from its source. If a radon source is present, the ability of radon to move upward through the soil into overlying structures is facilitated by high soil permeability. Conversely, radon movement is impaired in soils having low permeability. Saturation of soil by groundwater inhibits radon movement by dissolving radon in the water and reducing its ability to migrate upward through the soil (Black, 1996). However, surficial geologic materials in Davis County have significantly high uranium levels; therefore, the effects of impermeable soils and shallow groundwater inhibition is limited.

The NRCS reported hydraulic conductivity (Ksat) values of saturated soil for their soil units based on testing performed at representative locations (NRCS, 2006, 2013). The NRCS assigned permeability classes to their soil units based on the hydraulic conductivity of the unit. The hydraulic conductivity values of non-soil map units (water, borrow pits, and other artificial units as mapped by the NRCS) are reported as zero; however, they do not necessarily represent impermeable surfaces. Therefore, we assign the hydraulic conductivities of adjacent soil units to the non-soil map units.

Saturation of soil by shallow groundwater (less than approximately 30 feet [9 m]) inhibits radon movement by dissolving radon in the water and reducing its ability to migrate upward through foundation soil (Black, 1996). Our groundwater mapping focused on the principal aquifer where it is shallow and unconfined or artesian, and on locally unconfined or perched aquifers 30 feet (9 m) or less below the ground surface. Geotechnical data were incorporated into a geodatabase to map shallow groundwater. Groundwater levels are shallow throughout most valley locations and there are many seeps and springs along the Wasatch fault zone.

Geologic mapping is important for identifying geologic units having high uranium content, particularly outside of areas covered by previous investigations where radiometric data are limited. Metamorphic and igneous rocks of the Precambrian Farmington Canyon Complex compose much of the Wasatch Range in the eastern part of the investigation area and have high uranium content (Black, 1993). In the valley, lake deposits, landslide deposits, and alluvial-fan deposits are derived from bedrock to the east and therefore retain a high uranium content. Consequently, it is possible to obtain high indoor radon readings in many areas where the geologic contribution is moderate or low based on uranium-bearing subsurface geologic units not shown on geologic mapping, variable soil permeability, and groundwater conditions. This mapping methodology assumes that the radon source is below the overlying soils and groundwater. It is important to note that in southern Davis County, valley surficial deposits likely contribute to high radon levels at the surface, minimizing the effect of impermeable soils and shallow groundwater.

The radon hazard potential in southern Davis County is generally highest along the benches and in the canyons of the Wasatch Range. The hazard potential is high along the lower benches that are underlain by highly permeable sand and gravel derived from geologic units with high uranium concentrations. The hazard potential generally decreases westward as near-surface groundwater, silts, and clays increase toward Great Salt Lake. However, many areas along the valley floor have a high radon hazard potential, where underlain by large debris-flow deposits, young stream deposits, and landslide deposits that have mobilized material with high uranium concentrations from the mountain front. Along with geologic factors, a number of non-geologic factors also influence indoor radon levels. Although the influence of geologic factors can be estimated, the influence of non-geologic factors such as occupant lifestyle and home construction are highly variable. As a result, indoor radon levels fluctuate and can vary in different structures built on the same geologic unit; therefore, the radon level must be measured in each structure to determine if a problem exists. Testing is easy, inexpensive, and may often be conducted by the building occupant, but professional assistance is available (for more information, see http://radon.utah.gov). Evaluation of actual indoor radon levels across the mapped area was beyond the scope of this investigation.

The hazard-potential categories shown on this map are approximate and mapped boundaries are gradational. Localized areas of higher or lower radon potential are likely to exist within any given map area, but their identification is precluded because of the generalized map scale, relatively sparse data, and non-geologic factors, such as variability in structure construction. The use of imported fill for foundation material can also affect radon potential in small areas, as the imported material may have different geologic characteristics than the native soil.

If professional assistance is required to test for radon or reduce the indoor radon hazard, a qualified contractor should be selected. The EPA provides guidelines for choosing a contractor, and a listing of state radon offices, in the Consumer's Guide to Radon Reduction (EPA, 2010). The Davis County Health Department offers free radon testing for Davis County residents at specific times throughout the year; more information on this program can be found at http://www.daviscountyutah.gov/health/environmental-health-services/environmental_testing/radon.

ACKNOWLEDGMENTS

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Table 1. Factors that contribute to radon hazard potential. From Black and Solomon (1996).

Factor	Point Value		
	1	2	3
Uranium (ppm, estimated)	<2	2-3	>3
Permeability (K, in/hr)	Low 0.06-0.6	Moderate 0.6-6.0	High 6.0-20.0
Groundwater depth (feet)	<10	10-30	>30

Table 2. Radon hazard potential mapping criteria and indoor radon potential. From Black and Solomon (1996).

Category	Point Range	Potential indoor radon concentration (pCi/L)
Low	3-4	<2
Moderate	5-7	2-4
High	8-9	>4