LOCATION RESTRICTIONS DEMONSTRATION REPORT CCR LANDFILL

Iatan Generating Station

Presented to:
Kansas City Power & Light Company
Iatan Generating Station
Iatan, Missouri

SCS ENGINEERS

27218131.02 | October 2018

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Overland Park, Kansas 66210
913-681-0030

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1 INTRODUCTION AND PURPOSE

The Disposal of Coal Combustion Residuals (CCR) from Electric Utilities Final Rule (CCR Rule) 40 CFR 257.60 through 257.64 requires owner/operators of existing CCR units to make demonstrations in the event a unit is located in certain areas. The purpose of this report is to demonstrate whether the CCR Landfill (Unit) at Kansas City Power & Light Company's (KCP&L) Iatan Generating Station (Iatan) is located in any of those areas; and, if so, to make certain demonstrations per the CCR Rule that will permit continued CCR disposal/management operations.

The Unit, which is an existing CCR landfill, is located at the Iatan Generating Station in Platte County, Missouri, as indicated in **Figure 1**.

SCS Engineers (SCS) has reviewed the documents referenced in Section 3 and completed site visit(s) to develop this report. This document provides demonstrations that documents if the Unit is located:

- in an unstable area (40 CFR §257.64).

The applicable CCR Rule requirement for the above is listed in Section 2 in italics followed by an explanation of the review and determinations completed by SCS.

2 UNSTABLE AREAS (§257.64)

§257.64 (a) An existing or new CCR landfill, existing or new CCR surface impoundment, or any lateral expansion of a CCR unit must not be located in an unstable area unless the owner or operator demonstrates by the dates specified in paragraph (d) of this section that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted.

SCS evaluated the location of the Unit for the presence of on-site or local unstable areas as defined in §257.53. Evaluations of the conditions listed in §257.64 (b)(1) through (3) were evaluated and are discussed below. Based on this review, SCS determined the Unit is not located within an unstable area as defined in §257.53. Consequently, no additional demonstration is necessary.

257.64 (b) The owner or operator must consider all of the following factors, at a minimum, when determining whether an area is unstable:

2.1 UNSTABLE FACTORS CONSIDERED: DIFFERENTIAL SETTLING (§257.64(b)(1))

On-site or local soil conditions that may result in significant differential settling;

SCS has visited the Unit and evaluated site-specific reports detailing the conditions of the on-site and local soils for conditions that could result in significant differential settling. The site was characterized in the "Detailed Hydrogeologic Site Characterization Report" (DSI) prepared by Burns & McDonnell in October 2017. The Iatan Generating Station is located within the Dissected Till Plains Subprovince of the Central Lowlands Physiographic Province. The Dissected Till Plains Subprovince is usually characterized by a general lack of features normally associated with glaciation. According to Shimer (1972), the time since deposition by ice sheets has been long enough that lakes and swamps have been filled in and the original forms of glacial deposits have been destroyed by erosion. The regional land surface is that of an undulating to rolling plain with a few narrow strips of hilly land along the larger streams, including the Missouri River.

The regional geology consists of a thick cover of sediments and sedimentary rocks (Quaternary-age to Cambrian-age) deposited on top of older metamorphic and igneous rocks (Precambrian-age). The thick deposits of sedimentary rocks in the region predominately consist of limestone and dolomite and interbedded sequences of shale, sandstone, and coal. In most of the region north of the Missouri River, the sedimentary rocks are overlain by unconsolidated to semi-consolidated sediments consisting of glacial drift, loess, colluvium, and alluvium. The bedrock surface in the region is composed of Pennsylvanian limestones, shales, and sandstones with minor conglomerates and occasional remnants of Pennsylvanian-age channel-fill sandstone (Branson, 1944). Bedrock does not outcrop at the site. The alluvial materials of the Missouri River valley are composed of clay, silt, fine to coarse sand, and fine to medium gravel. The size of the alluvial materials typically increases with depth; finer-grained materials directly underlie the land surface, and coarser sands and gravels are found at depth. The alluvium ranges in thickness from less than a foot at the edge of the valley to as much as 150 feet. The alluvium is generally the thickest in the center part of the valley near the river, but there are instances where the thickest materials are near a valley wall (Miller and Vandike, 1997). From the Iowa State Line to Kansas City, the average thickness of the Missouri River alluvium has been reported to be approximately 90 feet and the average saturated thickness is approximately 80 feet. The alluvium generally consists of several feet of clay and silt near the surface, underlain by sand and gravel.

Based on the geologic description above and a review of geotechnical data in the report(s), it is SCS' professional opinion that the soils on site will not experience significant differential settlement. Pertinent sections of the 2017 Burns & McDonnell report are provided in **Appendix A.1** describing the soils at and near the Unit. Based on this review, SCS determined the Unit is not located within an area with on-site or local soil conditions that may result in significant differential settling.

2.2 UNSTABLE FACTORS CONSIDERED: GEOLOGIC/GEOMORPHOLOGIC FEATURES (§257.64(b)(2))

On-site or local geologic or geomorphologic features; and

SCS has visited the Unit and evaluated published data and site-specific reports for the presence of on-site or local geologic and geomorphologic features, to include karst terrain, steep slopes, and sinkholes. Documents and websites reviewed include:

- MDNR Geologic and Related Hazards in Missouri (https://dnr.mo.gov/geology/geosrv/geores/geohazhp.htm)
- Sinkholes in Missouri (https://dnr.mo.gov/geology/geosrv/envgeo/sinkholes.htm)
- Map of Sinkholes in Missouri (https://dnr.mo.gov/geology/geosrv/envgeo/images/sinkholesinmissouri.jpg)

SCS also used the Missouri Geologic Survey Geosciences Technical Resource Assessment Tool (GeoSTRAT) (http://dnr.mo.gov/geostrat/) database to identify geologic and geomorphologic features that may have an impact on the Unit. Data layers examined by SCS included the following:

- Geologic Structures,
- Earthquake Collapse Potential,
- Earthquake Liquefaction Potential,
- Mines,
- Springs,
- Cave Density,
- Sinkhole Areas, and
- Sinkhole Points.

As shown on the GeoSTRAT map in **Appendix A.2**, only geologic structures (Iatan Structure) and limestone surface mines were identified within the search area near the Unit. Neither the geologic structure or the limestone mining in the area should have an impact on the Unit.

Neither the GeoSTRAT database nor published data indicate the presence of karst terrain, sinkholes, caves, or ground conditions that could cause a structural failure in the area of the Unit or region around the Unit. SCS' visits to the Unit and a review of terrain at and near the Unit indicated no steep slopes, terrain features, or other local geologic or geomorphologic features that could feasibly result in an unstable condition. Pertinent documents and sections of documents reviewed are provided in **Appendix A.2**, and indicate the location of the Unit in relation to the known geologic or geomorphologic features nearest the Unit.

Based on this review, SCS determined the Unit is not located within an area with on-site or local geologic or geomorphologic features that would result in an unstable environment for the Unit.

2.3 UNSTABLE FACTORS CONSIDERED: HUMAN-MADE FEATURES OR EVENTS (§257.64(b)(3))

On-site or local human-made features or events (both surface and subsurface).

SCS has visited the Unit and evaluated published data and site-specific reports for the presence of on-site or local human-made features or events (both surface and subsurface), to include surface and subsurface mining, extensive withdrawal of oil and gas, steep slopes, and sources of rapid groundwater drawdown, in strata that could feasibly impact the Unit. Documents and websites reviewed include:

- Missouri Mine Maps (https://dnr.mo.gov/geology/geosrv/geores/mine-maps/)
- Mine Maps – Platte County (https://dnr.mo.gov/geology/geosrv/geores/minemapsplatte.htm)
- Oil and Gas in Missouri, Fact Sheet (https://dnr.mo.gov/pubs/pub652.pdf)
- Oil and Gas in the Show-Me State, The Geologic Column of Missouri, published by the MDNR Division of Geology and Land Survey, Volume 2, Issue 1, Summer 2007
- Aerial photographs

SCS used the Missouri GeoSTRAT database to identify man-made features or events that may have an impact on the Unit. Data layers examined by SCS included the following:

- Inventory of Mines, Occurrences and Prospects,
- Industrial Mineral Mines, and
- Oil and Gas Wells.

The GeoSTRAT maps indicated the presence of mines and oil and gas production in Platte County. However, the only mining in the area of the Unit consists of surface limestone mines along the eastern bluff of the Missouri River. Underground mining is limited to two underground limestones mines; one near Parkville and one near North Kansas City. The GeoSTRAT database showed the location of oil/gas wells in Platte County, but no oil/gas wells are within 5 miles of the Unit.

No evidence of steep slopes in the vicinity of the unit nor areas of rapid groundwater drawdown were identified.

Selected pertinent documents and sections of documents are provided in **Appendix A.3** to indicate the types and locations of human-made features in this area of Missouri and their locations relative to the Unit.

Based on this review, SCS determined the Unit is not located within an area with on-site or local human-made features or events (both surface and subsurface) that could feasibly result in an unstable condition at the Unit.

3 REFERENCES

Burns & McDonnell (2017), Detailed Hydrogeologic Site Characterization Report for CCR Landfill, Iatan Generating Station.

USGS, (2015), Geologic Units in Platte County, Missouri, https://mrdata.usgs.gov/geology/state/fips-unit.php?code=f29165, accessed August 2018.

MDNR, MDNR Geologic and Related Hazards in Missouri, https://dnr.mo.gov/geology/geosrv/geores/geohazhp.htm, accessed August 2018.

MDNR (2015), Geologic Hazards in Missouri, https://dnr.mo.gov/pubs/pub2467.pdf, accessed August 2018.

MDNR, Sinkholes in Missouri, https://dnr.mo.gov/geology/geosrv/envgeo/sinkholes.htm, accessed August 2018.

MDNR, Map of Sinkholes in Missouri, https://dnr.mo.gov/geology/geosrv/envgeo/images/sinkholesinmissouri.jpg, accessed August 2018

MDNR, Missouri Geologic Survey Geosciences Technical Resource Assessment Tool (GeoSTRAT), https://dnr.mo.gov/geology/geostrat.htm, accessed August 2018.

MDNR, Missouri Mine Maps, https://dnr.mo.gov/geology/geosrv/geores/mine-maps/, accessed August 2018.

MDNR, Mine Maps – Platte County, https://dnr.mo.gov/geology/geosrv/geores/minemapsplatte.htm, accessed August 2018.

MDNR, Oil and Gas in Missouri, Fact Sheet, https://dnr.mo.gov/pubs/pub652.pdf, accessed August 2018.

MDNR, Mineral Resources in Missouri, https://dnr.mo.gov/geology/adm/publications/docs/map-MinRes.pdf, accessed August 2018.

MDNR, Missouri Coal, https://dnr.mo.gov/geology/docs/BRO006MissouriCoal.pdf, accessed August 2018.

4 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION (§§257.64(C))

The undersigned registered professional engineer is familiar with the requirements of the CCR Rule and has visited and examined the Unit and/or has supervised examination of the Unit and development of this report by appropriately qualified personnel. I hereby certify based on a review of available information and observations, that this report meets the requirements of paragraphs §§257.64(a).

Professional Engineer: Company: Douglas L. Doerr, P.E.

SCS Engineers

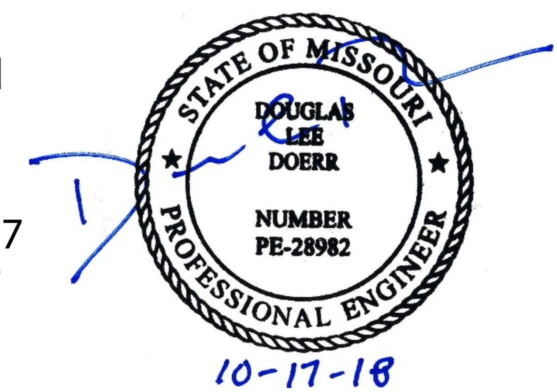
PE Registration State: Missouri

Registration Number: PE-28982

Professional Engineer Seal:

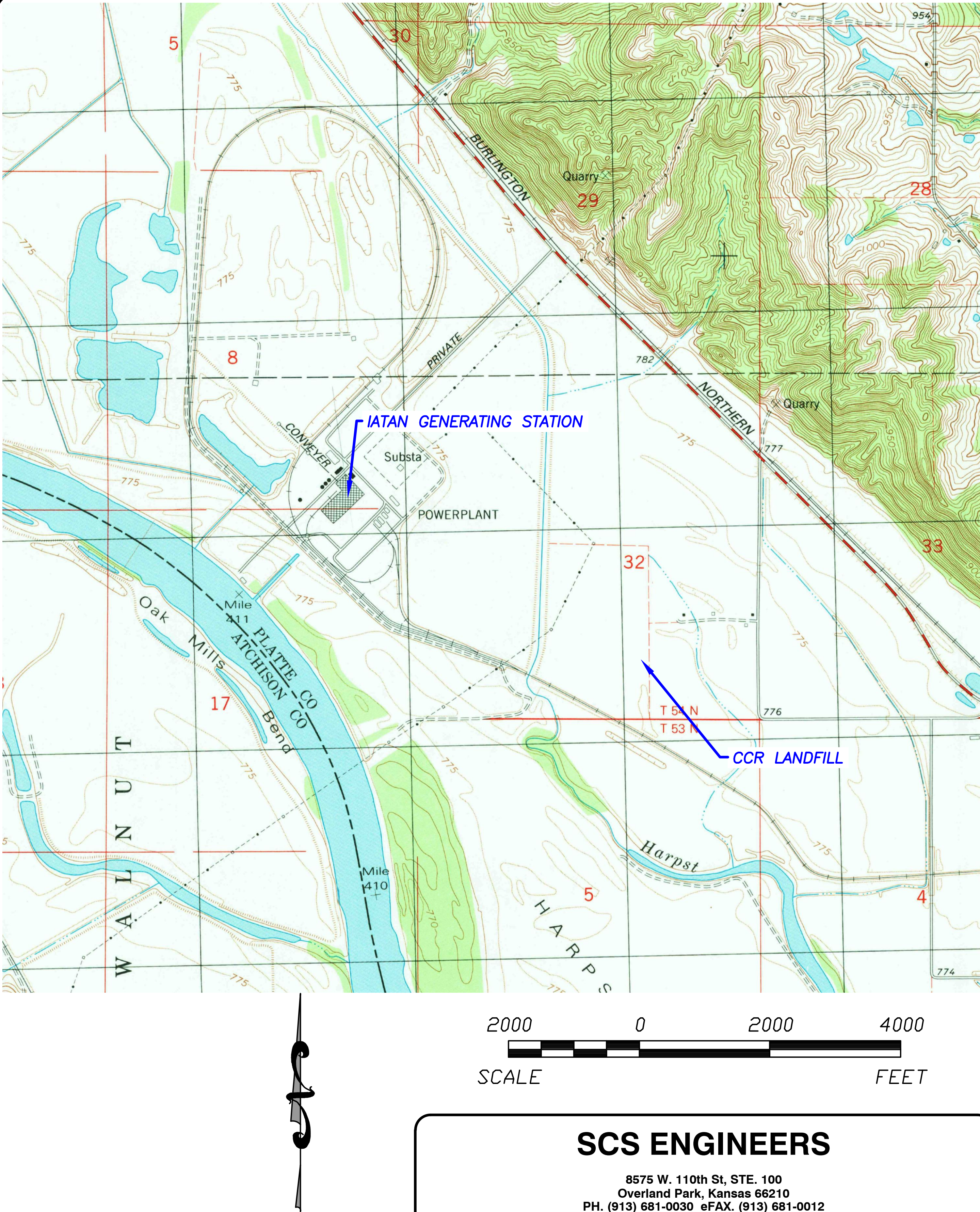
Douglas L. Doerr

Digitally signed by Douglas L. Doerr
Date: 2018.10.17 13:55:56 -05'00'



FIGURES

Figure 1 - Site Location Map



SOURCE:
1984 USGS MAP
WESTON QUADRANGLE
7.5 MINUTE SERIES (TOPOGRAPHIC)

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FIGURE 1
SITE LOCATION MAP
KCP&L IATAN GENERATING STATION - CCR LANDFILL
PLATTE COUNTY, MISSOURI

CHK. BY: DLD	DWN. BY: TGW	DSN. BY: TGW	PROJ. NO. 27218131.02
PROJ. MGR: DLD	DATE: 10/2018	CADD FILE: FIGURE 1_SITE MAP.DWG	DRAWING NO. 1

APPENDIX A

Unstable Areas Supporting Information

APPENDIX A.1

Portions of Detailed Hydrogeologic Site Characterization Report for CCR Landfill (Burns & McDonnell, 2017)

1.3 Land Use

1.3.1 Historic Land Use

Prior to construction of the generating station, the land was used for agricultural purposes, primarily cultivated crops. A residential structure was present to the southeast of the CCR Landfill but was unoccupied during the DSI (Burns & McDonnell, 2006). Historic land use and cultural resource impacts associated with the CCR Landfill were addressed in the permit application document with the Corps of Engineers during the DSI.

1.3.2 Current Land Use

The Iatan Generating Station, located to the west of the CCR Landfill, is zoned industrial. The residential structures formerly present near the southern and eastern portion of the CCR Landfill have since been demolished and the area currently consists of a few structures that serve as maintenance buildings for plant operations. The current land use within ¼ mile surrounding the landfill is for agriculture and industrial for the power generating station.

1.4 Regional Climate

Platte County, Missouri has a modified continental climate. Average annual precipitation is approximately 38 inches. May is generally the wettest month while January and February are the driest. Average monthly temperatures range from 25.7 degrees Fahrenheit (ºF) in January to 78.4 ºF in July according to the National Climatic Data Center.

1.5 Regional Geology and Hydrogeology

Information presented in this section was obtained from review of existing documentation and information from various sources, including previous field investigations at the site and published literature. Information presented in this section was obtained from review of the DSI (Burns & McDonnell, 2006), United States Geological Survey (USGS) *Ground Water Atlas of the United States: Kansas, Missouri, Nebraska* (Miller and Appel, 1997), USGS Ground Water Atlas of the United States: Introduction and National Summary (Miller, 1999), MDNR Well Information Management System (WIMS), and the Missouri Geological Survey (MGS) Geosciences Technical Resource Assessment Tool (GeoSTRAT).

1.5.1 Geomorphology

Eastern Kansas and northwestern Missouri lie within the Dissected Till Plains Subprovince of the Central Lowlands Physiographic Province. The Dissected Till Plains Subprovince is usually characterized by a general lack of features normally associated with glaciation. According to Shimer (1972), the time since deposition by ice sheets has been long enough that lakes and swamps have been filled in and the original forms of glacial deposits have been destroyed by erosion. The regional land surface is that of an undulating to rolling plain with a few narrow strips of hilly land along the larger streams, including the Missouri River. The dominant drainage pattern is dendritic although rectangular patterns on some of the smaller streams may occasionally be noted on topographic maps.

In northwestern Missouri and northeastern Kansas, the topographic surface elevation varies from a minimum of approximately 725 feet amsl in the Missouri River flood plain to about 1,225 feet amsl in the uplands. The average local relief is typically no more than 100 feet, but maximum local relief may reach 350 feet (Shimer, 1972). The Site is located within the Missouri River floodplain with the Missouri River located less than a mile to the west of the Site (see Figures 1 and 2). The Site is located within the 100-year flood plain (Platte County, 2002). Consequently, flood control measures for the landfill including a flood protection berm, and other ancillary flood control systems were included in the landfill engineering design.

1.5.2 Structural Features

The Iatan Generating Station is situated in the Forest City Basin, a depositional and structural basin that includes parts of northwestern Missouri, southwestern Iowa, southeastern Nebraska, and northeastern Kansas. Regional structural features bound the basin to the west and south. The Nemaha Anticline forms the western boundary, and, to the south, the Forest City Basin is separated from the Cherokee Basin by the Bourbon Arch in southeastern Kansas (McCracken, 1971).

Investigative activities from the DSI at the Site did not indicate the presence of any faults and that the Site is located in a low-impact seismic zone. Additionally, no springs, caves, sinkholes, or other significant geologic features within ¼ mile of the Site were found to be present as noted in the DSI.

1.5.3 Stratigraphy

The regional geology consists of a thick cover of sediments and sedimentary rocks (Quaternary-age to Cambrian-age) deposited on top of older metamorphic and igneous rocks (Precambrian-age) that form the “crystalline basement complex” (basement rocks) or foundation of the continental crust. Sediments were deposited on the surface of the basement rocks and lithified into sedimentary rocks during diagenesis. The thick deposits of sedimentary rocks in the region predominately consist of limestone and dolomite and interbedded sequences of shale, sandstone, and coal. In most of the region north of the Missouri River, the sedimentary rocks are overlain by unconsolidated to semi-consolidated sediments consisting of glacial drift, loess, colluvium, and alluvium.

The bedrock surface in the region is composed of Pennsylvanian limestones, shales, and sandstones with minor conglomerates and occasional remnants of Pennsylvanian-age channel-fill sandstone (Branson, 1944). The bedrock generally strikes north-northeast and dips gently to the northwest at approximately 25 feet per mile (Watney, 1984).

The alluvial materials of the Missouri River valley are composed of clay, silt, fine to coarse sand, and fine to medium gravel. The size of the alluvial materials typically increases with depth; finer-grained materials directly underlie the land surface, and coarser sands and gravels are found at depth. This clay or silt cap overlying the more permeable sands and gravels, where present, can retard infiltration of surface water. The alluvium ranges in thickness from less than a foot at the edge of the valley to as much as 150 feet. The alluvium is generally the thickest in the center part of the valley near the river, but there are instances where the thickest materials are near a valley wall (Miller and Vandike, 1997).

From the Iowa State Line to Kansas City, the average thickness of the Missouri River alluvium has been reported to be approximately 90 feet and the average saturated thickness is approximately 80 feet. The alluvium generally consists of several feet of clay and silt near the surface, underlain by sand and gravel. The alluvium in this area is underlain by Pennsylvanian-age shales, limestones, and sandstone, which are not considered important aquifers, yielding very little water, most of which is generally too highly mineralized for most uses (Miller and Vandike, 1997).

Groundwater flow throughout the region is largely driven by topography and is highly variable in response to regional points of groundwater discharge (e.g., springs, streams, rivers, shallow stream/river valley alluvial aquifers). Groundwater in aquifers locally move from topographically high recharge areas to regional points of groundwater discharge or localized discharges at surface (e.g., seeps and water supply wells).

1.6 Aquifers

The region consists of both surficial and bedrock aquifers. The uppermost aquifer beneath the Site consists of a surficial aquifer composed of stream-valley sediments (Missouri River alluvium).

1.6.1 Surficial Aquifers

The surficial aquifers are composed of Quaternary-age unconsolidated sediments that provide water for shallow water supply wells and consist primarily of material deposited during multiple advances of

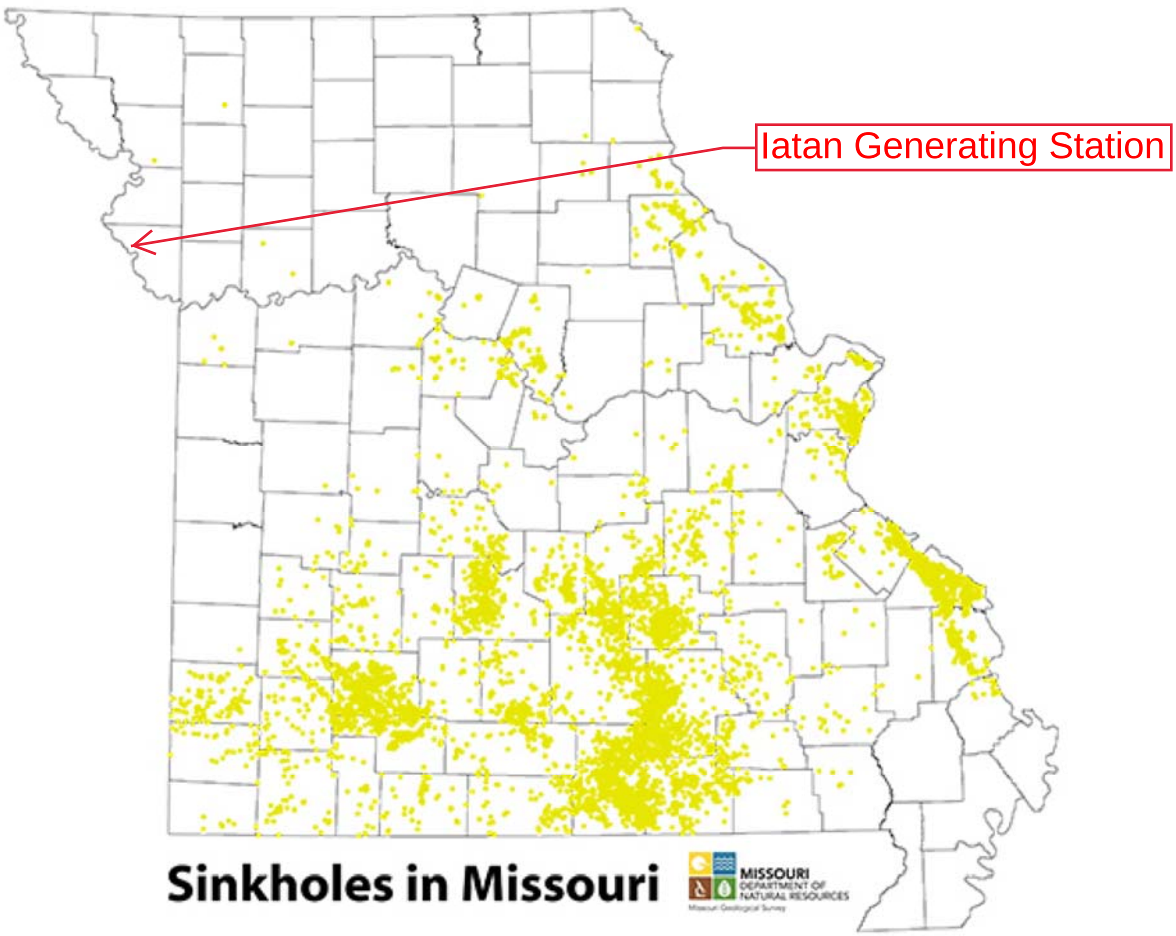
APPENDIX A.2

Geologic/Geomorphologic Features Documentation

Sinkholes in Missouri (MDNR)

Geologic Hazards in Missouri (MDNR, 2015)

GeoSTRAT Database Review


Iatan Generating Station
Sinkholes in Missouri
MISSOURI
DEPARTMENT OF
NATURAL RESOURCES

Abandoned Mines

Abandoned mines are found throughout Missouri. They include both surface pits and underground mines. These mines produced a variety of economic, industrial and energy minerals and provided raw materials that helped build Missouri and the nation. Some abandoned mines date back to the original French settlers in the 1700s and are a major part of Missouri's history.

Older mines typically were abandoned and seldom reclaimed or closed. These mines operated long before permitting laws established requirements for reclamation and closure. Today, these pits, voids, open adits and shafts can pose a public safety hazard.

Abandoned mine sites appear attractive to explore, but are unsafe to walk, climb or ride in. What appears to be solid ground may only have a thin veneer of cover hiding an abandoned shaft, which could collapse under the weight of a person walking. Embankments or high walls may be unstable or not visible behind piled material. High walls that appear to be stable can collapse. Piles of waste material called "tailings" or "slime" may be unstable and can slide and bury someone climbing on them. Abandoned quarries or other surface mines often are appealing swimming holes. However, from the surface it is impossible to tell how deep the mine is or if shallow ledges left from mining remain but cannot be seen.

Abandoned underground mines can have poor air quality. Active underground mines are ventilated to bring fresh air to miners. Abandoned mines, however, may have dangerous levels of carbon monoxide or methane.

The Missouri Geological Survey maintains the official Missouri Mine Map Repository and the Inventory of Mines, Occurrences and Prospects (IMOP). The Repository houses more than 2,000 maps of underground mines while the IMOP database contains locations of more than 27,000 surface and underground mines. Learn more at dnr.mo.gov/geology/geosrv/geores/minemaps.htm.

Publications

Geologic maps and other geologic and hydrologic publications are available from the Missouri Geology Store by visiting this website missourigeologystore.com.

Abandoned mine shaft in southwest Missouri.

Geological Survey Program
111 Fairgrounds Road • Rolla, MO 65401
Phone: 573-368-2143 • Fax: 573-368-2111
gspgeol@dnr.mo.gov
dnr.mo.gov/geology/geosrv

MISSOURI DEPARTMENT OF NATURAL RESOURCES
Missouri Geological Survey
PUB2467 9/15

GEOLOGIC HAZARDS in Missouri

Earthquakes
Sinkholes
Landslides
Abandoned Mines

MISSOURI DEPARTMENT OF NATURAL RESOURCES
Missouri Geological Survey

Earthquakes

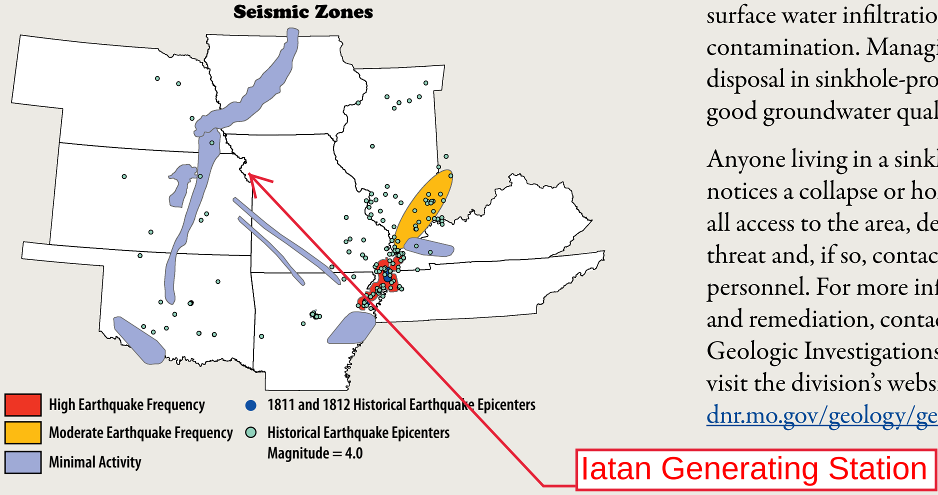
Most Missourians are familiar with the large 1811-1812 earthquakes that occurred in the New Madrid Seismic Zone (NMSZ) in southeast Missouri. However, Missouri experiences small earthquakes nearly every day. These earthquakes typically are too small to be felt but are recorded on seismographs, devices that measure the earth's movement. While these earthquakes are more frequent in the NMSZ in southeast Missouri, they also occur on other faults located in Missouri and surrounding states.

Earthquakes occur when pressure builds up on two sides of a fault. The fault sides slip against one another, shifting the rock and sending waves of motion through the earth. Movement along a fault can occur thousands of feet below ground surface, often with no visible signs of the fault at the surface.

It is impossible to predict when or where an earthquake might occur in Missouri or elsewhere. Based on the history of past earthquakes, U.S. Geological Survey seismologists (earthquake researchers) suggested in 2009 the chance of having a magnitude 7.0 - 8.0 earthquake in the NMSZ in the next 50 years is about 7 to 10 percent. Smaller earthquakes have a greater chance of occurring.

Knowledge and preparation are crucial to earthquake preparedness. Information related to earthquakes and disaster preparedness is available at dnr.mo.gov/geology/geosrv/earthquakes.htm.

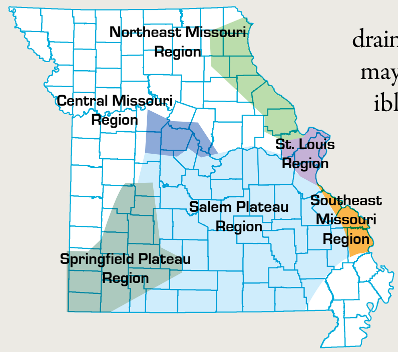
Seismic Zones



Sinkholes

Sinkholes are collapsed areas formed by the dissolution of carbonate bedrock or collapse of underlying caves. They range in size from several square yards to hundreds of acres and may be very shallow or hundreds of feet deep. Often, sinkholes are visible from the ground surface as circular depressions or areas of internal drainage. Other sinkholes may not be readily visible from the ground surface because they are plugged or capped with soil or thin layers of rock.

Primary Sinkhole Regions of Missouri



Development in areas prone to sinkhole formation can be very dangerous. Collapse of the plug or cap can open the underground void to the surface. Sinkholes may start as a small hole in the ground that slowly grows to full size or may form in a sudden catastrophic collapse that occurs with no warning. Collapsed sinkholes generally are steep-sided and very unstable. They often experience continued slumping and collapse along their edges; therefore, activities near sinkholes should be undertaken with great caution.

When sinkholes form, they can act as conduits for rapid surface water infiltration, often resulting in groundwater contamination. Managing storm water runoff and waste disposal in sinkhole-prone areas is important to maintaining good groundwater quality.

Anyone living in a sinkhole-prone area of the state who notices a collapse or hole opening should first block off all access to the area, decide if there is an immediate safety threat and, if so, contact their local emergency management personnel. For more information about sinkhole collapse and remediation, contact the Missouri Geological Survey's Geologic Investigations Unit by calling 573-368-2100 or visit the division's website at dnr.mo.gov/geology/geosrv/geores/geohazhp.htm.

Landslides

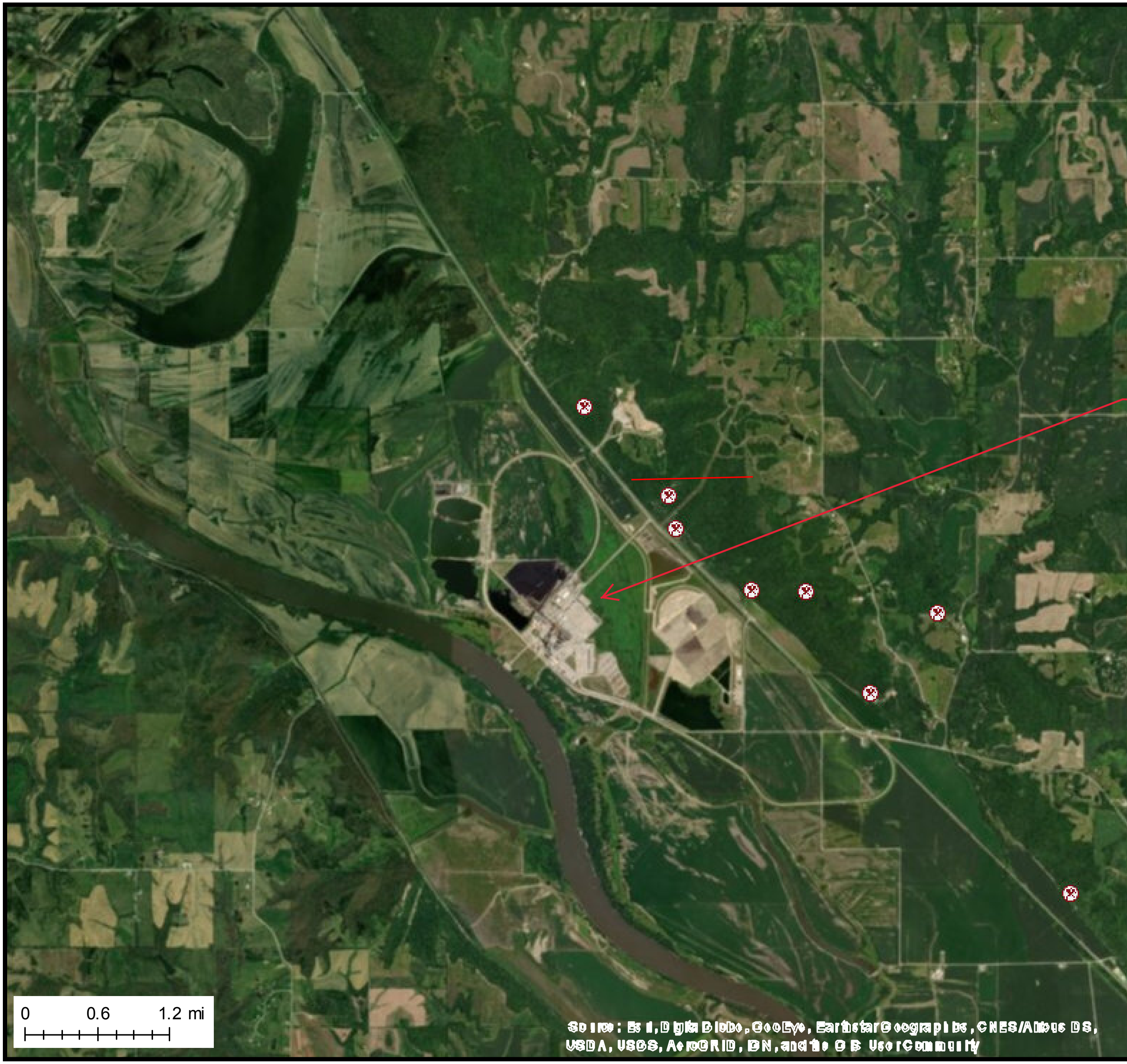
Landslides, slumps and rockfalls are potential geologic hazards throughout Missouri and can occur where there are bluffs or steep slopes. They often can be triggered when surficial materials are moved or modified by man. In general, the higher and steeper the slope, the farther and faster the slide will travel.

Landslides and slumps generally occur where there are steep slopes of unconsolidated material or thick soils. Slopes with shale are also susceptible to landslides. Slumps appear as curved scars along the slope and an uneven or unusually flat surface at the base of slopes. Slope stability often is reduced by change in water tables or when heavy rains oversaturate soils, by the removal of vegetation or by increased human activity. Modification of a slope, such as cutting a road in a hillside, can cause problems, even on slopes that appear stable. Care should be taken when modifying slopes or changing water's natural drainage course.

Rockfalls are common hazards in areas that have bluffs or extremely steep hillsides. The most hazardous are bluffs that contain thick beds of sandstone or carbonate rock underlain by shale. The shale will often become soft and weather out, leaving large pieces of balanced rock. Bluffs of highly fractured rock are also at great risk for rockfalls. As with landslides and slumps, rockfalls are also more likely to occur during times of heavy rains.

Landslide along a Missouri roadway.

Geo STRAT



Geologic Structures

(Iatan Structure)

Limestone Surface Mines

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Disclaimer: Although this map has been compiled by the Missouri Department of Natural Resources, no warranty, expressed or implied, is made by the department as to the accuracy of the data and related materials. The act of distribution shall not constitute any such warranty, and no responsibility is assumed by the department in the use of these data or related materials.

APPENDIX A.3

Human-made Features or Events Documentation

Mine Maps – Platte County (MDNR)

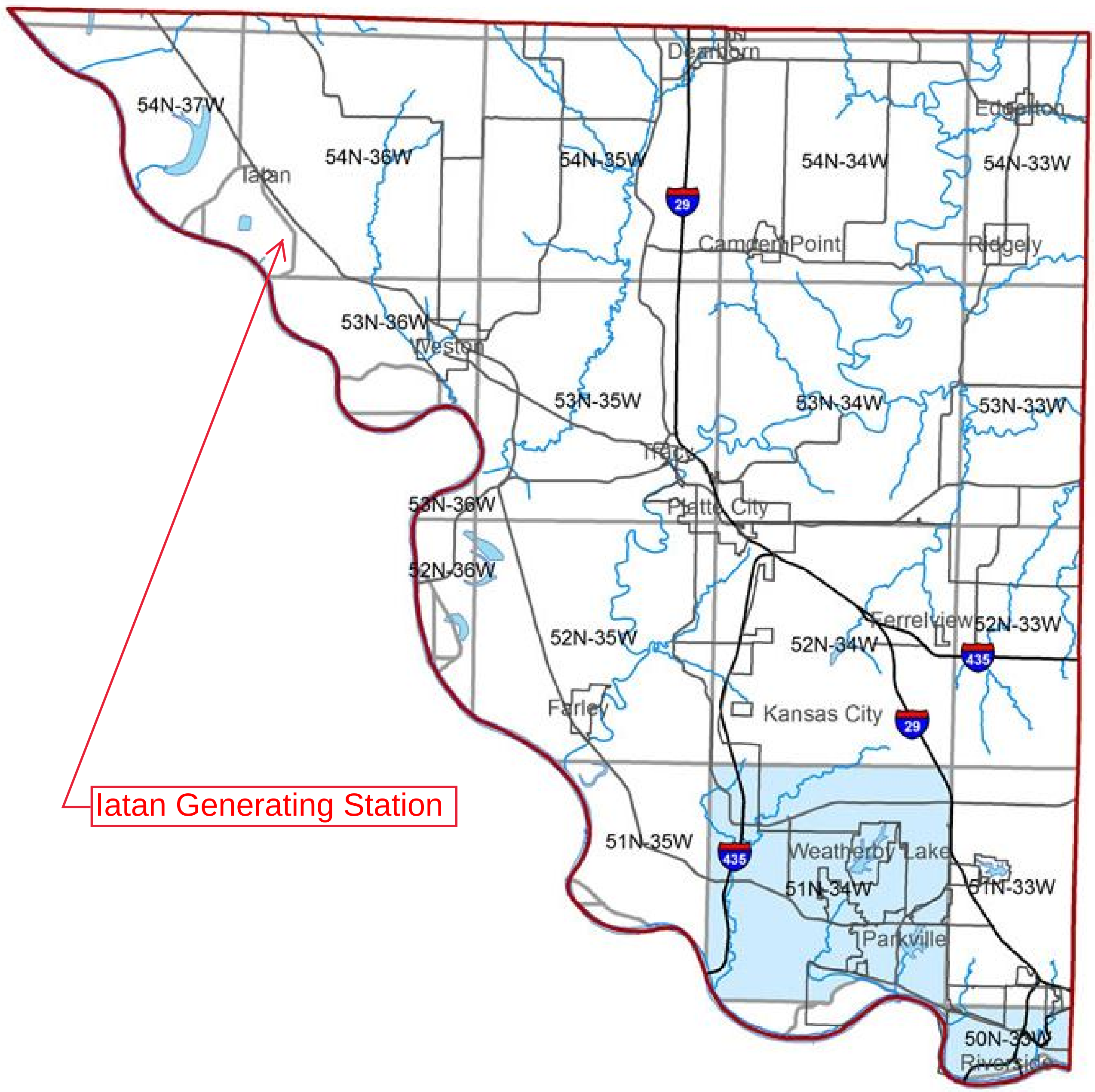
Oil and Gas in Missouri Fact Sheet (MDNR)

Mineral Resources in Missouri (MDNR)

Missouri Coal (MDNR)

Mine Maps -- Platte County

Blue tint indicates areas where mine maps are presently available. Click on a highlighted area to see a list of maps that are available.



Disclaimer – This information is inclusive of maps archived in or scanned by the Missouri Mine Map Repository. It does not contain maps for all underground mines in the state of Missouri.

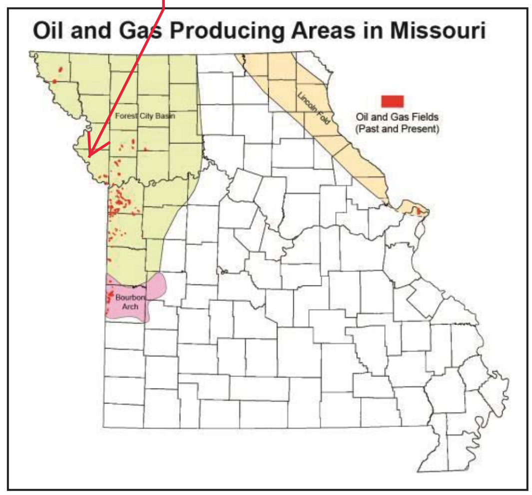
MISSOURI DEPARTMENT OF NATURAL RESOURCES

Oil and Gas in Missouri

Missouri Geological Survey fact sheet number 19
Missouri Geological Survey Director: Joe Gillman

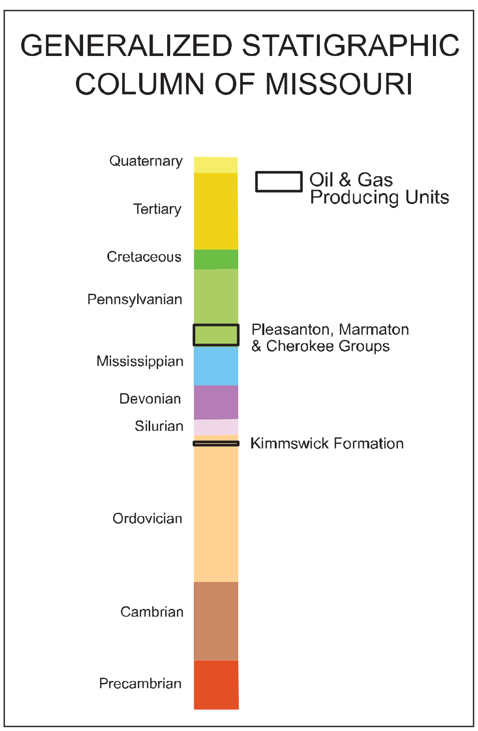
11/2016

Iatan Generating Station



Oil and gas are naturally occurring, combustible hydrocarbon substances. Oil is also called petroleum or crude oil. Gas is also known as natural gas. Oil is a very complex mixture of hydrocarbon liquids, whereas gas is simply methane gas that contains small to trace amounts of other gasses, including: ethane, propane, butane, nitrogen, carbon dioxide and helium. Varying amounts of gas are dissolved in most oils.

Oils are classified as light, intermediate and heavy based on their consistency at room temperature. Light oils are thin and flow readily like water or paint thinner. Their color ranges from pale yellow to nearly colorless. Intermediate oils have a syrupy consistency, with colors ranging from green to black. Heavy oils are thick and flow like molasses or not at all. Their color usually is black. The majority of Missouri's oil is in the intermediate to heavy range.



Oil and gas are both classified as sweet or sour, based on the amount of sulfur content. Sweet oil and gas have little or no sulfur and are considered high quality. Sour oil and gas contain undesirable amounts of sulfur, usually in the form of hydrogen sulfide, which smells like rotten eggs. Missouri's oil and gas deposits are considered to be sweet.

Oil and gas forms from the burial and thermal alteration of shale or mudstone containing abundant organic material from dead marine organisms. Tiny amounts of oil and gas are produced in the shale or mudstone. Under certain geologic conditions, oil and gas migrate and accumulate into pools. The pools typically are located in porous strata such as sandstones, conglomerates or fractured limestones and dolomites. These pools are trapped in the reservoir strata by impervious layers of shale within a geologic structure such as an anticline.

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Missouri Geological Survey
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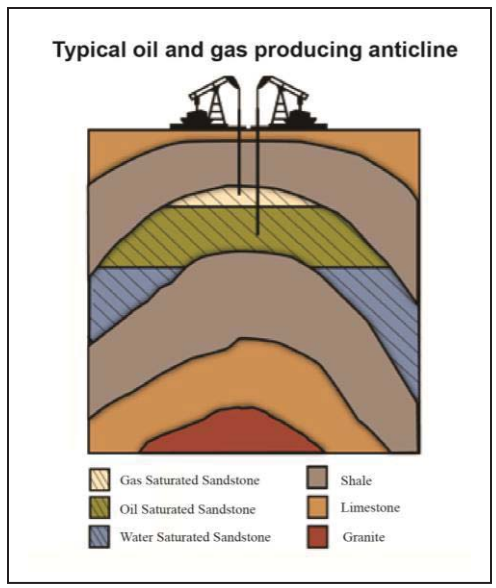
PO Box 250
111 Fairgrounds Road
Rolla, MO 65402

In Missouri, the first oil and gas wells were drilled in the Kansas City area shortly after the Civil War in the 1860s. Hundreds of shallow wells were drilled in western Missouri along the Kansas border during the late 1800s and early 1900s. Many of these wells produced gas used in private homes, farmsteads and small towns.

Due to the success of these wells, additional sites were explored in central and eastern Missouri. By the early 1930s, more than 2,500 wells had been drilled in search of oil and gas resources. Additional pools were discovered in Vernon County in the 1920s, Caldwell County in 1940, Atchison County in 1942, Clinton County in 1952 and St. Louis County in 1953. Missouri's newest field along the Holt and Atchison county border was discovered in 1987.

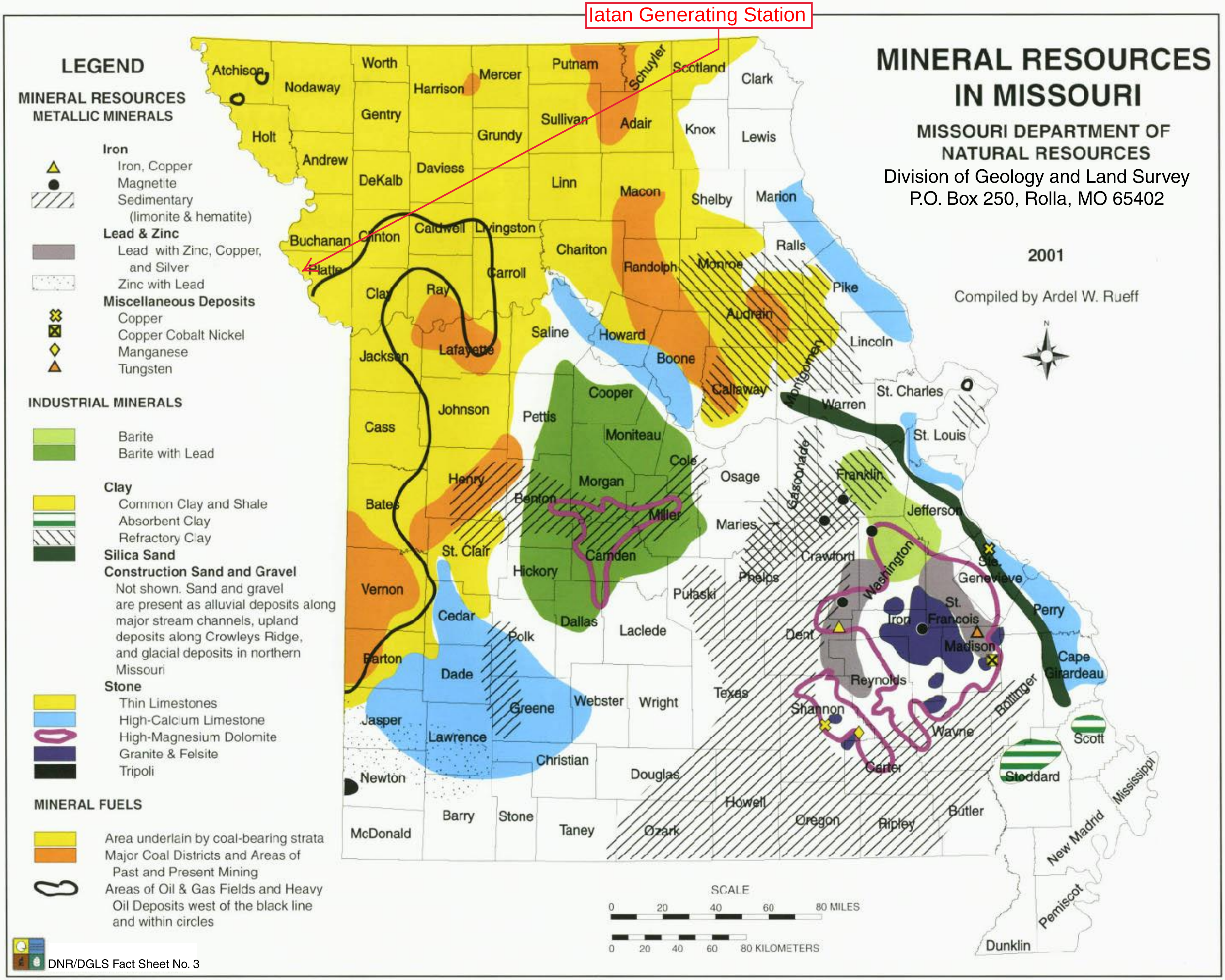
There are three areas of current oil and gas production in the state: the Forest City Basin in northwestern Missouri, the Bourbon Arch in western Missouri and the Lincoln Fold in northeastern Missouri. Within these fields, oil and gas production comes from two producing zones: the Pennsylvanian-age Pleasanton, Marmaton and Cherokee groups and the Ordovician-age Kimmswick Formation. The depth of production in the Cherokee Group ranges from less than 200 feet in the Eastern field of Vernon County to more than 1,500 feet in the Tarkio Field in Atchison County. Production in the Kimmswick Formation ranges from 1,200 feet in the Florissant Dome in St. Louis County to more than 2,800 feet in the Runamuck Field in Atchison County.

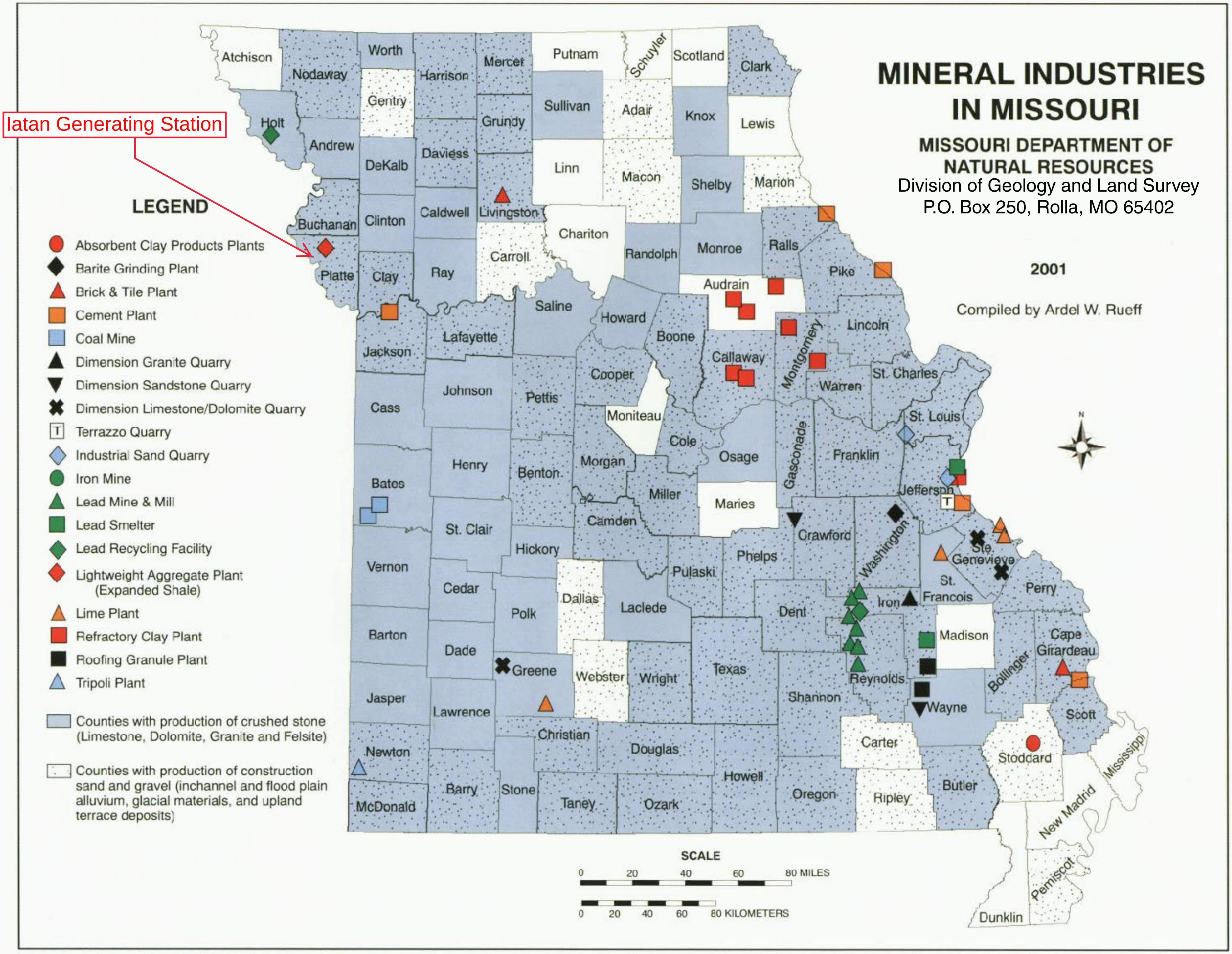
Producing intervals in the Pennsylvanian come from sandstones and black shales. The Ordovician Kimmswick is a fractured limestone. The structures most commonly associated with oil and gas production are anticlines (or elongated domes) and typically do not extend for more than one-quarter mile. In 2006, Missouri produced nearly 90,000 barrels of oil from 323 wells in five counties (Atchison, Cass, Jackson, St. Louis and Vernon). This oil was worth approximately $4.87 million. While there is currently no gas pro-duced for commercial sale in the state, gas was produced for private use from 45 registered wells. Additionally, two large wells produced gas for a private company.



The Missouri Geological Survey has a number of publications about petroleum production and exploration including: OFR-90-80-OG, *Heavy-Oil Resource Potential of Southwest Missouri*; RI-1, *Recent Drilling in Northwestern Missouri*; V-27, *The Oil and Gas Resources of Cass and Jackson Counties Missouri*; OFM-81-54-OG, *Oil and Gas Fields of Missouri*, as well as maps and other publications. Some are historical documents written in the early 1900s.

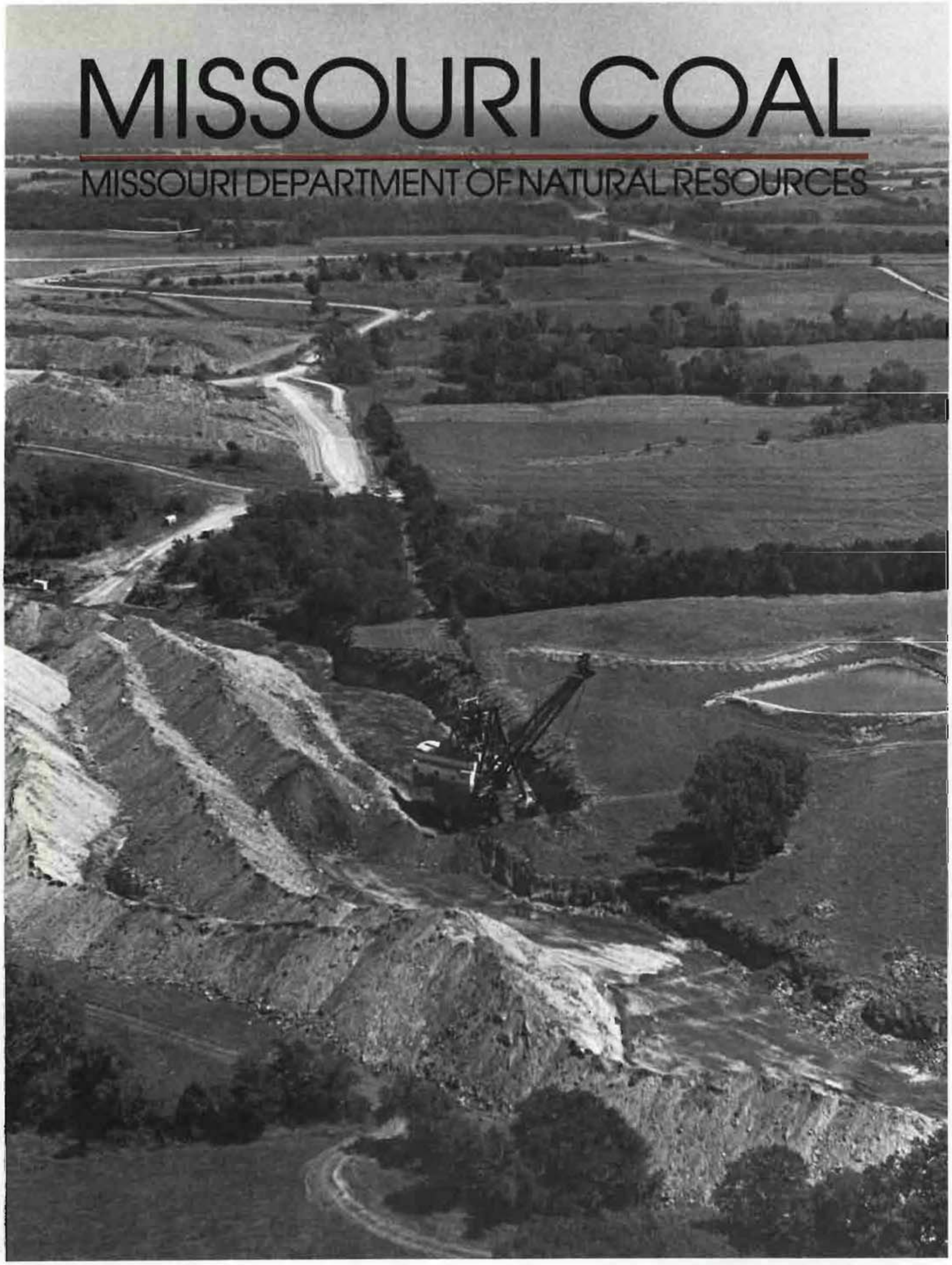
Nothing in this document may be used to implement any enforcement action or levy any penalty unless promulgated or authorized by statute.


Iatan Generating Station
MINERAL RESOURCES IN MISSOURI
MISSOURI DEPARTMENT OF NATURAL RESOURCES
Division of Geology and Land Survey
P.O. Box 250, Rolla, MO 65402
2001
Compiled by Ardel W. Rueff
LEGEND
MINERAL RESOURCES
METALLIC MINERALS
Iron
Iron, Copper
Magnetite
Sedimentary (limonite & hematite)
Lead & Zinc
Lead with Zinc, Copper, and Silver
Zinc with Lead
Miscellaneous Deposits
Copper
Copper Cobalt Nickel
Manganese
Tungsten
INDUSTRIAL MINERALS
Barite
Barite with Lead
Clay
Common Clay and Shale
Absorbent Clay
Refractory Clay
Silica Sand
Construction Sand and Gravel
Not shown. Sand and gravel are present as alluvial deposits along major stream channels, upland deposits along Crowleys Ridge, and glacial deposits in northern Missouri
Stone
Thin Limestones
High-Calcium Limestone
High-Magnesium Dolomite
Granite & Felsite
Tripoli
MINERAL FUELS
Area underlain by coal-bearing strata
Major Coal Districts and Areas of Past and Present Mining
Areas of Oil & Gas Fields and Heavy Oil Deposits west of the black line and within circles
SCALE
0 20 40 60 80 MILES
0 20 40 60 80 KILOMETERS
N
Atchison
Nodaway
Worth
Harrison
Mercer
Putnam
Schuyler
Scotland
Clark
Holt
Gentry
Grundy
Sullivan
Adair
Knox
Lewis
Andrew
DeKalb
Daviess
Linn
Macon
Shelby
Marion
Buchanan
Clinton
Caldwell
Livingston
Chariton
Randolph
Monroe
Ralls
Platte
Clay
Ray
Carroll
Audrain
Pike
Saline
Howard
Boone
Lincoln
Jackson
Lafayette
Montgomery
Callaway
St. Charles
Warren
Cooper
Johnson
Pettis
Moniteau
St. Louis
Cass
Cole
Osage
Franklin
Henry
Morgan
Gasconade
Benton
Miller
Maries
Jefferson
Bates
Camden
Crawford
St. Clair
Hickory
Washington
Ste. Genevieve
Phelps
Vernon
Pulaski
St. Francois
Perry
Cedar
Dallas
Iron
Polk
Laclede
Dent
Madison
Cape Girardeau
Barton
Dade
Reynolds
Bollinger
Greene
Webster
Wright
Texas
Shannon
Jasper
Wayne
Lawrence
Christian
Carter
Scott
Douglas
Stoddard
Newton
Howell
Mississippi
Barry
Stone
Taney
Ozark
Oregon
Ripley
Butler
McDonald
New Madrid
Pemiscot
Dunklin
DNR/DGLS Fact Sheet No. 3


MINERAL INDUSTRIES IN MISSOURI
MISSOURI DEPARTMENT OF NATURAL RESOURCES
Division of Geology and Land Survey
P.O. Box 250, Rolla, MO 65402
2001
Compiled by Ardel W. Rueff
Iatan Generating Station
LEGEND
Absorbent Clay Products Plants
Barite Grinding Plant
Brick & Tile Plant
Cement Plant
Coal Mine
Dimension Granite Quarry
Dimension Sandstone Quarry
Dimension Limestone/Dolomite Quarry
Terrazzo Quarry
Industrial Sand Quarry
Iron Mine
Lead Mine & Mill
Lead Smelter
Lead Recycling Facility
Lightweight Aggregate Plant (Expanded Shale)
Lime Plant
Refractory Clay Plant
Roofing Granule Plant
Tripoli Plant
Counties with production of crushed stone (Limestone, Dolomite, Granite and Felsite)
Counties with production of construction sand and gravel (inchannel and flood plain alluvium, glacial materials, and upland terrace deposits)
SCALE
0 20 40 60 80 MILES
0 20 40 60 80 KILOMETERS
N
Atchison
Nodaway
Worth
Harrison
Mercer
Putnam
Schuyler
Scotland
Clark
Holt
Andrew
Gentry
Grundy
Sullivan
Adair
Knox
Lewis
DeKalb
Daviess
Linn
Macon
Shelby
Marion
Buchanan
Clinton
Caldwell
Livingston
Chariton
Randolph
Monroe
Ralls
Platte
Clay
Ray
Carroll
Audrain
Pike
Saline
Howard
Boone
Lincoln
Jackson
Lafayette
Callaway
Montgomery
St. Charles
Warren
Cooper
Johnson
Pettis
Moniteau
Cass
St. Louis
Cole
Osage
Morgan
Franklin
Henry
Benton
Gasconade
Bates
Miller
Maries
Jefferson
Camden
St. Clair
Crawford
Washington
Hickory
Ste. Genevieve
Vernon
Phelps
Pulaski
St. Francois
Cedar
Dallas
Perry
Laclede
Iron
Polk
Dent
Madison
Barton
Cape Girardeau
Dade
Greene
Bollinger
Texas
Webster
Wright
Reynolds
Shannon
Jasper
Wayne
Lawrence
Scott
Christian
Carter
Stoddard
Douglas
Newton
Howell
Mississippi
Barry
Stone
Oregon
Butler
Ripley
Taney
Ozark
McDonald
New Madrid
Pemiscot
Dunklin

MISSOURI COAL

MISSOURI DEPARTMENT OF NATURAL RESOURCES



INTRODUCTION

Coal, sometimes nicknamed "the rock that burns," is a product of nature's continual growth and decay.

Although not a true coal, peat is considered to be its first stage of development. Further stages of development are the soft coals lignite, or brown coal; subbituminous coal; bituminous coal; and finally, anthracite, or hard coal.

The coal we use now is as much as 300 million years old, formed in an era when lush vegetation and steamy, tropical conditions existed over much of the world. As plants and animals died, the biomass accumulated in layers, eventually forming beds of peat.

Through the centuries, prehistoric seas alternately advanced and receded, depositing layers of sediment on the peat. The sediment accumulated and the earth's crust shifted, compressing the peat, squeezing out its moisture, and burying it deeper and deeper.

Heat generated by the tremendous pressure on the buried beds drove out most of the oxygen and hydrogen, leaving a residue of impure carbon — coal.

Peat continues to form in places like the Dismal Swamp in North Carolina and Virginia. However, it takes 36 feet of peat to form three feet of bituminous coal, in a process much slower than the rate at which we use it.

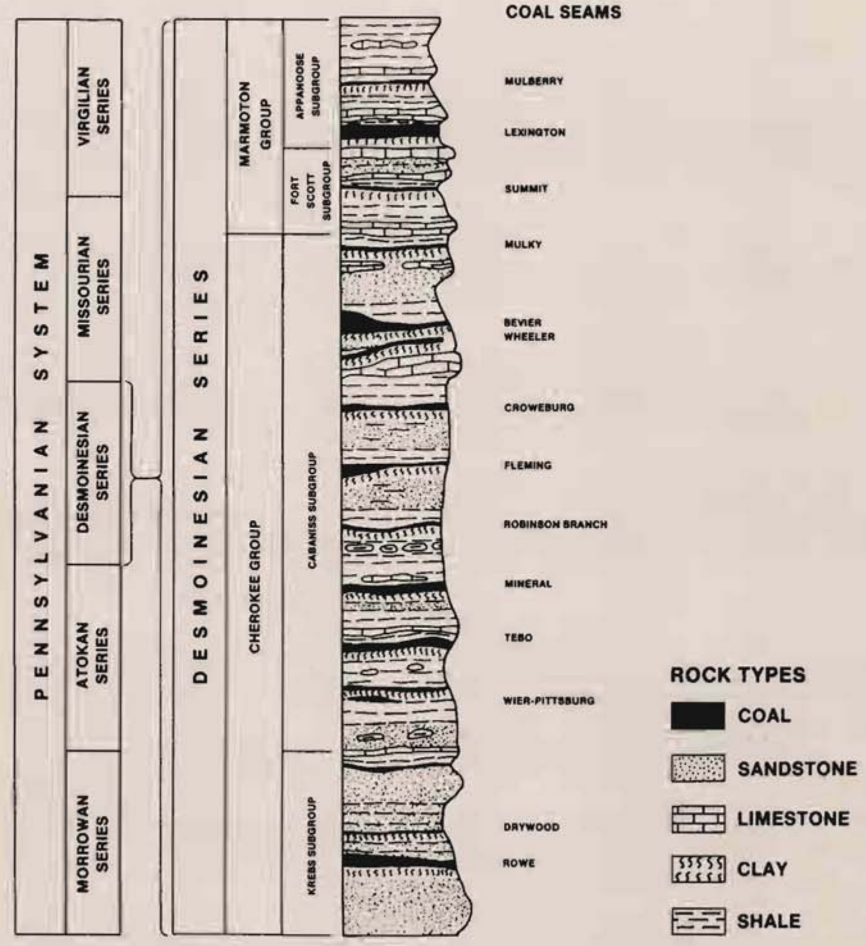
COAL QUALITY

The description of coal includes its stage of development and its quality. Quality refers to the desirability of coal for use as a fuel or for producing other commodities.

Coal quality includes such factors as ash content, sulfur content, and heat value. In fact, the principal value of coal is in the amount of heat it can generate, a factor directly related to stage of development. Heat value is measured in British Thermal Units, or BTUs. One BTU is the energy necessary to raise the temperature of one pound (one pint) of water one degree Fahrenheit.

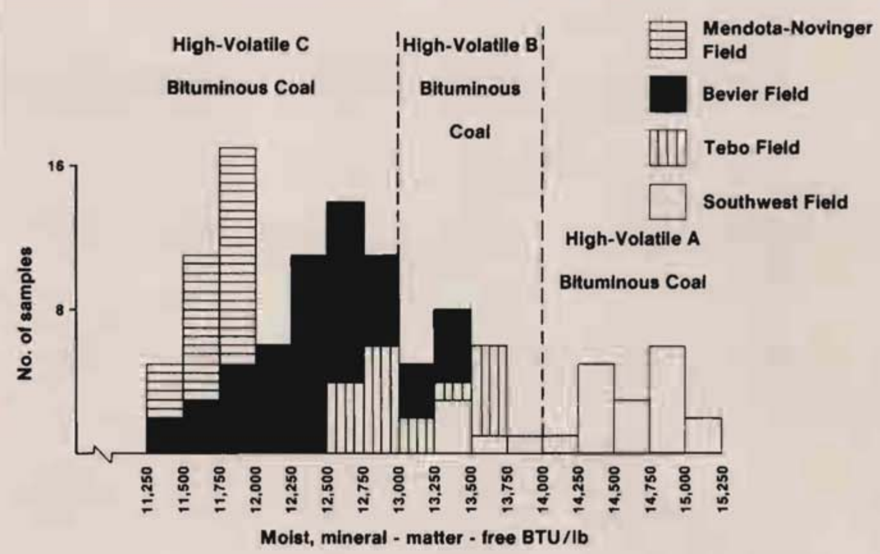
The stage of development, or rank, of coal is partly determined by the heat value of moist, mineral-matter-free coal samples. Heat values of Missouri coal

Cover: Coal mining in western Missouri



PRINCIPAL COAL SEAMS OF MISSOURI AND THEIR ASSOCIATED ROCK STRATA

The coal seams are shown in an idealized column in order of age, from the oldest at the bottom to the youngest at the top.



DISTRIBUTION OF MOIST, MINERAL-MATTER-FREE BTU/LB IN COAL SAMPLES FROM THE MENDOTA-NOVINGER, BEVIER, TEBO, AND SOUTHWEST FIELDS, MISSOURI

range from 11,250 BTUs per pound to 15,250 BTUs per pound. Missouri coal is classified by rank as high-volatile A, B, and C bituminous.

All but a small fraction of Missouri coal has a high sulfur content. More than one-half of the state's coal reserves contain 4 percent to 5 percent sulfur; one-fourth contains 3 percent to 4 percent; a small fraction contains less than 3 percent; and the remainder contains more than 5 percent sulfur.

The heat value of Missouri coal on an as-received basis ranges from just over 10,000 BTUs per pound to 12,500 BTUs per pound, with an average of 11,016 BTUs per pound. The moisture content averages 11.1 percent; the ash content, 11.5 percent. These qualities make Missouri coal a good fuel for heating boilers in steam electric-generating plants.

COAL IN MISSOURI

Coal-bearing strata underlie an estimated 24,000 square miles of northern and western Missouri, about 35 percent of the state's surface area. It occurs in seams or beds over large areas called coal fields. Coal seams currently mined are 12 to 42 inches thick. They are named for geographic features at or near where they typically occur. For example, the Drywood seam is named for Drywood Creek in Barton County, where the seam is exposed along its banks. Broader classifications of seams are based on world-wide standards derived from such factors as how readily identifiable the seams are and how long ago they were deposited. Fields usually are named for a principal coal seam mined in the area or for a nearby mining town. The Bevier field, for example, was named for a town of the same name in Macon County.

The Bevier field currently is the most productive in Missouri. It underlies several counties, but about 60 percent of the state's total annual production is mined in Howard and Randolph counties. The Bevier-Wheeler is the principal seam mined; the Summit, Mulky and Croweburg seams are lesser producers. At present, the second-largest producing coal field in the state is the Southwest field, which yields 24 percent of the state's annual coal production. Seams currently mined are the Mulberry in Bates County; the Mineral and Croweburg seams in Vernon County; and the Rowe and Drywood seams in Barton County.

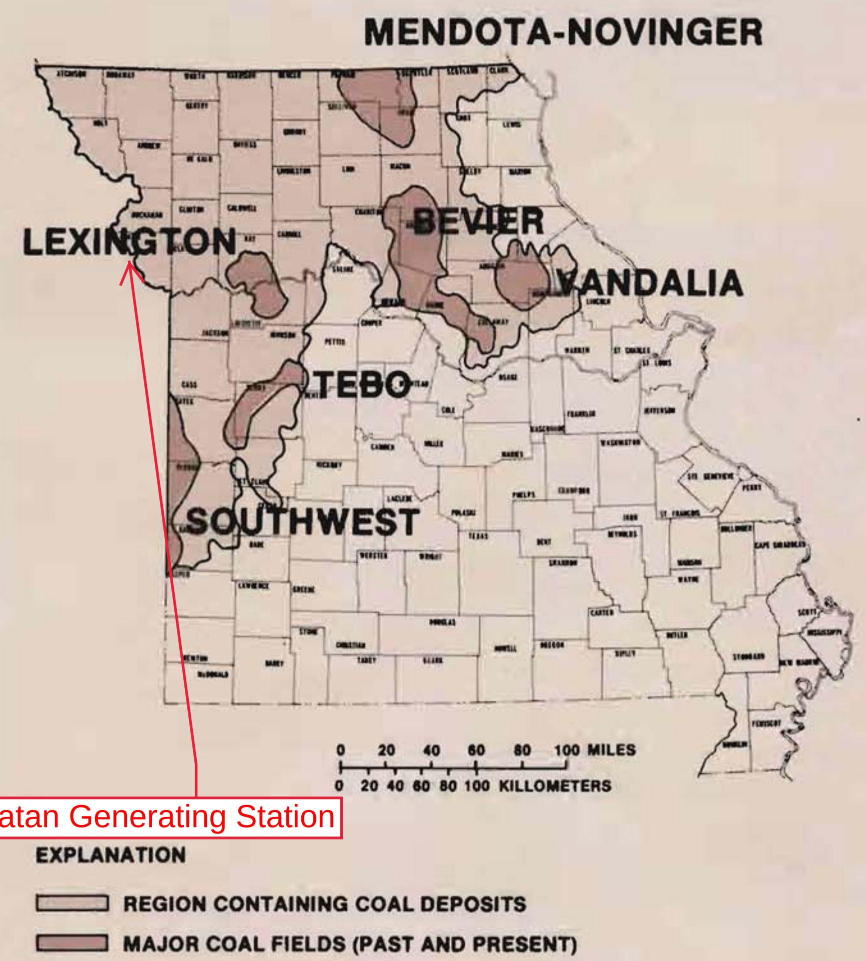
The Tebo field was the largest producing area in the state before mining activity increased in the Bevier field in the late 1970s. Current production from the Tebo field constitutes 10 percent of the state's annual coal production. Most of the coal produced in the region is mined from the Tebo seam. Small amounts are recovered from the Weir-Pittsburg seam.

The Mendota-Novinger and Vandalia coal fields yield less than 3 percent of the state's annual coal production. The Lexington and Mulky seams are the only seams currently being mined in those two fields.

The Lexington coal field is inactive at present, although it was an important producer in the past. The Lexington was the only seam mined, and recovery was primarily by underground methods.

COAL MINING IN MISSOURI

Missouri was the first state west of the Mississippi River to produce coal commercially. In 1806, Captain Zebulon Pike observed coal in bluffs along the Osage River, south of the present site of Prairie City in Bates County. "Black diamond" was mined from such outcrops by digging



PRINCIPAL COAL FIELDS OF MISSOURI

James Brothers Mine at Bevier, Missouri (circa 1911). The horse hoisted coal and supplies up the mine shaft, which is covered by the sheds. The mine car in the right foreground was used underground to haul coal from the working face to the main shaft.

drift mines as far into the hillside as good ventilation would allow, usually only a few hundred feet. Despite difficulties, coal mining had become a thriving enterprise by 1880.

Most early coal mines in Missouri were underground. Interest in strip mining developed in the mid-1930s, and by the late 1960s, it was the only method used. It is a simpler process and is cheaper in lives and dollars.

In early strip mining, horse-drawn scrapers moved the soil and shale, or overburden, covering the coal, beyond the outcropping. Only a few tons of coal could be mined, because the coal seams extended under thicker and thicker overburden that eventually was impossible to remove.

Today, mines use enormous electric shovels and draglines that can remove more than 100 feet of overburden. After topsoil removal, overburden is taken up in strips that may be more than a mile long, and the coal is mined by scrapers and dozers.The overburden is then removed from a second parallel strip and dumped into the first mined area. The process is continued as the machine moves slowly across the terrain, alternately removing overburden and mining coal. At the same time, reclamation begins on land already mined.

Missouri ranks 19th among the 27 states that produce bituminous coal. Currently, 14 surface mines in the state produce coal. In 1984, they produced almost seven million tons of it — a new state record and a dramatic increase from the mere 9,972 tons of coal mined in 1840.

ECONOMICS OF MINING COAL

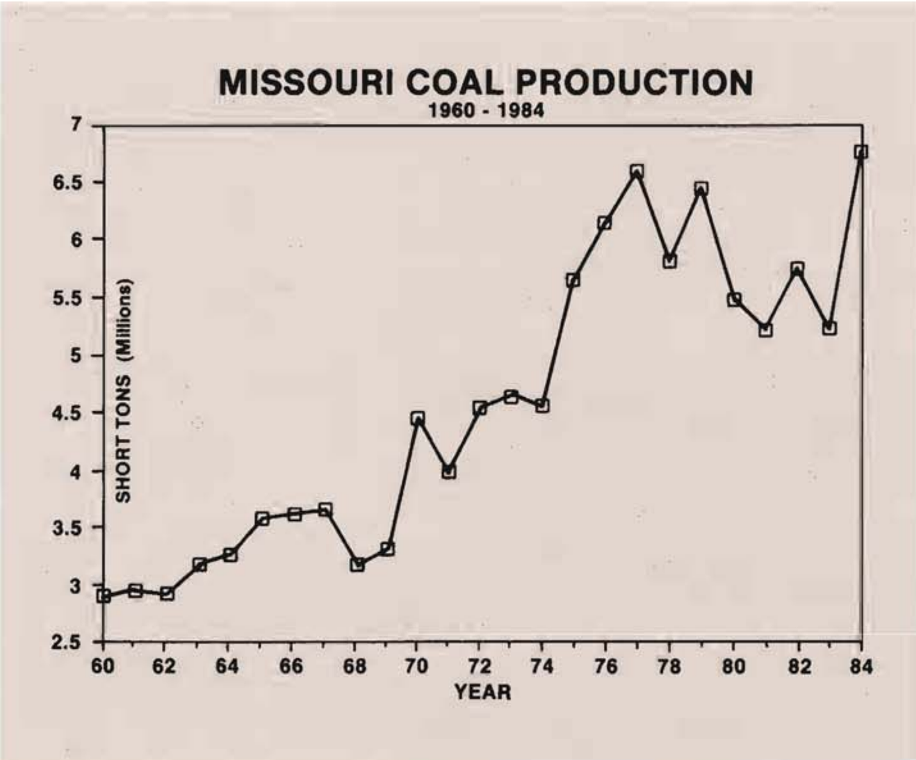
The 6,810,336 tons of coal mined in 1984 was valued at more than $170 million. That was an average price of $25 per ton received at the mine, a price that had changed little from the previous three years.

In 1984, Missouri's coal industry employed 1,217 miners, who earned about $35 million. These salaries generated additional revenue of more than $64 million in business, industry, and taxes. For every two miners employed, another job was created in support services.

The coal industry is subject to the same laws of supply and demand as are other industries. For example, when cheap natural gas and petroleum began flooding the market in the mid-1940s, demand for coal as locomotive and heating fuel declined until production reached a low of 2.5 million tons in 1958.

Energy-tax credits for coal users and the oil price hikes of 1979-80 also encouraged increased interest in coal, as did the realization that dependence on foreign oil supplies provides a shaky foundation for the American economy.

At present, coal is significantly cheaper than crude oil and natural gas. In 1983,



for example, $1.17 bought one million BTUs of coal, but we paid $4.51 for crude oil and $2.32 for natural gas having an equivalent heat value.

The cost of mining coal is about 30 percent of the total cost of using it. Prospecting, acquiring coal-bearing land, mining and processing equipment, mine development, and production are all factors that determine the initial price.

The ultimate cost of coal to users involves many other factors. Land reclamation expenses, for example, also must be considered; they depend on such factors as the thickness of the coal seam mined and the quality of the land disturbed.

Because transportation expenses add as much as 25 percent to the price of coal in Missouri, power plants located at the mine (mine-mouth plants) are significantly more economical to operate. In 1970, for example, the price of coal at the three mine-mouth plants in Missouri averaged $4.07 per ton, $1.27 less per ton than the average price statewide.

Cost of coal-burning equipment and of power-plant operation and maintenance, including pollution control and waste disposal, also affect the cost of coal to users, as does the quality of coal — high sulfur content, for example, means extra expenses for emissions-control equipment.

All these factors must be weighed in deciding the coal source to use. Missouri's coal must compete with coal from other areas. For example, power plants in the St. Louis metropolitan area use Illinois coal because the Missouri coal fields are farther away, in the northern and western parts of the state.

HOW MISSOURI COAL IS USED

During the 1800s, coal was used to fuel steam locomotives. It also heated homes and commercial buildings, gradually replacing wood as the primary heat source.

In the 1940s, petroleum and natural gas usurped coal as a fuel, but with construction of electric-generating utility plants in the 1950s came the increased need for coal to fire them. That need encouraged development of strip mining as a quick method of coal recovery.

Almost all Missouri coal is used by electric utilities in Missouri, Kansas, and Iowa. A small amount, about 3 percent, is used for manufacturing and for direct space heating.

In 1983, the coal that Missouri produced and used accounted for about 40 percent of the state's fuel needs. Missouri's reliance on coal was almost 18 percent higher than the national average. Natural gas supplied 19.3 percent of Missouri's energy, petroleum 41.2 percent, and hydroelectric power 1.2 percent.

Almost half the coal produced in the state is used by four electric utilities at mine-mouth sites: Thomas Hill Power Plant near Moberly, Asbury Power Plant north of Joplin, Montrose Power Plant near Clinton, and LaCygne Power Plant at LaCygne, Kan.

EFFECTS OF MINING AND USING COAL

Missouri's coal mining industry contributes substantially to the state's economy, particularly to that of the mining areas. In fact, many such areas are economically dependent on mining.

Reclamation of previously mined lands can improve recreation potential by creating lakes or improving wildlife habitats. It also can increase farming potential by recontouring the land, making it more accessible to farming equipment, or less subject to erosion caused by improper farming methods on steep, hilly land.

Uncontrolled mining damages the environment, and uncontrolled burning of coal produces serious side effects, notably air pollution from sulfur dioxide, nitrous oxide, and other contaminants. In the past, such side effects were taken for granted as the price of using coal.

During the 1960s, however, the nation became aware of the deterioration of our environment, resulting from misuse of our resources, including coal. Several remedial federal and state laws were enacted.

The federal Clean Air Act of 1965 and its amendments in 1970 and 1977 established the foundation for our air pollution control program. Federal and state regulations now limit the amount of sulfur and other pollutants that may be emitted during coal burning.

The 1965 Water Quality Act and the 1972 Water Pollution Control Act provided a means to restore the nation's lakes and rivers to good condition, and to protect them from further dumping or leaching of wastes.

Missouri has always had good water, but in 1973 the state enacted the Missouri Clean Water Law "to conserve the waters of the state and to protect, maintain, and improve the quality thereof."

The Missouri Land Reclamation Law of 1972 and amendments of 1978 require surface-mining companies in the state to return land disturbed by their activities to pre-mining stability. They must post a performance bond pledging to return the land to productive use.

The laws limit the amount of sediment and other substances allowed in drainage from mined lands. They also establish procedures for monitoring the quality of all water, including runoff, that mining may affect. Mining companies also must remove and save topsoil so that it can be replaced during reclamation, before new vegetation is planted.

About 67,000 acres in the state were mined before 1971 and are therefore unaffected by these regulations.

Much of the land has recovered through natural processes to become valuable fish and wildlife habitat. About 14,000 barren acres, however, continue to cause environmental problems; such areas left unmended leach acids into nearby streams, polluting the water and killing aquatic wildlife. The terrain of these abandoned mines is often ugly and unusable.

The federal Surface Mining Control and Reclamation Act, enacted in 1977, provides not only nationwide regulation of companies currently mining coal but also a means of restoring the productivity of abandoned, unrestored areas. This legislation requires mining companies to pay 35 cents per ton on all surface-mined coal, a fee that is used to fund reclamation of abandoned mined areas.

FUTURE OF COAL IN MISSOURI

Missouri has sufficient proven coal reserves to support a potential annual production of 28 million tons for 30 years. To realize this level of production, it would be necessary to secure new markets for Missouri coal and to expand existing markets.

Technologies being developed to reduce the sulfur content of coal hold promise for increased use of Missouri coal. They include advanced chemical cleaning of coal before combustion, and coal gasification, the conversion of coal to low- and medium-BTU gas.

Development of fluidized-bed combustion units for boilers in industry and for small electric power plants also may be a solution. These units remove sulfur during combustion.

Advanced levels of coal production will depend on the ultimate cost of large-scale operation of these new technologies. Meanwhile, current markets for Missouri coal will continue to exist. Demand for Missouri coal is influenced most strongly by the demand for electricity in Missouri, Kansas, and Iowa a demand that is slowly but steadily increasing.

MISSOURI DEPARTMENT OF NATURAL RESOURCES
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