PRAIRIE RESEARCH INSTITUTE COAL ASH RESPONSE TEAM FINAL REPORT

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Report Contributions

This report was jointly authored by the members of the Coal Ash Response Team, with contributions from other Prairie Research Institute staff.

Anne Huber conducted a literature review and wrote the introduction. Veronica Hemrich wrote the section on federal and state laws, regulations, and rules and Appendix B, with contributions from Rick Winkel. Laura Keefer, Scott Elrick, Alison Stodola, and Mark Yacucci wrote the assessment of Illinois data and Appendix C, with contributions by Randy Locke. Anne Huber, Walt Kelly, and Alison Stodola contributed to the section on CCR risks to people. Walt Kelly wrote the section on CCR Risks to Groundwater. Alison Stodola wrote the section on CCR Risks to the Environment. Scott Elrick and Laura Keefer wrote the section on geological and hydrologic factors. Nandakishore Rajagopalan wrote the section on beneficial use of CCR, with contributions from Veronica Hemrich. Randy Locke and Trish Barker coordinated overall report development and editing. Randy Locke and Laura Keefer developed the recommendations.

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Table of Contents

Abbreviations and Acronyms

CAPP Act	(Illinois) Coal Ash Pollution Prevention Act
CCP	coal combustion products
CCR	coal combustion residuals
CWA	Clean Water Act
FA	fly ash
FGD	flue gas desulfurization
GHG	greenhouse gas
IDOT	Illinois Department of Transportation
Illinois EPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
MCL	maximum contaminant level
mgd	million gallons per day
MSWLF	municipal solid waste landfill
NPDES	National Pollution Discharge Elimination Standards (of the Clean Water Act)
OPC	ordinary Portland cement
PC	pulverized coal
RCRA	Resource Conservation and Recovery Act
REE	rare earth elements
TDS	total dissolved solids
U.S. EPA	U.S. Environmental Protection Agency

Executive Summary and Recommendations

Like other states throughout the nation, Illinois is working toward solutions that reduce negative impacts from surface impoundments of coal combustion residuals (CCR, often called coal ash), which are byproducts of burning coal to generate electricity. Coal ash contains elements present in coal, including arsenic, boron, cadmium, chromium, cobalt, lead, lithium, manganese, molybdenum, radium, selenium, sulfur, and thallium. These elements can persist and accumulate in the environment and be associated with negative health impacts.

Federal and state regulations control the release of CCRs into the environment by requiring coal combustion facilities to capture coal ash. In Illinois, the regulatory framework related to coal ash impoundments is evolving. The Illinois Environmental Protection Agency (Illinois EPA) has proposed new rules for the Illinois Administrative Code (Title 35, Part 845). The new rules were filed with the Illinois Pollution Control Board (IPCB) on March 30, 2020, and as of this report's publication, were under consideration using the IPCB hearing process (see https://pcb.illinois.gov/Cases/GetCaseDetailsById?caseId=16858). The IPCB is required to adopt final rules by March 30, 2021. As new rules go into effect, they are expected to aid management and decision-making processes related to CCR and CCR impoundments in Illinois.

The Executive Director of the Prairie Research Institute (PRI) established the Coal Ash Response Team (CART) in part to assess coal ash related information that was available from the Illinois scientific surveys. This report provides an overview of knowledge and information within PRI about coal ash issues. Efforts by the CART are intended to be of value to all stakeholders (e.g., the public, Illinois EPA, site operators, governmental and non-governmental organizations, research institutions).

This report includes information about potential impacts of coal ash impoundments, a review of federal and state laws and regulations, and an overview of how coal ash can be beneficially used.

- **Exposure to CCR poses risks to people, surface water, groundwater, and the environment**. Human interaction with coal ash can occur through consumption of contaminated drinking water, contact during water recreation, ingestion of sport fish or wildlife, or contact with contaminated sediment. Potential effects include cancer, heart disease, reproductive failure, stroke, and/or neurological damage. Further, the effects of coal ash leachate on groundwater quality are a function of the characteristics of the ash, hydrogeology, and weather. The chemistry of the leachate can also affect the behavior of contaminants as the groundwater migrates away from the site. Elements from coal ash have been found in plants and aquatic and terrestrial animals; response to exposure varies with length of exposure, concentration of exposure, life-stage of the animal or plant, and composition of their habitat.
- **Nature and composition of subsurface geology, hydrologic regimes, and topography.** Local and regional physical conditions can potentially affect surface water flow, groundwater flow, stream bank stability, and coal ash impoundment integrity. In particular, areas under and surrounding coal ash impoundments are significant factors because of their proximity.
- **There are ways for CCR to be beneficially used**. Encapsulated uses, which involve binding the fly ash to minimize migration into the environment, are preferred. The leading beneficial use of fly ash is as a mixture in concrete and related products and in cement manufacture. Using fly ash to stabilize difficult-to-treat wastewater streams from power plants is gaining attention. There is significant research on fly ash as a source of rare earth elements (REE), which have numerous industrial uses.

Central to the report is an inventory of Illinois data relevant to coal ash impoundment locations and management issues that could inform further risk assessment, site evaluation, and decision making. These datasets including geology, hydrology, land use/soils, and environmental and sociopolitical factors are summarized in the Assessment of Illinois Data section, with a detailed description of each dataset in Appendix C.

Recommendations

There is a need for additional identification and evaluation of relative risks and risk factors with respect to human health and the environment among all impoundments in Illinois. Several themes emerged during the work of the CART that are recommended as priorities.

The Coal Ash Response Team recommends that PRI:

1. **Facilitate a systematic risk identification/evaluation process for coal ash impoundments in Illinois.** Subject to funding and stakeholder participation, development of a robust risk management framework is needed to prioritize use of limited resources and focus research and site management efforts on areas of most significant environmental concern and benefit. The Illinois EPA has developed a coal ash impoundment management strategy, and PRI has identified additional data for stakeholders. Further, PRI sees benefit to engaging in a systematic risk identification/evaluation process to develop a risk register that is specific for coal ash impoundments in Illinois. The development of an Illinois-specific risk register for all sites throughout the state would help better focus efforts to:
    a. Prioritize sites for more detailed site characterization or research based on the relative risks and potential impacts to human health and the environment,
    b. Develop enhanced geospatial data exploration methods to:
        i. Identify and rank risk factors to human health and the environment for all coal ash surface impoundments throughout the state, and
        ii. Estimate the scope of potential impacts due to berm failure and identify potential mitigation responses.
2. **Enhance current collaborations and seek new partners for prioritized collaborative work.** In alignment with a risk identification/evaluation process, collaborative projects should be conducted (subject to state appropriation or other funding) to:
    a. Continue data framework (e.g., GIS) development to support stakeholder decision making and site evaluations,
    b. Develop concept validation studies to support future site management protocols, and
    c. Develop targeted field studies to:
        i. improve site characterization and characterization methods,
        ii. test and validate pollution mitigation and site management strategies to address environmental concerns, and
        iii. identify environmental justice issues and opportunities for mitigation.
3. **Monitor both ongoing Illinois coal ash rule-making and federal coal ash policies.** The Illinois EPA submitted proposed regulations to the Illinois Pollution Control Board (IPCB) on March 30, 2020, and IPCB is required to finalize and adopt the new regulations by March 30, 2021. Implementation of the federal "Final Rule" may be impacted by court cases and administration changes.

PRI Coal Ash Response Team

The University of Illinois' Prairie Research Institute (PRI) provides objective scientific expertise, data, and applied research to aid decision-making and provide solutions for government, industry, and the people of Illinois. As the home of the state's five scientific surveys—the Illinois Natural History Survey (INHS), Illinois State Archaeological Survey (ISAS), Illinois State Geological Survey (ISGS), Illinois State Water Survey (ISWS), and Illinois Sustainable Technology Center (ISTC)—PRI is able to marshal a wide range of scientific expertise to provide information and insight relevant to the stewardship of Illinois' vital natural and cultural resources.

In 2019, PRI Executive Director Mark Ryan brought together a team of PRI science and policy experts to consider the issue of coal ash storage in Illinois. PRI scientists have conducted investigations related to coal ash for more than 50 years, and the range of scientific disciplines represented within PRI means that this interdisciplinary Coal Ash Response Team has been able to consider coal ash issues from diverse perspectives.

The Coal Ash Response Team (CART) first met on April 8, 2019, and then met monthly or bi-weekly to address its charge (see Appendix A). The team assessed its members' areas of experience and ways in which that expertise could be leveraged to provide a solid foundation for understanding essential components of coal ash issues in Illinois. The team conducted a general literature search, a law and policy review (Appendix B), technical literature summaries, and developed recommendations that are provided in this report.

What is coal ash?

Coal combustion products (CCPs) or coal combustion residuals (CCRs), commonly known as coal ash, are a byproduct of burning coal. Several types of byproducts are produced, including fly ash, bottom ash, boiler slag, and flue gas desulfurization materials. Coal ash is one of the largest industrial waste streams in the United States (U.S. EPA, 2016). In 2018, 102.3 million short tons of coal ash was produced in the United States (American Coal Ash Association, n.d.).

Federal and state regulations control the release of CCRs into the environment by requiring coal combustion facilities to install equipment to capture coal ash. Once captured, the coal ash is often disposed of in landfills or waste ponds, also called surface impoundments. As an alternative to disposal, coal ash can be beneficially recycled and used in various ways.

Coal ash contains varying levels of elements in coal, including arsenic, boron, cadmium, chromium, cobalt, lead, lithium, manganese, molybdenum, radium, selenium, sulfur, and thallium (Russ, Bernhardt, Evans, 2019). When coal ash is disposed of in unlined landfills or impoundments, constituents has the potential to migrate from their initial location (U.S. EPA, 2014b). When humans interact with or ingest constituents of concern at sufficient levels, there is the potential for negative health impacts, such as cancer, heart disease, reproductive failure, strokes, and neurological damage (U.S. EPA, 2010, 2013). Because inorganic components of coal ash do not degrade, they can persist and accumulate in the environment and can enter the food web, where they can cause detrimental impact (Gottlieb, Gilbert, and Evans, 2010).

Federal and state laws, regulations, and rules

In December 2008, a massive coal ash spill occurred at a Tennessee Valley Authority facility in Kingston, Tennessee. Failure of a dike on the north slope of the ash pond released approximately 5.4 million cubic yards of coal ash onto the adjacent land and eventually into the Emory River. The coal ash spilled into several miles of the riverway and affected more than 300 acres outside of the fly ash dewatering and storage areas. The U.S. Environmental Protection Agency (U.S. EPA) reported extensively on the impact of this incident (U.S. EPA, 2016). To address the issues of environmental contamination from improperly constructed and managed coal ash disposal facilities and to prevent another catastrophic failure, the U.S. EPA established comprehensive requirements for the disposal of CCRs in landfills and surface ponds.

In early 2015, the U.S. EPA published the first national regulations for the safe management and disposal of CCRs in landfills, surface impoundments, and lateral expansions of surface impoundments. These federal regulations—commonly referred to as the "Final Rule"—implement federal CCR law under Subtitle D of the Resource Conservation and Recovery Act (RCRA)[1]. From 2015 to the present, court cases and administration changes have resulted in challenges and changes to the Final Rule, the latest of which came out on Feb. 19, 2020.[2]

In Illinois, the Bureau of Air, Bureau of Water, and Bureau of Land have regulations covering coal ash. Illinois was one of the first states in the country to have and apply groundwater standards, groundwater monitoring requirements, and corrective actions to coal ash impoundments. Since the 1990s, new coal ash ponds have been required to be lined. Groundwater monitoring networks have been installed at many of these coal ash ponds (Illinois EPA, 2011).

Under the RCRA and the Final Rule, CCRs are regulated as non-hazardous solid waste, limiting both federal and state enforcement authority and making states primarily responsible for regulating CCRs. The federal government has encouraged states to pass their own CCR laws and regulations.

[1] RCRA and the Final Rule apply to all CCRs generated by electric utilities and independent power producers, owners and operators of new, existing, and expanding landfills and surface impoundments that manage or dispose of CCRs, any CCR units that receive CCR for disposal, and inactive CCR surface impoundments if the CCR unit still contains CCR and liquids.

[2] See A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments; Implementation of Closure Proposed Rule; Docket No.: EPA-HQ-OLEM-2019-0173 at pp. 12-26, available at https://www.epa.gov/sites/production/files/2020-2/documents/508_san7310_ccr_package_2_part_b_nprm_frdocument_2020-02-14.pdf. See also, http://www.regulations.gov.

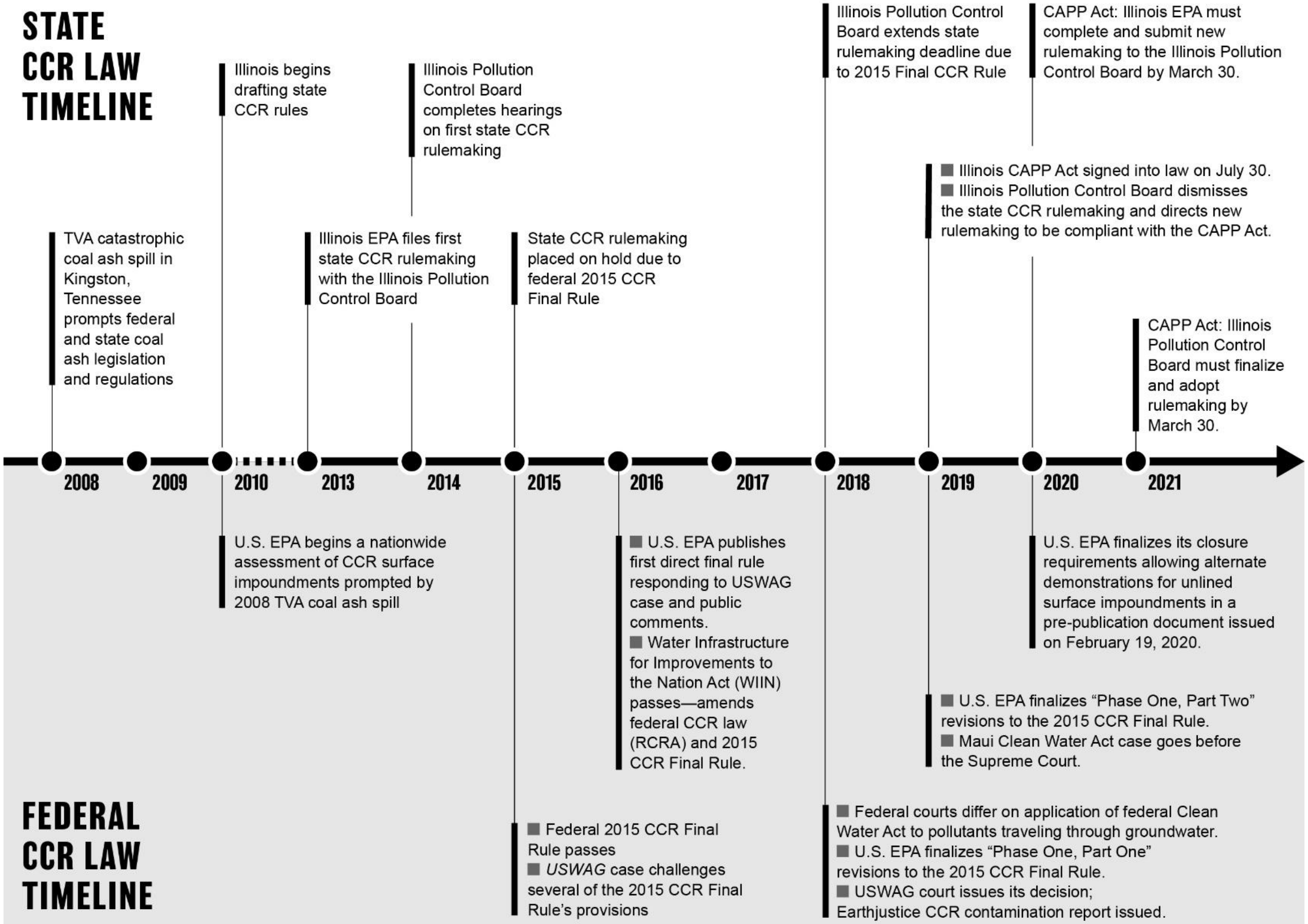

FIGURE 1: TIMELINE OF FEDERAL AND STATE CCR LAWS AND REGULATIONS.

On July 20, 2019, Illinois Gov. JB Pritzker signed Public Act 101-171, the Coal Ash Pollution Prevention or CAPP Act, to require additional protections on CCR surface impoundments. This new law amends the by directing how CCR surface impoundments are to be built, operated, and closed. The law also requires the impoundments to be monitored for groundwater contamination and remediated when necessary (Illinois EPA, n.d.).

The CAPP Act expressly prohibits any person from allowing CCR surface impoundment contaminants (alone or in combination with other contaminants) to discharge into the environment in violation of the Illinois Environmental Protection Act (415 ILCS 5/22.59(b)(1)) and generally prohibits causing or allowing the "discharge, deposit, injection, dumping, spilling, leaking, or placing" of CCRs on land (415 ILCS 5/22.59 (b)(3)).[3]

On March 30, 2020, the Illinois EPA submitted proposed regulations to the Illinois Pollution Control Board (IPCB) as required by the CAPP Act. The IPCB is required to finalize and adopt the new regulations by March 30, 2021.[4]

Also relevant to regulating coal ash is the U.S. Supreme Court decision in County of Maui v. Hawai'i Wildlife Fund, et al. (April 23, 2020).[5] The Court held that states can use the federal Clean Water Act's (CWA) National Pollution Discharge Elimination Standards (NPDES) permitting requirements to regulate pollution that results from either a direct discharge from a point source or an indirect discharge of pollutants that is the "functional equivalent" of a direct discharge from a point source into U.S. navigable waters. The Court's decision appears to close a federal "loophole" for coal ash ponds under the U.S. EPA's current regulations, which excluded pollution sources like leaks from coal ash ponds from the CWA NPDES permitting program.[6]

The Maui decision appears to shift the initial burden of determining what constitutes a functionally equivalent discharge to state courts and agencies like the IPCB. The Court laid out six factors states must consider in determining if an indirect discharge of a pollutant—like coal ash leaking from a surface impoundment through groundwater into a navigable river—is the "functional equivalent of a direct discharge:"

- transit time and distance traveled;[7]
- the nature of the material through which the pollutant travels;
- the extent to which the pollutant is diluted or chemically changed as it travels;
- the amount of pollutant entering the navigable waters relative to the amount of the pollutant that leaves the point source;
- the manner by or area in which the pollutant enters the navigable waters; and

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[3] The Illinois EPA Proposed Rule implementing the CAPP Act also address CCR impacts to water pursuant to statute at 615 ILCS 5 (Rivers, Lakes, and Streams Act); and regulations pursuant to 17 Ill. Adm. Code 3704 (Regulation of Public Waters) and 35 Ill Adm. Code 302 (Water Quality Standards).

[4] The IPCB also requested an economic impact analysis from the Illinois Department of Economic Opportunity (DCEO) on April 16, 2020.

[5] *County of Maui v. Hawaii Wildlife Fund*, 139 S. Ct. 1164, 203 L. Ed. 2d 196 (2019).

[6] The Court's decision does not resolve whether pollution from coal ash impoundments actually qualifies as "point source" pollution—a basic threshold for federal NPDES permitting requirements—leaving open the possibility of additional revisions to federal CWA regulations that could further define "functional equivalent." The Court's decision may also result in increased litigation at the state and federal levels. See "Clean Water Act ruling tees up coal ash brawl" in E&E News, published April 28, 2020.

[7] The Court said that "time and distance will be the most important factors in most cases, but not necessarily every case (Maui, at 16). These factors may be critical in determining whether coal ash pollution from impoundments is the "functional equivalent" of a direct discharge since so many coal ash impoundments are located near rivers fed by groundwater.

- the degree to which the pollution has maintained its specific identity.[8]

The Maui decision has the potential to extend the number and type of pollution sources subject to federal CWA permitting requirements enough to encompass potentially millions of originating sources of contamination that were previously regulated as nonpoint sources and create a greater liability for businesses and property owners.

PRI policy analyst Veronica Hemrich analyzed the current legislation and identified gaps between state and federal laws and regulations. See Appendix D for the detailed gap analysis.

Assessment of Illinois data

Geographic information systems (GIS) data cited in this report were compiled and visualized using ESRI's ArcGIS software version 10. Geospatial data and other datasets were selected based on an anticipated use in potential assessments related to characterization of natural or anthropogenic factors related to coal ash impoundment management and/or risk identification. Each dataset is assigned an alphanumeric reference ID, where the letter is associated with one of six data categories. The reference ID is included throughout the document to provide clarity to the application of the spatial datasets and how they relate to the processes being described. The reference ID will appear in the text between brackets, i.e. [H5]. The following is a brief description of the categories; each data type, and associated reference ID, is described in more detail in Appendix C:

- **Area of interest** [A] includes primary data, such as the locations of power plants and coal ash impoundments in Illinois.
- **Environmental** [E] pertains to biological data and the ecosystem with which it is associated. Though wetlands could be included in the hydrologic category, they are instead grouped in the Environmental category because the emphasis in on the environment in which the biology exists.
- **Geology** [G] includes data related to bedrock, consolidated or unconsolidated materials, and geologic structures and landscapes.
- **Hydrology** [H] includes data related to all forms of water from the atmosphere, rivers/waterbodies, and groundwater and can include the quality and quantity of that water.
- **Land Use and Soils** [L] includes data that represent the land surface, such as soil types, slope/elevation, and what covers that land or how it is being used.
- **Sociopolitical** [S] covers data associated with boundaries imprinted by society to manage the landscape.

[8] The Court said that "[w]hether pollutants that arrive at navigable waters after traveling through groundwater are "from" a point source depends upon how similar to (or different from) the particular discharge is to a direct discharge" (Maui, at 16). Notably, the Court's decision does not resolve how applicable (if at all) these factors are to pollutants discharged from coal ash impoundments and leaves open the possibility that states will need to develop additional criteria to make determinations about coal ash pollution either via caselaw or regulations, or both.

TABLE 1: CATEGORIES OF GEOSPATIAL DATA TYPES WITH REFERENCE IDS.

Reference ID	Type of Data
Area of Interest	
A1	Power plant locations
A2	Coal ash impoundment locations
Environmental	
E1	National Wetland Inventory
E2	Sensitive Habitats and Species in Illinois
E3	Illinois Natural Areas Inventory
E4	Illinois Nature Preserves
E5	Mines
Geology	
G1	Stack unit (15m)
G2	Drift thickness
G3	Geology/quaternary deposits
G4	Sinkhole/karst
G5	Seismic
G6	Bedrock geology
G7	Illinois Structural Geology (ILSTRUC)
G8	Stratigraphy of Illinois (ILSTRAT)
Hydrology	
H1	Water bodies
H2	Hydrography
H3	Major watershed boundaries: HUC 6-12
H4	Illinois EPA Source Water Assessment Program
H5	Depth to Aquifer within 300 ft.
H6	Major sand and gravel aquifers
H7	Potential aquifers less than 50 ft.
H8	Community water supplies-wells
H9	Community water supplies-surface water intakes
H10	Private water wells
H11	FEMA flood zones (DFIRM)
H12	Groundwater wells
H13	Groundwater quality
H14	Major shallow bedrock aquifers (< 300 ft)
H15	Climate
Land Use and Soils	
L1	U.S. EPA - Illinois Level IV Ecoregions
L2	SSURGO Soils Data
L3	LiDAR/Digital Elevation Models
L4	Land cover
L5	Historical Aerial Imagery
Sociopolitical	
S1	Population
S2	Demographics
S3	Illinois legislative districts
S4	U.S. Congressional districts
S5	Illinois county boundaries
S6	Illinois municipal boundaries
S7	Navigability

CCR Risks to People

Coal ash contains varying levels of constituents from the originating coal, including arsenic, boron, cadmium, chromium, cobalt, lead, lithium, manganese, molybdenum, radium, selenium, sulfur, and thallium. These constituents can make their way into the environment through groundwater [H5, H6, H7, H14] or surface water. Human contact with coal ash can occur through consumption of contaminated drinking water (via groundwater or surface water), contact during recreation in water bodies [H1] or rivers [H2] containing coal ash effluent, ingesting contaminants by eating sport fish or wildlife, or through contact with contaminated sediment.

Potential effects from significant or extended contact with coal ash constituents include cancer, heart disease, reproductive failure, stroke, and/or neurological damage (U.S. EPA, 2010, 2013).

The U.S. EPA has established Water Quality Criteria for Human Health, which are levels of the highest concentration of specific pollutants in water that are not expected to cause adverse effects to human health. These drinking water standards are based on tests of pollutants (e.g., selenium) or parameters (e.g., pH), and they are based on assumed levels of exposure over a specific amount of time to an individual (U.S. EPA, n.d.). Several components of CCR are regulated by the U.S. EPA, including arsenic, boron, cadmium, chromium, lead, and selenium.

Many of the potential contaminants have drinking water standards (maximum contaminant levels (MCLs)) developed by U.S. EPA (Table 2) for public water systems.

TABLE 2: POTENTIAL COAL ASH CONTAMINANTS THAT HAVE PRIMARY OR SECONDARY U.S. EPA DRINKING WATER STANDARDS (MAXIMUM CONTAMINANT LEVELS (MCLS)).

Contaminant	Primary MCL (mg/L)
Antimony	0.006
Arsenic	0.010
Barium	2
Beryllium	0.004
Cadmium	0.005
Copper	1.3 (action level)*
Lead	0.015 (action level)*
Mercury (inorganic)	0.002
Selenium	0.05
Thallium	0.002
	Secondary MCL (mg/L)
Aluminum	0.05 - 0.2
Chloride	250
Copper	1.0
Iron	0.3
Manganese	0.05
Silver	0.1
Sulfate	250
Total Dissolved Solids (TDS)	500
Zinc	5

* Action levels for lead and copper are related to the Lead and Copper Rule, which limits the concentration of lead and copper allowed in public drinking water at the consumer's tap.

CCR Risks to Groundwater

A potential threat with disposal of coal ash is groundwater contamination[9]. Groundwater [H8, H10, H12] is an important source for drinking water in Illinois. Public water use in Illinois is approximately 370 million gallons per day (mgd), and of that amount about 25 percent, or 90 mgd, is sourced from groundwater. There are about 800,000 private domestic wells [H10, H12] in Illinois, serving about 2 million people. Water well construction is regulated partly under the Illinois Administrative Code (Title 77) in the Illinois Water Well Construction code (Part 920) (Illinois General Assembly, 2015). In most Illinois counties, groundwater quality is required to be tested only when a new well is installed, and then only for coliform bacteria and nitrate.

Of the two major coal ash disposal methods, surface impoundments are of more concern than landfills, especially if the impoundments are unlined, as is the case with many legacy sites. Regardless of whether impoundments are lined or not, coal ash in an impoundment may produce biogeochemical conditions that increase the likelihood that potentially toxic trace elements—including boron, arsenic, barium, cadmium, chromium, copper, lead, mercury, zinc, and selenium (Carlson & Adriano, 1993; Gulec et al., 2001)—leach into groundwater[10]. The age of the ash deposits is a key variable, as the ash generally becomes less reactive with time. The effects of leaching on groundwater quality are a function of the characteristics of the ash, hydrogeologic characteristics, and weather.

There have been a number of investigations of groundwater quality at coal ash deposit sites throughout the world, and many have shown some degree of contamination (Khan & Umar, 2019; Praharaj et al., 2002; Praharaj et al., 2003; Jiang et al. 2010; Simsiman et al., 1987; Harkness et al., 2016). Most recently, a review of data from 265 coal-fired power plants in the United States found that groundwater near most coal-ash-disposal sites contains levels of one or more pollutants, including arsenic and lithium, that exceed U.S. EPA drinking water standards (Russ, Bernhardt, & Evans, 2019). While conditions should be assessed on a site by site basis, some field studies suggest a fairly small zone (< 200 m) of groundwater contamination, as toxic metals tend to be adsorbed or precipitated out of solution as the groundwater migrates and geochemical conditions change (Cherkauer, 1980; Spencer & Drake, 1987; Carlson & Adriano, 1993). Contaminant migration is a function of many factors, including geology and soil characteristics.

The chemistry of the leachate can also affect the behavior of contaminants as the groundwater migrates away from the site. Some coal ash, especially in the eastern United States, can produce acidic leachate, which can be buffered by dissolving secondary carbonate minerals in soils. Gschwend et al. (1990) suggested that this might cause the release of soil silicate colloids into solution, which may enhance contaminant transport in groundwater.

The Environmental Integrity Project published a report on groundwater contamination by coal ash in Illinois (2018). They evaluated groundwater quality data released by the U.S. EPA in 2018 pursuant to the Coal Ash Rule (Table 3). The data were collected from dedicated monitoring wells by the facility owners. Data are reported for 24 sites, 16

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[9] Federal and state laws address groundwater protection standards for CCRs. The federal RCRA and Final Rule establish CCR groundwater protection standards for specified constituents, including CCRs, listed in Appendix IV of the Final Rule (40 CFR §257.95(h)). The CAPP Act prohibits CCRs from exceeding comparable Illinois Class I Groundwater Standards (415 ILCS 5/3.135 (a-5) (B)).

[10] These conditions include reducing and low pH waters. When coal ash is deposited, there is generally a high initial release of soluble salts, i.e., a large increase in total dissolved solids (TDS), with calcium (Ca) and sulfate (SO_4) being the major ions. Coal-ash leachate is highly variable but typically high in TDS, calcium, sulfate, boron, iron, and aluminum. It can be acidic and is typically reducing (Milligan & Ruane, 1980).

operating at the time of the report and eight closed. Arsenic was the most common contaminant detected, found at 17 of the sites. Other contaminants found in at least half of the sites included boron, cobalt, and sulfate.

These results indicate groundwater contamination at most coal ash sites in Illinois, but whether the contamination is a threat to public health via drinking water would require site-specific studies. Questions that would need to be addressed for each site include: (1) what subsurface formation(s) are contaminated [H5, H6, H7, H14]; (2) are there drinking water wells in affected formation(s) or formations connected to the affected formation(s) [H8, H10, H12]; (3) what are the hydrogeologic conditions of these formation(s), including transmissivity and groundwater flow directions; and (4) how are hydrogeologic and geochemical conditions affecting contaminant fate and transport and ultimately water quality [H13]?

TABLE 3: CONTAMINANTS EXCEEDING U.S. EPA HEALTH-BASED STANDARDS IN MONITORING WELLS AT COAL ASH SITES IN ILLINOIS. (ENVIRONMENTAL INTEGRITY PROJECT REPORT, 2018).

Site	Contaminants exceeding health-based thresholds in at least one monitoring well
Baldwin	arsenic, boron, cobalt, lithium, manganese, sulfate
Coffeen	arsenic, boron, cadmium, cobalt, lead, lithium, manganese, sulfate
Crawford	cobalt, manganese, sulfate
Dallman/Lakeside	arsenic, boron, sulfate
Duck Creek	arsenic, boron, cobalt, lead, lithium
Edwards	arsenic, cobalt, lead, lithium
Havana	None
Hennepin	arsenic, boron, cobalt, lithium, molybdenum, selenium
Hutsonville	boron, manganese
Joliet 9	arsenic, boron, lithium, molybdenum, sulfate
Joliet 29	cobalt, manganese, sulfate
Joppa	cobalt, lead
Kincaid	None
Marion	arsenic, boron, cobalt, lithium, selenium, titanium
Meredosia	arsenic, boron
Newton	arsenic, cobalt
Pearl	arsenic, sulfate
Powerton	arsenic, boron, cobalt, manganese, sulfate, titanium
Prairie State	arsenic, cobalt, lead
Venice	arsenic, boron, manganese, sulfate
Vermilion	boron, sulfate
Waukegan	arsenic, boron, manganese, chromium, lithium, molybdenum, sulfate
Will County	arsenic, boron, manganese, sulfate
Wood River	arsenic, boron, lithium, molybdenum, sulfate

CCR Risk to the Environment

Coal ash can have wide-ranging impacts in the environment, particularly in aquatic systems, and trace elements from coal ash have been documented in plants, algae, plankton, aquatic and terrestrial insects, mollusks, crayfish, fishes, amphibians, reptiles, birds, and mammals (Rowe et al., 2002; Chapman et al., 2010; DeForest & Adams, 2011; Sherrard et al., 2014). A plant or animal's response to contaminant exposure varies with length of exposure, concentration of exposure, life-stage of the animal or plant, and specific composition of their habitat.

Often, trace elements from coal ash are present in small amounts over long periods of time (known as chronic exposure). Many studies have found that organisms are able to survive chronic exposure but may have reduced growth rates, reduced reproductive success, physical deformities, or other internal malformations. Younger age classes of aquatic organisms tend to be more susceptible to negative impacts from trace elements; reproductive failure, mortality, or failure to metamorphose from larvae to adult may occur (e.g., Jacobsen et al., 1997; Janz et al., 2010; Wesner et al., 2014).

Environmental impacts from selenium, a component of coal ash, have been particularly well researched. Documented impacts include reproductive failure of fishes, amphibians, and birds, declines in species diversity, and uptake and storage of selenium in tissues or organs of many organisms (Janz et al., 2010). Selenium accumulation in contaminated areas has been documented in all levels of the food web, from plankton to predators, such as snakes (Chapman et al., 2010; DeForest & Adams, 2011). One particularly detrimental impact from selenium exposure is the accumulation of selenium in organs, such as livers in fish (Brandt et al., 2019) and subsequent maternal transfer of selenium to eggs. Maternal transfer has been observed in amphibians, fish, turtles, alligators, birds (Bryan et al., 2003).

Large ash spills (e.g., from a dam breach) introduce a slurry of sediment into an aquatic environment, which may cause immediate kills of aquatic organisms like fish, mollusks, macroinvertebrates, or amphibians due to rapid reduction in available oxygen—Cairns et al. (1970) summarizes the kill of 162,000 fishes in the Clinch River in 1967—or physically stranding fishes that were blown from the water. In some cases, increased turbidity or sediment are more problematic to organisms than metals or toxicants (Cherry et al., 1978). Elements like selenium released during a spill will persist in the food web for years (at least seven years in Martin Creek Reservoir, Texas, according to Garrett and Inman (1984)). Recovery of systems with an acute spill may take decades; diversity is often reduced immediately, and recolonization by more sensitive species takes years or decades (Garrett & Inman 1984; Janz et al. 2010). In some instances, species diversity is reduced until only the most-common species survive (Warren & Haag, 2005).

Coal ash effluent often contains mixtures of trace elements (Ruhl et al., 2012; Brandt et al., 2019). Detrimental impacts of mixtures are more difficult to understand, as most laboratory studies focus on impacts from single elements or parameters (e.g., only selenium or pH). In many cases, the levels of each individual element near a coal ash disposal site may be below the regulated values listed for aquatic life. However, trace element mixtures in coal ash react in specific ways based on particular water chemistry, such as hardness, temperature, or pH of a water body, and this makes it complicated to predict reactions or environmental response for all water bodies (Cormier et al., 2013).

Geologic and Hydrologic Factors

The nature and composition of subsurface geology, hydrologic regimes, and topography both regionally and more specifically in areas under and surrounding coal ash impoundments, can potentially affect surface water flow, groundwater flow, stream bank stability, and coal ash impoundment integrity.

Geology

In the near surface, unconsolidated sediment mantling the bedrock can vary in geometry, thickness, physical and chemical composition, spatial extent, and relationships with underlying geologic units [G1, G2, G3, G4]. As an example, the presence of gravel lenses or clay rich zones in the subsurface can affect the hydrologic character of sites, enhancing or diminishing lateral or vertical flow.

Similarly, the geometry and composition of the underlying bedrock strata can also potentially impact the groundwater and surface water hydrology of coal ash sites [G6, G7, G8]. In general, most, but not necessarily all, coal ash sites in Illinois are likely to be on bedrock of either Pennsylvanian or Mississippian age. Pennsylvanian age strata are dominantly composed of shales and siltstones, coals, some sandstone, and some limestone. Mississippian strata are composed of smaller amounts of shale, siltstones, sandstone, a few coals, and greater amounts of limestone. These differences can be important as shale layers can act as low-permeability barriers to groundwater flow, also known as an aquitards. Conversely, geologic strata that have higher relative permeability (e.g., sandstone or limestone with karst development) can act as conduits for groundwater flow. Both lower and higher permeability strata can potentially alter subsurface and near-surface fluid flow patterns. Bedrock in the near surface also contains natural openings, joints, and fractures. These openings can be additional conduits for fluid flow, potentially allowing higher flow rates through more densely fractured strata, or in cases where highly fractured bedrock is exposed at the surface, increase susceptibility to erosion by rivers and streams [G7]. In areas where fractures are wide enough to coalesce through dissolution of limestone, and thereby create identifiable karst features, groundwater flow rates can be extremely high.

Illinois is within two significant seismic zones that have had both recent and historical high-amplitude activity [G5, G7]. The New Madrid and Wabash Valley Seismic Zones include bedrock fault systems that extend into southern and southeastern Illinois. These fault systems have historically produced earthquakes, some of which have been catastrophic (1811-1812 of estimated magnitude 7.5-8) while others have been less extreme but still damaging (1987: magnitude 5.0 at Lawrenceville, Illinois; 2002: magnitude 4.6 near Evansville, Indiana; 2008: magnitude 5.4 near Mount Carmel, Illinois). The largest of these historical events, repeated today, would strongly impact the entire state of Illinois. Shaking from earthquakes can affect bank stability of rivers or ash impoundments via liquefaction of water-saturated unconsolidated sediments, or simple failure via slumping.

Underground coal mines and aggregate (limestone) mines are located throughout Illinois [E5]. Over time, there is potential for the roofs of these underground mines to collapse and for their floors to buckle, which in turn would create subsidence at the land surface (Bauer, 2008). A change in surface topography from subsidence could alter hydrologic flow pathways or induce slumping. Subsidence can also cause bedrock overlying the mine voids to be broken and fractured, altering groundwater flow patterns, or even directly breaking impoundments. Identification of mine locations and consideration of their potential to interact with groundwater flow, surface water, and surface impoundments would need to be included in an impoundment risk assessment framework.

Surface Water

Surface water bodies [H1] and streams [H2] can be significantly affected by coal ash, as documented by Rowe et al. (2002). Coal ash can alter surface water habitat conditions via sedimentation and water quality by affecting turbidity, pH, conductivity, or temperature, or via the introduction of trace elements such as arsenic, cadmium, chromium, copper, lead, and selenium.

The disposal of coal ash into wet settling ponds has the potential to threaten rivers and streams due to their inherent proximity to these water bodies within flood zones. Coal ash can enter surface waters through two paths. Coal ash settling pond levees can be vulnerable to catastrophic failure when stream channels migrate into them.

Also, lateral deposits of the character of the soil and geological materials, together with the local topography (slope) surrounding unlined ponds, will directly affect the horizontal seepage to surface waters.

The amount and quality of water and sediment moving through surface water are highly dynamic. Natural and human factors influence these changes, which can occur anywhere in a watershed at any time. Changes in factors such as climate [H15], vegetation [L4], land conversion [L5], and channelization [L5] can slow or accelerate water movement, thereby influencing the energy water has to erode and transport sediment both over land and through stream channels. Accordingly, a watershed and associated stream channels are constantly and dynamically adjusting to maintain a balance between streamflow/channel slope and sediment load/sediment particle size. It is when natural or human changes in the watershed or stream channels cause an imbalance in this process that increased rates of erosion and/or sedimentation are observed (Federal Interagency Stream Restoration Working Group, 1998). These imbalances can cause stream channels to migrate laterally and erode in ways that can compromise structures and property. Channel forms and floodplains continuously adjust to convey water and sediment supplies downstream. Those adjustments influence how future water and sediment interact with the evolving channels and floodplains (Knighton, 1998). Aspects of the geologic setting—including soils [L2], slope [L3], depositional environments [E1, G2, G3], and bedrock outcrops [G6]—are some of the controlling (resisting) factors in an adjustment feedback process. In the case of coal ash ponds, levees can be weakened by adjacent stream erosion or changes in groundwater conditions, thereby promoting seepage or increasing risk of failure. Due to the complex natural and systemwide scale of streamflow dynamics, particularly in areas with evidence of increased rates of erosion, assessments performed beyond local stream reaches provide a better context of the processes.

Beneficial Use of CCR

While CCR is most often thought of in terms of disposal, containment, and risk, there are also opportunities to reuse CCR while still protecting people and the environment. There are two broad categories of beneficial use: encapsulated and unencapsulated. Encapsulated use involves binding fly ash (FA) in a way that minimizes the chance it will migrate into the surrounding environment. An unencapsulated use is one where FA is used in a loose particulate, sludge, or other unbound form.

A summary of key points is provided below, and additional information is provided later in this section.

- FA is a mineral resource that can have a valuable role in lowering greenhouse gas emissions in cement manufacture, concrete, and in other infrastructure settings.
- Application of FA in asphalt appears to be a promising underused market opportunity that could benefit from more research. It is also an encapsulated use and one that is tolerant of carbon contamination.
- Another underused opportunity appears to be in flowable fills.
- The use of beneficiation (the treatment of fly ash to improve physical or chemical properties) can play an important role in the closure of legacy ash ponds and in diverting current FA not conforming to end-use specifications in encapsulated applications.
- The use of beneficiation can also alleviate concerns with the use of FA in unencapsulated use. A survey of the literature on beneficiation of FA, particularly with reducing contaminants of concern, suggests that there is room for improvement with respect to both efficacy and related environmental impacts.
- The use of beneficiation in conjunction with byproduct capture could result in FA becoming a viable commercial resource for multiple products, including critical elements.

- Potential environmental impacts from the beneficial use of CCR need to be evaluated on a case-by-case basis. There is, however, widespread consensus that encapsulated uses are preferable to unencapsulated uses (Slesinger, 2014). Relatively little monitoring of the environmental impacts of unencapsulated use of FA in structural fills/embankments appears to have been carried out (Aydilek & Cetin, 2013), leading some stakeholders to argue that this application increases the risk of contamination of groundwater and surface water by toxic metals (Natural Resources Defense Council, 2007).

Federal and State Definitions of Beneficial Use

The federal RCRA and Final Rule define beneficial use as the recycling or reuse of coal ash instead of its disposal into landfills, surface impoundments, or as mine fill. Under federal law, CCRs that are beneficially used must meet three criteria:

1. CCR use must provide a functional benefit (40 CFR § 257.53);
2. CCR use must substitute for the use of a virgin material to conserve natural resources (40 CFR § 257.53); and,
3. CCR use must meet relevant product specifications, regulatory standards, or design standards when available, and when such standards are not available, must not be used in excess quantities (40 CFR § 257.53).

The Illinois CAPP Act adopts the Illinois Environmental Protection Act's definition of beneficial use, which allows CCRs to be beneficially used to extract or recover material compounds in the CCR; as a substitute for agricultural lime for soil conditioning; as a synthetic gypsum when defined under the Act; and, for mine subsidence, fire control, sealing, and/or reclamation. Like the federal law, the Illinois Environmental Protection Act allows CCRs to be used as a raw ingredient (i.e., "virgin material") or mineral filler to conserve natural resources and to help manufacture specific commercial products like cement, asphalt, plastics, and paints (415 ILCS 5/3.135 (a) (2)).

The Illinois Environmental Protection Act allows CCRs to be used "as an effective substitute for a similar commercially available material." This is comparable to the federal law's functional benefit requirement (415 ILCS 5/3.135(a) (3) (B)) and the federal law's definition of CCR used as a "functionally equivalent" substitute for agricultural lime or synthetic or mined gypsum used as a fertilizer or soil amendment (provided the CCR has not been mixed with any waste and is in accordance with industry standards) (415 ILCS 5/3.135 (a) (6) – (6.5 (A) through (E)).

The CAPP Act is similar to the federal law because it allows CCR to be beneficially used according to approved Illinois Department of Transportation (IDOT) specifications for IDOT projects to stabilize or modify soils (415 ILCS 5/3.135 (a)(3) and (5)); as bottom ash in non-IDOT pavement sub-base or base, pipe bedding, or foundation backfill (415 ILCS 5/135 (a) (7); and as structural fill pursuant to ASTM and IDOT standards (415 ILCS 5/3.135 (a) (8)). Like the federal law, the CAPP Act generally allows beneficial use determinations for any CCR that is not mixed with hazardous waste before use, does not exceed Class I Illinois Groundwater Standards for metals, and will not cause, threaten, or allow the discharge of any contaminant into the environment; will otherwise protect human health and safety and the environment; and constitutes a legitimate use of the coal-combustion waste as an ingredient or raw material (415 ILCS 5/3.135 (b)).

Illinois state law and the CAPP Act define beneficial use of CCRs more broadly than federal law. For example, the CAPP Act considers bottom ash used in antiskid material for athletic tracks or footpaths, in non-IDOT pavement bases and sub-bases, or as foundation backfill as beneficially used (415 ILCS 5/3.135 (a) (4)); considers the extraction or recovery of material compounds in the CCR as beneficial use (415 ILCS 5/3.135 (a) (1)); and, categorizes CCR as beneficially used when CCR is used for mine subsidence, fire control, sealing, and/or reclamation (415 ILCS 5/3.135 (a) (9)).

In some cases, the CAPP Act is more stringent than federal law. For example, the following precautionary provisions in the CAPP Act have no counterpart in federal law:

- The CAPP Act's requirement that CCR users provide public notice and documentation of all CCRs beneficially used to the Illinois EPA (415 ILCS 5/3.135 (a-5) (C));
- The requirement that owners of CCR surface impoundments generating CCRs and who either sell or "otherwise provide" CCRs for beneficial use post a report specifying the volume or weight of the CCR in cubic yards or tons they sold or provided over the last year on their publicly available website every 12 months (415 ILCS 5/22.59 (h));
- The requirement of five-year time limits on approvals for beneficial use, which must be proactively renewed with the Illinois EPA; and,
- The express prohibition against CCRs being mixed with hazardous waste prior to being beneficially used (415 ILCS 5/3.135 (a-5) (A)).

The federal RCRA and Final Rule apply to both encapsulated and unencapsulated CCR and generally allow beneficial use determinations for both types of CCR provided environmental releases of the CCRs are comparable to or lower than those from analogous non-CCR products or are at or below relevant regulatory and health-based benchmarks (FR 80 21309, April 17, 2015; and 40 CFR § 257.53).[11] Illinois law does not expressly distinguish between unencapsulated and encapsulated CCRs, however, the CAPP Act does require that CCRs in the form of (unencapsulated) fly ash be managed to minimize airborne particles and dust (415 ILCS 5/3.135 (a-5) (D)). Although Illinois law does not expressly distinguish between unencapsulated and encapsulated CCRs, the CAPP Act does require that CCRs in the form of (unencapsulated) fly ash be managed to minimize airborne particles and dust (415 ILCS 5/3.135 (a-5) (D)); and, the Illinois EPA Proposed Rule implementing the CAPP Act requires CCR beneficially used in the State to meet all the federal RCRA requirements including the current[12] 12,400 ton federal limits on the amount of unencapsulated CCR that can be beneficially used in non-roadway applications (40 CFR § 257.53). Illinois law does not address limits on the amount of unencapsulated CCR, however, and Illinois must follow the federal law on this issue.

Encapsulated Use of Fly Ash

There is widespread consensus that encapsulated uses are preferable to unencapsulated uses (Slesinger, 2014). The leading beneficial use of FA is as an admixture in concrete and related products and in cement manufacture.

[11] The U.S. EPA uses its *Methodology for Evaluating Beneficial Uses of Industrial Non-Hazardous Secondary Materials* (BU Methodology).

[12] The U.S. EPA plans to close this potential loophole as part of its proposed rulemaking sometime in "early" 2020 by replacing the current 12,400 ton numerical threshold with location-based criteria as the trigger for an environmental demonstration including: distance from the uppermost aquifer; placement in a wetland; placement in an unstable area; placement in a flood plain; distance from a fault area; and, placement in a seismic zone.

FA also can be used as a mineral filler in asphalt mix (Federal Highway Administration, n.d.). Fly ash can replace about 10% of the asphalt in pavement construction. The encapsulated nature of the application, existence of use guidelines, and tolerance to impurities make this a particularly attractive end-use. However, current use is not significant from a volumetric perspective.

FA-based bricks and other masonry products have been well researched and are used in other countries, including India; for an Illinois example see Chou and Botha (2003). However, significant market barriers appear to exist in the United States (Ehrlich, 2015). The utility of FA in autoclaved aerated bricks has also been established.

The use of FA in the development of cement substitutes is ongoing. While there are many variations[13], they share the common objective of reducing the amount of ordinary Portland cement (OPC) used and reducing associated greenhouse gas (GHG) emissions.

Not all fly ash is suitable for use in concrete without post-combustion processing. For example, CCR in legacy impoundments may not be suitable for direct use in concrete due to the presence of unburnt carbon. The injection of powdered activated carbon for mercury control also results in contamination of fly ash with high surface area carbon. The presence of carbon interferes with the air entrainment in concrete and increases the cost of chemical additives to compensate. The carbon can be separated using electrostatic separation and other methods, such as carbon burnout and surface oxidation. As an alternative, chemical passivation using sacrificial reagents that adsorb onto carbon can also be used—collectively these practices are called passivation or beneficiation. Commercial installations are operational in Maryland and South Carolina, and additional facilities are being considered by utilities such as Dominion Energy (Gardner & Greenwood, 2017).

Unencapsulated Use of Fly Ash

The largest unencapsulated use of FA in the past was as structural fills/embankments, though there has been a significant decrease from 2014-2016. Relatively little monitoring of the environmental impacts of this use appears to have been carried out (Aydilek & Cetin, 2013), leading some stakeholders to argue that this application increases the risk of contamination of groundwater and surface water by toxic metals (Natural Resources Defense Council, 2007).

Concerns about leaching of toxic elements from FA in landfills have spurred research into FA beneficiation, which is in the early stage (Neupane et al., 2017; Bhattacharyya et al., 2009; Kashiwakura et al., 2009, 2010, 2011). There is need for more research into developing beneficiation methods for FA that have a low environmental impact. If cost-effective methods can be developed, the use of FA in unencapsulated use may be more acceptable to all stakeholders.

[13] At one extreme are formulations that eschew OPC altogether (US 8,202,362B2, WO2014075134A1). For example, WO2014075134A1 describes the production of a cement that is produced by mixing fly ash, slag, sodium carbonate, and sodium silicate prepared at a temperature of 10 °C to 40 °C (Chalmers, Kidd, & Sleep, 2014). The same technique can be used to produce concrete when prepared with aggregate. The advantage of using these geopolymer cements is that the embodied CO_2 emissions can be as much as 90% lower than OPC. There are examples of the use of geopolymer concrete in commercial settings. The Australian company Wagners markets an earth-friendly concrete that has been used in many projects. An iron powder-based cement (Ferrock) that incorporates about 20 wt% Class F FA is also known. While the amount of FA used is smaller than in other cement alternatives compositions, it is interesting as it uses carbon dioxide as a reactant. About 10% of the resultant product is carbon dioxide.

FA in Waste Stabilization

The use of FA to stabilize a difficult-to-treat wastewater stream from a power plant—FGD scrubber blowdown—is gaining attention (Sniderman; Barbel & Charhut, 2016). This technology combines fly ash with gypsum and scrubber blowdown (possibly with small amounts of lime or OPC) to generate a stabilized waste with low leaching potential. The technology is flexible as it can be carried out on site or remotely after transportation by pipeline. While the basic chemistry is well known, site-specific modifications may be required to accommodate the various wastewater streams.

FA as Mineral Resource

There is growing interest in using FA as a source of other elements. In the past few years, there has been significant research on FA as a source of rare earth elements (REE), which have numerous industrial uses. This interest has been spurred by U.S. national security concerns regarding reliance on external sources for REE[14].

FA can also be a source for other elements, such as aluminum, germanium, gallium, lithium, vanadium, and nickel (Rasoulnia & Mousavi, 2016; Sen et al., 2016; Arroyo, et al., 2009).

While coal fly ash, at least those of Illinois Basin, may not be a viable source of individual minerals, there may be opportunities to capture some of this value as part of beneficiation schemes.

Miscellaneous Uses of FA

FA has been used as a raw material for the manufacture of zeolites, aluminosilicate minerals used as adsorbents and catalysts. In general, hydrothermal treatments yield a mixture of zeolites and residual fly ash. Two-step processes can produce pure zeolites. However, the commercial case for conversion of FA to zeolite is not strong.

Fly ash has been used as a filler in carpets, bowling balls, etc. However, the largest carpet manufacturer has phased out use of fly ash (Healthy Building Network, 2017). FA also can be used as a mineral filler in asphalt mix (Federal Highway Administration, n.d.).

Bottom Ash Beneficial Uses

Bottom ash is coarser and more porous than fly ash. The larger size fraction allows it to substitute for fine aggregate. The size and shape, particularly the angular nature, provide both friction and shear strength, enabling its application in structural fills, snow and ice control, and as blasting grit. Over the last few years, its use has grown.

FGD Gypsum

FGD scrubber systems that are operated wet and with forced oxidation produce gypsum (technically calcium sulfate dihydrate ($CaSO_4 2H_2O$)). Lee et al. (2012) state that the use of FGD gypsum in place of mined gypsum results in significant energy, water, and cost saving. The primary uses for FGD gypsum are in manufacture of wall boards, cement manufacture, concrete products, agriculture, mine applications, and as structural fill. The largest application is in the use of wallboard.

[14] See Presidential Executive Order: https://www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals/

Questions have been raised over the potential contamination of wallboard with heavy metal from FGD gypsum as well as the fate of mercury during manufacturing and over its use cycle. An evaluation by U.S. EPA concluded that environmental releases of constituents of potential concern from FGD gypsum wallboard during use by the consumer are comparable to or lower than those from analogous non-CCR products, or are at or below relevant regulatory and health-based benchmarks for human and ecological receptors (U.S. EPA, 2014a).

Summary

Coal combustion products and residuals (CCR) are a byproduct of burning coal to generate electricity. Coal ash contains varying levels of the potentially toxic elements in coal, including arsenic, boron, cadmium, chromium, cobalt, lead, lithium, manganese, molybdenum, radium, selenium, sulfur, and thallium. These elements can persist and accumulate in the environment and can cause negative health impacts, such as cancer, heart disease, reproductive failure, strokes, and neurological damage.

Federal and state regulations control the release of CCRs into the environment by requiring coal combustion facilities to capture coal ash, and regulations have been in development since 2008 (Figure 1). Most significantly, in 2015, the U.S. EPA imposed national regulations for the safe management and disposal of CCRs in landfills, surface impoundments, and lateral expansions of surface impoundments, referred to as the “Final Rule.” Changes to the Final Rule came out on Feb. 19, 2020. In July 2019, the Coal Ash Pollution Prevention or CAPP Act (Public Act 101-171), which requires additional protections on CCR surface impoundments, was signed into law in Illinois. The Illinois EPA submitted proposed regulations to the IPCB to finalize and adopt the new regulations by March 2021.

Geospatial data and other datasets were selected based on an anticipated use in potential assessments related to characterization of natural or anthropogenic factors related to coal ash impoundment management and/or risk identification and organized into six categories: area of interest, geology, hydrology, land use/soils, environmental, and sociopolitical.

Exposure to CCR poses risks to people, surface water, groundwater, and the environment. Human interaction with coal ash can occur through consumption of contaminated drinking water, contact during water recreation, ingestion of sport fish or wildlife, or contact with contaminated sediment. Potential effects include cancer, heart disease, reproductive failure, stroke, and/or neurological damage. Further, the effects of coal ash leachate on groundwater quality are a function of the characteristics of the ash, hydrogeology, and weather. The chemistry of the leachate can also affect the behavior of contaminants as the groundwater migrates away from the site. Trace elements from coal ash have been found in plants and aquatic and terrestrial animals; response to exposure varies with length of exposure, concentration of exposure, life-stage of the animal or plant, and composition of their habitat. Organisms can survive low-dose, chronic exposure but may have reduced growth rates, reduced reproductive success, physical deformities, or other internal malformations. Large ash spills release sediment into an aquatic environment and may cause immediate kills through rapid reduction in available oxygen, where recovery of systems may take decades.

Local and regional physical conditions (i.e., the nature and composition of subsurface geology, hydrologic regimes, and topography) can potentially affect surface water flow, groundwater flow, stream bank stability, and coal ash impoundment integrity. In particular, areas under and surrounding coal ash impoundments are significant factors because of their proximity.

The near surface unconsolidated sediment mantling the bedrock can vary in geometry, thickness, physical and chemical composition, spatial extent, and relationships with underlying geologic units. The geometry and composition of the underlying units can also potentially impact the groundwater and surface water hydrology of coal ash sites. Other factors include significant seismic zones in Illinois, as well as underground mines with potential for roof collapses that could create subsidence at the land surface. The disposal of coal ash into wet settling ponds has the potential to negatively impact rivers and streams due to their proximity to flood zones. Also, lateral deposits of soil and geological materials, together with the local topography (slope) surrounding unlined ponds, will directly affect the horizontal seepage to surface waters. Levees could be weakened by adjacent stream erosion or changes in groundwater conditions, thereby promoting seepage or increasing risk of failure.

There are two categories of beneficial use: encapsulated and unencapsulated. Encapsulated use, which is preferred, involves binding the fly ash to minimize migration into the surrounding environment. An unencapsulated use is one where fly ash is in an unbound form, such as loose particulate matter or sludge. The leading beneficial use of fly ash is as a mixture in concrete and related products and in cement manufacture or mineral filler in asphalt mix. Using unencapsulated fly ash to stabilize difficult-to-treat wastewater streams from power plants is gaining attention. There is significant research on fly ash as a source of rare earth elements (REE), which have numerous industrial uses.

Recommendations

There is a need for additional identification and evaluation of relative risks and risk factors with respect to human health and the environment among all impoundments in Illinois. Several themes emerged during the work of the CART that are recommended as priorities.

The Coal Ash Response Team recommends that PRI:

1. **Facilitate a systematic risk identification/evaluation process for coal ash impoundments in Illinois.** Subject to funding and stakeholder participation, development of a robust risk management framework is needed to prioritize use of limited resources and focus research and site management efforts on areas of most significant environmental concern and benefit. The Illinois EPA has developed a coal ash impoundment management strategy, and PRI has identified additional data for stakeholders. Further, PRI sees benefit to engaging in a systematic risk identification/evaluation process to develop a risk register that is specific for coal ash impoundments in Illinois. The development of an Illinois-specific risk register for all sites throughout the state would help better focus efforts to:
    a. Prioritize sites for more detailed site characterization or research based on the relative risks and potential impacts to human health and the environment,
    b. Develop enhanced geospatial data exploration methods to:
        i. Identify and rank risk factors to human health and the environment for all coal ash surface impoundments throughout the state, and
        ii. Estimate the scope of potential impacts due to berm failure and identify potential mitigation responses.
2. **Enhance current collaborations and seek new partners for prioritized collaborative work.** In alignment with a risk identification/evaluation process, collaborative projects should be conducted (subject to state appropriation or other funding) to:

   a. Continue data framework (e.g., GIS) development to support stakeholder decision making and site evaluations,
   b. Develop concept validation studies to support future site management protocols, and
   c. Develop targeted field studies to:
      i. improve site characterization and characterization methods,
      ii. test and validate pollution mitigation and site management strategies to address environmental concerns, and
      iii. identify environmental justice issues and opportunities for mitigation.

3. **Monitor both ongoing Illinois coal ash rule-making and federal coal ash policies.** The Illinois EPA submitted proposed regulations to the Illinois Pollution Control Board (IPCB) on March 30, 2020, and IPCB is required to finalize and adopt the new regulations by March 30, 2021. Implementation of the federal "Final Rule" may be impacted by court cases and administration changes.

References

American Coal Ash Association, n.d., An American recycling success story: Beneficial use of coal combustion products: Farmington Hills, Michigan, https://www.acaa-usa.org/publications/productionusereports.aspx (accessed September 23, 2020).

Arroyo, F., O. Font, C. Fernández-Pereira, X. Querol, R. Juan, C. Ruiz, and P. Coca, 2009, Germanium recovery from gasification fly ash: Evaluation of end-products obtained by precipitation methods: Journal of Hazardous Materials, v. 167, no. 1–3, p. 582–588, https://doi.org/10.1016/j.jhazmat.2009.01.021.

Aydilek, A.H., and B. Cetin, 2013, Geoenvironmental impacts of using high carbon fly ash in structural fill applications: Hanover, Maryland Department of Transportation, https://www.roads.maryland.gov/OPR_Research/MD-13-SP909B4P-Geoenvironmental-Impacts-Of-Using-HCFA-In-Structural-Fill-Applications.pdf (accessed September 23, 2020).

Barbel, J. and D. Charhut, 2016, FGD byproduct fixation and stabilization alternatives with ash systems: PowerEngineering, v. 120, no. 5, https://www.power-eng.com/2016/05/23/zero-liquid-discharge-solutions/ (accessed September 23, 2020).

Bhattacharyya, S., R.J. Donahoe, and D. Patel, 2009, Experimental study of chemical treatment of coal fly ash to reduce the mobility of priority trace elements: Fuel, v. 88, no. 7, p. 1173-1184, https://doi.org/10.1016/j.fuel.2007.11.006 (accessed September 24, 2020).

Bauer, R., 2008, Planned coal mine subsidence in Illinois: A public information booklet: Illinois State Geological Survey, Circular 573, http://hdl.handle.net/2142/73425 (accessed September 23, 2020).

Berg, R.C. and M.R. Greenpool, 1994, Stack-unit map of Paducah 1º x 2º quadrangle : geologic materials to a depth of 15 meters: Illinois State Geological Survey

Brandt, J.E., M. Simonin, R.T. Di Giulio, and E.S. Bernhardt, 2019, Beyond selenium: Coal combustion residuals lead to multielement enrichment in receiving lake food webs: Environmental Science and Technology, v. 53, no. 8, 4119–4127, https://doi.org/10.1021/acs.est.9b00324.

Bryan, A.L., W.A. Hopkins, J.A. Baionno, and B.P. Jackson, 2003, Maternal transfer of contaminants to eggs in common grackles (*Quiscalus quiscala*) nesting on coal fly ash basins: Archives of Environmental Contamination and Toxicology, v. 45, no. 2, p. 273–277, https://doi.org/10.1007/s00244-002-0212-9.

Cairns, J., K.L. Dickson, and J.S. Crossman, 1970, Biological recovery of the Clinch River following a fly ash pond spill: Proceedings of the 25th Industrial Waste Conference, Purdue University, p. 182–192, http://128.210.126.179/cdm/ref/collection/engext/id/18364 (accessed September 23, 2020).

Carlson, C.L., and D.C. Adriano, 1993, Environmental impacts of coal combustion residues: Journal of Environmental Quality, v. 22, no. 2, p. 227–247, https://doi.org/10.2134/jeq1993.00472425002200020002x.

Chalmers, D.P., P.G. Kidd, and P.D. Sleep, 2014, Geopolymer cement: WO Patent No. WO2014075134A1, https://patents.google.com/patent/WO2014075134A1 (accessed September 23, 2020).

Chapman, P.M., W.J. Adams, and M. Brooks, C.G. Delos, S.N. Luoma, W.A. Maher, H.M. Ohlendorf, T.S. Presser, and P. Shaw, eds., 2010, Ecological assessment of selenium in the aquatic environment: Boca Raton, Florida, Taylor & Francis.

Cherkauer, D.S., 1980, The effect of flyash disposal on a shallow ground-water system: Ground Water, v. 18, no. 6, p. 544–550, https://doi.org/10.1111/j.1745-6584.1980.tb03648.x.

Cherry, D.S., R.K. Guthrie, F.F. Sherberger, and S.R. Larrick, 1979, The influence of coal ash and thermal discharges upon the distribution and bioaccumulation of aquatic invertebrates: Hydrobiologia, v. 62, no. 3, 257–267, https://doi.org/10.1007/BF00043543.

Chou, M., and F. Botha, 2003, Manufacturing commercial bricks with Illinois coal fly ash: Lexington, University of Kentucky, Center for Applied Energy Research, http://www.flyash.info/2003/25cho.pdf (accessed September 23, 2020).

Cormier, S.M., G.W. Suter, L. Zheng, and G.J. Pond, 2013, Assessing causation of the extirpation of stream macroinvertebrates by a mixture of ions: Environmental Toxicology and Chemistry, v. 32, no. 2, p. 277–287, https://doi.org/10.1002/etc.2059.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe, 1979, Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. FWS/OBS-79/31.

DeForest, D., and W.J. Adams, 2011, Selenium accumulation and toxicity in freshwater fishes, *in* W.N. Beyer and J.P. Meador, Environmental contaminants in biota: Interpreting tissue concentrations, 2nd ed.: Pensacola, Florida, CRC Press, p. 193–229, https://doi.org/10.1201/b10598.

Ehrlich, B., 2015, CalStar suspends fly ash brick production: Brattleboro, Vermont, BuildingGreen, https://www.buildinggreen.com/newsbrief/calstar-suspends-fly-ash-brick-production (accessed September 23, 2020).

Environmental Integrity Project, 2018, Cap and run: Toxic coal ash left behind by big polluters threatens Illinois water: Washington, DC, Environmental Integrity Project, https://illinoiscoalash.files.wordpress.com/2018/11/capandrun-ilcoalash_web.pdf (accessed September 23, 2020).

Federal Highway Administration, n.d., User guidelines for waste and byproduct materials in pavement construction: Washington, DC, Federal Highway Administration, Publication No. FHWA-RD-97-148, https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/cfa52.cfm (accessed September 23, 2020).

Federal Interagency Stream Restoration Working Group, 1998/2001, Stream Corridor Restoration: Principles, Processes, and Practices: Washington, DC, U.S. Department of Agriculture, Natural Resources Conservation Service, GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653, https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044574.pdf (accessed September 23, 2020).

Gallant, A.L., T.R. Whittier, D.P Larsen, J.M. Omernik, and R.M. Hughes, 1989, Regionalization as a Tool for Managing Environmental Resources: Corvallis, Oregon, U.S. Environmental Protection Agency EPA/600/3-89/060.

Gardner, K.H., and S. Greenwood, 2017, Beneficial reuse of coal ash from Dominion Energy coal ash sites feasibility assessment: Washington, DC, Potomac Riverkeeper Network and Charlottesville, Virginia, Southern Environmental Law Center, https://www.southernenvironment.org/uploads/words_docs/Coal_Ash_Recycling_Feasiblity_Assessment.pdf (accessed September 23, 2020).

Garrett, G.P., and C.R. Inman, 1984, Selenium-induced changes in fish populations in a heated reservoir: Annual Conference of Southeast Association of Fish and Wildlife Agencies, v. 38, p. 291–301, http://www.seafwa.org/publications/proceedings/?id=10129 (accessed September 23, 2020).

Gottlieb, B., S.G. Gilbert, and L.G. Evans, 2010, Coal ash: The toxic threat to our health and environment: A report from Physicians for Social Responsibility and Earthjustice: Earthjustice, p. 27, https://earthjustice.org/sites/default/files/files/CoalAsh_Earthjustice.pdf (accessed September 23, 2020).

Gschwend, P.M., D.A. Backhus, J.K. MacFarlane, and A.L. Page, 1990, Mobilization of colloids in groundwater due to infiltration of water at a coal ash disposal site: Journal of Contaminant Hydrology, v. 6, no. 4, p. 307–320, https://doi.org/10.1016/0169-7722(90)90031-B.

Gulec, N., B. Gunal, and A. Erler, 2001, Assessment of soil and water contamination around an ash-disposal site: A case study from the Seyitomer coal-fired power plant in western Turkey: Environmental Geology, v. 40, no. 3, p. 331–344, https://doi.org/10.1007/s002540000228.

Harkness, J.S., B. Sulkin, and A. Vengosh, 2016, Evidence for coal ash ponds leaking in the southeastern United States: Environmental Science and Technology, v. 50, no. 12, p. 6583–6592, https://doi.org/10.1021/acs.est.6b01727.

Healthy Building Network, 2017, Eliminating toxics in carpet: Lessons for the future of recycling: Washington, DC, Healthy Building Network, https://s3.amazonaws.com/hbnweb.dev/uploads/files/eliminating-toxics-in-carpet-lessons-for-the-future-of-recycling.pdf (accessed September 23, 2020).

Illinois Environmental Protection Agency, 2011, Illinois EPA's ash impoundment strategy progress report, October 2011: Springfield, Illinois Environmental Protection Agency, 10 p., https://www2.illinois.gov/epa/Documents/iepa/water-quality/watershed-management/ash-impoundment/ash-impoundment-progress-102511.pdf (accessed September 23, 2020).

Illinois General Assembly, 2015, Water Well Construction Code, Title 77, Part 920, Illinois Administrative Code: Springfield, Illinois General Assembly, http://www.ilga.gov/commission/jcar/admincode/077/07700920sections.html (accessed September 23, 2020).

Jacobson, P.J., R.J. Neves, D.S. Cherry, and J.L. Farris, 1997, Sensitivity of glochidial stages of freshwater mussels (Bivalvia: Unionidae) to copper: Environmental Toxicology and Chemistry, v. 16, no. 11, p. 2384–2392, https://doi.org/10.1002/etc.5620161126.

Janz, D.M., D.K. DeForest, M. Brooks, P.M. Chapman, G. Gilron, D. Hoff, W.A. Hopkins, D.O. McIntyre, C.A. Mebane, V.P. Palace, J.P. Skorupa, and M. Wayland, 2010, Selenium toxicity to aquatic organisms, *in* Chapman, P.M., W.J. Adams, and M. Brooks, C.G. Delos, S.N. Luoma, W.A. Maher, H.M. Ohlendorf, T.S. Presser, and P. Shaw, eds., Ecological assessment of selenium in the aquatic environment: Pensacola, Florida, CRC Press, p. 141–232.

Jiang, S.M., M. Hua, and M.H. Zheng, 2010, An assessment of soil contamination due to selenium around an ash pond of a coal-based thermal power plant in China [abstract]: Geochimica et Cosmochimica Acta, v. 74, no. 12, Supplement, p. A466.

Kashiwakura, S., H. Kubo, Y. Kumagai, H. Kubo, K. Matsubae-Yokoyama, K. Nakajima, and T. Nagasaka, 2009, Removal of boron from coal fly ash by washing with HCl solution: Fuel, v. 88, no. 7, p. 1245–1250, https://doi.org/10.1016/j.fuel.2008.12.027.

Kashiwakura, S., H. Ohno, K. Matsubae-Yokoyama, Y. Kumagai, H. Kubo, and T. Nagasaka, 2010, Removal of arsenic in coal fly ash by acid washing process using dilute H_2SO_4 solvent: Journal of Hazardous Materials, v. 181, no. 1–3, p. 419–425, https://doi.org/10.1016/j.jhazmat.2010.05.027.

Kashiwakura, S., H. Ohno, Y. Kumagai, H. Kubo, K. Matsubae, and T. Nagasaka, 2011, Dissolution behavior of selenium from coal fly ash particles for the development of an acid-washing process: Chemosphere, v. 85, no. 4, p. 598–602, https://doi.org/10.1016/j.chemosphere.2011.06.099.

Khan, I., and R. Umar, 2019, Environmental risk assessment of coal fly ash on soil and groundwater quality, Aligarh, India: Groundwater for Sustainable Development, v. 8, p. 346–357, https://doi.org/10.1016/j.gsd.2018.12.002.

Knighton, D., 1998, Fluvial forms and processes: A new perspective: London, Hodder Arnold, https://doi.org/10.4324/9780203784662.

Lee, J.C., S.L. Bradshaw, T.B. Edil, and C.H. Benson, 2012, Quantifying the Benefits of Using Flue Gas Desulfurization Gypsum in Sustainable Wallboard Production: Coal Combustion and Gasification Products, v. 4, no. 1, https://doi.org/10.4177/CCGP-D-11-00007.1. (accessed September 24, 2020).

Milligan, J.D., and R.J. Ruane, 1980, Effects of coal-ash leachate on ground water quality: Chattanooga, Tennessee, and Washington, DC, U.S. Environmental Protection Agency, Interagency Energy/Environment R&D Program Report, https://nepis.epa.gov/Exe/ZyPDF.cgi/9101FPKG.PDF?Dockey=9101FPKG.PDF (accessed September 23, 2020).

Natural Resources Defense Council, 2007, Dangerous disposals: Keeping coal combustion waste out of our water supply: New York, Natural Resources Defense Council, https://www.nrdc.org/sites/default/files/coalwater.pdf (accessed September 23, 2020).

Neupane, G., R.J. Donahoe, S. Bhattacharyya, and P. Dhakal, 2017, Leaching kinetics of As, Mo, and Se from acidic coal fly ash samples: Journal of Water Resource and Protection, v. 9, p. 890–907, https://doi.org/10.4236/jwarp.2017.98060.

Omernik, J.M., 1995a, Ecoregions: a spatial framework for environmental management, in Davis, W.S. and Simon, T.P. (eds.), Biological assessment and criteria, tools for water resource planning and decision making: Boca Raton, Florida, Lewis Publishers, p. 31-47.

Omernik, J.M., 1995b, Ecoregions: a framework for managing ecosystems: The George Wright Forum, v. 12, no. 1, p. 35-50.

Omernik, J.M., S.S. Chapman, R.A. Lillie, R.T. and Dumke, 2000, Ecoregions of Wisconsin: Transactions of the Wisconsin Academy of Science, Arts and Letters, v. 88, p. 77-103.

Praharaj, I., S.P. Swain, M.A. Powell, B.R. Hart, and S. Tripathy, 2002, Delineation of groundwater contamination around an ash pond: Geochemical and GIS approach: Environment International, v. 27, no. 8, p. 631–638, https://doi.org/10.1016/S0160-4120(01)00121-0.

Praharaj, T., S. Tripathy, M.A. Powell, and B.R. Hart, 2003, Geochemical studies to delineate topsoil contamination around an ash pond of a coal-based thermal power plant in India: Environmental Geology, v. 45, no. 1, p. 86–97, https://doi.org/10.1007/s00254-003-0860-8.

Rasoulnia, P., and S.M. Mousavi, 2016, Maximization of organic acids production by *Aspergillus niger* in a bubble column bioreactor for V and Ni recovery enhancement from power plant residual ash in spent-medium bioleaching experiments: Bioresource Technology, v. 216, p. 729–736, https://doi.org/10.1016/j.biortech.2016.05.114.

Rowe, C.L., W.A. Hopkins, and J.D. Congdon, 2002, Ecotoxicological implications of aquatic disposal of coal combustion residues in the United States: A review: Environmental Monitoring and Assessment, v. 80, no. 3, p. 207–276, https://doi.org/10.1023/A:1021127120575.

Ruhl, L., A. Vengosh, G.S. Dwyer, H. Hsu-Kim, G. Schwartz, A. Romanski, and S.D. Smith, 2012, The impact of coal combustion residue effluent on water resources: A North Carolina example: Environmental Science and Technology, v. 46, no. 21, p. 12226–12233, https://doi.org/10.1021/es303263x.

Russ, A., C. Bernhardt, and L. Evans, 2019, Coal's poisonous legacy: Groundwater contaminated by coal ash across the U.S.: Washington, DC, Environmental Integrity Project, https://www.environmentalintegrity.org/wp-content/uploads/2019/03/National-Coal-Ash-Report-Revised-7.11.19.pdf (accessed September 23, 2020).

Sen, S.K., M.M. Das, P. Bandyopadhyay, R.R. Dash, and S. Raut, 2016, Green process using hot spring bacterium to concentrate alumina in coal fly ash: Ecological Engineering, v. 88, p. 10–19, https://doi.org/10.1016/j.ecoleng.2015.12.012.

Sherrard, R.M., N.E. Carriker, and M.S. Greeley, 2015, How toxic is coal ash? A laboratory toxicity case study: Integrated Environmental Assessment and Management, v. 11, no. 1, p. 5–9, https://doi.org/10.1002/ieam.1587.

Simsiman, G.V., G. Chesters, and A.W. Andren, 1987, Effect of ash disposal ponds on groundwater quality at a coal-fired power-plant: Water Research, v. 21, no. 4, p. 417–426, https://doi.org/10.1016/0043-1354(87)90189-8.

Slesinger, S., 2014, Coal ash: Why it is better recycled than as a waste [blog post]: Washington, DC, Natural Resources Defense Council, https://www.nrdc.org/experts/scott-slesinger/coal-ash-why-it-better-recycled-waste (accessed September 23, 2020).

Sniderman, D., 2017, From power plant to landfill: Encapsulation: EPRI [Electric Power Research Institute] Journal, http://eprijournal.com/from-power-plant-to-landfill-encapsulation/ (accessed September 23, 2020).

Spencer, L.L., and L.D. Drake, 1987, Hydrogeology of an alkaline fly ash landfill in eastern Iowa: Ground Water, v. 25, no. 5, p. 519–526, https://doi.org/10.1111/j.1745-6584.1987.tb02881.x.

Treworgy, J.D., 1981, *Structural Features in Illinois - A Compendium:* Champaign, IL, Illinois State Geological Survey, Circular 519, http://hdl.handle.net/2142/43536 (accessed September 24, 2020).

U.S. Environmental Protection Agency, n.d., National Primary Drinking Water Regulations: Washington, DC, U.S. Environmental Protection Agency,https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations (accessed September 23, 2020).

U.S. Environmental Protection Agency, 2010, Human and ecological risk assessment of coal combustion wastes: Washington, DC, U.S. Environmental Protection Agency, Regulation Identifier Number (RIN) 2050-AE81, https://earthjustice.org/sites/default/files/library/reports/epa-coal-combustion-waste-risk-assessment.pdf (accessed September 23, 2020).

U.S. Environmental Protection Agency, 2013, Integrated Risk Information System: Washington, DC, U.S. Environmental Protection Agency, https://www.epa.gov/iris (accessed September 23, 2020).

U.S. Environmental Protection Agency, 2014a, Coal combustion residual beneficial use evaluation: Fly ash concrete and FGD gypsum wallboard: Washington, DC, U.S. Environmental Protection Agency, https://www.epa.gov/sites/production/files/2014-12/documents/ccr_bu_eval.pdf (accessed September 23, 2020).

U.S. Environmental Protection Agency, 2014b, Frequent questions about the 2015 coal ash disposal rule [policies and guidance]: Washington, DC, U.S. Environmental Protection Agency, https://www.epa.gov/coalash/frequent-questions-about-2015-coal-ash-disposal-rule (accessed September 23, 2020).

U.S. Environmental Protection Agency, 2016, EPA response to Kingston TVA coal ash spill [overviews and factsheets]: Washington, DC, U.S. Environmental Protection Agency, https://www.epa.gov/tn/epa-response-kingston-tva-coal-ash-spill (accessed September 23, 2020).

Warren, M.L., and W.R. Haag, 2005, Spatio-temporal patterns of the decline of freshwater mussels in the Little South Fork Cumberland River, USA: Biodiversity & Conservation, v. 14, no. 6, p. 1383–1400, https://doi.org/10.1007/s10531-004-9664-8.

Wesner, J.S., J.M. Kraus, T.S. Schmidt, D.M. Walters, and W.H. Clements, 2014, Metamorphosis enhances the effects of metal exposure on the mayfly, *Centroptilum triangulifer*: Environmental Science & Technology, v. 48, p. 10415–10422, https://doi.org/10.1021/es501914y.

Appendix A: Charge to Coal Ash Response Team

Justification for formation of response team

- Coal ash storage is an important historical and future issue with impacts on the environment, economy, and public health of people in the state of Illinois.
- Issues related to coal ash are directly relevant to PRI's mission and research themes.
- PRI Surveys have conducted scientific investigations related to coal ash for over 50 years.
- PRI has current expertise from multiple perspectives and scientific disciplines to study issues related to coal ash and make timely and useful recommendations.
- A PRI Coal Ash Response Team is needed to provide relevant science-based input for policymaking, (including legislation or rulemaking, and a potential legislative task force), which could result in PRI performing additional targeted investigations via a range of funding mechanisms.

Charge to the Response Team and Duration

The Coal Ash Response Team in cooperation with interested stakeholders (e.g., the Illinois Environmental Protection Agency or Illinois EPA) is appointed to conduct a detailed review of existing scientific literature and federal and State laws, regulations, and rules relevant to the subject matter, defined as:

1. Characterization of coal ash sites
    a. geology
    b. hydrology
2. Monitoring of coal ash sites for impacts on or risk to
    a. drinking water sources
    b. watersheds (streams, rivers, lakes, reservoirs, wetlands, and underlying groundwater)
    c. Aquatic species diversity and their habitats
3. Mitigation of impacts
4. Utilization of coal ash

By **Dec. 31, 2019**, the Coal Ash Response Team shall submit to the Office of Executive Director a **preliminary report** of its findings that shall include:

- Definition of the scope of the study and methodology used by the Coal Ash Response Team.
- A public policy analysis of existing federal and State laws, regulations, and rules related to the subject matter.
- A compilation of existing recommendations from a detailed review of existing scientific literature related to the subject matter.
- Coal Ash Task Force summaries within the areas of expertise of its members, including:
    a. Aspects of coal ash impacts on the environment, economy, and public health of people in the state of Illinois, and
    b. Potential or needed research or policymaking, including legislation or administrative rulemaking.

The Coal Ash Response Team will complete its charge and be dissolved when it submits its **final report**, or on **Dec. 31, 2020**, whichever occurs first, unless otherwise instructed by the PRI Executive Director.

Appendix B: Federal and state characterization, monitoring, and mitigation of CCRs

How federal and state law define CCR

Federal and state law define coal combustion residuals similarly. The federal RCRA and Final Rule and the CAPP Act define coal combustion residuals or CCRs as fly ash, bottom ash, boiler slag, and flue gas desulfurization materials generated from burning coal for electrical generation. Both the federal and state laws apply only to CCRs produced by electric utilities and independent power producers (40 CFR § 257.53 and 415 ILCS 5/3.142).

The federal RCRA and Final Rule extend the characterization of CCR to include CCR fugitive dust, defined as solid airborne particulate matter containing CCR or derived from CCR, emitted from any source other than a stack or chimney (40 CFR §257.53). The Illinois EPA Proposed Rule defines "CCR fugitive dust" as solid airborne particulate matter that contains or is derived from CCR, emitted from any source other than a stack or chimney (Section 845.120); the CAPP Act requires dust controls as part of responsible CCR removal (415 ILCS 5/22.59(g)(10)) and the management of CCR fly ash so as to minimize CCR dust (415 ILCS 5/3.135 (a-5) (C)).

CCRs excluded from federal and state definitions

The federal RCRA and Final Rule do not apply to CCRs that are beneficially used or to CCRs placed at active or abandoned underground or surface coal mines (40 CFR §257.50(d) through (89)). The Illinois Environmental Protection Act also excludes beneficially used CCRs (415 ILCS 5/3.135 (a)) as well as CCRs that are used in mine subsidence, mine fire control, mine sealing, and mine reclamation (415 ILCS 5/3.135 (a)(9)).

The federal RCRA and Final Rule do not apply to CCRs from municipal solid waste landfills (MSWLFs). Since the Illinois Environmental Protection Act requires the IPCB to adopt municipal solid waste landfill rules that are "identical in substance to federal regulations" under the RCRA (415 ILCS 5/22.40 (a)), it appears that Illinois law also does not apply to CCRs from MSWLFs.

Finally, the federal RCRA and Final Rule do not apply to CCRs generated at non-electrical or power-producing facilities (i.e., manufacturing facilities, universities, hospitals) (40 CFR §257.50(f)). Likewise, the Illinois EPA Proposed Rule excludes CCR generated at non-electrical or power-producing facilities from regulation under the CAPP Act.

Monitoring and Mitigation

The federal RCRA and Final Rule address six areas involving the monitoring (management) and mitigation (remediation) of CCRs' potential and actual impacts:

1. Assessment monitoring (groundwater) and corrective action requirements (retrofitting) for CCR units[15];
2. Liner design requirements prescribing how CCR units must be protectively lined;
3. Location restrictions prescribing where CCR units can and cannot be placed;
4. Operating and inspection requirements for all CCR units;
5. Structural integrity requirements addressing CCR unit hazard potential, corrective measures, and mitigation; and,

[15] Defined in federal law as landfills, surface impoundments, and lateral expansions of surface impoundments containing CCR (40 CFR §257.50(b)).

6. Closure and post-closure care requirements for active and inactive CCR units.

Comparable federal and state CCR law requirements

Monitoring

Assessment (groundwater) monitoring

Federal law requires complete assessment monitoring for statistically significant increases of certain constituents[16] and establishes groundwater protection standards for all constituents detected (40 CFR §257.95 and §257.96). Federal groundwater monitoring requirements are very specific and include sampling from the uppermost aquifer (40 CFR §257.91), sampling and analysis programs for groundwater monitoring (40 CFR §257.93), semi-annual detection monitoring for specific constituents at all groundwater monitoring wells[17] (40 CFR §257.94), and assessment monitoring, groundwater protection standards, and corrective measures (40 CFR §257.95).[18]

Similarly, the CAPP Act prohibits CCRs from exceeding Illinois Class I Groundwater Standards (415 ILCS 5/3.135 (a-5) (B))[19] and requires CCR surface impoundment permits to contain compliance schedules for, among other things, the Illinois Groundwater Protection Act and related regulations (415 ILCS 5/39 (y)). The Illinois EPA Proposed Rule requires CCR surface impoundment owners or operators to follow the groundwater quality standards in 35 Ill. Adm. Code 620, which incorporate additional constituents, as well as Illinois Class I Groundwater Standards under 35 Ill. Adm. Code 620.410 (Section 845.600(a)(1)). In fact, the Proposed Rule's standards exceed Class I Groundwater standards for cobalt and radium 226 and 228 and set additional standards for lithium and molybdenum—neither of which are listed in Illinois' Class I groundwater standards, effectively adding to Illinois' already well-established procedures and protocols for the management and protection of groundwaters in the state.[20]

The CAPP Act also requires its implementing regulations to describe the process for owners or operators to—when applicable—identify a specific alternative source of groundwater pollution (415 ILCS 5/22.59(g)(11)). The Illinois EPA Proposed Rule sets forth requirements for the process and standards for identifying alternative sources of groundwater pollution in Section 845.650(d)(4), allowing the owner or operator of a CCR surface impoundment to submit a demonstration to the Illinois EPA that a source other than the CCR surface impoundment caused the contamination and the CCR surface impoundment did not contribute to the contamination, or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, natural variation in groundwater quality, or a change in the potentiometric surface and groundwater flow direction.

Overall, the Illinois EPA Proposed Rule is more protective than federal law and establishes additional precautionary groundwater requirements that include: hydrogeologic site characterization; design and construction plan

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[16] Boron, calcium, chloride, fluoride, pH sulfate (Total Dissolved Solids (TDS)); 80 FR 21500, Appendix III, Apr. 17, 2015).

[17] Boron, calcium, chloride, fluoride, pH Sulfate (Total Dissolved Solids (TDS)) (80 FR 21500, Appendix III, Apr. 17, 2015]

[18] Federal law also gives state EPA directors the option to suspend groundwater monitoring requirements if there is evidence that there is no potential for hazardous constituents to migrate to the uppermost aquifer. See *Utility Solid Waste Activities Group, et al v. EPA* (D.C. Circuit Court) (2015) (*USWAG case*).

[19] The CAPP Act requires CCR surface impoundment permits to contain compliance schedules for, among other things, the Illinois Groundwater Protection Act and related regulations (415 ILCS 5/39 (y)).

[20] See the Illinois Groundwater Quality Regulations at 35 Ill. Admin. Code Part 620 and see Illinois Effluent Standards at 35 Ill. Admin. Code Part 30420, which includes a recommendation for maximum effluent concentration levels for iron and manganese—two components of CCR.

parameters for groundwater monitoring systems; groundwater sampling and analysis program requirements; a groundwater monitoring program for all listed constituents; and corrective measures assessment and corrective action plan parameters.

Inspection requirements

The federal RCRA and Final Rule have inspection requirements: Owners or operators of CCR units must use “a qualified person” to inspect CCR units every seven days for structural weakness, discharges, and other safety conditions, while instrumentation inspection for CCR surface impoundments and lateral expansions must be made every 30 days. Annual inspections must be done by a qualified engineer and produce an inspection report that covers specific inspection criteria (40 CFR §257.83 and §257.84).

The CAPP Act and the Illinois EPA Proposed Rule establish closure and post-closure care requirements that are comparable to the federal requirements and that include requirements for completing a closure alternatives analysis that must include an analysis of the complete removal of CCR (415 ILCS 5/22.59(g) and 415 ILCS 5/22.59(d); Section 845.710(b) and Section 845.710(c)). The CAPP Act requires cost estimates for post-closure care to be calculated using a minimum of a 30-year post-closure care period (415 ILCS 5/22.59(f)(1)), and the Illinois EPA Proposed Rule addresses the same cost estimate time limits for any post-closure care time period (Section 845.930(b)(6).[21]

Public notice

Federal law requires CCR unit owners or operators to follow detailed recordkeeping, notification, and internet posting requirements to help monitor CCR landfills, surface impoundments, and lateral expansions of surface impoundments.

Similarly, the CAPP Act and the Illinois EPA Proposed Rule require “meaningful” public participation procedures for issuing CCR surface impoundment construction and operating permits (415 ILCS 5/22.59(g)(6) and Sections 845.240, 845.260, and 845.810). Under state law and the Illinois EPA Proposed Rule, owners or operators of CCR surface impoundments must post permit and application documents, closure plans, and other supporting documentation on their public websites ((415 ILCS 5/22.59(h) (i) and Section 845.810), as well as make permit and application documents publicly available in the county or municipality where the CCR will be permanently disposed (415 ILCS 5/39 (y)). In addition, state law and the Illinois EPA Proposed Rule require opportunities to submit public comments; opportunities for public hearings before permits are issued; and responsiveness summaries by the Illinois EPA (Section 845.240 and 845.260).

Finally, the CAPP Act requires owners or operators that beneficially use CCR to post a report every 12 months on their publicly available websites that specifies the volume or weight of CCR that has been sold or provided in the last 12 months (415 ILCS 5/22.59(h)). At the time of this review, the Illinois EPA Proposed Rule does not contain a comparable requirement.

[21] Section 845.930(b)(6) requires that the cost estimate for closure and post-closure care include at a minimum, “all costs for all activities necessary to close the CCR surface impoundment and provide post-closure care in accordance with all requirements of this part.” Although not explicitly stated this would by definition have to be calculated using the required 30-year post-closure care period as a minimum baseline.

Recordkeeping

The federal RCRA and Final Rule require CCR unit owners or operators to keep and maintain files of the information required for location restrictions, liner design criteria, structural integrity requirements, operating and inspection criteria, groundwater monitoring and corrective action requirements, and closure and post-closure care requirements in a written operating record[22] at the CCR unit for at least five years (40 CFR §257.105). Federal law also requires CCR unit owners or operators to notify states and relevant tribal authorities each time they put information into the operating record (40 CFR §257.106) and requires them to keep and maintain a publicly accessible internet site that contains all the information for at least five years (40 CFR §257.107).[23]

The Illinois EPA Proposed Rule requires impoundment owners and operators to keep a facility operating record (Section 845.800). Contents of the facility operating record are comparable to the federal requirements, and Section 845.800(b) requires the contents to be retained for at least three years after the date the Illinois EPA approved the request for post-closure care termination when the closure is with a final cover system or, when the closure is by removal upon the completion of groundwater monitoring.

Mitigation

Closure and post-closure care requirements

Federal law establishes closure and post-closure care requirements for CCR units, most of which are addressed by, and some of which are exceeded by, the CAPP Act. Federal CCR unit closure and post-closure care requirements generally apply to both active and inactive CCR surface impoundments (40 CFR §257.100); require unlined CCR units to either retrofit or close if specific constituents[24] are detected above the federal groundwater protection standard (40 CFR §257.101); and, require closure of existing CCR surface impoundments and CCR landfills that are not in compliance with location, structural integrity, or safety requirements (40 CFR §257.60 through §257.64, §257.73 and §257.74, and §257.101).

The IEPA Proposed Rule contains provisions that are comparable to the federal requirements and that specify which types of permits are needed for closure, post-closure, remediation and all other requirements applicable to CCR surface impoundments (415 ILCS 5/22.59(g)(3)). At the time of this review, the Illinois EPA Proposed Rule appears to apply the 30-year post-closure care requirements only to active impoundments (Section 845.170 and Section 845.780(c))[25] and does not seem to have the same requirements for closure of inactive impoundments.

Federal law also establishes specific closure criteria for existing CCR surface impoundments, CCR landfills, and lateral expansions of CCR surface impoundments, requiring CCR unit owners or operators to either (i) leave the

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[22] For example, federal law requires that the written post-closure plan contain a description of post-closure monitoring and maintenance and establishes a 30-year minimum post-closure CCR unit care period (40 CFR §257.104).

[23] The internet site must be titled “CCR Rule Compliance Data and Information.”

[24] Boron, calcium, chloride, fluoride, pH sulfate (Total Dissolved Solids (TDS)) (80 FR 21500, Appendix III, Apr. 17, 2015].

[25] The Illinois EPA Proposed Rule defines “Inactive CCR surface impoundment” as a CCR surface impoundment in which CCR was placed before but not after October 19, 2015 and still contains CCR on or after October 19, 2015. Inactive CCR surface impoundments may be located at an active facility or inactive facility (Section 845.120).

CCR in place and install a final cover system;[26] or, (ii) remove the CCR and decontaminate the unit.[27] Additional requirements include a written closure plan and schedule for completing closure; timeframes for initiating and completing closure (along with numerous exceptions); and, notice of closure requirements (40 CFR §257.102).[28]

Generally, the CAPP Act and the Illinois EPA Proposed Rule contain closure and post-closure care provisions that are comparable to, or are more protective than, the federal requirements; these include:

- The “closure alternatives analysis” requirement to analyze all the closure methods being considered including the complete removal of CCR (415 ILCS 5/22.59(d) and Section 845.710).
- The requirement to specify when permit applications for existing CCR surface impoundments must be submitted, taking into consideration whether the CCR surface impoundment must close under the RCRA (415 ILCS 5/22.59(g)(4)).
- The requirement to define when complete removal of CCR is achieved and specify the standards for responsible removal of CCR from surface impoundments, including, but not limited to, dust controls and the protection of adjacent surface water and groundwater (415 ILCS 5/22.59(g)(10)).

The IEPA’s Proposed Rule does not, however, specify a procedure to identify areas of environmental justice concern in relation to CCR surface impoundments as required by 415 ILCS 5/22.59(g)(8). Section 845.700(g)(6) of the Proposed Rule does identify literal “areas of environmental justice concern” but limits the application to CCR surface impoundment closures or retrofitting only. And, Section 845.700(g)(1) gives CCR surface impoundments with the highest risk to public health and the environment first and second priority, but CCR surface impoundments “located in areas of environmental justice concern as determined by the [IEPA]” only third priority.

Corrective action requirements

Federal law requires characterizing releases showing statistically significant increases of certain constituents to accurately assess corrective measures, remediate any releases, and restore affected areas to their original conditions (40 CFR §257.95 and §257.96). The federal RCRA and Final Rule also require: that remedial activities be initiated within 90 days of selecting a remedy; a notification of compliance completion; semiannual reports describing the selection and design of remedies in response to the corrective assessment that, among other things, protect human health and the environment (40 CFR §257.98 and §257.97); and, assessment of unit structural stability including identifying deficiencies and recommending corrective measures, at least every five years (40 CFR §257.73 and §257.74).

The Illinois EPA Proposed Rule requires comparable corrective actions, some of which are more protective than the federal requirements. Illinois requirements would include: outlining the decision-making process for corrective

[26] According to the Final Rule, when leaving CCR units in place owners or operators of the unit must ensure that, among several other criteria, the final cover system will “control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere,” include slope stability measures, and minimize maintenance.

[27] According to the Final Rule: “CCR removal and decontamination of the CCR unit are complete when constituent concentrations throughout the CCR unit and any areas affected by releases from the CCR unit have been removed and groundwater monitoring concentrations do not exceed the groundwater protection standard” under §257.95(h) for constituents listed in Appendix IV.

[28] Federal law also specifies criteria for alternative closure requirements that apply to all CCR units and include timelines, written progress reports, and notice and recordkeeping requirements (40 CFR §257.103).

action alternatives and closure alternatives considered as part of a construction permit for corrective action (Section 845.240(f)); sufficient documentation of general groundwater monitoring and corrective actions in the operating record to support a full assessment of corrective measures needed (Section 845.610); assessment of corrective measures and corrective action plan contents and implementation (Sections 845.660, 845.670, and 845.680); twice-yearly reporting describing the progress of implementing the corrective action (Section 845.660(a)); selected remedies in the corrective action plan (Section 845.660(d)); corrective action alternatives analysis to assess the risks inherent in different plans which must include long and short-term risks to the environment and human health, the effectiveness of the remedy, the ease or difficulty of implementing the remedy, and the "degree to which community concerns are addressed by a potential remedy" (Section 845.660(e)); a schedule for implementing and completing remedial activities with specific contents including groundwater quantity and quality assessments (Section 845.660(f)); and, the mandatory implementation of the corrective action plan within 90 days of IEPA's approval of the plan including taking any needed interim measures to reduce contamination from the CCR surface impoundment (Section 845.680(a)).

CAPP Act requirements exceeding federal law

Monitoring

Financial assurances

The CAPP Act requires owners or operators of CCR surface impoundments to pay fees for various impoundment statuses (415 ILCS 5/22.59 (j)); post performance bonds with the Illinois EPA along with related requirements (415 ILCS 5/22.59(f)); and, requires the Illinois EPA to issue a written explanation of why it granted or denied a CCR permit (415 ILCS 5/39 (y)). Federal law does not address financial assurances.

Public participation

The CAPP Act and the Illinois EPA Proposed Rule contain meaningful public participation procedures surrounding the issuance of CCR surface impoundment construction and operating permits. These procedures include public notice, opportunity to submit public comments, and a public hearing before CCR permits can be issued (415 ILCS 5/22.59(g)(6)) as well as public notice for beneficially used CCRs (415 ILCS 5/22.59(h)). While federal law requires publicly accessible internet sites to contain certain information about CCR surface impoundments, lateral expansions and CCR landfills (40 CFR §257.107), it does not contain public participation requirements or address public notice requirements for beneficially used CCR (40 CFR §257.50(g)).

Permitting requirements

Federal law does not address permitting requirements related to mitigation, while the CAPP Act and Illinois EPA Proposed Rule contain several requirements relevant to mitigating the potential and actual effects of CCR on the environment and public health, including:

- Prohibiting the construction, installation, modification, operation, or closure of any CCR surface impoundment without a permit (415 ILCS 5/22.59(b)(2));
- Requiring CCR surface impoundments to obtain Illinois EPA permits for waste storage, treatment and disposal—without exception (415 ILCS 5/21(d)(1));
- Requiring owners of CCR surface impoundments to publicly post certain information on their websites, to post closure plans, permit applications and other supporting documentation on their websites, and by

requiring owners or operators to pay fees for various impoundment statuses (415 ILCS 5/22.59(h) (i) and (j));

- Requiring specific standards for Illinois EPA review and approval of CCR surface impoundment permit applications (415 ILCS 5/22.59(g)(5));
- Not automatically granting CCR surface impoundment permits where the Illinois EPA has failed to take final action within 90 days on a CCR application under Section 5/39 (y) (415 ILCS 5/39 (a));
- Requiring CCR surface impoundment permits to contain compliance schedules for the Illinois EPA, IPCB regulations, the Illinois Groundwater Protection Act and related regulations, and the RCRA and related regulations (415 ILCS 5/39 (y)); and,
- Requiring the Illinois EPA to issue CCR surface impoundment permits under Section 415 ILCS 5/39 (y) while allowing the Illinois EPA to issue federal RCRA permits exclusively under Section 415 ILCS 5/39(d).

Mitigation

Funding for remediation

Federal law does not address funding or financial sureties for costs of CCR remediation/mitigation, while the CAPP Act and Illinois EPA Proposed Rule address potential costs of mitigation in the form of performance bonds and securities that can be used to help pay for the cost of CCR remediation/mitigation. The CAPP Act sets forth the type and amount of performance bonds or other securities required and under what conditions the state can collect monies from them (415 ILCS 5/22.59 (f) and (g)(7)).

The CAPP Act requires CCR surface impoundment owners or operators to pay closure fees to be deposited into the Environmental Protection Permit and Inspection Fund.[29] The fund finances the Illinois EPA's "manifest, permit, and inspection activities" as well as Illinois EPA's functions, powers, and duties under the Solid Waste Site Operator Certification Law[30]–duties that entail safeguarding the public's health and the state's environment by monitoring the design, operation, and maintenance of landfill sites, including CCR surface impoundments (415 ILCS 5/22.59(k)).

The CAPP Act also creates the Coal Combustion Residual Surface Impoundment Financial Assurance Fund, a special fund in the state treasury made up of money forfeited to the state from performance bonds or other securities required under the CAPP Act that can be used by the Illinois EPA to, among other things, ensure closure of the CCR surface impoundment and post-closure care in accordance with the Environmental Protection Act and/or insure remediation of releases from CCR surface impoundments (415 ILCS 5/22.59(f) and 415 ILCS 5/22.59 (l)).

Environmental justice

Federal law does not address environmental justice issues, while the CAPP Act requires its implementing regulations to specify a procedure to identify areas of environmental justice concern in relation to CCR surface impoundments. The CAPP Act requires that, where the federal 2015 Final CCR Rule does not specify how to prioritize CCR surface impoundments required to close under the RCRA, then the IEPA must "specify a method to prioritize CCR surface impoundments required to close under RCRA […] so that the CCR surface impoundments

[29] See http://www.ilga.gov/legislation/ilcs/fulltext.asp?DocName=041500050K22.8.
[30] See http://www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=1338&ChapterID=24.

with the highest risk to public health and the environment, and areas of environmental justice concern are given first priority" (415 ILCS 5/22.59(g)(9)).

At the time of this review, the IEPA Proposed Rule does not specify any procedure to identify areas of environmental justice concern in relation to CCR surface impoundments as required by the CAPP Act (415 ILCS 5/22.59(g)(8)); limits application to CCR surface impoundment closures or retrofitting only (Section 845.700(g)(6)); and, gives CCR surface impoundments "located in areas of environmental justice concern as determined by the [IEPA]" third priority (Section 845.700(g)(1)).

Federal requirements exceeding the CAPP Act

Monitoring

Liner design requirements

Federal law establishes liner design and related requirements for CCR units that are not comparably addressed by the CAPP Act. Federal law requires composite liners and leachate collection and removal systems for new CCR landfills and lateral expansions of CCR surface impoundments (40 CFR §257.70). Federal law also requires existing CCR surface impoundment owners or operators to characterize and document the status of their liner design and specifies when existing unlined CCR surface impoundments have to retrofit or close (40 CFR §257.71 citing 40 CFR §257.101(a)). Finally, federal law requires that new CCR surface impoundments and lateral expansions of *both* new and existing CCR surface impoundments have a composite liner that covers all surrounding earth likely to be in contact with the CCR (40 CFR §257.72).

While the CAPP Act does not specifically address liner design requirements for CCR landfills and lateral expansions of CCR surface impoundments, it does require the IPCB to adopt rules that address CCR surface impoundment design standards and that must be at least as protective and comprehensive as the federal law (415 ILCS 5/22.59(g)). The IEPA Proposed Rule establishes liner requirements in Section 845.400 and 845.410 for new and existing surface impoundments and lateral expansions that are comparable to the federal liner requirements.

Location restrictions

Federal law establishes location restrictions for CCR units. Unless an exception applies, under the federal RCRA and Final Rule, CCR units cannot be placed within 5 feet above an aquifer (40 CFR §257.60); in wetlands (40 CFR §257.61); within 200 feet of a fault area (40 CFR §257.62); in seismic impact zones (40 CFR §257.63); or, in unstable areas (40 CFR §257.64).

While the CAPP Act does not address CCR unit location restrictions, it does require adoption of state regulations that are at least as protective and comprehensive as the federal law and which will presumably include CCR location restrictions (415 ILCS 5/22.59(g)(1)). The IEPA Proposed Rule establishes addresses comparable location restrictions in Section 845.230(a)(1) and 845.300 through 845.340 for existing and new surface impoundments and lateral expansions that are comparable to the federal requirements.

Operating and inspection requirements

Federal law establishes detailed operating and inspection requirements for all CCR units, some of which are addressed by the CAPP Act. Federal law requires owners and operators of CCR units to follow air control measures that minimize CCR air pollution—including having a fugitive dust control plan and an annual CCR fugitive dust control report (40 CFR §257.80). Federal law also requires run-on and run-off control systems to prevent flow into and out of the CCR unit that must be revised every five years (40 CFR §257.81). Finally, federal law requires an inflow design flood control system for CCR units and a plan that must also be revised every five years (40 CFR §257.82).

The CAPP Act and Illinois EPA Proposed Rule set forth dust control requirements that are comparable to the federal law's air control measures. The Illinois EPA Proposed Rule also specifically addresses air control measures to minimize CCR air pollution (Section 845.500); run-on and run-off control systems (Section 845.740(b)(4)(B)(5), 845.780(b)(1), and 845.930(b)(7)(A); and, CCR unit flood control systems (Section 845.510(c)(3)).

Mitigation

Retrofitting

Federal law establishes criteria for retrofitting existing CCR surface impoundments that include timelines, written plan components, and notice and recordkeeping requirements (40 CFR §257.102). Similarly, the Illinois EPA Proposed Rule also provides comparable requirements for retrofitting CCR surface impoundments (Section 845.770).

Structural integrity requirements

Federal law establishes structural integrity requirements for CCR units. The federal RCRA and Final Rule require owners and operators of CCR units to, every five years, classify their units' hazard potential, develop an emergency action plan that includes response and mitigation requirements for unit failure and environmental contamination, assess their units' structural stability, identify deficiencies, recommend corrective measures, and assess their units' safety based on qualified engineering standards (40 CFR §257.73 and §257.74).

The Illinois EPA Proposed Rule contains comparable structural integrity requirements for CCR landfills, CCR surface impoundments, and lateral expansions of CCR surface impoundments in Section 845.450 which also requires an initial structural stability assessment certification from a qualified professional engineer (Section 845.450(c)) and an annual structural stability assessment certification to be completed along with the annual inspection of the unit under Section 845.540(b). The Proposed Rule also incorporates structural integrity considerations vis-à-vis site locations in or near fault areas (Section 845.320) and other unstable areas (Section 845.340).

Appendix C: Description of Data Sources

Information included below is generally taken from abstracts included in metadata records for each dataset or from descriptions from public webpages of the data source. If a link is not provided, data should be requested directly from their source.

Area of Interest

A1: Power plant locations

U.S. Environmental Protection Agency, n.d., EPA Environmental Dataset Gateway (EDG): Washington, D.C., U.S. Environmental Protection Agency, https://edg.epa.gov/data/Public/OEI/OIC/FRS_PowerPlants.zip (accessed September 24, 2020).

This GIS dataset contains data on power plants, based on the Energy Information Administration's EIA-860 dataset and supplemented with data from EPA's Facility Registry Service (FRS) compiled from various EPA programs.

This dataset was developed to serve as a general-purpose GIS layer depicting power generation locations, together with a set of core attributes. The primary facility and locational information was compiled from EPA's FRS, and attribute data was compiled from EIA. Anticipated uses include emergency response, critical infrastructure, and policy and planning.

A2: Coal ash impoundment locations

These data were originally requested directly from the Illinois EPA and are now available from the agency website at https://www2.illinois.gov/epa/topics/water-quality/watershed-management/ccr-surface-impoundments/Pages/default.aspx. This dataset includes the general locations of power generation facilities where coal ash impoundments occur but is not in GIS format.

Environmental

E1: National Wetlands Inventory

U.S. Fish and Wildlife Service, 2019, Classification of Wetlands and Deepwater Habitats of the United States. [Dataset]: Washington DC: U.S. Fish and Wildlife Service, https://www.fws.gov/wetlands/data/Data-Download.html (accessed September 23, 2020).

This dataset represents the extent, approximate location, and type of wetlands and deepwater habitats in the United States and its territories. These data delineate the areal extent of wetlands and surface waters as defined by Cowardin et al. (1979). The National Wetlands Inventory (NWI) - Version 2, Surface Waters and Wetlands Inventory was derived by retaining the wetland and deepwater polygons that compose the NWI digital wetlands spatial data layer and reintroducing any linear wetland or surface water features that were orphaned from the original NWI hard copy maps by converting them to narrow polygonal features. Additionally, the data are supplemented with hydrography data, buffered to become polygonal features, as a secondary source for any single-line stream features not mapped by the NWI and to complete segmented connections. Wetland mapping conducted in WA, OR, CA, NV and ID after 2012 and most other projects mapped after 2015 were mapped to include all surface water features and are not derived data. The linear hydrography dataset used to derive Version 2 was the U.S. Geological Survey's National Hydrography Dataset (NHD). Specific information on the NHD version used to derive Version 2 and where Version 2 was mapped can be found in the 'comments' field of the

Wetlands_Project_Metadata feature class. Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and near shore coastal waters. Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery. By policy, the Service also excludes certain types of "farmed wetlands" as may be defined by the Food Security Act or that do not coincide with the Cowardin et al. definition. Contact the Service's Regional Wetland Coordinator for additional information on what types of farmed wetlands are included on wetland maps. This dataset should be used in conjunction with the Wetlands_Project_Metadata layer, which contains project specific wetlands mapping procedures and information on dates, scales and emulsion of imagery used to map the wetlands within specific project boundaries

E2 & E3: Sensitive Habitats and Species in Illinois

Barnes, J., 2019, November 19, Illinois Natural Areas Inventory data and threatened and endangered species occurrences since 2000 [written correspondence]: Springfield, Illinois Department of Natural Resources, Division of Natural Heritage.

This dataset includes locations of endangered and threatened species in Illinois recorded since the year 2000 and sensitive habitats listed on the Illinois Natural Areas Inventory (INAI). Specifically, these element occurrence data include Endangered or Threatened Species, Unusual Concentrations of Flora or Fauna, High Quality Natural Communities listed on the INAI (such as a forested fen) and Geologic Features. These types of habitats or species may be particularly sensitive to impacts from Coal Ash due to their rarity or sensitivity.

E4: Illinois Nature Preserves

Barnes, J., 2019, November 19, Nature preserves [written correspondence]: Springfield, Illinois Department of Natural Resources, Division of Natural Heritage.

These are high-quality natural areas and habitats of endangered and threatened species that are protected in perpetuity through voluntary dedication by private and public landowners through the Illinois Nature Preserves System. These lands are significant due to the presence of rare, sensitive, or high-quality habitats in Illinois.

E5: Mines

Illinois State Geological Survey, n.d., Coal Mines in Illinois Viewer (ILMINES) [dataset]: Champaign, Illinois State Geological Survey, https://isgs.illinois.edu/ilmines (accessed September 23, 2020).

These data were compiled by the ISGS for known underground and surface coal mines as well as underground industrial mines. For more information including coal mine maps and other information, please see the County Coal Map Series (https://isgs.illinois.edu/research/coal/maps/county).

The underground coal mine points consist of mine entrances and may also contain uncertain underground mine locations. The underground mine proximity region incorporates coal mines as well as industrial mines, and it was calculated and constructed using the methodology outlined in ISGS Circular 575. These generalized areas are not meant to replace site-specific studies; they conservatively illustrate areas overlying and adjacent to underground coal and industrial mines that may potentially be exposed to subsidence based on 1) angle of draw from the edge of the underground workings up to the land surface, and 2) potential inaccuracy or uncertainty in mine boundary locations. Please see ISGS Circular 575 for a full explanation. Areas outside the proximity region also could be undermined. Old, undocumented mine openings have been discovered in many parts of the state. However, most undocumented mines were prospect pits or short-term operations that undermined only a few acres.

The maps and digital files used for this study were compiled from data obtained from a variety of public and private sources and have varying degrees of completeness and accuracy. They present reasonable interpretations of the geology of the area and are based on available data. Locations of some features may be offset by 500 feet or more due to errors in the original source maps, the compilation process, digitizing, or a combination of these factors. These data are not intended for use in site-specific screening or decision-making without further investigation.

Geology

G1: Stack Unit (15M)

Berg, R.C., and J.P. Kempton, 1988, Stack-unit mapping of geologic materials in Illinois to a depth of 15 meters: Illinois State Geological Survey, Circular 542, http://hdl.handle.net/2142/96249 (accessed September 23, 2020).

This is a polygon feature class containing stack-unit map designations for Illinois. The primary source is ISGS Circular 542, Stack-unit Mapping of Geologic Materials in Illinois to a Depth of 15 Meters, Berg and Kempton (1988). The data have been subsequently updated from various sources. The nominal scale is 1:250,000. Stack-unit maps show the distribution of earth materials vertically from the surface to a specified depth and horizontally over a specified area. They also show the succession of geologic units in their order of occurrence within the specified depth. This information is now available for the entire state of Illinois with the publication of the statewide stack-unit map of geologic materials to a depth of 15 meters (49.3 ft.). The statewide stack-unit map, originally made up of four separate regional maps, provides basic geologic information for interpretive mapping for regional, resource-based land-use planning and decision making. This feature class is the result of appending the four digital files into one statewide dataset. Note also that this feature class incorporates stack-unit data from the ISGS Paducah Stack-Unit map (Berg & Greenpool, 1994). The portion that falls within the 1 x 2 degree Paducah quadrangle had been entirely updated with data from the Paducah stack-unit map coverage.

G2: Drift Thickness

Piskin, K., and R.E. Bergstrom, 1975, Glacial drift in Illinois: Thickness and character: Illinois State Geological Survey, Circular 490, http://hdl.handle.net/2142/95088 (accessed September 23, 2020).

This is a feature dataset showing drift thickness in Illinois. Data are originally from ISGS Circular 490 by Piskin and Bergstrom (1975), Plate 1. Contours (lines) are coded with thickness, and polygons (areas between contours) are coded with range of thickness. Nominal scale is 1:500,000. Unconsolidated deposits, mainly glacial drift, overlie the bedrock surface in most of Illinois. Glacial drift ranges from less than a few feet to approximately 600 feet in thickness. The thickest drift occurs in major preglacial valleys cut into the bedrock and filled with glacial sediments. Regionally thick drift occurs in the N.E. portions of the state. The thinnest drift, less than 25 feet thick and intersected by numerous bedrock outcrops, occurs widely in southern and western portions of the state. Drift, as shown on this map, may include any of the following: unconsolidated deposits, glacial drift, Wisconsinan deposits, Illinoian deposits, till, glaciofluvial deposits, glaciolacustrine deposit, wind-blown deposits (loess).

G3: Geology/quaternary deposits

Illinois State Geological Survey, 1979, Quaternary deposits of Illinois, 1979 [dataset]: Champaign, Illinois State Geological Survey, Edition 20040422, https://clearinghouse.isgs.illinois.edu/data/geology/quaternary-deposits-1979 (accessed September 23, 2020).

Digital representation of the Quaternary Deposits in Illinois map by Lineback (1979). Map scale is 1:500,000. Shows Quaternary deposits that lie at or near the land surface, including loess deposits.

G4: Sinkhole/Karst

Illinois State Geological Survey, 1997, Sinkhole areas (an indicator of karst terrain) in Illinois [dataset]: Champaign, Illinois State Geological Survey, Edition 20040408, https://clearinghouse.isgs.illinois.edu/data/hydrology/sinkhole-areas-indicator-karst-terrain (accessed September 23, 2020).

This feature class shows the distribution of areas that contain one or more sinkholes throughout the state of Illinois. Areas that contain sinkholes are susceptible to aquifer contamination and may also lack the stability required for certain land-uses. Sinkholes are one of the major indicators of karst terrains. This map provides basic data for land-use planning and decision making.

G5: Seismic

Central United States Earthquake Consortium, n.d., Earthquake maps & GIS data: Memphis, Tennessee, Central United States Earthquake Consortium, https://cusec.org/earthquake-maps-data/ (accessed September 23, 2020).

The CUSEC State Geologists produced a regional Soil Site Class map (NEHRP Soil Profile Type Map), a Liquefaction Susceptibility Map and a Soil Response Map for the 8 states to be used in the FEMA New Madrid Catastrophic Planning Initiative Phase II work. The USGS Geologic Investigation Series I-2789 *Map of Surficial Deposits and Materials in the Eastern and Central United State* (East of 102 degrees West Longitude) by David S. Fullerton, Charles A. Bush and Jean N. Pennell (2003) was the base map used for this work. Each State Geological Survey produced its own state map version of the Soil Site Class and Liquefaction Susceptibility maps.

G6: Bedrock geology

Kolata, D.R., 2005, Bedrock geology of Illinois: Illinois State Geological Survey, Illinois Map 14, 1:500,000, http://hdl.handle.net/2142/55796 (accessed September 23, 2020).

This feature dataset shows the distribution and extent of the bedrock geologic units within the State of Illinois, as depicted on the map Bedrock Geology of Illinois (2005) by D. Kolata (compiler), published by the Illinois State Geologic Survey. The component feature classes show geologic units (polygons) and faults (lines.) The nominal scale of the published hardcopy map is 1:500,000. In some areas data of greater scale were generalized and incorporated.

G7: Illinois Structural Geology (ILSTRUC)

Nelson, W.J., 1995, Structural features in Illinois: Illinois State Geological Survey, Bulletin 100, http://hdl.handle.net/2142/43644 (accessed September 23, 2020).

Structural geologic features that lie wholly or partly within the state of Illinois have been compiled into a comprehensive catalog. The starting point for this work was *Structural Features in Illinois - A Compendium* by Janis D. Treworgy (1981). Treworgy's report consisted of a statewide map and bibliography of all previously named and many significant unnamed structural features. All references cited by Treworgy were reviewed, along with many more recently published and unpublished maps and reports on the structural geology of Illinois. The result is an alphabetical listing of 450 named structural features. All well documented significant structures are mapped on Plate 1; 167 previously named structures no longer considered valid are listed in the catalog. In addition, 33 structural features have been renamed and 33 newly named structures introduced. This report also discusses the regional setting of major structures of Illinois and summarizes the structural history of the state.

G8: Stratigraphy of Illinois (ILSTRAT)

Willman, H.B., E. Atherton, T.C. Buschbach, C. Collinson, J.C. Frye, M.E. Hopkins, J. Lineback, and J.A. Simon, 1970, Handbook of Illinois stratigraphy: Illinois State Geological Survey, Bulletin 95, http://hdl.handle.net/2142/35115 (accessed September 23, 2020).

Illinois State Geological Survey, n.d., Welcome to ILSTRAT: The online handbook of Illinois stratigraphy: Champaign, Illinois State Geological Survey, https://isgs.illinois.edu/ilstrat/index.php/Main_Page (accessed September 23, 2020).

The purpose of ILSTRAT is to provide a single location in which to find the most up-to-date information on the stratigraphy of Illinois. As ILSTRAT evolves, each webpage will reflect the most current published research on a given geologic unit. This format allows for the addition of maps, cross-sections, core and outcrop photos, and more to enhance the text descriptions.

To maintain context for those using old publications or literature, each page contains a Historical tab at the top that will take you to the "historical" description of the unit discussed on that particular page (from ISGS Bulletin 95, or Bulletins 94 and 104 for the Quaternary). In this way, older publications can be more easily interpreted, as previous unit descriptions or units that have been changed or fallen into disuse over time can be put into context and translated into the most recent understanding. The Historical pages are locked from editing and represent a faithful digitization of the information in the original Bulletins.

Hydrology

H1: National Hydrography Dataset–Waterbodies

H2: National Hydrography Dataset–Hydrography

H3: National Hydrography Dataset–Major watershed boundaries-HUC 6-12

U.S. Geological Survey, n.d., National hydrography dataset: Reston, Virginia, U.S. Geological Survey, https://www.usgs.gov/core-science-systems/ngp/national-hydrography (accessed September 23, 2020).

The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD data was originally developed at 1:100,000-scale and exists at that scale for the whole country. This high-resolution NHD, generally developed at 1:24,000/1:12,000 scale, adds detail to the original 1:100,000-scale NHD. (Data for Alaska, Puerto Rico and the Virgin Islands was developed at high-resolution, not 1:100,000 scale.) Local resolution NHD is being developed where partners and data exist. The NHD contains reach codes for networked features, flow direction, names, and centerline representations for areal water bodies. Reaches are also defined on waterbodies and the approximate shorelines of the Great Lakes, the Atlantic and Pacific Oceans and the Gulf of Mexico. The NHD also incorporates the National Spatial Data Infrastructure framework criteria established by the Federal Geographic Data Committee.

H4: Illinois EPA Source Water Assessment Program

Illinois Environmental Protection Agency, n.d., Source Water Assessment Protection Program [dataset]: Springfield, Illinois Environmental Protection Agency, https://illinois-epa.maps.arcgis.com/apps/webappviewer/index.html?id=4d37a05f5ba441f1b30dab54ccb81fc8 (accessed September 23, 2020).

The 1996 amendments to the federal Safe Drinking Water Act (SDWA) required states to develop and implement a source water assessment program (SWAP). Source water protection (SWP) is a proactive approach to protecting our critical sources of public water supply and assuring that the best source of water is being used to serve the public. It involves implementation of pollution prevention practices to protect the water quality in a watershed or wellhead protection area serving a public water supply. Along with treatment, it establishes a multi-barrier approach to assuring clean and safe drinking water to the citizens of Illinois.

Pollution prevention, like preventive medicine, starts with awareness. Thus, source water assessment is the cornerstone essential to the development and implementation of source water protection plans and includes the following:

- Delineating the source water protection area (e.g., watersheds and wellhead protection areas);
- Inventorying potential contamination sources;
- Determining the susceptibility of the source water to contamination
- Providing recommendations to protect the source water; and
- Providing this information to the public.

The Illinois EPA has implemented a SWAP to assist with wellhead and watershed protection of public drinking water supplies.

More than 11 million people in Illinois rely on public water supplies for drinking water. Assessments have been conducted for all public water supplies in Illinois, including approximately 1,800 community water supplies. In addition, more than 4,100 non-community water supplies have been assessed. Illinois SWAP activities are divided into the following areas: 1) community surface water supplies; 2) non-community surface water supplies; 3) Community groundwater supplies; Great Lakes (Lake Michigan supplies); 4) non-community groundwater supplies; and 5) mixed ground and surface water community water supplies.

The Source Water Assessment Program, as implemented by Illinois EPA, will help communities make important decisions about how to protect their drinking water. By working to ensure safe drinking water supplies, the health and economy of the community, as well as the preservation of natural resources, will be greatly improved. In addition, investments in drinking water treatment will be sustained for a longer time.

H5: Depth to Aquifer within 300 ft. / Aquifer Potential for Contamination

Keefer, D., 2019, Depth to aquifer within 300 feet [unpublished dataset]: Champaign, Illinois State Geological Survey.

This shapefile shows areas where aquifers are mapped as within 20 feet of land surface, between 20 and 50 feet of land surface and not within 50 feet of land surface. Sand and gravel deposits less than 20 feet thick and within 20 feet of land surface were not considered aquifers for this interpretation, as they are expected to be periodically dry and too thin for reliable use even for domestic supplies. This map was derived from source material that was published at a scale of 1:250,000 and is intended for use in evaluating the shallow aquifer distribution over areas significantly larger than specific sites. This map is not suitable for use to reliably predict the geology at specific point locations.

This shapefile was generated circa 1990 by Don Keefer (ISGS) as a derivative from a digitized version of the Stack-Unit Map of Geological Deposits to a Depth of 15m (Berg and Kempton, 1988), and remains unpublished as a separate map layer. This map is not suitable for use to reliably predict the geology at specific point locations. This shapefile shows areas where aquifers are mapped as within 20 feet of land surface, between 20 and 50 feet of land surface and not within 50 feet of land surface. Sand and gravel deposits less than 20 feet thick and within 20 feet of land surface were not considered aquifers for this interpretation, as they are expected to be periodically dry and too thin for reliable use even for domestic supplies. Aquifers include deposits mapped as sand and gravel, eolian sand, bedrock of predominantly limestone lithology and bedrock of predominantly sandstone lithology.

This map has an attribute, "Poten-Contam4", that contains values of: A, B, C, S, and W. Polygons with a PC3 value of "A" designate areas where the top of shallow aquifers were mapped as being within 20 feet of land surface. Polygons with a PC3 value of "B" designate areas where the top of shallow aquifers were mapped as being between 20 and 50 feet from land surface. Polygons with a PC3 value of "C" designate areas where no shallow aquifers were mapped as being found within 50 feet of land surface. Polygons with a PC3 value of "S" designate areas where surface mines and disturbed lands were mapped as being at land surface. Polygons with a PC3 value of "W" designate areas where lakes, ponds and large river segments were mapped as being at land surface. There are approximately 2-3 dozen sliver polygons with a PC3 value of "". These should not be colored and represent errors incurred in digitization due to base map differences and stability problems with the Mylar and paper sheets used to digitize the original stack-unit map. Other attributes in this shapefile relate to basemap features, as a statewide county boundary base map was combined with this map.

This metadata description was originally generated 10/10/2014 by D. Keefer (Illinois State Geological Survey).

H6: Major Sand and Gravel Aquifers

Miller, J., 1994, Major bedrock aquifers within 300 feet of ground surface [dataset]: Champaign, Illinois State Geological Survey, Edition 20040401, https://clearinghouse.isgs.illinois.edu/data/hydrology/major-bedrock-aquifers-within-300-feet-ground-surface (accessed September 23, 2020).

This map shows the distribution of major sand and gravel aquifers at any depth in Illinois. Generally, the tops of such aquifers lie within 300 feet of the surface and the bases occur within 500 feet. Major aquifers are defined as geologic units capable of yielding 70 gallons of potable water per minute. Potable water is defined as containing less than 2,500 milligram per liter total dissolved solids. Major sand and gravel aquifers are generally Quaternary deposits found within pre-glacial bedrock valleys or along modern streams and rivers. They are commonly separated from shallower aquifers by layers of less permeable till or fine-grained lacustrine deposits. The scale of these data is 1:500,000.

H7: Potential aquifers less than 50 ft.

Illinois State Geological Survey, 1997, Coarse-grained materials within 50 feet of the ground surface in Illinois [dataset]: Champaign, Illinois State Geological Survey, Edition 20040401, https://clearinghouse.isgs.illinois.edu/data/hydrology/coarse-grained-materials-within-50-feet-ground-surface-illinois (accessed September 23, 2020).

This map shows the distribution of coarse-grained materials and permeable bedrock within 50 feet of ground surface in Illinois. This includes bedrock, sand and gravel, and alluvial units with characteristics that suggest a potential to store or conduct groundwater and yield potable water to wells and springs. It was derived from stack-unit map data. Aquifers or potential aquifers on this map are defined as sand and gravel units at least five feet thick, sandstone at least ten feet thick, and fractured limestone or dolomite at least fifteen feet thick with a lateral extent of at least one square mile. Minor aquifers typically yield from five to seventy gallons of potable water per minute. Potable water is defined as water containing less than 2,500 mg/L of total dissolved solids. For use in this data set, the following stratigraphic units are considered to be aquifers or potential aquifers meeting these criteria: Cahokia Alluvium (although primarily fine-grained, Cahokia Alluvium is included because it contains numerous sand and gravel deposits), Parkland Sand Equality Formation, Dolton Member Henry Formation, Sand and gravel within Wedron Formation, Sand and gravel within Winnebago Formation, Pearl Formation (includes Hagarstown Member) Sand and gravel within Glasford Formation, Mounds gravel and related units, Cretaceous sediments, silts, sands, etc., Pennsylvanian rocks (mainly sandstones), Mississippian rocks (mainly limestones and some sandstones), Silurian and Devonian rocks (mainly dolomite), Ordovician and Cambrian rocks (mainly dolomite and sandstone). The scale of these data is 1:250,000.

H8: Resource Management Mapping Service (RMMS)–Community Water Supplies-wells

H9: Resource Management Mapping Service (RMMS)–Community Water Supplies-surface water intakes

University of Illinois, College of Agricultural, Consumer and Environmental Sciences, n.d., Resource Management Mapping Service [dataset]: Champaign, University of Illinois, College of Agricultural, Consumer and Environmental Sciences, Version 2014, https://www.rmms.illinois.edu (accessed September 23, 2020).

The Resource Management Mapping Service (RMMS) uses a wide range of coordinated natural resource-related databases to provide an online, interactive mapping environment that is designed to help government agencies, non-governmental organizations, and the public evaluate and manage geographically-based information about Illinois' natural resources, particularly water resources, so that they can more effectively develop and implement appropriate resource protection and enhancement measures. The RMMS website also contains tools (requiring a login/password for access) for direct data entry of specific databases. These databases are only available at the RMMS website. Specific Illinois EPA layers are available for extraction and download. Continuing development of RMMS is provided at the University of Illinois CIGI Lab with support from the Illinois EPA and other state agencies as well as match funds from the University of Illinois.

H10: Water Wells and Borings Database

Illinois State Geological Survey, 2019, Location points from the ISGS wells and borings database [dataset]: Champaign, Illinois State Geological Survey, Edition 20080221, https://clearinghouse.isgs.illinois.edu/data/geology/location-points-isgs-wells-and-borings-database (accessed September 23, 2020).

This dataset contains point locations from the ISGS Wells and Borings database. The attribute information includes API_NUMBER, STATUS (well or boring type code), STATUS_TEXT (verbose description of the well or boring type), COMP_DATE (the well completion date), LATITUDE, and LONGITUDE. The spatial reference is geographic coordinates, decimal degrees, NAD83. The data are exported to a shapefile weekly from the Wells and Borings (source) database for Internet distribution. The source database is updated daily. Thus, there may be recent updates (last 7 days) in the source database that are not reflected in this shapefile. The data are primarily oil, gas, and water wells but also include other designations, such as engineering boring, stratigraphic test hole, injection well, etc. The collection contains data for over 580,000 wells and borings, some dating back to 1801 (assumed.) Most locations have not been field verified. The nominal scale is 1:62,500, however locations have been determined in several different ways at different scales. Most commonly, the location is derived by converting a legal (i.e. Public Land Survey Systems (PLSS)) description to a point location. The stated accuracy is +/- 100 feet, however some points may be inaccurate by as much as one mile due to irregularities in the Illinois PLSS and associated descriptions. For legal descriptions that indicate only a PLSS section or quarter-section, the point is assumed to be in the center of the respective section or quarter-section. Additional detailed information about these wells and borings is available free of charge online through the Illinois State Geological Survey in the ILOIL (oil and gas) and ILWATER (water and related wells) interactive map services. Additional information may include owner, permit details, PLSS location, total depth, surface elevation, geologic formation and material description, driller's log, and down-hole logs.

H11: FEMA Flood Zones (DFIRM)

IllinoisFloodmaps.org, n.d., FEMA flood insurance rate maps, studies, and database products [dataset]: Champaign, Illinois State Water Survey, http://illinoisfloodmaps.org/default.aspx (accessed September 23, 2020).

The FIRM is the basis for floodplain management, mitigation, and insurance activities for the National Flood Insurance Program (NFIP). Insurance applications include enforcement of the mandatory purchase requirement of the Flood Disaster Protection Act, which "... requires the purchase of flood insurance by property owners who are being assisted by Federal programs or by Federally supervised, regulated or insured agencies or institutions in the acquisition or improvement of land facilities located or to be located in identified areas having special flood hazards," Section 2 (b) (4) of the Flood Disaster Protection Act of 1973. In addition to the identification of Special Flood Hazard Areas (SFHAs), the risk zones shown on the FIRMs are the basis for the establishment of premium rates for flood coverage offered through the NFIP.

The DFIRM Database presents the flood risk information depicted on the FIRM in a digital format suitable for use in electronic mapping applications. The DFIRM database is a subset of the Digital FIS database that serves to archive the information collected during the FIS.

H12: Groundwater Wells

Illinois State Water Survey, n.d., Domestic wells database [dataset]: Champaign, Illinois State Water Survey, https://www.isws.illinois.edu/data/gwdb/helpme.asp.

The Illinois State Water Survey well points database is a geographic-based inventory of water well records on file at ISWS. Source documents represented in the database primarily include drillers' well construction reports with geologic logs, particularly of water wells completed after 1967 when submittal was first required. Documents in the collection also include records from past field inventories of wells in selected areas, reports of water quality analyses conducted by the ISWS Public Service Laboratory, and well closure documents. Database records can include limited summary information about a given well installation. Details available on source documents, the extent of available details entered in the records database, and the accuracy of well location descriptions all vary significantly.

The ISWS Online Domestic Wells Database website allows users to browse the subset of these inventory records that describe domestic – i.e., household – supply wells, once the user obtains a login from ISWS staff.

The Illinois State Water Survey is regarded as the steward of a permanent, long-term collection of water well construction documentation and hydrogeologic data recorded in Illinois, consistent with the original functions authorized to the Scientific Surveys to document and assess natural resources. Water well construction reports are required by law and are thus public record. While much of the data in well construction reports is collected by and transferred from other parties, both private providers and public agencies rely on ISWS and ISGS to maintain and make available the accumulated record of groundwater resources in the state. Local public health agencies rely on ISWS to retain records of individual well construction in the long term, as most do not have the resources or institutional capacity to do so.

As developed to date, the ISWS well points database is essentially the catalog of records in the ISWS collection, that while in itself provides limited details of water availability and use by location, is a primary reference that ISWS staff use to respond to requests for archived records or to identify documentation of further interest when researching groundwater resource issues in Illinois.

H13: Groundwater Quality

Illinois State Water Survey, n.d., Domestic wells database [dataset]. Champaign, Illinois State Water Survey, https://www.isws.illinois.edu/data/gwdb/helpme.asp.

The Illinois State Water Survey maintains a groundwater quality database for samples collected from wells in Illinois. Data sources include Illinois EPA ambient water quality data from public water supply wells dating back to the 1970s, ISWS Public Service Laboratory data primarily from domestic wells, ISWS research project data, and several other sources. There are more than 60,000 samples in the database dating back to the 1890s. The data are searchable by location, facility, specific well, well depth, aquifer tapped, sample date, sample number, and water quality parameter(s). The data are available to the public by request, and the information is used by ISWS staff to better understand the groundwater resources of Illinois. Most of the sample data include chemical results of inorganic constituents, metals, and standard water chemistry parameters.

H14: Major Shallow Bedrock Aquifers (< 300 ft)

Miller, J., 1994, Major bedrock aquifers within 300 feet of ground surface [dataset]: Champaign, Illinois State Geological Survey, Edition 20040401, https://clearinghouse.isgs.illinois.edu/data/hydrology/major-bedrock-aquifers-within-300-feet-ground-surface (accessed September 23, 2020).

This map shows the distribution of major bedrock aquifer units within 300 feet of ground surface in Illinois. Major aquifers can yield 70 gallons of water per minute. Potable water contains less than 2,500 milligrams per liter of total dissolved solids. Bedrock aquifers within 300 feet of ground surface cover most of northern Illinois and are commonly overlain only by thin layers of less permeable silts and clays. Many are directly overlain by shallow or major sand and gravel aquifers allowing direct hydrologic communication with shallower aquifer systems. Stratigraphic units considered to be major bedrock aquifers are: Hunton Limestone Megagroup Ancell Group Prairie du Chien Group Ironton-Galesville Sandstone Elmhurst-Mt. Simon Sandstone. The scale of these data is 1:500,000.

H15: Climate

Midwestern Regional Climate Center, 2019, Data and services [dataset]: Champaign, Midwestern Regional Climate Center, https://mrcc.illinois.edu/includes/menu_text.jsp#data (accessed September 23, 2020).

Illinois State Water Survey, 2015, Water and Atmospheric Resources Monitoring Program, Illinois Climate Network [dataset]: Champaign, Illinois State Water Survey, https://dx.doi.org/10.13012/J8MW2F2Q.

Illinois State Water Survey, 2015, Water and Atmospheric Resources Monitoring Program, Sediment Monitoring Network [dataset]: Champaign, Illinois State Water Survey, https://dx.doi.org/10.13012/J83X84KP.

Illinois State Water Survey, 2015, Water and Atmospheric Resources Monitoring Program, Shallow Groundwater Network [dataset]: Champaign, Illinois State Water Survey, https://dx.doi.org/10.13012/J8CC0XMK.

Illinois State Water Survey, 2015, Water and Atmospheric Resources Monitoring Program, Reservoir Observation Network—Background [dataset]: Champaign, Illinois State Water Survey, https://www.isws.illinois.edu/warm/reservoirs/ (accessed September 23, 2020).

The Midwestern Regional Climate Center is a cooperative program between the National Centers for Environmental Information (NCEI) and the Illinois State Water Survey in Champaign, Illinois. Our center is a partner in a national climate service program that includes NCEI, five other Regional Climate Centers, and State Climate Offices. The NCEI is part of the Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). The MRCC serves the nine-state Midwest region (Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin). MRCC services and research help to better explain climate and its impacts on the Midwest, provide practical solutions to specific climate problems, and allow us to develop climate information for the Midwest on climate-sensitive issues such as agriculture, climate change, energy, the environment, human health, risk management, transportation, and water resources.

The Water and Atmospheric Resources Monitoring (WARM) Program and its networks conduct long-term monitoring across Illinois, measuring the state's waters, soils, and climate. Provisional and statistical monthly streamflow data from selected USGS stream gages are also on the WARM website (see https://www.isws.illinois.edu/warm/streamflow/). Data from WARM and other monitoring programs are reported monthly in the Illinois Water and Climate Summary, which provides information on the current and trending conditions of the state's water and weather and their impacts on other resources.

Land Use and Soils

L1: USEPA–Illinois Level IV Ecoregions

U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, 2012, Level IV ecoregions of Illinois: Corvallis, Oregon, U.S. Environmental

Protection Agency, https://www.epa.gov/eco-research/ecoregion-download-files-state-region-5#pane-11 (accessed September 23, 2020).

Ecoregions by state were extracted from the seamless national shapefile. Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. These general-purpose regions are critical for structuring and implementing ecosystem management strategies across federal agencies, state agencies, and nongovernment organizations that are responsible for different types of resources within the same geographical areas. The approach used to compile this map is based on the premise that ecological regions can be identified through the analysis of patterns of biotic and abiotic phenomena, including geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The relative importance of each characteristic varies from one ecological region to another. A Roman numeral hierarchical scheme has been adopted for different levels for ecological regions. Level I is the coarsest level, dividing North America into 15 ecological regions. Level II divides the continent into 50 regions (Commission for Environmental Cooperation Working Group, 1997). At Level III, the continental United States contains 105 regions, whereas the conterminous United States has 85. Level IV ecoregions are further subdivisions of Level III ecoregions. Methods used to define the ecoregions are explained in Omernik (1995a, 1995b), Omernik and others (2000), and Gallant and others (1989).

L2: SSURGO Soils Data

U.S. Department of Agriculture, Natural Resources Conservation Service, 2019, Web Soil Survey: Washington, DC, U.S. Department of Agriculture, Natural Resources Conservation Service, https://websoilsurvey.nrcs.usda.gov/ (accessed September 23, 2020).

The SSURGO database contains information about soil as collected by the National Cooperative Soil Survey over the course of a century. The information can be displayed in tables or as maps and is available for most areas in the United States and the Territories, Commonwealths, and Island Nations served by the USDA-NRCS. The information was gathered by walking over the land and observing the soil. Many soil samples were analyzed in laboratories. The maps outline areas called map units. The map units describe soils and other components that have unique properties, interpretations, and productivity. The information was collected at scales ranging from 1:12,000 to 1:63,360. More details were gathered at a scale of 1:12,000 than at a scale of 1:63,360. The mapping is intended for natural resource planning and management by landowners, townships, and counties. Some knowledge of soils data and map scale is necessary to avoid misunderstandings.

L3: LiDAR / Digital Elevation Model

Illinois State Geological Survey, n.d., Illinois Height Modernization (ILHMP): LiDAR data [dataset]: Champaign, Illinois State Geological Survey, https://clearinghouse.isgs.illinois.edu/data/elevation/illinois-height-modernization-ilhmp-lidar-data (accessed September 23, 2020).

Historically, Digital Elevation Model (DEM) data for Illinois have been mainly based on 5- to 10-foot contour data. Large-scale, digital topographic maps are most common; many data resources contain elevation information acquired in the 1920s and 1930s. DEM data collections are now being developed based on data with a contour resolution of 2 feet to 6 inches. A comparison between older data and newer high-resolution data shows remarkable improvement in recorded detail.

ILHMP has established data sharing agreements to archive and distribute elevation data for select Illinois counties. Data have been acquired using Light Detection and Ranging (LiDAR) technology, in compliance with different contract specifications. Data are offered as originally deliver LAS tile or as the derivative product of DEM/DTM or DSM.

L4: Land Cover

U.S. Geological Survey, EROS Data Center, 2019, NLCD 2001 land cover conterminous United States [dataset]: Sioux Falls, South Dakota, U.S. Geological Survey, Edition 201901, https://www.mrlc.gov/data?f%5B0%5D=category%3ALand%20Cover&f%5B1%5D=category%3Aland%20cover&f%5B2%5D=region%3Aconus&f%5B3%5D=year%3A2001 (accessed September 24, 2020).

NLCD 2001 Land Cover Conterminous United States, U.S. Geological Survey, 201901, Sioux Falls, SD

The U.S. Geological Survey (USGS), in partnership with several federal agencies, has developed and released four National Land Cover Database (NLCD) products over the past two decades: NLCD 1992, 2001, 2006, and 2011. These products provide spatially explicit and reliable information on the Nation's land cover and land cover change. To continue the legacy of NLCD and further establish a long-term monitoring capability for the Nation's land resources, the USGS has designed a new generation of NLCD products named NLCD 2016. The NLCD 2016 design aims to provide innovative, consistent, and robust methodologies for production of a multi-temporal land cover and land cover change database from 2001 to 2016 at 2–3-year intervals. Comprehensive research was conducted and resulted in developed strategies for NLCD 2016: a streamlined process for assembling and preprocessing Landsat imagery and geospatial ancillary datasets; a multi-source integrated training data development and decision-tree based land cover classifications; a temporally, spectrally, and spatially integrated land cover change analysis strategy; a hierarchical theme-based post-classification and integration protocol for generating land cover and change products; a continuous fields biophysical parameters modeling method; and an automated scripted operational system for the NLCD 2016 production. The performance of the developed strategies and methods were tested in twenty World Reference System-2 path/row throughout the conterminous U.S. An overall agreement ranging from 71% to 97% between land cover classification and reference data was achieved for all tested area and all years. Results from this study confirm the robustness of this comprehensive and highly automated procedure for NLCD 2016 operational mapping. Questions about the NLCD 2016 land cover product can be directed to the NLCD 2016 land cover mapping team at USGS EROS, Sioux Falls, SD (605) 594-6151 or mrlc@usgs.gov.

L5: Historical Aerial Imagery

Illinois State Geological Survey, n.d., 1937–1947 Illinois historical aerial photographs [dataset]: Champaign, Illinois State Geological Survey, Version 4 (2008), https://clearinghouse.isgs.illinois.edu/data/imagery/1937-1947-illinois-historical-aerial-photography (accessed September 23, 2020).

The primary dataset consists of historical black and white aerial photographs from Illinois acquired during 1936 to 1941. Alternative years of photography are used for certain counties when a quality set from between 1936 and 1941 cannot be located. The original paper prints have been scanned and stored as TIFF format images. The online images available are MrSID format images in which the original TIFF files have been compressed at a target ratio of 12:1, with the exception of 17 counties (Alexander, Boone, DeWitt, Douglas, Edwards, Gallatin, Hardin, Jackson, JoDaviess, Massac, Menard, Perry, Pope, Randolph, Saline, Williamson and Winnebago Counties) that were compressed at a target ratio of 6:1. The original photographic paper prints are at a scale 1:20,000.

Socio-Political

U.S. Census Data–Quick Facts

QuickFacts is an easy to use application that provides tables, maps, and charts of frequently requested statistics from many Census Bureau censuses, surveys, and programs. Profiles are available for the nation, all 50 states plus the District of Columbia and Puerto Rico, and all counties. Cities and towns with a population of 5,000 or more are also included. See https://www.census.gov/quickfacts/fact/table/US/PST045218.

S1: Population; S2: Demographics

U.S. Census Bureau, 2019, QuickFacts [dataset]: Suitland, Maryland, U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/US/PST045218 (accessed September 23, 2020).

S3: Illinois Legislative Districts

U.S. Census Bureau, Geography Division, 2019, TIGER/line shapefiles [state, Illinois; Current State Legislative District (SLD), Upper Chamber State-based; dataset]: Suitland, Maryland, U.S. Census Bureau, https://www.census.gov/cgi-bin/geo/shapefiles/index.php (accessed September 23, 2020).

U.S. Census Bureau, Geography Division, 2019, TIGER/line shapefiles, [state, Illinois; Current State Legislative District (SLD), Lower Chamber State-based; dataset]: Suitland, Maryland, U.S. Census Bureau, https://www.census.gov/cgi-bin/geo/shapefiles/index.php (accessed September 23, 2020).

The TIGER/Line shapefiles and related database files (.dbf) are an extract of selected geographic and cartographic information from the U.S. Census Bureau's Master Address File / Topologically Integrated Geographic Encoding and Referencing (MAF/TIGER) Database (MTDB). The MTDB represents a seamless national file with no overlaps or gaps between parts, however, each TIGER/Line shapefile is designed to stand alone as an independent data set, or they can be combined to cover the entire nation. State Legislative Districts (SLDs) are the areas from which members are elected to State legislatures. The SLDs embody the upper (senate) and lower (house) chambers of the state legislature. Nebraska has a unicameral legislature and the District of Columbia has a single council, both of which the Census Bureau treats as upper-chamber legislative areas for the purpose of data presentation; there are no data by SLDL for either Nebraska or the District of Columbia. A unique three-character census code, identified by State participants, is assigned to each SLD within a state. In Connecticut, Illinois, Louisiana, Maine, Maryland, Massachusetts, Michigan, Ohio, and Puerto Rico, the Redistricting Data Program (RDP) participant did not define the SLDs to cover all the state or state equivalent area. In these areas with no SLDs defined, the code "ZZZ" has been assigned, which is treated as a single SLD for purposes of data presentation. The boundaries of the 2018 State legislative districts were provided by state-level participants through the RDP and reflect the districts used to elect members in or prior to the November 2018 election

S4: U.S. Congressional Districts

U.S. Census Bureau, Geography Division, 2019, TIGER/line shapefiles [nation, U.S.; 116th Congressional District, National; dataset]: Suitland, Maryland, U.S. Census Bureau, https://www.census.gov/cgi-bin/geo/shapefiles/index.php (accessed September 23, 2020).

The TIGER/Line shapefiles and related database files (.dbf) are an extract of selected geographic and cartographic information from the U.S. Census Bureau's Master Address File / Topologically Integrated Geographic Encoding and Referencing (MAF/TIGER) Database (MTDB). The MTDB represents a seamless national file with no overlaps or gaps between parts, however, each TIGER/Line shapefile is designed to stand alone as an independent data set, or they can be combined to cover the entire nation. Congressional Districts are the 435 areas from which people are elected to the U.S. House of Representatives. After the apportionment of congressional seats among the States based on census population counts, each State is responsible for establishing congressional districts for the purpose of electing representatives. Each congressional district is to be as equal in population to all other congressional districts in a State as practicable. The 116th Congress is seated from January 2019 to 2021. The TIGER/Line shapefiles for the District of Columbia, Puerto Rico, and the Island Areas (American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, and the U.S. Virgin Islands) each contain a single record for the non-voting delegate district in these areas. The boundaries of all other congressional districts reflect information provided to the Census Bureau by the states by May 1, 2018.

S5: Illinois County Boundaries

Illinois State Geological Survey, 2003, Illinois county boundaries, polygons and lines [dataset]: Champaign, Illinois State Geological Survey, Edition 2.0, https://clearinghouse.isgs.illinois.edu/data/reference/illinois-county-boundaries-polygons-and-lines (accessed September 23, 2020).

This dataset contains Illinois county boundaries in line and polygon formats. The polygon attribute data include county name and number (FIPS) designations. The line attributes indicate which county lines also form the state boundary. The data were extracted from, and are redundant with, ISGS feature dataset IL_Public_Land_Survey_System. The dataset is maintained as a separate entity for ease of query and display.

The nominal scale is 1:62,500. As of 2003, the data are typically distributed in geographic coordinates (longitude and latitude), decimal degrees, and the North American Datum (NAD) of 1983, and this is the default spatial reference of the ArcSDE feature dataset in which the data are stored. The data were originally developed, however, in a custom Lambert Conformal Conic projection and were distributed in that coordinate system for several years.

The data were digitized in the late 1960s and in 1984-85 from 7.5- and 15-minute USGS topographic quadrangles. Errors in the location of a given feature are dependent on the accuracy of the original maps and on the accuracy of digitizing. Estimates are that features have an average locational error of at least plus/minus 100 feet.

S6: Illinois Municipal Boundaries

Illinois State Geological Survey, 2006, Municipal boundaries in Illinois: Incorporated places 2000 [dataset]: Champaign, Illinois State Geological Survey, Edition 20060425, https://clearinghouse.isgs.illinois.edu/data/infrastructure/municipal-boundaries-incorporated-places-2000 (accessed September 23, 2020).

This polygon feature class shows incorporated places and census designated places in Illinois as of the 2000 U.S. census. The data are identical to that provided by the U.S. Census except that field names have been changed or fields deleted to conform with data already in use at the ISGS. The attribute data include FIPS place ID, name, and type of municipality. Boundaries are generalized from the original TIGER data.

Incorporated places recognized in decennial U.S. census data products are those reported to the U.S. Census Bureau as legally in existence on Jan. 1, 2000, under the laws of their respective states, as cities, boroughs, towns, and villages.

Census designated places (CDPs) are delineated for each decennial census as the statistical counterparts of incorporated places. CDPs are delineated to provide data for settled concentrations of population that are identifiable by name but are not legally incorporated under the laws of the state in which they are located.

These are generalized cartographic boundaries originally produced to support the spatial geographic infrastructure for certain mapping functions within the Census Bureau's American Fact Finder and in support of the LandView Geographic Data Viewer. The data are a generalized extraction from the Census Bureau's TIGER database. The suggested scale for use of these data is 1:5,000,000. The data were obtained from the US Census website.

S7: Navigability–National Hydrography Dataset

U.S. Geological Survey, n.d., National hydrography dataset: Reston, Virginia, U.S. Geological Survey, https://www.usgs.gov/core-science-systems/ngp/national-hydrography (accessed September 23, 2020).

The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD data was originally developed at 1:100,000-scale and exists at that scale for the whole country. This high-resolution NHD, generally developed at 1:24,000/1:12,000 scale, adds detail to the original 1:100,000-scale NHD. (Data for Alaska, Puerto Rico and the Virgin Islands was developed at high-resolution, not 1:100,000 scale.) Local resolution NHD is being developed where partners and data exist. The NHD contains reach codes for networked features, flow direction, names, and centerline representations for areal water bodies. Reaches are also defined on waterbodies and the approximate shorelines of the Great Lakes, the Atlantic and Pacific Oceans and the Gulf of Mexico. The NHD also incorporates the National Spatial Data Infrastructure framework criteria established by the Federal Geographic Data Committee.

Appendix D: Gaps Between State and Federal Laws and Regulations

Regulatory Subject Area	State and Federal Laws and Regulations	Concerns and/or Impacts
Permitting: liner requirements	The Illinois EPA Proposed Rule does not allow CCR surface impoundments to operate without a liner, i.e., with clay or other naturally occurring media as lining (Section 845.400). A U.S. EPA proposed revision to the federal Final CCR Rule under proposed §257.71 *would* allow some surface impoundments to operate with clay or other naturally occurring media as liners where an owner or operator obtains an "alternate liner demonstration" approval.[31]	Concern: since the CAPP Act makes RCRA permits as valid as state permits (415 ILCS 5/22.59(c)) both federal and state permitting requirements may be treated as equally lawful. Notwithstanding the relative stringency of the federal alternate liner demonstration requirements, this could result in some CCR surface impoundments in Illinois being able to circumvent the state law's liner requirements and continue to operate without a liner under federal law.
Permitting: liner requirements	The U.S. EPA Proposed Revisions to the federal liner requirements for surface impoundments allow impoundment owners or operators to beneficially use CCR as an additional option during closure for cause. The federal example given: Using CCR as "fill placed beneath the final cover system to achieve the needed subgrade elevations to ensure that precipitation will drain off the closed unit."[32] The Illinois EPA Proposed Rule does not explicitly allow CCR to be beneficially used during closure unless owners or operators can demonstrate that the impoundment will *remove* CCR for the purposes of beneficial use and specify deadlines for such use (Section 845.730(a)(2) and (b)).	Concern: the federal option allowing beneficial use of CCR during closure may conflict with the Illinois EPA Proposed Rule's closure initiation requirements and timeframes since the federal requirements do not require removal of beneficially used CCR while the Illinois EPA Proposed Rule requires *the actual removal* of beneficially used CCR to: (1) start the 30-day clock to initiate closure; and, (2) grant an additional 2 years to initiate closure by demonstrating that the impoundment will remove CCR for the purposes of beneficial use (Section 845.730(a)(2) and (b)).
Groundwater Requirements	Section 845.600(a)(1) of the Illinois EPA Proposed Rule requires that CCR surface impoundments follow the groundwater quality standards in 35 Ill. Adm. Code 620. The Proposed Rule also identifies additional groundwater standards (Sections 845.600	Impact: The Illinois EPA Proposed Rule appears to have more stringent groundwater protection than provided under either the Illinois Class I Groundwater Standards (35 Ill. Adm. Code 620.410) or federal law.

[31] See *Hazardous and Solid Waste Management System: Disposal of CCR; A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments; Implementation of Closure,* §257.71 at pp. 12475 through 12477, available at https://www.govinfo.gov/content/pkg/FR-2020-03-03/pdf/2020-04033.pdf. See also, http://www.regulations.gov.

[32] Id., at page 12467.

	and 845.710) that exceed the Class I Groundwater standards for Cobalt and Radium 226 and 228 and set additional standards for Lithium and Molybdenum (neither of which are listed in the Class I Groundwater standards).	
Closure and Post-Closure Care	The Illinois EPA Proposed Rule contains provisions comparable to the federal requirements that specify which types of permits are needed for closure, post-closure, remediation, and all other requirements applicable to CCR surface impoundments. Unlike the federal requirements, however, the Illinois EPA's rulemaking does *not* apply these closure requirements to inactive CCR surface impoundments; as written, the Proposed Rule appears to apply the 30-year post-closure care requirements only to active impoundments (Section 845.170 and Section 845.780(c)).	Concern: since the CAPP Act makes no distinction between active and inactive surface impoundments (415 ILCS 5/22.59(a)(3) and (m)), it is unclear why the Proposed Rule's application would be limited to only active CCR surface impoundments.
Closure and Post-Closure Care	The U.S. EPA revisions would create an additional closure option for CCR units being closed by complete removal of CCR that would allow groundwater corrective actions to be completed during the post-closure care period.[33] A second federal option for units closing for cause would allow CCR to be added to a unit after closure deadlines if done under an approved closure plan (proposed §257.102(d)(4)).[34]	Concern: since the Illinois EPA Proposed Rule requires groundwater corrective actions to be completed *before* closure by removal (Section 845.740(b) and (f)),[35] the first federal option would allow impoundments to close before State Groundwater requirements in Section 845.600 are met.

[33] These actions would not reduce the requirement to conduct post-closure care for 30 years and could extend that requirement beyond 30 years until all groundwater monitoring and corrective actions are completed.

[34] See *Hazardous and Solid Waste Management System: Disposal of CCR; A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments; Implementation of Closure, supra*, at page 12477.

[35] The state requires closure to occur within five years of initiation of closure but allows extensions for a total of up to two years (for impoundments of 40 acres or less) or 10 years (for impoundments of more than 40 acres) (Section 845.760). Similar to the federal law, the state requires continued groundwater monitoring and corrective action after the impoundment closes for a minimum of 30 years or until the groundwater monitoring data shows that concentrations are below the groundwater protections standards (Section 845.600) and are not increasing for those parameters over background levels (Section 845.780).

Environmental Justice Requirements	The Illinois EPA Proposed Rule does not specify a procedure to identify areas of environmental justice concern in relation to CCR surface impoundments[36] or give priority to impoundments with environmental justice issues[37] as required by the CAPP Act.	Concern: These regulatory gaps can cause problems in meaningfully addressing and enforcing the CAPP Act's environmental justice (and other public health and environmental) requirements.
Public Notice & Engagement	The Illinois EPA Proposed Rule does not include beneficially used CCR as part of the information required to be posted on a publicly accessible website (Section 845.810) and has no requirement to post annual reports about the volume or weight of beneficially used CCR that owners or operators sold or provided over the last year as required by the CAPP Act (415 ILCS 5/22.59(h)).	Concern: Public notification impacts public safety and risk assessment and can have generational impacts as well as other public health and environmental impacts.

[36] 415 ILCS 5/22.59(g)(8).
[37] 415 ILCS 5/22.59(g)(9). The Illinois EPA Proposed Rule makes environmental justice issues a third priority. See Section 845.700 (g)(1)(C)).