BEFORE THE
ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	
PETITION OF SOUTHERN ILLINOIS POWER COOPERATIVE FOR AN ADJUSTED STANDARD FROM 35 ILL. ADMIN. CODE PART 845 OR, IN THE ALTERNATIVE, A FINDING OF INAPPLICABILITY	AS 2021-006 (Adjusted Standard)

NOTICE OF FILING

To: Don Brown, Clerk of the Board
Illinois Pollution Control Board
60 E. Van Buren St., Ste 630
Chicago, Illinois 60605

Carol Webb, Hearing Officer
Illinois Pollution Control Board
60 E. Van Buren St., Suite 630
Chicago, Illinois 60605

Stefanie N. Diers, Deputy General Counsel
Gabriel H. Neibergall, Assistant Counsel
Rebecca Strauss, Assistant Counsel
Kaitlyn Hutchison
Illinois Environmental Protection Agency
1021 N. Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Pollution Control Board the attached Errata Sheet and Corrected Exhibits 36, 37, and 38 to the Second Amended Petition of Southern Illinois Power Cooperative for an Adjusted Standard from 35 Ill. Admin. Code Part 845 and a Finding of Inapplicability and a Certificate of Service, copies of which are herewith served upon you.

Respectfully Submitted,

SOUTHERN ILLINOIS POWER
COORPERATION

/s/ *Sarah L. Lode*

Dated: January 30, 2025

Joshua R. More
Bina Joshi
Sarah L. Lode
Amy Antoniolli
ArentFox Schiff LLP
233 South Wacker Drive, Suite 7100
Chicago, Illinois 60606
(312) 258-5500
Joshua.More@afslaw.com
Bina.Joshi@afslaw.com
Sarah.Lode@afslaw.com
Amy.Antoniolli@afslaw.com

CERTIFICATE OF SERVICE

I, the undersigned, certify that on this day of:

> I have electronically served a true and correct copy of the attached ERRATA SHEET and CORRECTED EXHIBITS 36, 37, AND 38 TO THE SECOND AMENDED PETITION OF SOUTHERN ILLINOIS POWER COOPERATIVE FOR AN ADJUSTED STANDARD FROM 35 ILL. ADM. CODE PART 845 AND A FINDING OF INAPPLICABILITY by electronically filing with the Clerk of the Illinois Pollution Control Board and by e-mail upon the following persons:
>
> Don Brown, Clerk of the Board
> Carol Webb, Hearing Officer
> 100 West Randolph Street
> James R. Thompson Center, Suite 11-500
> Chicago, Illinois 60601-3218
> Don.Brown@illinois.gov
> Carol.Webb@illinois. gov
>
> Stefanie N. Diers, Deputy General Counsel
> Gabriel H. Neibergall, Assistant Counsel
> Rebecca Strauss, Assistant Counsel
> Kaitlyn Hutchison
> Illinois Environmental Protection Agency
> 1021 N. Grand Avenue East
> P.O. Box 19276
> Springfield, Illinois 62794-9276
> Stefanie.Diers@illinois.gov
> Gabriel.Neibergall@illinois.gov
> Rebecca.Strauss@illinois.gov
> Kaitlyn.Hutchison@illinois.gov
>
> My e-mail address is Sarah.Lode@afslaw.com;
>
> The number of pages in the e-mail transmission is 212.
>
> The e-mail transmission took place before 5:00 p.m.

/s/ *Sarah L. Lode*

Dated: January 30, 2025

Joshua R. More
Bina Joshi
Sarah L. Lode

Amy Antoniolli
ArentFox Schiff LLP
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ERRATA SHEET AND CORRECTED EXHIBITS 36, 37, AND 38

Southern Illinois Power Cooperative ("SIPC"), by and through its attorneys, ArentFox Schiff LLP, files this Errata Sheet and attached corrected Exhibits 36, 37, and 28, identifying and correcting data in certain tables contained within Exhibit 36—Ari Lewis, M.S., *Support for the Petition of an Adjusted Standard for Pond 4, Ponds 3 and 3A, Pond S-6, Former Pond B-3, and South Fly Ash Pond* (Dec. 20, 2024); Exhibit 37—Gradient, *Human Health Risk Assessment, Marion Power Station* (Dec. 20, 2024); and Exhibit 38—Andrew Bittner, M.Eng., P.E., *Closure Impact Assessment, Pond 4* (Dec. 20, 2024) to the Second Amended Petition of Southern Illinois Power Cooperative for an Adjusted Standard from 35 Ill. Adm. Code Part 845 and a Finding of Inapplicability (the "Second Amended Petition").

The corrections rectify a calculation error that occurred due to a formula in an underlying spreadsheet referring to an incorrect cell and clarify the description of table A.5. The chart below lists the corrections made in the attached corrected Exhibits 36, 37, and 38.

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Corrected on January 29, 2025</td></tr>
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<td>Att. A, App. A, Page A-i</td>
<td>Table A.5 Surface Water Modeling Results for Little Saline Creek</td>
<td>Table A.5 Surface Water **and Sediment** Modeling Results for Little Saline Creek</td>
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<td>Att. A, App. A, Page A-4</td>
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<tr><td>Arsenic</td><td>1.20E-01</td><td>**1.15E-06**</td><td>**2.09E-04**</td></tr>
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EXHIBIT 37		
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PDF Page 1	December 20, 2024	December 20, 2024 **Corrected on January 29, 2025**

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<td>Table A.5 Surface Water Modeling Results for Little Saline Creek</td>
<td>Table A.5 Surface Water <u>and Sediment</u> Modeling Results for Little Saline Creek</td>
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<td>For each COI, the modeled total water column concentration<s>, dry weight sediment concentration,</s> and concentration sorbed to sediment are presented in Table A.5.</td>
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Respectfully Submitted,

SOUTHERN ILLINOIS POWER
COORPERATION

/s/ *Sarah L. Lode*

Dated: January 30, 2025

Joshua R. More
Bina Joshi
Sarah L. Lode
Amy Antoniolli
ArentFox Schiff LLP
233 South Wacker Drive, Suite 7100
Chicago, Illinois 60606
(312) 258-5500
Joshua.More@afslaw.com
Bina.Joshi@afslaw.com
Sarah.Lode@afslaw.com
Amy.Antoniolli@afslaw.com

CORRECTED
EXHIBIT 36

Support for the Petition of an Adjusted Standard for Pond 4, Ponds 3 and 3A, Pond S-6, Former Pond B-3, and South Fly Ash Pond at the Marion Generating Station

Prepared by

Ari Lewis

Ari Lewis, M.S.

Prepared for

Southern Illinois Power Company
11543 Lake of Egypt Rd
Marion, IL 62959

December 20, 2024
Corrected on January 29, 2025

GRADIENT

www.gradientcorp.com
One Beacon Street, 17th Floor
Boston, MA 02108
617-395-5000

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Abbreviations

CCR	Coal Combustion Residuals
CM	Conceptual Model
COI	Constituent of Interest
ESV	Ecological Screening Value
FGD	Flue Gas Desulfurization
GHG	Greenhouse Gas
GWPS	Groundwater Protection Standard
HTC	Human Threshold Criteria
IEPA	Illinois Environmental Protection Agency
MGS	Marion Power Generating Station
PLM	Polarized Light Microscopy
PWS	Public Water Supply
SIPC	Southern Illinois Power Cooperative
SWQS	Surface Water Quality Standard
US EPA	United States Environmental Protection Agency

Executive Summary

Southern Illinois Power Cooperative (SIPC) owns and operates the Marion Power Generating Station (MGS), a gas and coal-fired power generating facility located in Marion, Illinois. The station began operations in 1963 and features several waste and water storage areas (including storage ponds[1]) that were utilized to support the station's operations. Some of these areas were specifically designed to store coal combustion residuals (CCR) produced from burning coal; these include Pond A-1, Former Fly Ash Holding Units, and Former Fly Ash Holding Areas. Other storage areas, including some storage ponds, were utilized for different operational purposes, such as wastewater storage or overflow and run-off management. The storage ponds in the latter category include:

- Pond 4
- Pond 3 and Pond 3A
- Pond S-6
- Former Pond B-3
- South Fly Ash Pond

These storage ponds (hereafter referred to as "storage ponds of interest") received negligible amounts of CCR over their operational history and, consequently, do not carry the same human health risk and environmental risk as posed by the CCR storage units that are subject to federal regulations regarding the disposal of CCR in surface impoundments (*i.e.*, the 2015 CCR Rule by the United States Environmental Protection Agency [US EPA]) or Illinois State CCR Regulations (*i.e.*, Illinois Administrative Code Part 845 [Part 845] by Illinois Environmental Protection Agency [IEPA]), which is fundamentally based on the 2015 US EPA CCR Rule.

The US EPA established national regulations for CCR management in 2015 (US EPA, 2015), which included requirements for both existing surface impoundments and landfills. The clear differences between the storage ponds of interest at MGS compared to surface impoundments that are subject to federal and state CCR regulations can be established based on the definitions for surface impoundment offered in the 2015 CCR Rule, the human health and ecological risk assessment (2014 CCR Risk Assessment) that supports the 2015 CCR Rule; the history of use and investigations conducted at the storage ponds of interest; and a site-specific risk assessment based on the groundwater and surface water data collected at MGS. Based on this information, I can conclude the following:

- The storage ponds of interest at MGS are not considered primary storage units for CCR; the small amounts of CCR present in these storage ponds are *de minimis*, placing the storage ponds of interest outside the regulatory requirements of state and federal regulations.
- Due to the minimal quantity of CCR in the MGS storage ponds of interest, the risk assessment conducted by US EPA in support of the CCR Rule is not applicable to the MGS storage units of interest.

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[1] When referring to waste disposal, the terms "pond" and "surface impoundment" are often used interchangeably.

- A site-specific risk assessment has confirmed that the 2014 US EPA risk assessment does not adequately characterize the conditions at MGS and has demonstrated that the storage ponds of interest at MGS do not pose a risk to human health or the environment.

For these reasons, the storage ponds of interest at MGS do not qualify as surface impoundments as intended by the federal and state CCR Rules and are eligible for a petition for an adjusted standard under Part 845.

1 Introduction

In 2015, the United States Environmental Protection Agency (US EPA) promulgated national standards for the regulation of coal combustion residuals (CCR) disposal units (US EPA, 2015). The 2015 CCR Rule (formally known as "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities") set forth a nationally consistent standard for the current and future management of CCR disposal units (surface impoundments and landfills) (US EPA, 2015). The Rule put forth a number of key provisions related to location, liner design, structural integrity, operating criteria related to controlling run-off and fugitive dust, and recordkeeping for CCR disposal units. Some of the most consequential requirements, however, relate to the establishment of a groundwater monitoring system at the waste containment boundary to detect exceedances of groundwater protection standards (GWPSs) of CCR-related constituents. If monitoring indicates that any of the identified constituents in CCR exceed the GWPSs, potential closure and corrective action must be initiated.

In the preamble to the Rule, US EPA justifies its regulatory determination based on three key reasons (US EPA, 2015):

- "EPA had completed a quantitative risk assessment that estimated significant risks to human health and the environment."
- "…consideration related to how effectively state regulatory programs address the risks associated with the improper management of these wastes…" and "lack of substantial details regarding the full extent of state regulatory authority over the disposal of these materials, and the manner in which states have, in practice, implemented this oversight."
- "…information documenting continued instances involving the contamination of ground or surface water from the management of these wastes."[2]

Following the promulgation of the CCR Rule, several states initiated or enhanced existing CCR management programs, including Illinois. In 2021, Illinois established 35 Illinois Administrative Code Part 845 (Part 845), which put forth "rules for the design, construction, operation, corrective action, closure and post-closure care of surface impoundments containing CCR at power plants" (IEPA, 2021). Part 845 shares many features of the 2015 CCR Rule but is solely focused on the regulation of surface impoundments, including the need to initiate corrective action in response to a GWPS exceedance. Importantly, Part 845 has retained US EPA's definition of a surface impoundment as "a natural topographic depression, man-made excavation, or diked area, which is designed to hold an accumulation of CCR and liquids, and the unit treats, stores, or disposes of CCR" (IEPA, 2021).

Based on the information that was provided to me, it is my understanding that the Illinois Environmental Protection Agency (IEPA) has taken the position that the CCR storage ponds of interest at MGS are "surface impoundments" and within the scope of the 2015 CCR Rule and Part 845. Several of the storage ponds, however, are inconsistent with the definition of a surface impoundment. In particular, the CCR storage ponds of interest at MGS were never designed to routinely receive sluiced CCR or other significant CCR from plant operations. Consequently, the storage ponds contain negligible amounts of CCR that would qualify them as "de minimis" ponds. As noted by US EPA, "de minimis" levels of CCR in a pond are

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[2] This justification specifically relates to cases proven as potential "damage cases," which is a regulatory designation given by US EPA indicating proven or potential damage to human health or the environment.

unlikely to present a significant risk to human health or the environment and are out of the scope of the CCR Rule (US EPA, 2015).

In the following sections, I present several lines of evidence demonstrating that the storage ponds of interest at MGS do not meet the definition of a surface impoundment as specified in Part 845. These storage ponds of interest are fundamentally different from the CCR storage units that US EPA associated with risks in its risk assessment supporting the 2015 CCR Rule and, which was used to support the promulgation of Part 845 and, thus, should not be the target of Part 845 regulation.

Additionally, I will summarize the findings of a recent site-specific risk assessment evaluating potential human health and environmental risks from the storage ponds of interest at MGS. The results confirm that the storage ponds in question are significantly different from those evaluated by US EPA in its risk assessment in support of 2015 CCR Rule and relied upon to promulgate Part 845. Moreover, the findings demonstrate that these storage ponds do not pose a substantial or significant adverse threat to human health or the environment that warrant regulation under Part 845.

2 Qualifications

I am a Principal at Gradient, an environmental consulting firm located in Boston, Massachusetts, with a Master's degree in environmental toxicology. I have over 20 years of professional experience in toxicology and risk assessment. In this capacity, I lead a variety of projects, including product safety evaluations, regulatory comments, green chemistry assessments, and technical support for the utility and mining industries. Recently, I have served on two US EPA Science Advisory Panels in support of developing technical, risk-based tools to support environmental justice assessments. I have particular expertise in evaluating the potential human health and environmental risks of CCR. Example projects and activities have included providing congressional testimony on the risk assessments of CCR; providing regulatory comment on risk assessment-related aspects of national CCR rules; participating as a member of the National Ash Management Advisory Board; and providing ongoing support for utilities with CCR storage units subject to the state and federal CCR rules. I have given dozens of presentations related to CCR risk at national conferences and was the lead author of the book chapter, "Storage of Coal Combustion Products in the United States: Perspectives on Potential Human Health and Environmental Risk" in the book *Coal Combustion Products (CCPs): Characteristics, Utilization, and Beneficiation.* My full *Curriculum Vitae* is in Attachment B.

3 The MGS storage ponds of interest qualify as *de minimis* and are outside the regulatory requirements of the CCR Rule

Part 845 requirements are applicable to CCR units that qualify as surface impoundments. The sections below provide support that the storage ponds of interest at MGS (the South Fly Ash Pond, Ponds 3 and3A,[3] Pond S-6, Pond 4, and Former Pond B-3) do not meet the intended definition of a CCR surface impoundment as specified under Part 845 (*i.e.*, an impoundment "designed to hold an accumulation of CCR and liquids, and the surface impoundment treats, stores, or disposes of CCR"; IEPA, 2021). In summary, none of these ponds were designed to treat, store, or dispose of CCR; principally, these ponds only indirectly received small amounts of CCR *via* overflow from other areas or process wastewater discharge. While some CCR are present in these ponds as a result of these activities, the amount of CCR in these ponds is negligible, and a small fraction of what would be expected in an impoundment intended to directly receive CCR from coal-burning operations. The evidence presented collectively indicates that the ponds of interest at MGS are not subject to regulation under Part 845. Further detailed information supporting this conclusion is provided below.

3.1 The regulatory definition of "de minimis" is presented by US EPA in the 2015 CCR Rule and has been adopted by IEPA under Part 845

As noted in Section 1, in 2015, the US EPA promulgated comprehensive regulations for the management of CCR disposal units, including surface impoundments and landfills. As part of these regulations, US EPA needed to clearly define what qualifies as a CCR storage unit. In its initial draft, US EPA defined a surface impoundment as "natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials) which is designed to hold an accumulation of CCR containing free liquids, and which is not an injection well" (US EPA, 2015). Public commenters on the Rule reasoned that this definition was overly broad because it would include "downstream" impoundments (*e.g.*, wastewater and holding ponds) that contained *de minimis* (*i.e.*, inconsequential) amounts of CCR (US EPA, 2015).

In response to the comments, US EPA acknowledged that a change in definition was needed and introduced a new definition of a surface impoundment in the final Rule:

> [A] CCR surface impoundment as defined in this rule must meet three criteria: (1) The unit is a natural topographic depression, manmade excavation or diked area; (2) the unit is designed to hold an accumulation of CCR and liquid; and (3) the unit treats, stores or disposes of CCR (US EPA, 2015).

This definition is functionally identical to the definition adopted in Part 845:

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[3] Pond 3 was initially built in 1979, but in 1982 a berm was built to divide the pond into ponds 3 and 3A (SIPC, 2021; Kleinfelder Inc., 2013).

> "CCR surface impoundment" or "impoundment" means a natural topographic depression, man-made excavation, or diked area, which is designed to hold an accumulation of CCR and liquids, and the surface impoundment treats, stores, or disposes of CCR (IEPA, 2021).

While Part 845 does not provide any specific language or more specific criteria that qualifies a surface impoundment for regulation, the CCR Rule, on which Part 845 is based, provides further clarification on the type of units covered. US EPA states:

> [A] constructed primary settling pond that receives sluiced CCR directly from the electric utility would meet the definition of a CCR surface impoundment because it meets all three criteria of the definition: It is a man-made excavation and it is designed to hold an accumulation of CCR (*i.e.,* directly sluiced CCR). It also engages in the treatment of CCR through its settling operation (US EPA, 2015; emphasis added).
>
> Similarly, secondary or tertiary impoundments that receive wet CCR or liquid with significant amounts of CCR from a preceding impoundment (*i.e.,* from a primary impoundment in the case of a secondary impoundment, or from a secondary impoundment in the case of a tertiary impoundment), even if they are ultimately dredged for land disposal elsewhere are also considered CCR surface impoundments and are covered by the rule (US EPA, 2015; emphasis added).

This definition emphasizes that a surface impoundment was meant to represent a unit that received and stored significant amounts of CCR, most typically in the form of sluiced CCR.

On the other hand, US EPA notes that:

> [U]nits containing only truly "de minimis" levels of CCR are unlikely to present the significant risks this rule is intended to address (US EPA, 2015).

While a quantitative definition of "de minimis levels of CCR" was not provided in the rule, US EPA clarifies the following characteristics for units that are not covered by the 2015 CCR Rule:

> CCR surface impoundments do not include units generally referred to as cooling water ponds, process water ponds, wastewater treatment ponds, storm water holding ponds, or aeration ponds. These units are not designed to hold an accumulation of CCR, and in fact, do not generally contain significant amounts of CCR. Treatment, storage, or disposal of accumulated CCR also does not occur in these units (US EPA, 2015; emphasis added).
>
> [U]nits that present significantly lower risks, such as process water or cooling water ponds, [are not meant to be covered by the rule] because, although they will accumulate any trace amounts of CCR that are present, they will not contain the significant quantities that give rise to the risks modeled in EPA's assessment (US EPA, 2015).

US EPA's acknowledgement that *de minimis* units will not "give rise to the risks modeled in EPA's risk assessment" is particularly key, because as further detailed in Sections 4 and 5, the surface impoundments modeled in US EPA's risk assessment are not characteristic of the storage ponds of interest at MGS.

In addition to these points, the sections below provide detailed support for why the storage ponds of interest at the MGS have characteristics similar to those of units excluded from the 2015 CCR Rule. Consequently, the storage ponds of interest should be exempt from complying with federal and state regulations.

3.2 The history of use of the MGS storage ponds of interest places them outside the definition of a CCR surface impoundment

The MGS property features a series of ponds that have been utilized for the management and treatment of site-related waste (see Figure 3.1). Some of these ponds (*e.g.*, Pond A-1), were specifically designed to "treat, store, and dispose" CCR, while others serve different operational purposes, including the storage and treatment of wastewater. Below, I provide descriptions of the ponds that did not directly receive CCR, which are the focus of this petition. See also Table 3.1.

- South Fly Ash Pond: The South Fly Ash Pond, which covers an area of approximately 12.2 acres, was constructed in 1989 and was originally intended to be a replacement for Pond A-1, which was designed to directly accept and store CCR (Figure 3.1; SIPC, 2021). Ultimately, Pond A-1 did not need to be replaced. Thus, the South Fly Ash Pond was only used to receive decant water from the Former Emery Pond[4] while it was operational. No CCR was ever directly sent to or disposed of in the South Fly Ash Pond (SIPC, 2021).
- Ponds 3/3A: Ponds 3 and 3A, with approximate areas of 1.9 and 1.7 acres, respectively, were secondary ponds that received overflow from the Fly Ash Holding Areas[5] (Figure 3.1; SIPC, 2021). They also received stormwater runoff, coal pile runoff, and water from the facility floor drains. In approximately 1982, Pond 3A was separated from Pond 3 by construction of an internal berm, and Pond 3A received some overflow from the Former Fly Ash Holding Units.[6] All sediment and debris were removed from Pond 3 in 2006 and 2011. All sediment and debris were removed from Pond 3A in 2014. Subsequently, no CCR was ever directly sent to or disposed in Ponds 3 or 3A. Currently, water from the South Fly Ash Pond flows into Pond 3 (SIPC, 2021).
- Pond S-6: Pond S-6 was originally built to manage stormwater associated with the Former Landfill[7] (Figure 3.1; SIPC, 2021). Initially, water in Pond S-6 discharged to the Little Saline Creek through Outfall 001; however, in approximately 1993, water from Pond S-6 was pumped to Pond 4. Pond S-6 is expected to receive non-CCR runoff from the Former Landfill in the future. No CCR was ever directly sent to or disposed in Pond S-6 (SIPC, 2021).
- Pond 4: Pond 4, which was built in 1979 and covers an area of approximately 3.7 acres, historically received decant water from Ponds 1 and 2[8] for secondary treatment and runoff from the coal pile (Figure 3.1; Kleinfelder Inc., 2013; SIPC, 2021). No CCR was ever directly sent to or disposed in the Pond 4. All sediment and debris were removed from Pond 4 in 2012 (SIPC, 2021). Currently, Pond 4 receives overflow from Pond S-6; water in Pond 4 discharges into the Little Saline Creek *via* Outfall 002 (Kleinfelder Inc., 2013; SIPC, 2021).
- Former Pond B-3: Pond B-3, which was built in 1985 and approximately covers 6.4 acres, was primarily used as a secondary pond that received water from Pond A-1 (Figure 3.1; SIPC, 2021). During shutdowns of Pond A-1, Pond B-3 may have received short-term discharges of fly ash.

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[4] The Former Emery Pond was constructed in the late 1980s. It received process wastewater (including flue gas desulfurization [FGD] decant excess water and air heater wash water) and stormwater from areas of the MGS. The Former Emery Pond stopped receiving process wastewater discharges in 2020, and its closure is ongoing (SIPC, 2021).

[5] The Former Fly Ash Holding Areas and Extension (Figure 3.1) were used to store fly ash before the construction of Pond A-1 in 1985 (SIPC, 2021).

[6] The Former Fly Ash Holding Units are three former fly ash ponds that were closed and dewatered "decades ago" (SIPC, 2021).

[7] The Former Landfill is a permit-exempt landfill that received scrubber sludge mixed with fly ash. It was built in the early 1990s on top of the Former Fly Ash Holding Units and also partially covered the Former Fly Ash Holding Areas and Extension after they were drained (Figure 3.1). The Former Landfill stopped accepting wastes in 2015, and a closure plan was submitted to IEPA (SIPC, 2021).

[8] Ponds 1 and 2 received sluiced bottom ash, which was later removed for beneficial use. These ponds are not currently in use and are being closed (SIPC, 2021).

These shut-downs were very infrequent and for very short periods of time. Specifically, Pond A-1 was taken off-line approximately 3 to 4 times between 1985 and 2003, each lasting about 2 weeks. In 2017, Pond B-3 was dewatered and all sediment and CCR were excavated (SIPC, 2021).

Table 3.1 History of Use for the Storage Ponds of Interest

Ponds	Year Built	Duration of Operation	Uses
South Fly Ash Pond	1989	Approximately 30 years	- Built as potential replacement for Pond A-1 but was not needed. - Received decant water from Former Emery Pond.
Pond 3	1979	10-12 years	Received wastewater from multiple sources: - overflow from the Fly Ash Holding Areas; - stormwater runoff; - coal pile runoff; and - water from floor drains. Currently receives water from the South Fly Ash Pond.
Pond 3A	1982	8-10 years	Received wastewater from multiple sources: - overflow from the Former Fly Ash Holding Units; - stormwater; and - potential overflow from the South Fly Ash Pond.
Pond S-6	1988	Approximately 30 years	- Developed to manage stormwater from the Former Landfill. - Expected to receive non-CCR runoff from the Former Landfill in the future.
Pond 4	1979	Approximately 30 years	Received wastewater from multiple sources: - decant water from Ponds 1 and 2 until 2020; - water from the South Fly Ash Pond; and - coal pile runoff starting in 2003. Currently receives overflow from Pond S-6 and discharges into the Little Saline Creek.
Former Pond B-3	1985	18 years	- Used as a secondary pond to Pond A-1 (which received fly ash and coal pile runoff until 2003) - Received short-term discharges of fly ash during periodic outages of Pond A-1 (outages occurred 3-4 times between 1985 and 2003, two weeks at a time).

Notes:
CCR = Coal Combustion Residuals.
Source: SIPC (2021); Kleinfelder Inc. (2013).

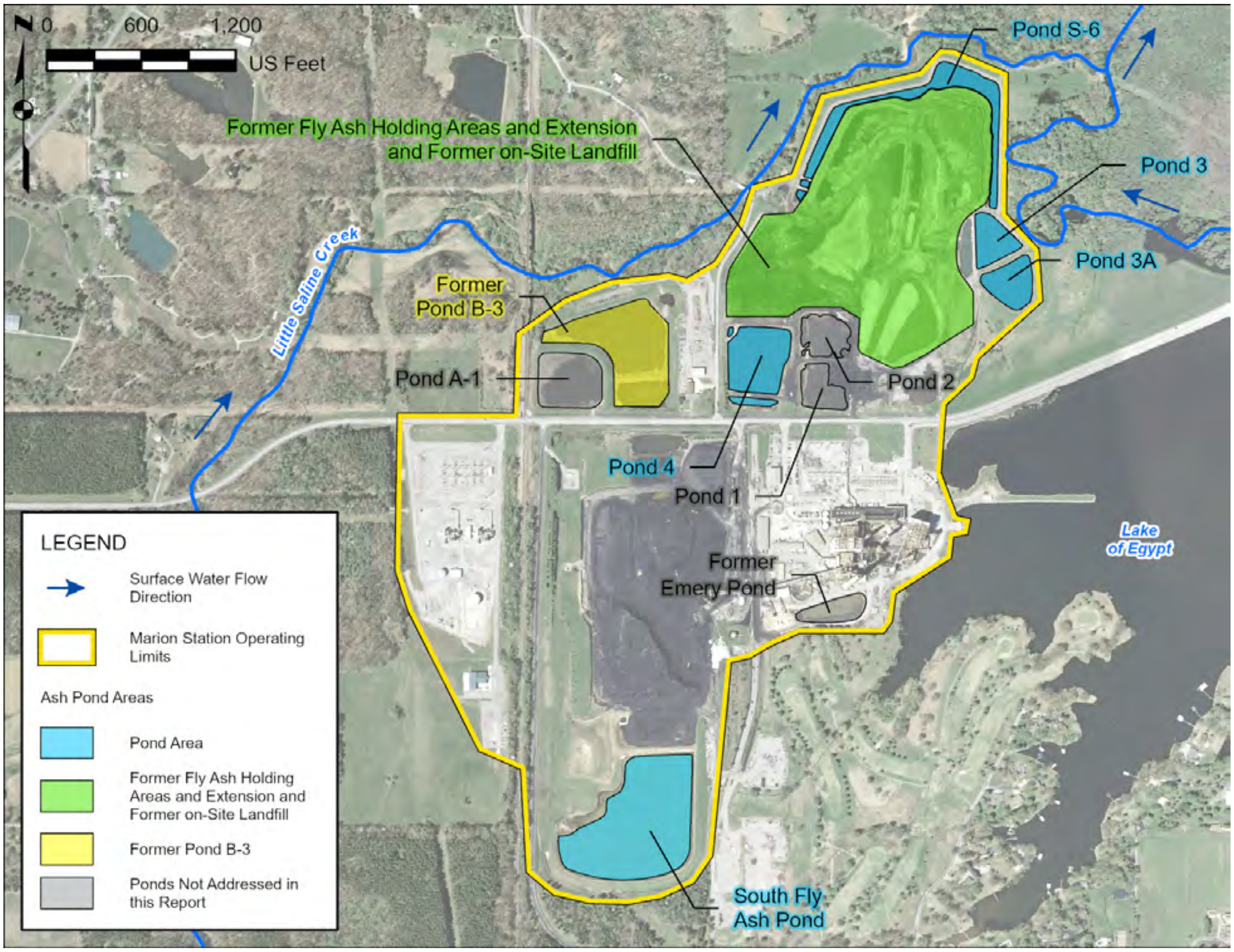

Figure 3.1 Marion Power Generating Station Layout. Sources: Golder Associates Inc. (2021); USGS (2022, 2011); Andrews Engineering (2021); SIPC (2021).

3.3 Investigations at MGS show that the storage ponds of interest contain minimal amounts of CCR

As discussed above, the South Fly Ash Pond, Ponds 3 and 3A, Pond S-6, and Pond 4 were never used to store or dispose CCR (*i.e.*, they did not receive sluiced CCR directly). While Former Pond B-3 did receive 3-4 short-term discharges of fly ash over 18 years (Table 3.1), the amount of fly ash that it received would be very small in comparison to CCR surface impoundments that routinely received sluiced CCR. As a result, the amount of CCR in these impoundments is a small fraction of what would be expected in an impoundment intended to directly receive CCR from coal burning operations. The *de minimis* amounts of CCR present in the storage ponds of interest would put them outside the intent of the state and federal CCR regulations.

To further support the position that the storage ponds of interest contain *de minimis* amounts of CCR, Haley & Aldrich, Inc., characterized the CCR present (if any) in the storage ponds of interest[9] in 2021 (Haley & Aldrich, Inc., 2021). This investigation included the following:

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[9] Former Pond B-3 was dewatered in 2017, and sediments were removed from it (SIPC, 2021). Thus, Haley & Aldrich, Inc. (2021) did not investigate the Former Pond B-3.

- A bathymetric survey to determine the sediment thickness in each pond;
- A polarized light microscopy (PLM) analysis[10] to estimate the CCR content in each sediment sample; and
- A carbon content analysis (Haley & Aldrich, Inc., 2021).

The results from Haley & Aldrich, Inc. (2021) are presented in Tables 3.2 and 3.3. One of the key parameters evaluated was the sediment thickness in each pond. For the storage ponds of interest, the sediment is expected to contain CCR that may have settled out of the wastewater, as well as other mineral and organic matter typically found in surface water bodies (*e.g.*, soil, decomposed leaves, branches). The analysis found that the total sediment thickness in each surface impoundment was minimal, ranging from 0.84 feet to 1.67 feet (*i.e.*, 10-20 inches). While this level of sediment, in and of itself, is not typical for a surface impoundment designated to directly receive CCR, the analysis further assessed the fraction of the sediment that could be conclusively attributed to CCR. As shown in Table 3.2, the percentage of CCR in the sediment samples collected from the storage ponds of interest ranged between 10% and 68%, with the average for each pond ranging between 27% and 54%. This translates to a CCR thickness of 0.35 to 0.90 feet (*i.e.*, 4.2 to 10.8 inches) if the CCR are assumed to be present as a layer within the sediment (instead of being vertically interspersed in the sediment). For perspective, in the nationwide survey that US EPA conducted, surveyed surface impoundments contained between 0.5 and 190 feet of wet CCR (see Section 4.3 for more details; US EPA, 2014).

Table 3.2 Measured Total Sediment Thickness and Estimated CCR in Sediment

Pond	Mean Sediment Thickness (feet)	Slag + Fly Ash + Bottom Ash (*i.e.*, CCR)	Coal[a]	Other[b]	Maximum Estimated CCR Thickness (feet)[c]
South Fly Ash Pond	1.57	10-64% (40%)	1-6% (3.5%)	34-84% (56.5%)	0.63
Pond 3	1.38	23-34% (28.5%)	4-7% (5.5%)	62-70% (66%)	0.39
Pond 3A	1.45	20-34% (27%)	13-48% (30.5%)	18-67% (42.5%)	0.39
Pond S-6	0.84	30-53% (41.5%)	0-2% (1%)	47-68% (57.5%)	0.35
Pond 4	1.67	25-68% (54%)	0-23% (6%)	32-52% (40%)	0.90

Notes:
CCR = Coal Combustion Residuals; FGD = Flue Gas Desulfurization; PLM = Polarized Light Microscopy.
The average amount of CCR, coal, and other materials is indicated in parentheses.
(a) The results of the PLM analysis of pond sediment samples were compared with the results of some control samples, including a coal sample. Thus, some fraction of the sediments were identified as coal in this analysis.
(b) Haley & Aldrich, Inc., noted that other materials in the sediment samples could include scrubber sludge or FGD material, but the amount of such materials in the pond sediments was likely to be small because scrubber sludge was not sent to the ponds for disposal.
(c) Calculated using the mean sediment thickness and the average amount of CCR in each pond.
Sources: Haley & Aldrich, Inc. (2021); SIPC (2021).

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[10] Haley & Aldrich, Inc., noted that "PLM is an optical microscopy method … [that] can be used to distinguish particles of coal ash from other dust particles, and … [is] able to estimate the abundance of CCR materials in a sample" (Haley & Aldrich, Inc., 2021).

Haley & Aldrich, Inc., also measured the sediment volume and the total volume for each pond. As shown in Table 3.3, when using the total sediment depth as a worst-case scenario, Haley & Aldrich, Inc.'s results showed that the sediment volume as a fraction of the pond volume ranged between 8.2% and 21.8% for the storage ponds of interest[11] (Haley & Aldrich, Inc., 2021). A more refined analysis that considers only the CCR fraction of the sediment demonstrates that the amount of CCR in these ponds is only 2.6% to 7.6% of the total volume.

Table 3.3 Estimated CCR Volume as a Fraction of the Total Pond Volume

Pond	Sediment Volume (cubic feet)	Pond Volume (cubic feet)	Area (acres)	Estimated Pond Depth[a] (feet)	Sediment Volume as Fraction of Pond Volume	Estimated CCR Volume as Fraction of Pond Volume
South Fly Ash Pond	563,055	2,944,553	12.2	5.5	19.1%[b]	7.6%
Pond 3	83,988	936,162	1.9	11.3	9%	2.6%
Pond 3A	95,666	717,739	1.7	9.7	13.3%	3.6%
Pond S-6	103,453	1,264,398	3.4	8.5	8.2%	3.4%
Pond 4	91,077	1,370,059	3.7	8.5	6.6%[c]	3.6%

Notes:
CCR = Coal Combustion Residuals.
(a) Mean pond depth was estimated as the ratio of the pond volume to its area.
(b) Based on the sediment and pond volumes reported by Haley & Aldrich, Inc. (2021), the sediment volume in the South Fly Ash Pond is 19.1% of its total volume. But Haley & Aldrich, Inc. (2021) reported a value of 21.8%.
(c) Based on the sediment and pond volumes reported by Haley & Aldrich, Inc. (2021), the sediment volume in Pond 4 is 6.6% of its total volume. But Haley & Aldrich, Inc. (2021) reported a value of 10.9% instead.
Sources: Haley & Aldrich, Inc. (2021); SIPC (2021).

The amounts of CCR that have settled in the storage ponds of interest throughout MGS's operational life are inconsistent with what would be expected from a surface impoundment designed to store, treat, and dispose of CCR. On the contrary, the low amounts of CCR in these ponds are consistent with receiving discharges of decant water or other wastewaters rather than significant CCR deposits. While Pond B-3 did receive some direct CCR, this activity occurred infrequently – only three times for about 2 weeks over several years. Moreover, this pond was dewatered and sediments were excavated in 2017. The presence of such minimal amounts of CCR in the storage ponds of interest and the fact that they were not designed to treat, store, or dispose of CCR puts these ponds squarely in US EPA's category of units that contain *de minimis* amounts of CCR. And units with "de minimis" CCR are out of the scope of CCR regulatory requirements.

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[11] For the South Fly Ash Pond and Pond 4, the values of the sediment volume as a fraction of the pond volume reported by Haley & Aldrich, Inc. (2021) did not equal the ratio of the sediment volume to the pond volume (Table 3.2).

4 The risk assessment conducted by US EPA in support of the CCR Rule is not applicable to the MGS storage units of interest

A human health or environmental risk assessment is often needed to support regulatory determinations made by US EPA and other state environmental agencies. After initial drafts in 2007 and 2010, in 2014 US EPA published its final risk assessment titled, "Human Health and Ecological Risk Assessment of Coal Combustion Residuals" (US EPA, 2014). As previously mentioned, the findings of this risk assessment were one of the key underpinnings for the 2015 CCR Rule (US EPA, 2015). This is evident in the preamble to the CCR Rule, which states, "[t]he available information demonstrates that the risks posed to human health and the environment by certain CCR management units warrant regulatory controls" (US EPA, 2015). The US EPA 2014 CCR Risk assessment was a large undertaking involving the collection and analysis of data from 734 surface impoundments and 309 landfills across the US.

4.1 Risks from the 2014 CCR Risk Assessment were limited to surface impoundments at the 90th percentile (high-end CCR management scenarios); surface impoundments with more typical features and all landfills posed no risk

CCR stored in units can potentially reach human and ecological receptors in various ways. The CCR Risk Assessment was designed to characterize the full range of possible risks to human health posed by CCR disposal units across the US. Key human health exposure pathways that were addressed included the following (pathways indicated in bold were evaluated in an initial screening assessment and carried forward into a more refined risk assessment):

- **The ingestion of drinking water from groundwater impacted by CCR**
- Direct contact during showering and bathing with groundwater impacted by CCR
- **Ingestion of fish from surface water affected by groundwater impacted by CCR**
- Direct contact from surface water affected by groundwater impacted by CCR
- Inhalation of windblown CCR dust
- The incidental ingestion of soil impacted by CCR windblown dust and runoff
- The ingestion of produce, dairy products, and beef from soil impacted by CCR

Key ecological pathways that were addressed included:

- Aquatic receptors exposed to wastewater
- Aquatic receptors exposed from soil impacted by CCR runoff
- Terrestrial receptors exposed from soil impacted by CCR runoff

- **Aquatic receptors exposed to sediment affected by groundwater impacted by CCR**
- **Aquatic receptors exposed to surface water affected by groundwater impacted by CCR**

The pathways were evaluated during an initial screening phase that used high-end, worst-case exposure assumptions. In this phase, pathways that did not pose a risk were eliminated from further consideration. The exposures that did present a risk were carried forward and assessed using more refined exposure assumptions and risk assessment approach. In the list above, the pathways in bold were retained for further evaluation, while the others were determined to be low risk, even under extreme high-end exposure assumptions, and were not evaluated further. In general, the pathways that were retained focused on exposures related to the groundwater pathway. More specifically, from a human health perspective, the risk concern related to the potential for CCR constituents to leach from the landfill or surface impoundment into groundwater and migrate to drinking water wells off-site or into surface water bodies that could affect fish that humans could consume

US EPA employed a probabilistic risk assessment methodology for the more refined assessment focused on the groundwater pathway. This means that US EPA identified a full range of CCR management scenarios and unit characteristics to calculate a distribution of potential risks. Using this approach, US EPA presented a typical CCR management risk (50th percentile) and a high-end CCR management risk (90th percentile). The approach was designed to characterize the potential risks associated with CCR storage nationwide and did not reflect the risks at any specific individual facility.

A large number of factors were considered in the risk assessment to build the CCR risk model, which accounts for the full range of potential risks associated with CCR storage units. Some factors pertained to the characteristics of the storage units, such as the size of the storage unit, the concentrations of CCR constituents in the leachate, the type of waste, and the presence of a liner. Other factors related to how the CCR constituents leached out of the unit and traveled through the environment. Additionally, factors concerning the nature of the exposed population, the proximity to drinking water wells, and the proximity to surface water bodies were also taken into account.

The risk assessment concluded several key findings:

- For the ingestion of drinking water from groundwater impacted by CCR
  - At the 50th percentile, no human health risks for landfills or impoundments
  - At the 90th percentile, no human health risks for landfills, except when restricted to unlined units only
  - At the 90th percentile, some human health risk exceedances associated with arsenic (III and V), lithium, and molybdenum *via* drinking water ingestion for impoundments. When restricted to an assessment of unlined units only, there were also risk exceedances for thallium.
- For the ingestion of fish from surface water affected by groundwater impacted by CCR
  - No risk at the 50th or 90th percentile for surface impoundments or landfills
- No risk to aquatic organisms for landfills or impoundments

The specific quantitative risk findings for the human health assessment for surface impoundments, which are most relevant to the storage ponds of interest at MGS, are shown in the table below. In this table, cancer risk above 1×10^{-5} and noncancer risk above 1 are considered unacceptable risks by US EPA.

Table 4.1 50th and 90th Percentile Risks for Surface Impoundments (All Units) from the 2014 CCR Risk Assessment

CCR Constituent	Groundwater Ingestion		Fish Ingestion	
	50th Percentile	90th Percentile	50th Percentile	90th Percentile
Cancer Risk				
Arsenic III	No risk	2×10^{-4}	No Risk	No Risk
Arsenic V		1×10^{-5}		
Chromium VI		No Risk		
Noncancer Risk				
Arsenic III	No Risk	5	No Risk	No Risk
Arsenic V		No Risk		
Boron		No Risk		
Cadmium		No Risk		
Cobalt		No Risk		
Fluoride		No Risk		
Lead		No Risk		
Lithium		2		
Mercury		No Risk		
Molybdenum		2		
Selenium IV		No Risk		
Selenium VI		No Risk		
Thallium		No Risk		

Notes:
CCR = Coal Combustion Residuals.
No Risk = No risk exceedance or not evaluated.

The finding that only surface impoundments present a risk, and only at the 90th percentile, is particularly significant concerning the storage ponds of interest at MGS. If only surface impoundments with high-end exposure characteristics pose a risk to human health or the environment, this implies that the vast majority of CCR storage units, particularly those with lower risk characteristics such as containing *de minimis* amounts of CCR, do not present an unreasonable risk to human health and the environment.

4.2 The surface impoundments modeled in the 2014 CCR Risk Assessment were conceptually different than the storage ponds of interest at MGS

An initial step in a risk assessment is developing a conceptual model (CM). To assess the potential risk to groundwater from surface impoundments, US EPA needed to develop a conceptual model that could represent potential releases from surface impoundments and examine the downstream fate and transport, and ultimately risk, of CCR constituents. US EPA (2014) described the surface impoundment model as follows:

> Surface impoundments are conceptualized as square units that are constructed anywhere from entirely above grade to entirely below ground surface. During operation, a surface impoundment receives waste sluiced from the facility. Over time, impoundment water may be lost to some combination of infiltration, evaporation, and controlled discharges to other impoundments and nearby water bodies, while the CCR solids either accumulate until the surface impoundment's capacity is reached or are periodically dredged for final disposition elsewhere. To reflect that the majority of impoundments are periodically dredged, the conceptual model assumes that dredging losses are balanced out by continued loading from

> the facility, resulting in a constant ponding depth over the operational life (US EPA, 2014; emphasis added).

As described in detail in Section 3, the storage ponds of interest differ significantly from the surface impoundments that were the focus of the 2014 CCR Risk Assessment. Most notably, the storage ponds did not receive sluiced CCR from the facility. Sluiced CCR refers to the practice of mixing CCR generated at the coal-burning facility with water for the purpose of transport to the surface impoundment. The assumption that surface impoundments used to model risk were receiving large volumes of CCR mixed with water is essential. As noted in the 2015 CCR Rule, "units that contain a large amount of CCR managed with water, under a hydraulic head that promotes the rapid leaching of contaminants," which, in turn, will drive risk.

Additionally, the conceptual model presented by US EPA suggests that the CCR solids accumulate "until the surface impoundment capacity was reached, at which point they are periodically dredged for final disposition elsewhere." While some of the storage ponds of interest were dredged, this process was not conducted regularly or because the CCR was "at capacity." As indicated in Table 4.2, some of the storage ponds of interest never had CCR removed (except in a 2003 cleaning event when the MGS switched to full dry-handling of fly ash), while others had CCR (mainly sediment and other debris) removed only once or twice throughout their operational lifespan, or only had sediment removed when the pond was closed (SIPC, 2021).

Table 4.2 Dredging and Cleaning Activities at the Storage Ponds of Interest

Ponds	Dredging or Cleaning Activities[a]
South Fly Ash Pond	Debris/sediment removed in 2003.
Pond 3	Debris/sediment removed in 2003, 2006, and 2011.
Pond 3A	Debris/sediment removed in 2003. Water drained and sediment cleaned in 2014.
Pond S-6	Debris/sediment removed in 2003.
Pond 4	Debris/sediment removed in 2003 and 2012.
Former Pond B-3	Debris/sediment removed in 2003. Dewatered and cleaned down to the clay in 2017.

Notes:
CCR = Coal Combustion Residuals.
(a) When MGS switched to full dry-handling of fly ash in 2003, all of the storage ponds of interest had debris (and any CCR) cleaned (SIPC, 2021).
Source: SIPC, 2021.

4.3 The depth of CCR in the ponds of interest at MGS were significantly smaller than the surface impoundments modeled in the 2014 CCR Risk Assessment

Due to the probabilistic design of the 2014 CCR Risk Assessment, it is challenging to determine where the storage ponds of interest at MGS fit within the nationwide distribution of CCR storage conditions that form the basis of the risk assessment. However, an important factor influencing risk is the amount of CCR stored in the surface impoundments. The depth and volume of the sediment/CCR mixture (including an estimate of CCR only) for each storage pond of interest at MGS is presented in Section 3.3. These values are also replicated below in Table 4.4. The 2014 CCR Risk Assessment does not explicitly provide the CCR volume in each impoundment. Instead, it presents the total depth of the surface impoundments based on a nationwide survey (US EPA, 2014). The total surface impoundment depth data, which ranged from 0.5 to 190 feet (Table 4.3), serve as a proxy for the depth (*i.e.*, thickness) of the CCR-water mixture (*i.e.*, sluiced CCR) in each impoundment.

Table 4.3 Depth of Surface Impoundments (in Feet) Presented in the 2014 CCR Risk Assessment

Minimum	50th Percentile	90th Percentile	Maximum
0.5	13.6	36.6	190.1

Source: US EPA (2014).

Table 4.4 provides a comparison of the depth of CCR at the storage ponds of interest at MGS compared to the surface impoundments evaluated in the 2014 CCR Risk Assessment (US EPA, 2014). Because the information available for the MGS storage ponds of interest varies slightly from the data used by US EPA, several comparisons are presented.

- Using the estimated thickness of CCR: The MGS storage ponds of interest have a CCR thickness less than all surface impoundments across the US, with the exception of the South Fly Ash Pond and Pond 4, which both have a CCR thickness less than 99% of all of the nationwide surface impoundments that were modeled as part of this risk assessment.
- Using the estimated thickness of sediment: When using a more conservative approach that considered the total measured thickness of the sediment/CCR mixture, the MGS storage ponds of interest still have a CCR thickness that is less than 98%-99% of surface impoundments across the US.

Table 4.4 Comparison of Thicknesses with SI Depth Distribution

Storage Pond	CCR Thickness (ft)	Sediment Thickness (ft)	CCR Thickness as Percentile of Depth Distribution of SI in 2014 CCR Risk Assessment	Sediment Thickness as Percentile of Depth Distribution of SI in 2014 CCR Risk Assessment
South Fly Ash Pond	0.63	1.57	1%	2%
Pond 3	0.39	1.38	< Minimum SI Depth	1%
Pond 3A	0.39	1.45	< Minimum SI Depth	2%
Pond S-6	0.35	0.84	< Minimum SI Depth	1%
Pond 4	0.90	1.67	1%	2%

Notes:
CCR = Coal Combustion Residuals; SI = Surface Impoundment.
Source: Haley & Aldrich, Inc. (2021); US EPA (2014).

4.4 The US EPA risk assessment was broadly applied even though most impoundments would not be expected to pose a risk

Although risk to human health was observed for 90th percentile for surface impoundments only, the CCR Rule was applied to all existing CCR disposal units. US EPA's rationale around this point was that it did not have direct authority to enforce the CCR Rule when it was established. Consequently, the requirements developed would need to be protected against the highest-risk CCR disposal scenarios. This intention is clearly expressed in the Rule:

> …the regulatory structure under which this rule is issued effectively limits the Agency's ability to develop the type of requirements that can be individually tailored to accommodate particular site conditions. Under sections 1008(a) and 4004(a), EPA must establish national criteria that will operate effectively in the absence of any guaranteed regulatory oversight (i.e., a permitting program), to achieve the statutory standard of 'no reasonable probability of adverse effects on health or the environment' at all sites subject to the standards. EPA

> was unable to develop a performance standard that would allow for alternatives to closure, but would also be sufficiently objective and precise to minimize the potential for abuse (US EPA, 2015).

Further to this point, as noted in the Introduction, one of the main reasons US EPA determined that CCR regulations were necessary is that state CCR management programs were inconsistent or, in some cases, nonexistent. This inconsistency meant that US EPA could not be assured that states had adequate programs to ensure that CCR units did not pose a risk to human health and the environment. However, Illinois has established a robust CCR regulatory program that allows for differentiation between surface impoundments with "a reasonable probability of adverse effects on health or the environment" and those ponds containing "de minimis" amounts of CCR that are materially different from the surface impoundments evaluated in the 2014 CCR Risk Assessment, and do not pose a risk. Indeed, as summarized in Section 5 and detailed in Attachment A, a risk assessment conducted at MGS has demonstrated that the storage ponds of interest do not pose a risk to human health or the ecological receptors in the environment.

5 A site-specific risk assessment has confirmed that the US EPA risk assessment does not adequately characterize the conditions at MGS and has demonstrated that the CCR storage ponds of interest at MGS do not pose a risk to human health or the environment

The primary directive of Part 845 is to ensure that existing or inactive surface impoundments "do not pose a reasonable probability of adverse effects on health or the environment" (IEPA, 2021). To evaluate this important criterion, Gradient conducted a risk assessment to evaluate the potential human health and environmental risks associated with the storage ponds of interest at the MGS site (Gradient, 2024a). This assessment was performed using widely accepted scientific methods, models, and approaches that align with the guidance provided by IEPA and US EPA, while also considering the federal CCR Rule.

Gradient relied on groundwater data collected between 2018 and 2023, surface water data from the Lake of Egypt (from June 2020, and 2018-2023), and modeled surface water and sediment data for the Little Saline Creek. The assessment focused on how CCR constituents measured in the groundwater at and near the site could impact human receptors in the vicinity, based on site-specific groundwater characteristics.

The evaluation focused on the storage ponds of interest, specifically those that contain minimal amounts of CCR. Because different storage ponds are located in various areas of the property and are influenced by different groundwater flow patterns, the South Fly Ash Pond was assessed separately from Pond 4, Pond S-6, Pond 3/3A, and Former Pond B-3. It is important to consider the risk assessment as a screening assessment. Some of the exposure assumptions used, such as using the maximum groundwater constituent concentration instead of a central tendency or a value that better reflects specific receptor locations, may result in an overestimation of risk.

The full risk assessment can be found in Attachment A, but a summary of our approach, as well as key observations and conclusions from the risk evaluation, are highlighted below.

Conceptual Site Model

- The uppermost water-bearing zone (*i.e.*, the Unlithified Unit) at the MGS is a shallow, hydraulically perched layer consisting of fill and residuum (silts and clays), with a saturated thickness of up to 10 feet approximately (Hanson Professional Services Inc., 2021). Groundwater (and CCR-related constituents originating from the MGS) may migrate vertically downward through the Unlithified Unit and migrate away from the impoundments.
- Groundwater at the MGS generally flows northeast toward the Little Saline Creek. However, south of the Lake of Egypt Road, groundwater has an eastern flow component toward the Lake of Egypt (SIPC, 2007).

Data Used to Characterize Risk to Human Health and the Environment

- Monitoring data (2018-2023) from two different sets of wells were collected to characterize the groundwater in the vicinity of the impoundments of interest. Samples were analyzed for metals specified in Part 845.600 (IEPA, 2021), as well as for general water quality parameters, including pH, chloride, fluoride, sulfate, and total dissolved solids.
    - Wells C-1, C-2, C-3, and well EBG were used to characterize groundwater quality near the South Fly Ash Pond.
    - Wells S-1, S-2, S-3, S-4, S-5, and S-6 were used to characterize groundwater quality near Pond 4, Ponds 3 and 3A, Pond S-6, and Former Pond B-3.
- Surface water samples were collected from five locations in the Lake of Egypt in June 2020. Analyses were performed on a variety of metals as outlined in Part 845.600 (IEPA, 2021), along with several general water quality parameters. The risk assessment also used surface water data obtained from the public water supply (PWS) intake on the Lake of Egypt for 2018-2023.
- No surface water or sediment data were available for Little Saline Creek; therefore, Gradient estimated (*i.e.*, modeled) concentrations of both media in the Little Saline Creek using the data from the groundwater monitoring wells located in the north portion of the site (*i.e.*, S-wells) and assuming that all the impacted groundwater flows to the Little Saline Creek. Gradient ignored any adsorption by subsurface soil and conservatively assumed that the groundwater concentrations were uniformly equal to the maximum detected concentration of each individual constituent.

Human Health Risk Evaluation

- The human health risk evaluation considered risks for all receptors potentially exposed to CCR constituents *via* impacted groundwater related to the storage ponds of interest including nearby residents using groundwater and surface water for drinking water; recreators using the Lake of Egypt for boating, swimming, and fishing; and recreators using the Little Saline Creek for fishing.
- To evaluate human health risks, maximum concentrations of CCR-related constituents in the groundwater were compared to Part 845 GWPSs to identify human health constituents of interest (COIs).
- Using this approach, the COIs for the South Fly Ash Pond based on data from the C-wells and EBG well included boron, cadmium, cobalt, and thallium. The COIs associated with the remaining storage ponds of interest (Pond 3, Pond S-6, Ponds 3/3A, and Former Pond B-3) based on data from the S-wells included arsenic, beryllium, boron, cadmium, cobalt, lead, and thallium.
- Based on the screening approach and principles and procedures consistent with IEPA (*e.g.*, IEPA, 2013, 2019) and the US EPA guidance (US EPA, 1989), Gradient concluded that none of the COIs evaluated pose a risk concern to residents or recreators impacted by CCR constituents. More details on the risk evaluation for each receptor group are discussed below.
    - <u>Groundwater Used for Drinking Water</u>: A survey of potential drinking water wells identified four private water wells within 1,000 meters of the facility, although the use of these wells for drinking water has not been confirmed. These wells were not considered part of a complete exposure pathway. One private well is located upgradient of the facility, while the other three wells are situated side-gradient. As a result, it is unlikely that these wells will be affected by any CCR constituents in groundwater originating from the storage ponds of interest. Additionally, the private wells are significantly deeper than the monitoring wells used to assess

groundwater quality around the impoundments, with depths ranging from 95 to 260 feet compared to depths ranging from 12 to 28 feet for the monitoring wells.

- Surface Water Used for Drinking Water: The Lake of Egypt serves as a public water supply (IEPA, 2024). There have been no exceedances of the Illinois GWPSs. Consequently, using surface water from the Lake of Egypt for residential drinking water does not present an unacceptable risk to residents.
- Lake of Egypt Recreators: Measured concentrations of COIs in surface water were compared to the calculated Illinois human threshold criteria (HTC) values (IEPA, 2019). These values are designed to protect against recreational exposure through water and/or fish ingestion. All surface water concentrations were below the benchmarks, indicating that recreational exposure to COIs is not expected to pose an unacceptable risk.
- Little Saline Lake Recreators: Modeled concentrations of COIs in surface water were compared to the calculated Illinois HTC values. All surface water concentrations were below the benchmarks, indicating that recreational exposure to COIs is not expected to pose an unacceptable risk.

Environmental Risk Evaluation

- The environmental risk evaluation considered risks to aquatic ecological receptors (*i.e.,* ecological risk) in Little Saline Creek. Both direct toxicity as well as secondary toxicity *via* bioaccumulation were evaluated.
- Although ecological receptors are not exposed to groundwater, groundwater can migrate into the adjacent surface water and impact ecological receptors. To identify ecological receptor COIs, maximum concentrations of CCR-related constituents in the groundwater (as measured in the S-wells) were compared to ecological surface water benchmarks protective of aquatic life (*i.e.*, IEPA [2019] surface water quality standards [SWQSs], US EPA Region IV [2018] surface water Ecological Screening Values [ESVs]).
- Using this approach, the ecological COIs were cadmium, cobalt, lead, and thallium.
- Based on the screening approach and principles and procedures consistent with IEPA (*e.g.*, IEPA, 2013, 2019) and the US EPA guidance (US EPA, 1989), Gradient concluded that none of the COIs evaluated to pose a risk concern to ecological receptors impacted by CCR constituents. More specifically with regard to specific media:
  - The maximum modeled COI concentrations in surface water were compared to the benchmarks protective of aquatic life. The modeled surface water concentrations for the COIs were below their respective benchmarks. Thus, none of the COIs evaluated are expected to pose an unacceptable risk to aquatic life in the Little Saline Creek from surface water exposure.
  - The maximum modeled COI sediment concentrations were below their respective sediment screening benchmarks. Thallium did not have a sediment screening level, but the modeled thallium sediment concentration was below the soil ESV value protective for ecological receptors. Thus, none of the COIs evaluated are expected to pose an unacceptable risk to aquatic life in the Little Saline Creek from sediment exposure.
  - None of the COIs – cadmium, cobalt, lead, and thallium – are considered bioaccumulative.

Based on the available data, the results of the site-specific risk assessment at MGS confirm that there is no unacceptable risk to human health or the environment from CCR constituents that may have migrated to groundwater. These findings indicate that the storage ponds of interest do not present the same level of risk as the surface impoundments evaluated in the US EPA CCR risk assessment, particularly the high-end (90th percentile) risks that served as basis for the 2015 CCR Rule. Notably, there were no human health risks from arsenic, lithium, or boron, as observed in the US EPA's risk assessment. The site-specific environmental risks at MGS were consistent with the 2014 US EPA CCR risk assessment, which also showed no risk, even at the 90th percentile. Taken together, the MGS risk assessment findings satisfy the overarching principle of Part 845, which states that "CCR surface impoundments [should] not pose a reasonable probability of adverse effects on health or the environment."

The lack of current risk at MGS suggests that granting a petition for an adjusted standard exempting the storage ponds of interest from the requirements of Part 845 will not change risks to human health or the environment; that is, subjecting the storage ponds of interest to Part 845 requirements will not result in a meaningful reduction in risk. In contrast, it is possible that some remediation activities, including those involving closure-by-removal, may lead to short-term impacts on air quality, increased greenhouse gas (GHG) emissions, and heightened energy consumption. Additionally, these activities could lead to a rise in worker injuries, increased accidents, and greater traffic and noise disturbances for nearby communities. The absence of a clear risk-benefit was specifically demonstrated in the impact assessment for Pond 4 (Gradient, 2024b) and may also be absent for the other storage ponds of interest at MGS.

6 Conclusions

Based on my understanding of the 2015 CCR Rule, the 2014 CCR Risk Assessment by US EPA in support of the Rule, as well as the history of operations of the ponds of interest at MGS, I conclude that the MGS ponds qualify as ponds containing minimal amounts of CCR and should not be regulated as surface impoundments under Part 845. This conclusion is supported by the following key evidence:

- US EPA's definition of a surface impoundment, which as adopted by Part 845, excludes surface impoundments with *de minimis* CCR, noting that "[U]nits containing only truly 'de minimis' levels of CCR are unlikely to present the significant risks this rule is intended to address" (US EPA, 2015).
- The MGS ponds in question were never used to store or dispose of wet CCR; they did not receive sluiced CCR directly. Any amount of CCR that entered these ponds was minimal compared to CCR surface impoundments that received sluiced CCR over an extended period. Consequently, the amount of CCR present in these ponds is only a small fraction of what would be expected in an impoundment designed to receive CCR from coal-burning operations directly. Instead, the use of these storage ponds – such as for wastewater management and run-off control – is consistent with practices that would result in *de minimis* CCR levels.
- The minimal amount of CCR in the storage ponds of interest has been quantified, confirming that the amount of CCR is *de minimis*; the estimated amount of CCR in almost all the MGS storage ponds of interest is lower than all of the CCR surface impoundments evaluated in US EPA's 2014 CCR Risk Assessment in support of the 2015 CCR Rule.
- The surface impoundments evaluated in US EPA's 2014 CCR Risk Assessment were fundamentally different from the storage ponds at MGS. Specifically, US EPA's risk assessment assumed that the surface impoundments received high volumes of sluiced CCR, which required periodic dredging. In contrast, the ponds at MGS did not regularly receive wet CCR, except for one pond on three to four isolated occasions. As a result, periodic CCR removal was not necessary. Any CCR removal that did occur was minimal and limited to those isolated instances.
- A risk assessment conducted at MGS has demonstrated that the storage ponds of interest do not pose a risk to human health or the environment. This finding confirms that the storage ponds of interest are unlike the 90th percentile surface impoundments that formed the risk-basis of the 2015 CCR Rule. The MGS risk assessment supports the Part 845 directive that requires that "CCR surface impoundments do not pose a reasonable probability of adverse effects on health or the environment."

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Attachment A

Human Health and Ecological Risk Assessment, Marion Power Station, Southern Illinois Power Cooperative, Marion, Illinois

Human Health and Ecological Risk Assessment
Marion Power Station
Southern Illinois Power Cooperative
Marion, Illinois

Prepared by

Ari Lewis

Ari S. Lewis, M.S.
Principal

December 20, 2024
Corrected on January 29, 2025

GRADIENT
www.gradientcorp.com
One Beacon Street, 17th Floor
Boston, MA 02108
617-395-5000

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Abbreviations

ADI	Acceptable Daily Intake
BCF	Bioconcentration Factor
CCR	Coal Combustion Residuals
CEM	Conceptual Exposure Model
COI	Constituent of Interest
COPC	Constituent of Potential Concern
CSM	Conceptual Site Model
GWPS	Groundwater Protection Standard
GWQS	Groundwater Quality Standard
HTC	Human Threshold Criteria
ID	Identification
IEPA	Illinois Environmental Protection Agency
ISGS	Illinois State Geological Survey
K_d	Equilibrium Partitioning Coefficient
MCL	Maximum Contaminant Level
MGS	Marion Power Generating Station
NRWQC	National Recommended Water Quality Criteria
ORNL RAIS	Oak Ridge National Laboratory's Risk Assessment Information System
pCi/L	Picocuries per Liter
PRG	Preliminary Remediation Goal
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SIPC	Southern Illinois Power Cooperative
SWQS	Surface Water Quality Standard
US EPA	United States Environmental Protection Agency

1 Introduction

Southern Illinois Power Cooperative (SIPC) owns and operates the Marion Power Generating Station (MGS), a gas and coal-fired electric power generating facility in Marion, Illinois. The MGS is located in Williamson County, approximately eight miles south of Marion, Illinois, on the northwestern bank of the Lake of Egypt (Figure 1.1). The MGS began operation in 1963. The area surrounding the facility is a rural agricultural community (Kleinfelder, 2013). The MGS has several surface impoundments that have been used for storage of coal combustion residuals (CCR) and several impoundments that were used to support other operational purposes (*e.g.*, wastewater storage, surface water run-off collection). This report addresses potential impacts from the surface impoundments (*i.e.*, storage ponds) that did not routinely receive CCRs and consequently contain a *de minimis* amount of CCRs. These storage ponds include:

- Pond 4
- Pond 3 and Pond 3A
- Pond S-6
- Pond B-3
- South Fly Ash Pond

This report presents the results of an evaluation that characterizes potential risk to human and ecological receptors that may be exposed to CCR constituents in environmental media originating from the storage ponds listed above. This risk evaluation was performed to support a petition for relief from the closure schedule required under the Illinois coal ash rule (IEPA, 2021). Human health and ecological risks were evaluated for Site-specific constituents of interest (COIs). The conceptual site model (CSM) assumed that Site-related COIs in groundwater may migrate to the Lake of Egypt or to Little Saline Creek and affect surface water in the vicinity of the Site.

Consistent with United States Environmental Protection Agency (US EPA) guidance (US EPA, 1989), this report used a tiered approach to evaluate potential risks, which included the following steps:

1. Identify complete exposure pathways and develop a conceptual exposure model (CEM).
2. Identify Site-related COIs: Constituents detected in groundwater were considered COIs if their maximum detected concentration over the period from 2018 to 2023 exceeded a groundwater protection standard (GWPS) identified in Part 845.600 (IEPA, 2021), or a relevant surface water quality standard (SWQS) (IEPA, 2019).
3. Perform screening-level risk analysis: Compare maximum measured or modeled COI concentrations in surface water and sediment to conservative, health-protective benchmarks in order to determine constituents of potential concern (COPCs).
4. Perform refined risk analysis: If COPCs are identified, perform a refined analysis to evaluate potential risks associated with the COPCs.
5. Formulate risk conclusions and discuss any associated uncertainties.

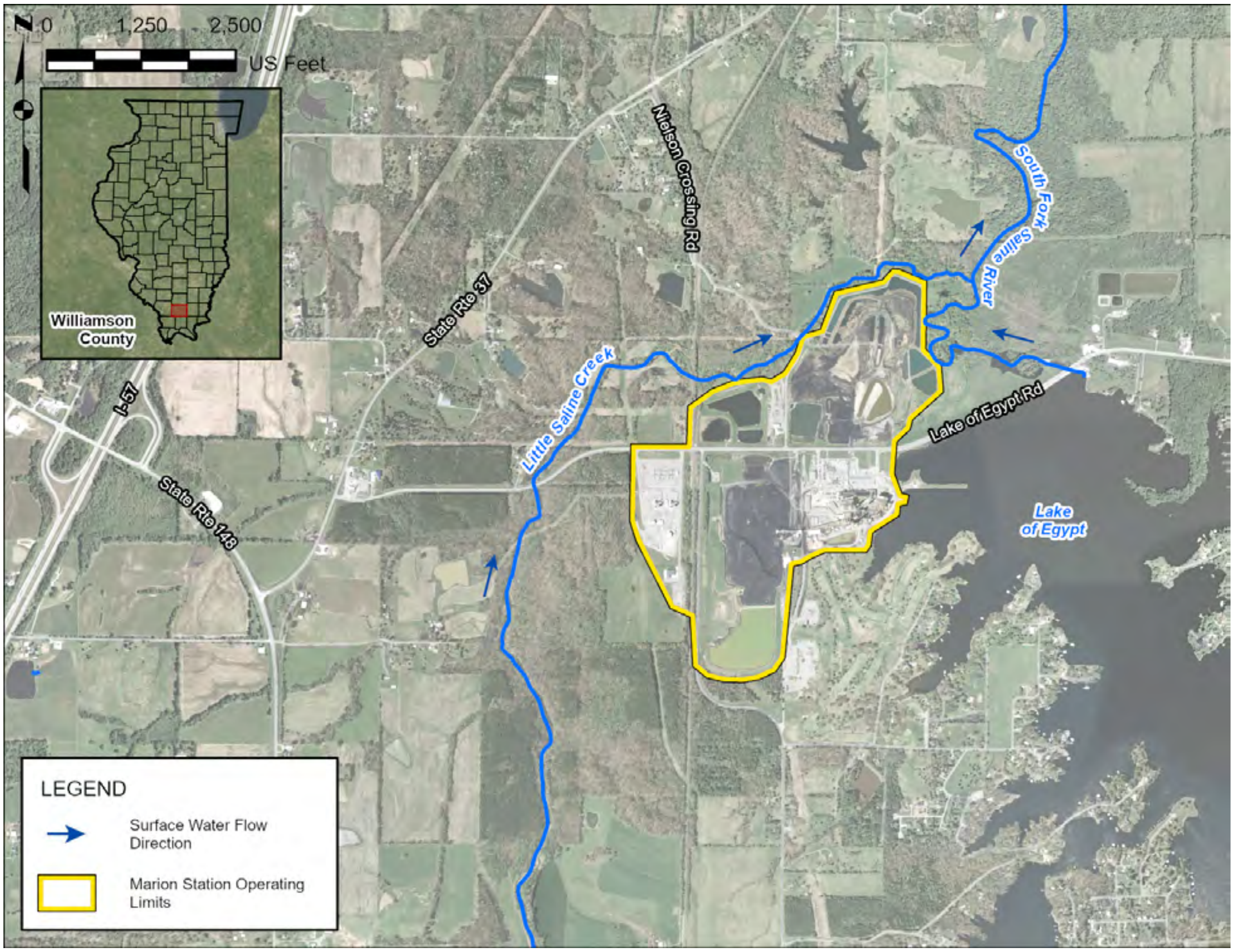

Figure 1.1 Site Location Map. Sources: Golder Associates Inc., 2021; USGS, 2022; US Census Bureau, 2016; USGS, 2011.

This assessment relies on a conservative (*i.e.*, health-protective) approach and is consistent with the risk approaches outlined in US EPA guidance (US EPA, 1989; US EPA, 2004; US EPA [Region IV], 2018). Specifically, we considered evaluation criteria detailed in Illinois Environment Protection Agency (IEPA) guidance documents (*e.g.*, IEPA, 2013, 2019), incorporating principles and assumptions consistent with the Federal CCR Rule (US EPA, 2015a) and US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals" (US EPA, 2014).

US EPA has established acceptable risk metrics. Risks above these US EPA-defined metrics are termed potentially "unacceptable risks." Based on the evaluation presented in this report, no unacceptable risks to human or ecological receptors resulting from CCR exposures associated with the ponds listed above were identified. This means that the risks from the Site are likely indistinguishable from normal background risks. Specific risk assessment results include the following:

- No completed exposure pathways were identified for any groundwater receptors; consequently, no risks were identified relating to the use of groundwater for drinking water and other household purposes.
- No unacceptable risks were identified for the use of Lake of Egypt surface water as drinking water.
- No unacceptable risks were identified for recreators boating in Lake of Egypt.

- No unacceptable risks were identified for anglers consuming locally-caught fish.
- No unacceptable risks were identified for ecological receptors exposed to surface water or sediment.
- No bioaccumulative ecological risks were identified.

It should be noted that this evaluation incorporates a number of conservative assumptions that tend to overestimate exposure and risk (discussed in Section 3.5).

2 Site Overview

2.1 Site Description

The MGS is located in Williamson County, approximately eight miles south of Marion, Illinois, on the northwestern bank of the Lake of Egypt. The MGS facility is bordered to the east by Lake of Egypt, to the southeast by a golf course (Lake of Egypt Country Club), and to the south, west, and north by farmland (Figure 2.1). Little Saline Creek is located just north of the MGS facility boundary; it flows northeast and joins the South Fork Saline River about 600 feet east of the facility boundary (Figure 2.1).

Only "relatively small amounts of fly ash" were produced at the Site (SIPC, 2021a). Fly ash that was generated was transported and stored in the Initial Fly Ash Holding Area, Replacement Fly Ash Holding Area, Pond A-1, or the Former On-Site Landfill (SIPC, 2021a). The former Fly Ash Holding Areas are within the cover area for the Former On-Site Landfill (SIPC, 2021a). Other ponds located on Site (Figure 2.1) and a description of their historic and current operation are described below.

- Ponds 1 and 2 received sluiced bottom ash from power generation units 1, 2, 3, and 4 (Figure 1.1; SIPC, 2021a). During the entire pond operational life, bottom ash was removed from Ponds 1 and 2, and sold for beneficial reuse to shingle manufacturers, grit blasting companies, and local highway departments. Decanted water from Ponds 1 and 2 flowed into Pond 4.
- The Former Emery Pond was constructed in the late 1980s to hold stormwater drainage from the generating station (Figure 1.1; SIPC, 2021a). All CCRs in Emery Pond have been removed and the pond has been closed (SIPC, 2021a). Groundwater corrective action is currently on-going (Hanson Professional Services Inc., 2021).
- South Fly Ash Pond was constructed in 1989 and was originally intended to be a replacement for Pond A-1 (Figure 1.1; SIPC, 2021a). Ultimately, Pond A-1 did not need to be replaced. Thus, the South Fly Ash Pond was only used to receive decant water from the Former Emery Pond while it was operational. No CCRs were ever directly sent to or disposed of in the South Fly Ash Pond (SIPC, 2021a).
- Ponds 3 and 3-A were secondary ponds that received overflow from the fly ash holding areas (Figure 1.1; SIPC, 2021a). They also received storm water runoff, coal pile runoff, and water from the facility floor drains. In approximately 1982, Pond 3-A was separated from Pond 3 by construction of an internal berm. All sediment and debris were removed from Pond 3 in 2006 and 2011. All sediment and debris were removed from Pond 3-A in 2014. Subsequently, no CCRs were ever directly sent to or disposed in Ponds 3 or 3-A. Currently, water from the South Fly Ash Pond flows into Pond 3 (SIPC, 2021a).
- Pond S-6 was originally built to manage stormwater associated with the Former Landfill (Figure 1.1; SIPC, 2021b). Initially, water in Pond S-6 discharged to Little Saline Creek through Outfall 001; however, in approximately 1993, water from Pond S-6 was pumped to Pond 4. No CCRs were ever directly sent to or disposed in the Pond S-6 (SIPC, 2021a).
- Pond B-3 was built in 1985 and was primarily used as a secondary pond that received water from Pond A-1 (Figure 1.1; SIPC, 2021a). During periodic shutdowns of Pond A-1, Pond B-3 may have received some short-term discharges of fly ash from Unit 1, 2, and 3 prior to their shutdown (SIPC, 2021a). In 2017, Pond B-3 was dewatered and all sediment and CCR were excavated.

- Pond 4 was built in 1979 and historically received decant water from Ponds 1 and 2 for secondary treatment and received runoff from the coal pile (Figure 1.1; Kleinfelder, 2013; SIPC, 2021 a,b). No CCRs were ever directly sent to or disposed in the Pond 4. All sediment and debris were removed from Pond 4 in 2012. Currently, Pond 4 receives overflow from Pond S-6; water in Pond 4 discharges into the Little Saline Creek *via* Outfall 002 (Kleinfelder, 2013; SIPC, 2021a).

The ponds are shown in Figure 2.1. This Risk Assessment focuses on the storage ponds that supported operations but never directly received CCRs on a routine basis. These storage ponds include: Pond 4, Pond 3 and 3A, Pond S-6, Pond B-3, and the South Fly Ash Pond.

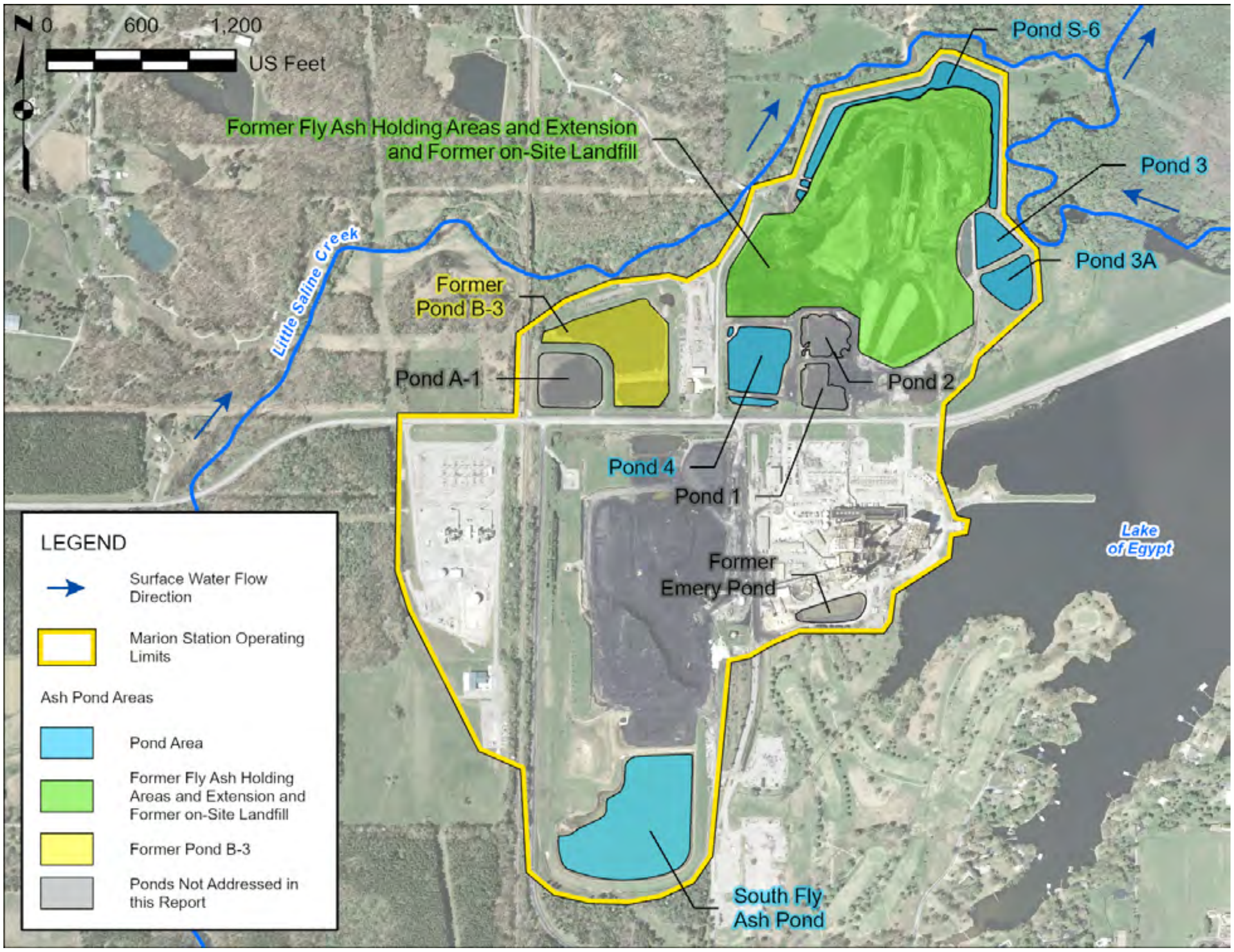

Figure 2.1 Site Layout. Sources: Golder Associates Inc., 2021; USGS, 2022; Andrews Engineering, 2021; SIPC, 2021a; USGS, 2011.

2.2 Geology/Hydrogeology

The Site is located at the southern edge of the Illinois Basin in the Shawnee Hills Section of the Interior Low Plateaus physiographic province (Golder Associates Inc., 2021). The Illinois Basin is a depositional and structural basin composed of sedimentary rocks ranging in age from Cambrian to Permian. The southern portion of the basin is characterized by extensive faulting, and some of these faults host commercially significant fluorite vein deposits (Golder Associates Inc., 2021). The regional stratigraphic sequence includes the following, from the surface downward (Golder Associates Inc., 2021):

- The Caseyville/Tradewater Formation: consists of lenticular, vertically and horizontally interbedded layers of sandstone, siltstone, and shale beneath a relatively thin layer of unconsolidated materials. It ranges from 190 to 500 feet in thickness.
- The Kinkaid Formation: consists of limestone, shale, claystone, and sandstone. It is separated from the overlying Pennsylvanian rocks of the Caseyville Formation by a laterally extensive unconformity. It ranges from 120 to 160 feet in thickness.
- The Degonia Formation: consists of thin, very-fine grained sandstone, siltstone, shale, and irregular chert beds. It ranges from 20 to 64 feet in thickness.
- The Clore Formation: consists of sandstone, shale and limestone, which sporadically outcrops at the surface. It ranges from 110 to 155 feet in thickness.

On Site, soils overlying the Caseyville/Tradewater Formation consist of glacial and alluvial deposits including layers of silty clay, clayey silt, silty sand and clayey sand (Kleinfelder, 2013). Table 2.1 provides a detailed summary of the Site lithology for the upper 50 feet (Golder Associates Inc., 2021).

Table 2.1 Site Geology

Lithology	Description
Peoria/Roxana Silt	Light yellow-tan to gray, fine sandy silt
Glasford Formation	Silty/sandy diamictons with thin lenticular bodies of silt, sand, and gravel
Caseyville Formation/Bedrock	Sedimentary rocks including sandstone, limestone, and shales

Source: Golder Associates, Inc., 2021; Kleinfelder, 2013.

The Site is located within the South Fork Saline River/Lake Egypt watershed. Groundwater in the southern/eastern portion of the Site flows toward and discharges into the Lake of Egypt; groundwater throughout the rest of property flows in a northeasterly direction toward Little Saline Creek (Figure 3.3; SIPC, 2007). The uppermost water-bearing zone (*i.e.*, the Unlithified Unit) is a shallow, hydraulically perched layer consisting of fill and residuum (silts and clays), with a saturated thickness of approximately up to 10 feet (Hanson Professional Services Inc., 2021). The average horizontal hydraulic conductivity is estimated to be approximately 1.5×10^{-4} cm/s in the Unlithified Unit (Golder Associates Inc., 2021). The hydraulic gradient was estimated to be 0.019 based on measured groundwater elevations at monitoring wells S-3 and S-6 (SIPC, 2007).

2.3 Conceptual Site Model

A CSM describes sources of contamination, the hydrogeological units, and the physical processes that control the transport of water and solutes. In this case, the CSM describes how groundwater underlying the MGS migrates and potentially interacts with surface water and sediment in the Lake of Egypt and Little

Saline Creek. The CSM was developed using site-specific hydrogeologic data, including information on groundwater flow and surface water characteristics.

Groundwater (and CCR-related constituents originating from the MGS) may migrate vertically downward through the Unlithified Unit. As noted in Section 2.2, the dominant groundwater flow direction at the Site is to the northeast toward Little Saline Creek. However, south of Lake of Egypt Road, groundwater has an eastern flow component toward the Lake of Egypt (SIPC, 2007). Dissolved constituents in groundwater that flows into these two water bodies may partition between sediment and surface water.

2.4 Groundwater Monitoring

Data from the following monitoring wells were included in this risk assessment, as they are used to monitor groundwater quality downgradient and upgradient of the MGS (Figure 2.3):

- Wells C-1, C-2, C-3 and Well EBG; these wells were used to characterize groundwater quality near the South Fly Ash Pond.
- Wells S-1, S-2, S-3, S-4, S-5, S-6; these wells were used to characterize groundwater quality near the Pond 4, Pond 3 and 3A, Pond S-6, and Pond B-3.

The monitoring well construction details are presented in Table 2.2. The analyses presented in this report rely on the available data from these wells collected between 2018 and 2023. Groundwater samples were analyzed for a suite of total metals, specified in Illinois CCR Rule Part 845.600 (IEPA, 2021),[1] as well as general water quality parameters (pH, chloride, fluoride, sulfate, and total dissolved solids). A summary of the groundwater data used in this risk evaluation is presented in Tables 2.3a and 2.3b. The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with operations at MGS or that they have been identified as potential groundwater exceedances.

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[1] Samples were analyzed for a longer list of inorganic constituents and general water quality parameters (chloride, fluoride, sulfate, and total dissolved solids), but these constituents were not evaluated in the risk evaluation.

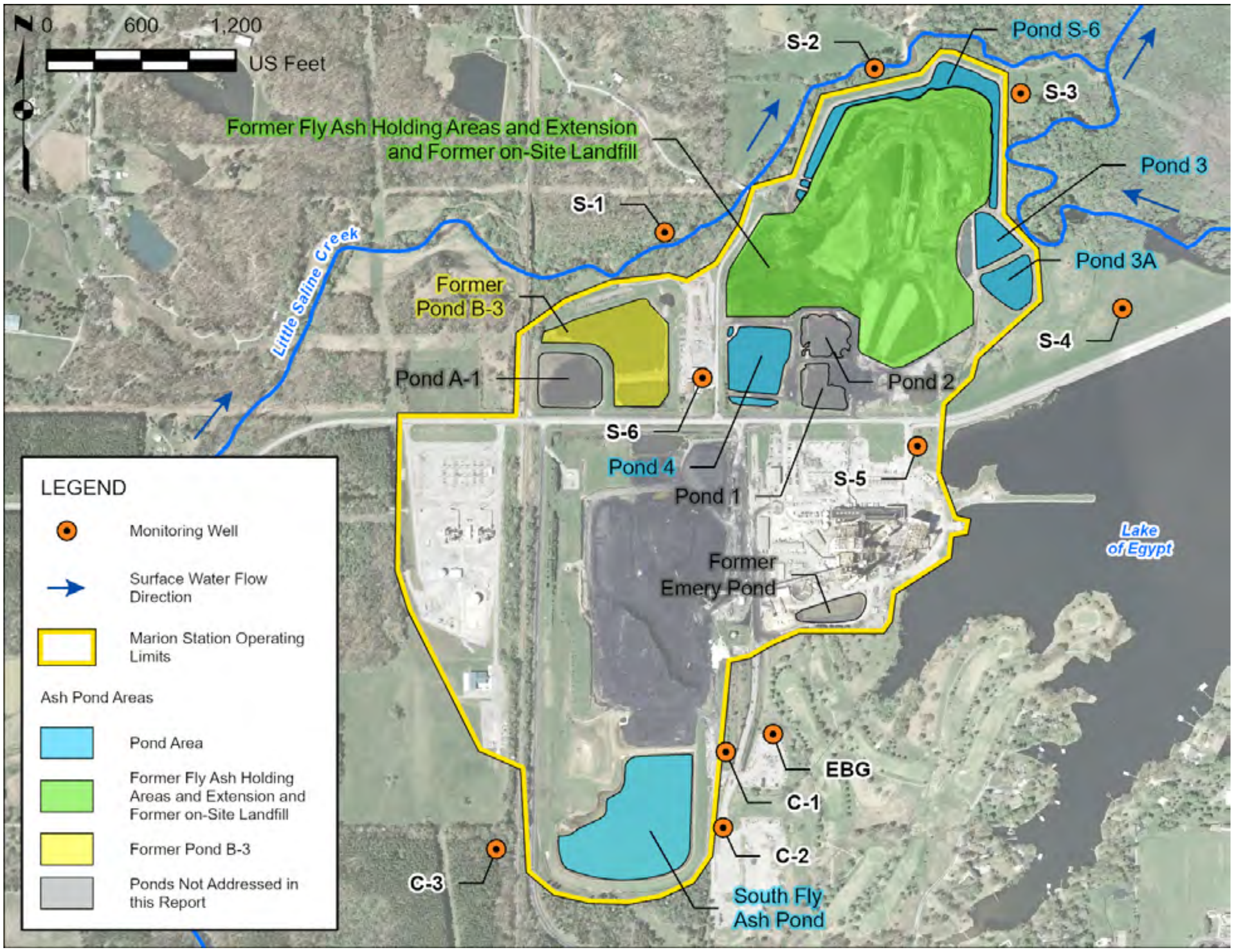

Figure 2.2 Monitoring Well Locations. Sources: Golder Associates Inc., 2021; USGS, 2022; SIPC, 2007; Andrews Engineering, 2021; SIPC, 2021a; USGS, 2011.

Table 2.2 Groundwater Monitoring Wells

Well	Date Constructed	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Well Depth (ft bgs)	Hydrostratigraphic Unit (Screened Interval)
C-1	2/16/2010	5	15	15	Unlithified Unit/Bedrock
C-2	2/16/2010	2	12	12	Unlithified Unit/Bedrock
C-3	(no info)	(no info)			Unlithified Unit/Bedrock
EBG	2/8/2017	18	28	28	Unlithified Unit/Bedrock
S-1	9/20/1993	15	25	25	Unlithified Unit/Bedrock
S-2	2/18/2010	16	26	27.5	Unlithified Unit/Bedrock
S-3	9/20/1993	15	25	25	Unlithified Unit/Bedrock
S-4	9/21/1993	8	18	18	Unlithified Unit/Bedrock
S-5	9/20/1993	12	22	22	Unlithified Unit/Bedrock
S-6	9/20/1993	12	22	22	Unlithified Unit/Bedrock

Notes:
bgs = Below Ground Surface; ft = Feet; EBG = Emery Pond Background Well.

Table 2.3a Groundwater Data Summary (2018-2023) for C-Wells + EBG

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	0	20	ND	ND	0.030
Arsenic	7	20	0.00040	0.0075	0.10
Barium	19	20	0.012	0.20	0.0050
Beryllium	3	21	0.00038	0.00060	0.020
Boron	36	81	0.011 J	12 J	0.50
Cadmium	5	77	0.00066	0.013	0.020
Chromium	8	21	0.00070	0.0042	0.030
Cobalt	13	21	0.00020 J	0.29 J	0.020
Lead	3	21	0.0011	0.0031	0.050
Lithium	8	13	0.014	0.024	0.060
Mercury	1	19	0.000070	0.000070	0.00020
Molybdenum	8	14	0.0012 J	0.015	0.040
Selenium	11	21	0.00060	0.033	0.025
Thallium	2	21	0.0012	0.031	0.040
Dissolved Metals (mg/L)					
Boron	12	24	0.040	0.92	0.50
Cadmium	0	24	ND	ND	0.0010
Radionuclides (pCi/L)					
Radium 226 + 228	9	11	0.12	2.7	0.33
Other (mg/L or SU)					
Chloride	61	63	2.4	570	20
Fluoride	19	24	0.10	0.68	0.50
pH	47	47	5.8	7.0	0
Sulfate	81	81	49	670	123
Total Dissolved Solids	51	51	100	4000	16

Notes:

EBG = Emery Pond Background Well; J = Estimated Value; mg/L = Milligrams per Liter; ND = Not Detected; pCi/L = Picocuries per Liter; SU = Standard Unit.

Blank cells indicate constituent not detected.

Table 2.3b Groundwater Data Summary (2018-2023) for S-Wells

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	0	12	ND	ND	0.0050
Arsenic	3	12	0.0089	0.12	0.050
Barium	12	12	0.020	1.5	NA
Beryllium	1	12	0.0081	0.0081	0.0050
Boron	35	126	0.0041	2.8	0.50
Cadmium	12	126	0.00068	0.055	0.002
Chromium	9	12	0.0014	0.069	0.0050
Cobalt	5	12	0.0012	0.054	0.010
Lead	7	12	0.0027	0.080	0.0050
Mercury	0	12	ND	ND	0.00020

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Selenium	3	12	0.0021	0.017	0.025
Thallium	1	12	0.046	0.046	0.025
Dissolved Metals (mg/L)					
Boron	14	48	0.0051	3.1	0.50
Cadmium	0	48	ND	ND	0.001
Other (mg/L or SU)					
Chloride	88	90	6.1	480	20
Fluoride	6	12	0.062	0.18	0.50
pH	66	66	5.7	6.9	NA
Sulfate	122	126	2.6	310	20
Total Dissolved Solids	66	66	78	4500	NA

Notes:
mg/L = Milligrams per Liter; NA = Not Available; ND = Not Detected; SU = Standard Unit.
Blank cells indicate constituent not detected.

2.5 Surface Water Monitoring

Surface water samples were collected by MGS from five locations in Lake of Egypt in June 2020. The sample locations are listed in Table 2.4, are shown in Figure 2.2, and the sampling results are summarized in Table 2.5. Surface water data are also available from the Lake of Egypt public water district as part of routine monitoring. The data used in this report were collected 2018-2023, and the sampling results are summarized in Table 2.6.

Table 2.4 Lake of Egypt Sample Locations

Sample ID	Description
LE-u	Upstream sample
LE-d	Spillway sample
LE-in	Public water supply intake
LE-b1	Bay sample #1
LE-b2	Bay sample #2

Figure 2.3 Surface Water Sample Locations. Source: Hanson (2021)

Table 2.5 Surface Water Data Summary for Lake of Egypt Samples

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Arsenic	0	5	ND	ND	0.025
Barium	5	5	0.00227	0.00265	NA
Boron	0	5	ND	ND	0.02
Cadmium	0	5	ND	ND	0.001
Chromium	0	5	ND	ND	0.005
Cobalt	0	5	ND	ND	0.005
Lead	0	5	ND	ND	0.001
Mercury	0	5	ND	ND	0.2
Selenium	0	5	ND	ND	0.001
Thallium	0	5	ND	ND	0.002
Other (mg/L)					
Chloride	1	5	4	4	4
Fluoride	0	5	ND	ND	0.1
pH	5	5	6.57	7.25	NA
Sulfate	5	5	16	17	NA
Total Dissolved Solids	5	5	44	60	NA

Notes:
mg/L = Milligrams per Liter; NA = Not Available; ND = Not Detected; SU = Standard Unit.
Blank cells indicate constituent was not detected.
Data collected on 6/1/2020.

Table 2.6 Surface Water Data Summary for Lake of Egypt Public Water District Data

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	0	6	ND	ND	0.003
Arsenic	0	6	ND	ND	0.001
Barium	6	6	0.021	0.0263	NA
Beryllium	0	6	ND	ND	0.001
Cadmium	0	6	ND	ND	0.003
Chromium	0	6	ND	ND	0.005
Mercury	0	6	ND	ND	0.0002
Selenium	1	6	0.0024	0.0024	0.002
Thallium	0	6	ND	ND	0.002
Radionuclides (pCi/L)					
Radium 226 + 228	1	1	1.03	1.03	NA
Other (mg/L)					
Chloride	6	6	10.4	23	NA
Fluoride	6	6	0.553	0.73	NA
Sulfate	6	6	34.6	51.7	NA
Total Dissolved Solids	6	6	87	158	NA

Notes:
mg/L = Milligrams per Liter; NA = Not Available; ND = Not Detected; pCi/L = Picocuries per Liter.
Data collected 2018-2023.

3 Risk Evaluation

3.1 Risk Evaluation Process

A risk evaluation was conducted to determine whether constituents present in groundwater underlying and downgradient of the MGS have the potential to pose adverse health effects to human and ecological receptors. The risk evaluation is consistent with the principles of risk assessment established by US EPA and has considered evaluation criteria detailed in Illinois guidance documents (*e.g.*, IEPA, 2013, 2019).

The general risk evaluation approach is summarized in Figure 3.1 and discussed below.

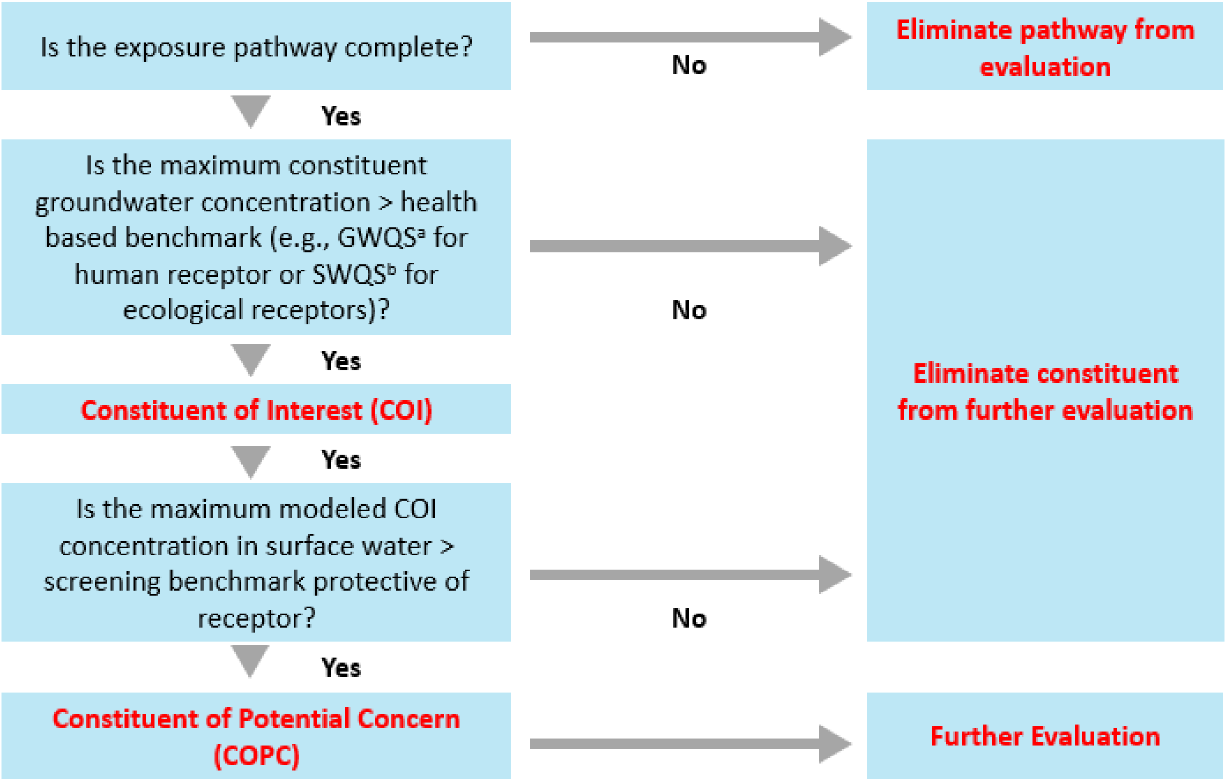

Figure 3.1 Overview of Risk Evaluation Methodology. IEPA = Illinois Environmental Protection Agency; GWQS = IEPA Groundwater Quality Standards; SWQS = IEPA Surface Water Quality Standards. (a) The IEPA Part 845 Groundwater Protection Standards (GWPS) were used to identify COIs. (b) IEPA SWQS protective of chronic exposures to aquatic organisms were used to identify ecological COIs. In the absence of an SWQS, US EPA Region IV Ecological Screening Values (ESVs) were used.

The first step in the risk evaluation was to develop the CEM and identify complete exposure pathways. All potential receptors and exposure pathways based on groundwater use and surface water use in the vicinity of the Site were considered. Exposure pathways that are incomplete were excluded from the evaluation.

Groundwater data were used to identify COIs. COIs were identified as constituents with maximum concentrations in groundwater in excess of groundwater quality standards (GWQS)[2] for human receptors, and SWQS for ecological receptors. Based on the CSM (Section 2.2), groundwater in the south half of the Site, on the west side of the South Fly Ash Pond, has the potential to interact with surface water in the Lake of Egypt. Therefore, potential facility-related constituents in groundwater may potentially flow toward and into surface water in the Lake of Egypt. Surface water samples have been collected from the Lake of Egypt adjacent to the Site, and Gradient used the measured surface data to evaluate potential risks to receptors in using the lake for recreation and as a source of drinking water.

Groundwater in the northern portion of the Site, near Pond 4, Pond 3 and 3A, Pond S-6, and Pond B-3 and in the northern portion of the South Fly Ash pond has the potential to interact with surface water in Little Saline Creek. No surface water has been collected from Little Saline Creek, therefore, Gradient modeled the COI concentrations in Little Saline Creek based on the groundwater data from the groundwater monitoring wells located in this portion of the Site (*i.e.*, S-wells). The measured and modeled COI concentrations in surface water and sediment were compared to conservative, generic risk-based screening benchmarks for human health and ecological receptors. These generic screening benchmarks rely on default assumptions with limited consideration of site-specific characteristics. Human health benchmarks are receptor-specific values calculated for each pathway and environmental medium that are designed to be protective of human health. Human health and ecological screening benchmarks are inherently conservative because they are intended to screen out chemicals that are of no concern with a high level of confidence. Therefore, a measured or modeled COI concentration exceeding a screening benchmark does not indicate an unacceptable risk, but only that further risk evaluation is warranted. COIs with maximum concentrations exceeding a conservative screening benchmark are identified as COPCs requiring further evaluation.

As described in more detail below, this evaluation relied on the screening assessment to demonstrate that constituents present in groundwater underlying the facility do not pose an unacceptable human health or ecological risk. That is, after the screening step, no COPCs were identified and further assessment was not warranted.

3.2 Human and Ecological Conceptual Exposure Models

A CEM provides an overview of the receptors and exposure pathways requiring risk evaluation. The CEM describes the source of the contamination, the mechanism that may lead to a release of contamination, the environmental media to which a receptor may be exposed, the route of exposure (exposure pathway), and the types of receptors that may be exposed to these environmental media.

3.2.1 Human Conceptual Exposure Model

The human CEM for the Site depicts the relationships between the off-Site environmental media potentially impacted by constituents in groundwater and human receptors that could be exposed to these media. Figure 3.2 presents a human CEM for the Site. It considers a human receptor who could be exposed to COIs hypothetically released into groundwater and surface water. The following human receptors and exposure pathways were evaluated for inclusion in the Site-specific CEM.

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[2] As discussed further in Section 3.3.2, GWQS are protective of human health and not necessarily of receptors. While receptors are not exposed to groundwater, groundwater can potentially enter into the adjacent surface water and impact receptors. Therefore, two sets of COIs were identified: one for humans and another for receptors.

- Residents – exposure to groundwater/surface water as drinking water;
- Residents – exposure to groundwater/surface water used for irrigation;
- Recreators in the Lake of Egypt to the east of the Site:
  - Boaters – exposure to surface water while boating;
  - Swimmers – exposure to surface water while swimming;
  - Anglers – exposure to surface water and consumption of locally caught fish.
- Recreators in Little Saline Creek to the north of the Site:[3]
  - Anglers – exposure to surface water and consumption of locally caught fish.

All of these exposure pathways were considered to be complete, except for residential exposure to groundwater used for drinking water or irrigation, and exposure to sediment. Section 3.2.1.1 explains why the residential drinking water and irrigation pathways are incomplete for groundwater. Section 3.2.1.2 discusses the use of surface water as a drinking water source. Section 3.2.1.3 provides additional description of the recreational exposures.

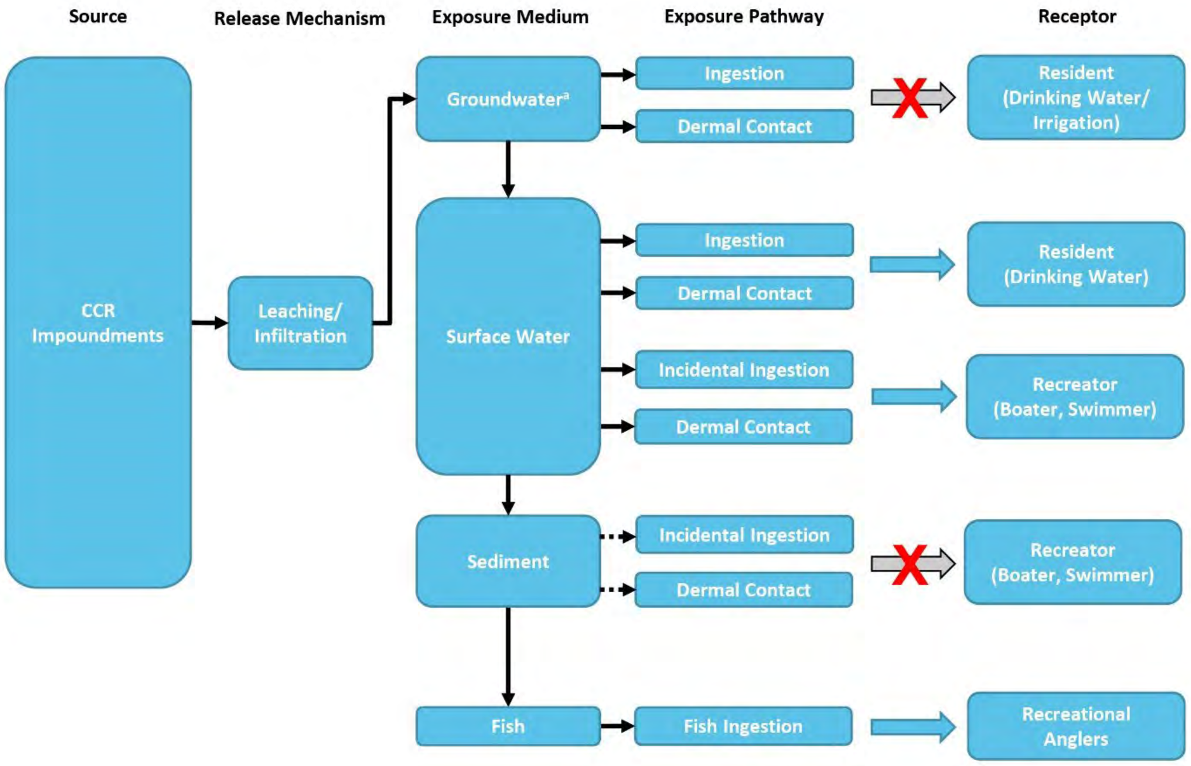

Figure 3.2 Human Conceptual Exposure Model. CCR = Coal Combustion Residuals. Dashed line/Red X = Incomplete or insignificant exposure pathway. (a) Groundwater in the vicinity of the Site is not used as a drinking water or irrigation source.

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[3] Boating and swimming are assumed not to occur in Little Saline Creek due to its small size.

3.2.1.1 Groundwater as a Drinking Water/Irrigation Source

Groundwater beneath the facility generally flows northeast towards the Little Saline Creek (SIPC, 2007). However, in the southern section of the Site, there is a component of groundwater flow that is to the east toward the Lake of Egypt (SIPC, 2007). Gradient conducted a receptor survey in 2024 to identify potential users of groundwater in the vicinity of the facility. Specific sources that were used in this survey include the Illinois State Geological Survey (ISGS) ILWATER database (ISGS, 2024). Four private water wells were identified within 1,000 meters of the facility (Table 3.1, Figure 3.3). One private well (121990235000) is upgradient of the facility, and the other three wells are sidegradient of the facility, such that these wells are not expected to be impacted by any CCR constituents in groundwater that originate from any of the ponds that are being evaluated (Figure 3.3). Further, wells are screened in the sandstone or lime sandstone water bearing unit and range in depth from 95 to 260 ft bgs, far below the depths of the monitoring wells at the site (12-28 feet bgs) where impacts, if any, from site-related activities would be observed. Moreover, three of the private wells are on the opposite side of Little Saline Creek, which provides hydraulic separation from any potential impacts at the site since shallow groundwater is likely to discharge into the creek rather than flow underneath it.

Table 3.1 Summary of Water Wells Within 1,000 Meters of the MGS

Well Number	Type	Date Drilled	Owner	Depth (ft)	Formation	Latitude	Longitude
121990235000	Water Well	2/29/1968	Morganthaler, Carrol	95	Sandstone	37.612148	-88.968285
121990235100	Water Well	4/30/1968	Propes, Charlie	98	Sandstone	37.611752	-88.950049
121990252500	Water Well	10/31/1971	Fisher, William	150	Sandstone	37.628378	-88.962144
121992397400[a]	Water Well	7/20/2003	Gordon, Steve	260	Lime Sandstone	37.628378	-88.962144

Notes:
ft = Feet; MGS = Marion Power Generating Station..
(a) This well, drilled in 2003, listed a pumping rate of 20 gallons per minute (gpm), while the well at the same location (121990252500), drilled in 1971 listed a pumping rate of 7 gpm. It is not known whether the 1971 is still in use.
Source: ISGS (2024).

3.2.1.2 Surface Water as a Drinking Water Source

The Lake of Egypt is used as a public water supply (IEPA, 2024a). The intake for the Lake of Egypt Public Water District (Facility ID IL1995200) is located at the northeast corner of the Lake of Egypt (Figure 3.3). The Lake of Egypt Public Water District serves a population of 11,368 (IEPA, 2024a) and supplies "approximately 1 million gallons per day of drinking water to Union, Jackson, and Williamson Counties" (SIPC, 2018a).

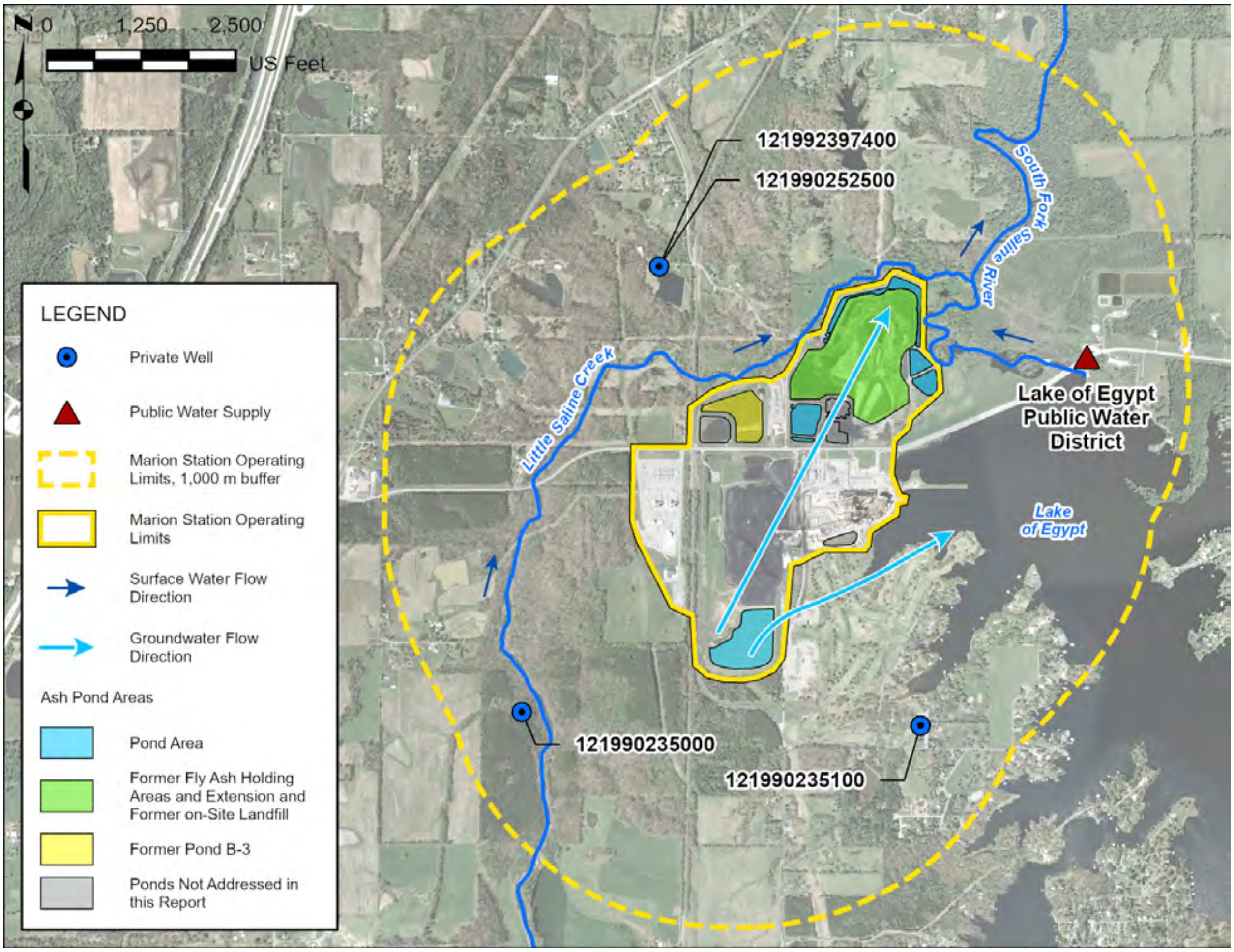

Figure 3.3 Water Wells Within 1,000 Meters of the Facility. Sources: Golder Associates Inc., 2021; USGS, 2022; Andrews Engineering, 2021; ISGS, 1909-2023; IEPA, 2024b; SIPC, 2007; USGS, 2011.

3.2.1.3 Recreational Exposures

Lake of Egypt, located to the east of the MGS facility, is a private lake owned by SIPC which allows the lake to be used for recreation. The lake is approximately 2,300 acres in size, and has an average depth of 18 feet and a maximum depth of 52 feet (SIPC, 2018a). The recreational uses of the Lake of Egypt include fishing, boating, swimming, and water sports such as water skiing (SIPC, 2018b). SIPC notes that "swimming is prohibited except at approved beaches marked by buoys" (SIPC, 2018b). Recreational exposure to surface water may occur during activities such as boating or fishing in the lake. Recreational anglers may also consume locally caught fish from the lake. The northwest bay of the lake (nearest the MGS) is a restricted area (SIPC, 2018b). Due to the depth of the lake, sediment exposure was not evaluated in Lake of Egypt.

Little Saline Creek is located immediately to the north of the Site. Gradient estimated the average creek width as 26 feet (based on measurements from an aerial photo), and the depth to be approximately 5 feet (based on a Google Earth photo from February 2020 in which bottom sediments were visible). Recreators in the Little Saline Creek may include anglers who could be exposed to surface water and consume locally caught fish. It is assumed that boating and swimming do not occur in Little Saline Creek due to its small size, and the availability of recreation areas at Lake of Egypt to the east.

3.2.2 Ecological Conceptual Exposure Model

The ecological CEM for the Site depicts the relationships between off-Site environmental media (surface water and sediment) potentially impacted by COIs in groundwater and ecological receptors that may be exposed to these media. The ecological risk evaluation considered both direct toxicity as well as secondary toxicity *via* bioaccumulation. Due to the fact that the dominant groundwater flow direction is to the northeast, and the relatively small size of Little Saline Creek, this surface waterbody has a higher potential to be influenced by CCR constituents. Given these factors, Little Saline Creek was identified as the primary focus for evaluating environmental risks for ecological receptors. Figure 3.4 presents the ecological CEM for the Site. The following ecological receptor groups and exposure pathways were considered:

- **Ecological Receptors Exposed to Surface Water:**
  - Aquatic plants, amphibians, reptiles, and fish.
- **Ecological Receptors Exposed to Sediment:**
  - Benthic invertebrates (*e.g.*, insects, crayfish, mussels).
- **Ecological Receptors Exposed to Bioaccumulative COIs:**
  - Higher trophic level wildlife (avian and mammalian) *via* direct exposures (surface water and sediment exposure) and secondary exposures through the consumption of prey (*e.g.*, plants, invertebrates, small mammals, fish).

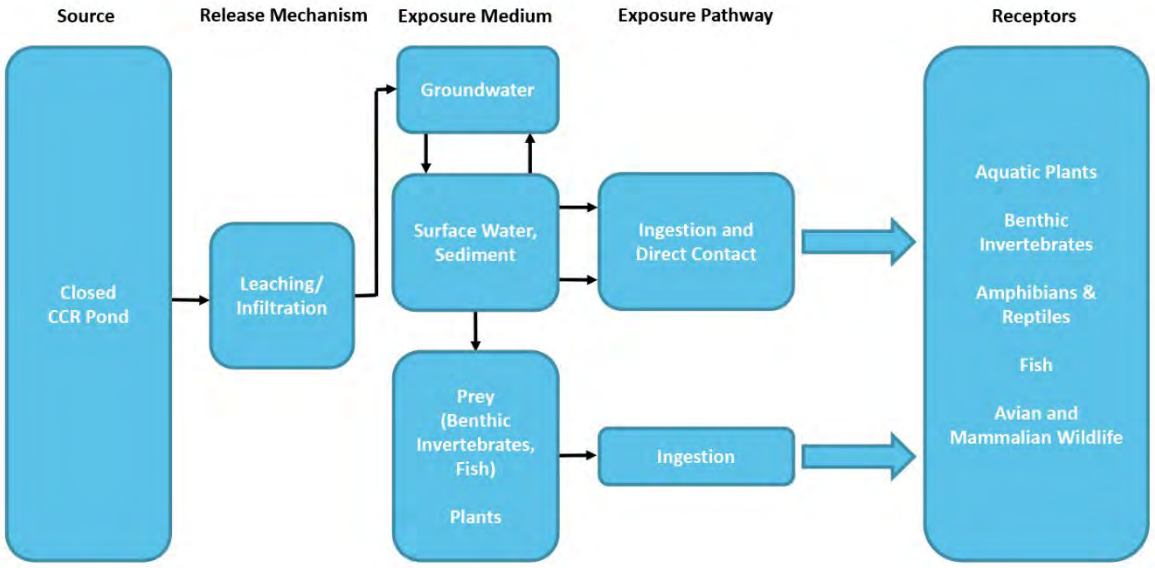

Figure 3.4 Ecological Conceptual Exposure Model. CCR = Coal Combustion Residuals.

3.3 Identification of Constituents of Interest

Risks were evaluated for COIs. A constituent was considered a COI if the maximum detected constituent concentration in groundwater exceeded a health-based benchmark. According to US EPA risk assessment guidance (US EPA, 1989), this screening step is designed to reduce the number of constituents carried through the risk evaluation that are anticipated to have a minimal contribution to the overall risk.

Identified COIs are the constituents that are most likely to pose a risk concern in the surface water adjacent to the Site.

3.3.1 Human Health Constituents of Interest

For the human health risk evaluation, COIs were conservatively identified as constituents with maximum concentrations in groundwater above the GWPS listed in the Illinois CCR Rule Part 845.600 (IEPA, 2021). The COIs were determined separately for the wells monitoring north and south of Lake of Egypt Road (the S-wells in the north that characterize groundwater quality near Pond 4, Pond 3 and 3A, Pond S-6, and Pond B-3, and the C-wells plus EBG well in the south that characterize groundwater quality near the South Fly Ash Pond). Gradient used the maximum detected concentrations from groundwater samples collected from these two groups of wells, regardless of hydrostratigraphic unit. The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with the facility or that they have been identified as potential groundwater exceedances. Using this approach, the COIs that were identified from the S-wells included arsenic, beryllium, boron, cadmium, cobalt, lead, and thallium (Table 3.2). For the S-wells, the maximum concentrations for arsenic, beryllium, cadmium, cobalt, and lead were detected in well S-1; the maximum concentrations for boron and thallium were detected in well S-2. The COIs that were identified from the C-wells+EBG included boron, cadmium, cobalt, and thallium (Table 3.3). For the C-wells, the maximum concentrations were detected in well EBG for boron and cobalt, well C-3 for cadmium, and well C-2 for thallium. Although these constituents were identified as COIs, it's important to re-emphasize that this identification was based solely on whether their maximum concentration exceeded the GWPS. We did not take into account overall temporal or spatial patterns, nor did we consider how these concentrations related to natural background levels or potential contamination from non-CCR sources.

The water quality parameters that exceeded the GWPS included chloride and total dissolved solids in the S-wells, and chloride, sulfate, and total dissolved solids in the C-wells. However, these constituents were not included in the risk evaluation because the GWPS is based on aesthetic quality and there is an absence of studies regarding toxicity to human health. The US EPA secondary maximum contaminant levels (MCLs) for chloride, sulfate, and total dissolved solids are based on aesthetic quality. The secondary MCLs for chloride and sulfate (250 mg/L) are based on salty taste (US EPA, 2021). The secondary MCL for total dissolved solids (500 mg/L) is based on hardness, deposits, colored water, staining, and salty taste (US EPA, 2021). Given that these parameters are not likely to pose a human health risk concern in the event of exposure, they were not considered to be human health COIs.

Table 3.2 Human Health Constituents of Interest Based on Groundwater for S-Wells - Near Pond 4, Pond 3 and 3A, Pond S-6, and Pond B-3 (2018-2022)

Constituent[a]	Detected Maximum[b]	GWPS[c]	Human Health COI[d]
Total Metals (mg/L)			
Antimony	*0.0050*	0.0060	No
Arsenic	0.12	0.010	Yes
Barium	1.5	2.0	No
Beryllium	0.0081	0.0040	Yes
Boron	2.8	2.0	Yes
Cadmium	0.055	0.005	Yes
Chromium	0.069	0.10	No
Cobalt	0.054	0.0060	Yes
Lead	0.080	0.0075	Yes
Mercury	*0.0002*	0.0020	No
Selenium	0.017	0.050	No
Thallium	0.046	0.0020	Yes
Dissolved Metals (mg/L)			
Boron	3.1	2.0	Yes
Cadmium	*0.001*	0.005	No
Other (mg/L or SU)			
Chloride	480	200	No[e]
Fluoride	0.18	4.0	No
pH	6.9	9.0	No
Sulfate	310	400	No
Total Dissolved Solids	4500	1200	No[e]

Notes:

COI = Constituent of Interest; GWPS = Groundwater Protection Standard; IL = Illinois; mg/L = Milligrams per Liter; SU = Standard Units.

Italics indicate constituent was not detected; the value reported is the maximum detection limit.

Shaded cell indicates a compound identified as a COI.

(a) The constituents are those listed in the IL Part 845.600 GWPS (IEPA, 2021).

(b) The maximum detected groundwater concentration was used to identify COIs.

(c) The IL Part 845.600 GWPS (IEPA, 2021) were used to identify COIs.

(d) COIs are constituents for which the maximum concentration exceeds the groundwater standard.

(e) Maximum exceeds the GWPS but analyte is not considered to be a COI because the GWPS is based on aesthetic quality.

Table 3.3 Human Health Constituents of Interest Based on Groundwater for C-Wells - Near the South Fly Ash Pond (2018-2023)

Constituent[a]	Maximum Groundwater Concentration[b]	GWPS[c]	Human Health COI[d]
Total Metals (mg/L)			
Antimony	*0.030*	0.0060	No[e]
Arsenic	0.0075	0.010	No
Barium	0.20	2.0	No
Beryllium	0.00060	0.0040	No
Boron	12	2.0	Yes
Cadmium	0.013	0.0050	Yes
Chromium	0.0042	0.10	No
Cobalt	0.29	0.0060	Yes
Lead	0.0031	0.0075	No
Lithium	0.024	0.040	No
Mercury	0.000070	0.0020	No
Molybdenum	0.015	0.10	No
Selenium	0.033	0.050	No
Thallium	0.031	0.0020	Yes
Dissolved Metals (mg/L)			
Boron	0.92	2.0	No
Cadmium	*0.0010*	0.0050	No
Radionuclides (pCi/L)			
Radium 226 + Radium 228	2.7	5.0	No
Other (mg/L or SU)			
Chloride	570	200	No[f]
Fluoride	0.68	4.0	No
pH	7.0	9.0	No
Sulfate	670	400	No[f]
Total Dissolved Solids	4000	1200	No[f]

Table 3.3 Notes:

COI = Constituent of Interest; GWPS = Groundwater Protection Standard; IL = Illinois; mg/L = Milligrams per Liter; pCi/L = Picocuries per Liter; SU = Standard Units.

Italics indicate constituent was not detected; the value reported is the maximum detection limit.

Shaded cell indicates a compound identified as a COI.

(a) The constituents are those listed in the IL Part 845.600 GWPS (IEPA, 2021).

(b) The maximum detected groundwater concentration was used to identify COIs.

(c) The IL Part 845.600 GWPS (IEPA, 2021) were used to identify COIs.

(d) COIs are constituents for which the maximum concentration exceeds the groundwater standard.

(e) Antimony was not detected in 32 groundwater samples. Only 2 of the 32 samples had detection limits above the GWPS; most of the DLs ranged from 0.001 to 0.005 mg/L and thus were below the GWPS of 0.006 mg/L. Thus antimony was not considered a COI.

(f) Maximum exceeds the GWPS but analyte is not considered to be a COI because the GWPS is based on aesthetic quality.

3.3.2 Ecological Constituents of Interest

The Illinois GWPS, as defined in IEPA's guidance, were developed to protect human health but not necessarily ecological receptors. While ecological receptors are not exposed to groundwater, groundwater can potentially migrate into the adjacent surface water and impact ecological receptors. Therefore, to identify ecological COIs, the maximum concentrations of constituents detected in groundwater were compared to ecological surface water benchmarks protective of aquatic life.

The surface water screening benchmarks for freshwater organisms were obtained from the following hierarchy of sources:

- IEPA (2019) SWQS. IEPA SWQS are health-protective benchmarks for aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). The SWQS for several metals are hardness dependent (cadmium, chromium, and lead). Screening benchmarks for these constituents were calculated assuming US EPA's default hardness of 100 mg/L (US EPA, 2022), due to an absence of hardness data for Little Saline Creek.[4]
- US EPA Region IV (2018) surface water Ecological Screening Values (ESVs) for hazardous waste sites.

Consistent with the human health risk evaluation, Gradient used the maximum detected concentrations from groundwater samples collected from the S-wells without considering spatial or temporal representativeness for ecological receptor exposures. The use of the maximum constituent concentrations in this evaluation is designed to conservatively identify COIs that warrant further investigation. The COIs identified for ecological receptors include cadmium, cobalt, lead, and thallium (Table 3.4).

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[4] Hardness data are available from the South Fork Saline River near Carrier Mills, Illinois (USGS Site No. 03382100), approximately 26 miles downstream of the MGS. Based on 208 samples collected from October 1976 to April 1997, the average hardness at this location was 438 mg/L (USGS, 2024c). Due to the age of the samples and the distance from the site, the US EPA (2022) default hardness of 100 mg/L was used. Use of a higher hardness value would result in less stringent screening values, thus, use of the US EPA default hardness is conservative.

Table 3.4 Ecological Constituents of Interest Based on Groundwater for S-Wells (2018-2022)

Constituent[a]	Maximum Detected Groundwater Concentration	Ecological Benchmark[b]	Basis	Ecological COI[c]
Total Metals (mg/L)				
Antimony	ND	0.19	EPA R4 ESV	No
Arsenic	0.12	0.19	IEPA SWQC	No
Barium	1.5	5.0	IEPA SWQC	No
Beryllium	0.0081	0.064	EPA R4 ESV	No
Boron	2.8	7.6	IEPA SWQC	No
Cadmium	0.055	0.0011	IEPA SWQC	Yes
Chromium	0.069	0.21	IEPA SWQC	No
Cobalt	0.054	0.019	EPA R4 ESV	Yes
Lead	0.080	0.020	IEPA SWQC	Yes
Mercury	ND	0.0011	IEPA SWQC	No
Selenium	0.017	1.0	IEPA SWQC	No
Thallium	0.046	0.0060	EPA R4 ESV	Yes
Dissolved Metals (mg/L)				
Boron	3.1	7.6	IEPA SWQC	No
Cadmium		0.00093	IEPA SWQC	No
Other (mg/L or SU)				
Chloride	480	500	IEPA SWQC	No
Fluoride	0.18	4.0	IEPA SWQC	No
Sulfate	310	NA	NA	No
Total Dissolved Solids	4500	NA	NA	No
pH	6.9	NA	NA	No

Notes:
Blank cells indicate constituent was not detected.
Shaded cell indicates a compound identified as a COI.
COI = Constituent of Interest; EPA R4 = United States Environmental Protection Agency Region IV; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; NA = Not Applicable; ND = Not Detected; SWQC = Surface Water Quality Criteria.
(a) The constituents are those listed in the IL Part 845.600 GWPS (IEPA, 2021) that were detected in at least one groundwater sample from the S-wells.
(b) Ecological benchmarks are from: IEPA SWQC (IEPA, 2019); EPA R4 ESV (US EPA Region IV, 2018).
(c) Constituents with maximum detected concentrations exceeding a benchmark protective of surface water exposure are considered ecological COIs.

3.3.3 Surface Water and Sediment Modeling

Surface water sampling has not been conducted in Little Saline Creek to the north of the Site. To estimate the potential contribution to surface water from groundwater specifically associated with the Site, Gradient modeled concentrations in Little Saline Creek surface water from groundwater flowing into the Creek for the detected human and ecological COIs. This is because the constituents detected in groundwater above a health-based benchmark are most likely to pose a risk concern in the adjacent surface water. Gradient modeled COI concentrations in the surface water using a mass balance calculation based on the surface water and groundwater mixing. The model assumes a well-mixed groundwater-surface water location.

The maximum detected concentrations in groundwater from the S-wells from 2018 to 2022 were conservatively used to model COI concentrations in surface water. For COIs that were measured as both total and dissolved fractions, we used the maximum of the total and dissolved COI concentrations for the modeling. For most metals, the maximum concentration was from the total fraction. Use of the total metal concentration for these COIs may overestimate surface water concentrations because dissolved concentrations, which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow into and mix with surface water.

The modeling approach does not account for geochemical transformations that may occur during groundwater mixing with surface water. Gradient assumed that predicted surface water concentrations were influenced only by the physical mixing of groundwater as it enters the surface water and were not further influenced by the geochemical reactions in the water and sediment, such as precipitation. In addition, the model only predicts surface water concentrations as a result of the potential migration of COIs in Site-related groundwater and does not account for background concentrations in surface water.

For this evaluation, Gradient adapted a simplified and conservative form of US EPA's indirect exposure assessment methodology (US EPA, 1998) that was used in US EPA's coal combustion waste risk assessment (US EPA, 2014). The model is a mass balance calculation based on surface water and groundwater mixing and the concept that the dissolved and sorbed concentrations can be related through an equilibrium partitioning coefficient (K_d). The model assumes a well-mixed groundwater-surface water location, with partitioning among total suspended solids, dissolved water column, sediment pore water, and solid sediments.

Sorption to soil and sediment is highly dependent on the surrounding geochemical conditions. To be conservative, we ignored the natural attenuation capacity of soil and sediment and estimated the surface water concentration based only on the physical mixing of groundwater and surface water (*i.e.*, dilution) at the point where groundwater flows into surface water.

The aquifer properties used to estimate the volume of groundwater flowing into Little Saline Creek and surface water concentrations are presented in Table 3.5. The surface water and sediment properties used in the modeling are presented in Tables 3.6 and 3.7. In the absence of Site-specific information for Little Saline Creek, Gradient used default assumptions (*e.g.*, depth of the upper benthic layer and bed sediment porosity) to model sediment concentrations. The modeled surface water and sediment concentrations are presented in Table 3.8. These modeled concentrations reflect conservative contributions from groundwater. A description of the modeling and the detailed results are presented in Appendix A.

Table 3.5 Groundwater Properties Used in Modeling

Parameter	Value	Units	Notes
Aquifer thickness	3	m	Thickness of the groundwater unit at the interface of unlithified deposits and bedrock (10 ft or 3 m) (SIPC, 2021b).
Length of River	840	m	Length of river receiving potentially-impacted groundwater (estimated using Google Earth).
Cross-Sectional Area	2560	m^2	Length × thickness
Hydraulic Gradient	0.019	m/m	Average hydraulic gradient (estimated using groundwater elevation in wells S3 and S6; SIPC, 2007).
Hydraulic Conductivity	1.50E-04	cm/sec	Average hydraulic conductivity (assumed to be the same as that for Emery Pond wells; Golder Associates Inc., 2021).
COI Concentration	Constituent specific	mg/L	Maximum detected concentration in groundwater.

Notes:
COI = Constituent of Interest
(a) The cross-sectional area represents the area through which groundwater flows from the unlithified unit to Little Saline Creek.

Table 3.6 Surface Water Properties Used in Modeling

Parameter	Value	Unit	Notes/Source
Flow rate in little saline creek	2.5×10^{11}	L/yr	Average of peak flows 1959-1980 for Little Saline Creek Tributary Near Goreville, IL (USGS, 2024a)
Total suspended solids (TSS)	49	mg/L	Average TSS concentration for South Fork Saline River, Carrier Mills, IL (USGS, 2024b)
Depth of water column	1.5	m	Mean depth of Little Saline Creek estimated from Google Earth photos.
Suspended Sediment to Water Partition Coefficient	Constituent specific	mg/L	Values based on US EPA (2014).

Notes:
IL = Illinois; US EPA = United States Environmental Protection Agency; USGS = United States Geological Survey.

Table 3.7 Sediment Properties Used in Modeling

Parameter	Value	Unit	Notes/Source
Depth of Upper Benthic Layer	0.03	m	Default (US EPA, 2014).
Depth of Water Column	1.5	m	Mean depth of Little Saline Creek estimated from Google Earth photos.
Bed Sediment Particle Concentration	1	g/cm^3	Default (US EPA, 2014).
Bed Sediment Porosity	0.6	–	Default (US EPA, 2014).
Total Suspended Solids (TSS) Mass per Unit Area	0.075	kg/m^2	Depth of water column × TSS × conversion factors (10^{-6} kg/mg and 1,000 L/m^3).
Sediment Mass per Unit Area	30	kg/m^2	Depth of upper benthic layer × bed sediment particulate concentration × conversion factors (0.001 kg/g and 10^6 cm^3/m^3).
Sediment to Water Partitioning Coefficients	Constituent specific	mg/L	Values based on US EPA (2014).

Note:
US EPA = United States Environmental Protection Agency.

Table 3.8 Surface Water and Sediment Modeling Results for Little Saline Creek

COI	Maximum Measured Groundwater Concentration (mg/L)	Modeled Surface Water Concentration (mg/L)	Modeled Sediment Concentration (mg/kg)
Arsenic	0.12	1.15E-06	2.09E-04
Beryllium	0.0081	7.79E-08	2.77E-05
Boron	3.1	2.98E-05	1.35E-04
Cadmium	0.055	5.29E-07	2.16E-04
Cobalt	0.054	5.19E-07	1.60E-04
Lead	0.08	7.69E-07	1.20E-03
Thallium	0.046	4.42E-07	5.46E-06

Notes:
COI = Constituent of Interest; mg/L = Milligrams per Liter.

3.4 Human Health Risk Evaluation

The section below presents the results of the human health risk evaluation for recreators (boaters, swimmers, and anglers) in the Lake of Egypt to the east of the Site, and anglers in the Little Saline Creek to the north of the Site. Risks were assessed using the maximum measured COIs in Lake of Egypt, and the modeled COIs in the Little Saline Creek.

3.4.1 Recreators Exposed to Surface Water

Screening Exposures: In Lake of Egypt, recreators could be exposed to surface water *via* incidental ingestion and dermal contact while boating or swimming, and anglers could consume fish caught in the lake. In Little Saline Creek, it is assumed that anglers could consume fish caught in the creek. Measured concentrations were used in Lake of Egypt, and modeled concentrations were used for Little Saline Creek due to lack of sampling data. The maximum measured or modeled COI concentrations in surface water were used as conservative upper-end estimates of the COI concentrations to which a recreator might be exposed directly (incidental ingestion of COIs in surface water while boating) and indirectly (consumption of locally caught fish exposed to COIs in surface water).

Screening Benchmarks: Illinois surface water criteria (IEPA, 2019), known as human threshold criteria (HTC), are based on incidental exposure through contact or ingestion of small volumes of water while swimming or during other recreational activities, as well as the consumption of fish. The HTC values were calculated from the following equation (IEPA, 2019):

$$\mathrm{HTC} = \frac{\mathrm{ADI}}{\mathrm{W} + (\mathrm{F} \times \mathrm{BCF})}$$

where:

HTC = Human health protection criterion in milligrams per liter (mg/L)
ADI = Acceptable daily intake (mg/day)
W = Water consumption rate (L/day)
F = Fish consumption rate (kg/day)
BCF = Bioconcentration factor (L/kg tissue)

Illinois defines the acceptable daily intake (ADI) as the "maximum amount of a substance which, if ingested daily for a lifetime, results in no adverse effects to humans" (IEPA, 2019). US EPA defines its chronic reference dose (RfD) as an "estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure for a chronic duration (up to a lifetime) to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime" (US EPA, 2011). Illinois lists methods to derive an ADI from the primary literature (IEPA, 2019). In accordance with Illinois guidance, Gradient derived an ADI by multiplying the MCL by the default water ingestion rate of 2 L/day (IEPA, 2019). In the absence of an MCL, Gradient applied the RfD used by US EPA to derive its Regional Screening Levels (RSLs) (US EPA, 2024) as a conservative estimate of the ADI. The RfDs are given in mg/kg-day, while the ADIs are given in mg/day; thus, Gradient multiplied the RfD by a standard body weight of 70 kg to obtain the ADI in mg/day. The calculation of the HTC values is shown in Appendix B, Table B.1.

Gradient used bioconcentration factors (BCFs) from a hierarchy of sources. The primary BCFs were those that US EPA used to calculate the National Recommended Water Quality Criteria (NRWQC) for human health (US EPA, 2002). Other sources included BCFs used in the US EPA coal combustion ash risk assessment (US EPA, 2014) and BCFs reported by Oak Ridge National Laboratory's Risk Assessment Information System (ORNL RAIS) (ORNL, 2020).[5] Lithium did not have a BCF value available from any authoritative source; therefore, the water quality criterion for lithium was calculated assuming a BCF of 1. This is a conservative assumption, as lithium does not readily bioaccumulate in the aquatic environment (ECHA, 2020a,b; ATSDR, 2010).

Illinois recommends a fish consumption rate of 0.020 kg/day (20 g/day) for an adult weighing 70 kg (IEPA, 2019). Illinois recommends a water consumption rate of 0.01 L/day for "incidental exposure through contact or ingestion of small volumes of water while swimming or during other recreational activities" (IEPA, 2019). Appendix B, Table B.1 presents the calculated HTC for fish and water and for fish consumption only.

The HTC for fish consumption for radium 226+228 was calculated as follows:

$$\mathrm{HTC} = \frac{\mathrm{TCR}}{(\mathrm{SF} \times \mathrm{BAF} \times \mathrm{F})}$$

where:

HTC = Human health protection criterion in picoCuries per liter (pCi/L)
TCR = Target cancer risk (1×10^5)
SF = Food ingestion slope factor (risk/pCi)
BAF = Bioaccumulation factor (L/kg tissue)
F = Fish consumption rate (kg/day)

The food ingestion slope factor (lifetime excess total cancer risk per unit exposure, in risk/pCi) used to calculate the HTC was the highest value of those for radium 226 (Ra226), radium 228 (Ra228), and "Ra228+D" (US EPA, 2001). According to US EPA (2001), "+D" indicates that "the risks from associated short-lived radioactive decay products (*i.e.,* those decay products with radioactive half-lives less than or equal to 6 months) are also included."

Screening Risk Evaluation, Lake of Egypt: The four COIs were not detected in the surface water data available from Lake of Egypt, therefore, Gradient used half of the maximum detection limit as the exposure concentration. The COI concentrations in surface water were compared to the calculated Illinois HTC values (Table 3.8). All surface water concentrations, all of which were non-detect, were below their respective benchmarks. The HTC values are protective of recreational exposure *via* water and/or fish ingestion and do not account for dermal exposures to COIs in surface water while boating. However, given that the measured COI surface water concentrations are well below HTC protective of water and/or fish ingestion, dermal exposures to COIs are not expected to be a risk concern. Moreover, the dermal uptake of metals is considered to be minimal and only a small proportion of ingestion exposures. Thus, none of the COIs evaluated pose an unacceptable risk to recreators exposed to surface water while boating and anglers consuming fish caught in the Lake of Egypt.

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[5] Although recommended by US EPA (2015b), US EPA EpiSuite 4.1 (US EPA, 2019) was not used as a source of BCFs because inorganic compounds are outside the estimation domain of the program.

Table 3.9 Risk Evaluation for Recreators Exposed to Surface Water in Lake of Egypt

COI	Maximum Surface Water Concentration (Measured)[a]	HTC for Water and Fish	HTC for Water Only	HTC for Fish Only	COPC
Total Metals (mg/L)					
Boron	*0.01*	467	1400	700	No
Cadmium	*0.0015*	0.0019	1.0	0.0019	No
Cobalt	*0.0025*	0.0035	2.1	0.0035	No
Thallium	*0.001*	0.0017	0.40	0.0017	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria; mg/L = Milligrams per Liter.
Concentrations are listed only for the constituents identified as COIs in the C-wells.
(a) Concentrations in italics were not detected; half the detection limit was used for non-detects.

Screening Risk Evaluation, Little Saline Creek: The modeled COI concentrations in surface water were compared to the calculated Illinois HTC values (Table 3.10). All surface water concentrations were below their respective benchmarks. Thus, none of the COIs evaluated pose an unacceptable risk for anglers consuming fish caught in Little Saline Creek.

Table 3.10 Risk Evaluation for Recreators Exposed to Surface Water in Little Saline Creek

COI	Maximum Surface Water Concentration (Modeled)	HTC for Water and Fish	HTC for Water Only	HTC for Fish Only	COPC
Total Metals (mg/L)					
Arsenic	1.15E-06	2.25E-02	2.00E+00	2.27E-02	No
Beryllium	7.79E-08	2.05E-02	8.00E-01	2.11E-02	No
Boron	2.98E-05	4.67E+02	1.40E+03	7.00E+02	No
Cadmium	5.29E-07	1.85E-03	1.00E+00	1.85E-03	No
Cobalt	5.19E-07	3.49E-03	2.10E+00	3.50E-03	No
Lead	7.69E-07	1.00E-02	1.00E-02	1.00E-02	No
Thallium	4.42E-07	1.72E-03	4.00E-01	1.72E-03	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria; mg/L = Milligrams per Liter.
Concentrations are listed only for the constituents identified as COIs in the S-wells.
Modeled concentrations represent the potential effect on surface water quality resulting from the measured groundwater concentrations.

3.4.2 Use of Surface Water as Drinking Water

The Lake of Egypt is used as a public water supply (IEPA, 2024a). Gradient compared the maximum detected concentrations (or the maximum detection limit) from the available public water supply data (2018-2023) to the Illinois Class I GWPS (Table 3.11). There were no exceedances of the IL GWPS, therefore the use of surface water from the Lake of Egypt for residential drinking water does not pose an unacceptable risk to residents.

Table 3.11 Lake Public Water Supply Data Compared to GWPS (2018-2023)

Constituent[a]	Number of Detects	Number of Samples	Detected Minimum	Detected Maximum[b]	Maximum Laboratory Detection Limit	GWPS[c]	Exceedance
Total Metals							
Antimony	0	6			0.003	0.006	No
Arsenic	0	6			0.001	0.01	No
Barium	6	6	0.021	0.0263	NA	2	No
Beryllium	0	6			0.001	0.004	No
Cadmium	0	6			0.003	0.005	No
Chromium	0	6			0.005	0.1	No
Mercury	0	6			0.0002	0.002	No
Selenium	1	6	0.0024	0.0024	0.002	0.05	No
Thallium	0	6			0.002	0.002	No
Other							
Chloride	6	6	10.4	23	NA	200	No
Fluoride	6	6	0.553	0.73	NA	4	No
Sulfate	6	6	34.6	51.7	NA	400	No
Total Dissolved Solids	6	6	87	158	NA	1200	No
Radionuclides							
Radium 226 + Radium 228	1	1	1.03	1.03	NA	5	No

Notes:
GWPS = Groundwater Protection Standard; NA = Not Available.

3.5 Ecological Risk Evaluation

Based on the ecological CEM (Figure 3.4), ecological receptors could be exposed to surface water and dietary items (*i.e.*, prey and plants) potentially impacted by identified COIs.

3.5.1 Ecological Receptors Exposed to Surface Water in Little Saline Creek

Screening Exposures: The ecological evaluation considered aquatic communities in Little Saline Creek potentially impacted by identified ecological COIs. Modeled surface water concentrations were compared to risk-based ecological screening benchmarks.

Screening Benchmarks: Surface water screening benchmarks protective of aquatic life were obtained from the following hierarchy of sources:

- IEPA SWQS (IEPA, 2019), regulatory standards that are intended to protect aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). For cadmium, the surface water benchmark is hardness dependent and calculated using a default hardness of 100 mg/L (US EPA, 2022);[6]
- US EPA Region IV (2018) surface water ESVs for hazardous waste sites.

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[6] Conservatisms associated with using a default hardness value are discussed in Section 3.6.

Risk Evaluation: The maximum modeled COI concentrations in surface water were compared to the benchmarks protective of aquatic life (Table 3.12). The modeled surface water concentrations for the COIs were below their respective benchmarks. Thus, none of the COIs evaluated are expected to pose an unacceptable risk to aquatic life in Little Saline Creek.

Table 3.12 Risk Evaluation for Ecological Receptors Exposed to Surface Water in Little Saline Creek

COI	Maximum Surface Water Concentration (modeled)	Ecological Freshwater Benchmark	Basis	COPC
Cadmium	5.29E-07	1.13E-03	IEPA SWQC	No
Cobalt	5.19E-07	1.90E-02	EPA R4 ESV	No
Lead	7.69E-07	2.01E-02	IEPA SWQC	No
Thallium	4.42E-07	6.00E-03	EPA R4 ESV	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; SWQC = Surface Water Quality Criteria; US EPA = United States Environmental Protection Agency.
Criteria sources: IEPA SWQC: IEPA (2019a); EPA R4 ESV: US EPA Region IV (2018)

3.5.2 Ecological Receptors Exposed to Sediment in Little Saline Creek

Screening Exposures: COIs in impacted groundwater flowing into Little Saline Creek can sorb to sediments *via* chemical partitioning. In the absence of sediment data, sediment concentrations were modeled using maximum detected groundwater concentrations. Therefore, the modeled COI sediment concentrations reflect the potential maximum Site-related sediment concentration originating from groundwater.

Screening Benchmarks: Sediment screening benchmarks were obtained from US EPA Region IV (2018). The majority of the sediment ESVs are based on threshold effect concentrations (TECs) from MacDonald *et al.* (2000), which provide consensus values that identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. The benchmarks used in this evaluation are listed in Table 3.13.

Screening Risk Results: The maximum modeled COI sediment concentrations were below their respective sediment screening benchmarks (Table 3.13). The modeled sediment concentrations attributed to potential contributions from Site groundwater for all COIs were less than 1% of the sediment screening benchmark. Although thallium does not have an ESV, the modeled concentration is well below the soil ESV of 0.05 mg/kg (US EPA Region IV, 2018); therefore, thallium does not present an unacceptable risk to ecological receptors. Thus, the modeled sediment concentrations attributed to potential contributions from Site groundwater are not expected to significantly contribute to ecological exposures in Little Saline Creek adjacent to the Site.

Table 3.13 Risk Evaluation for Ecological Receptors Exposed to Sediment in Little Saline Creek

COI	Modeled Sediment Concentration (mg/kg)	ESV[a] (mg/kg)	COPC	% of Benchmark
Cadmium	2.16E-04	1.0E+00	No	0.02
Cobalt	1.60E-04	5.0E+01	No	0.0003
Lead	1.20E-03	3.6E+01	No	0.003
Thallium	5.46E-06	NA	No	NA

Notes:

COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; NA = Not Available; US EPA = United States Environmental Protection Agency.

(a) ESV from US EPA Region IV (2018).

3.5.3 Ecological Receptors Exposed to Bioaccumulative Constituents of Interest

Screening Exposures: COIs with bioaccumulative properties can impact higher trophic level wildlife exposed to these COIs *via* direct exposures (surface water and sediment exposure) and secondary exposures through the consumption of dietary items (*e.g.*, plants, invertebrates, small mammals, and fish).

Screening Benchmark: US EPA Region IV (2018) and IEPA SWQS (IEPA, 2019) guidance were used to identify constituents with potential bioaccumulative effects.

Risk Evaluation: The ecological COIs (cadmium, cobalt, lead, and thallium) were not identified as having potential bioaccumulative effects. Therefore, these COIs are not considered to pose an ecological risk *via* bioaccumulation. IEPA (2019) identifies mercury as the only metal with bioaccumulative properties, however, mercury was not considered an ecological COI. US EPA Region IV (2018) identifies selenium as having potential bioaccumulative effects; although selenium was detected in groundwater, it was not considered an ecological COI.

3.6 Uncertainties and Conservatisms

A number of uncertainties and their potential impact on the risk evaluation are discussed below. Wherever possible, conservative assumptions were used in an effort to minimize uncertainties and overestimate rather than underestimate risks.

Exposure Estimates:

- The risk evaluation included the IL Part 845.600 constituents detected in groundwater samples (above GWPS) collected from wells associated with the MGS facility. However, it is possible that not all of the detected constituents are related specifically to the MGS facility.
- The human health and ecological risk characterization was based on the maximum measured or modeled COI concentrations, rather than on averages. Thus, the variability in exposure concentrations was not considered. Assuming continuous exposure to the maximum concentration overestimates human and ecological exposures, given that receptors are mobile and concentrations change over time. For example, US EPA guidance states that risks should be estimated using average exposure concentrations as represented by the 95% upper confidence limit on the mean (US EPA, 1992). Given that exposure estimates based on the maximum concentrations did not exceed risk benchmarks, Gradient has greater confidence that there is no risk concern.

- Only constituents detected in groundwater were used to identify COIs and model COI concentrations in surface water. For the constituents that were not detected in facility groundwater, the detection limits were below the IL Part 845.600 GWPS for all constituents except antimony, and thus do not require further evaluation. (Antimony was not detected in 32 groundwater samples from 2018 to 2023; 30 of the detection limits ranged from 0.001 to 0.005 mg/L, thus were below the GWPS of 0.006 mg/L.)
- There are limited groundwater data available that have been analyzed for Appendix IV constituents to specifically characterize the ponds of interest. If additional data are collected, the new data could lead to different risk estimates (either increased or decreased risk).
- COI concentrations in Little Saline Creek were modeled using the maximum detected total COI concentrations in groundwater from the S-wells. Modeling surface water concentrations using total metal concentrations may overestimate surface water concentrations because dissolved concentrations, which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow into and mix with surface water.
- The COIs identified in this evaluation also occur naturally in the environment. Contributions to exposure from natural or other non-MGS-related sources were not considered in the evaluation of modeled concentrations; only exposure contributions potentially attributable to Site groundwater mixing with surface water were evaluated. While not quantified, exposures from potential MGS-related groundwater contributions are likely to represent only a small fraction of the overall human and ecological exposure to COIs that also have natural or non-MGS-related sources.
- Screening benchmarks for human health were developed using exposure inputs based on US EPA's recommended values for reasonable maximum exposure (RME) assessments (Stalcup, 2014). RME is defined as "the highest exposure that is reasonably expected to occur at a site but that is still within the range of possible exposures" (US EPA, 2004). US EPA states the "intent of the RME is to estimate a conservative exposure case (*i.e.*, well above the average case) that is still within the range of possible exposures" (US EPA, 1989). US EPA also notes that this high-end exposure "is the highest dose estimated to be experienced by some individuals, commonly stated as approximately equal to the 90th percentile exposure category for individuals" (US EPA, 2015c). Thus, most individuals will have lower exposures than those presented in this risk assessment.

Toxicity Benchmarks:

- Screening-level ecological benchmarks were compiled from IEPA and US EPA guidance and designed to be protective of the majority of Site conditions, leaving the option for Site-specific refinement. In some cases, these benchmarks may not be representative of the Site-specific conditions or receptors found at the Site, or may not accurately reflect concentration-response relationships encountered at the Site. For example, the ecological benchmark for cadmium is hardness dependent, and Gradient relied on US EPA's default hardness of 100 mg/L. Use of a higher hardness value would increase the cadmium SWQS because benchmarks become less stringent with higher levels of hardness. Regardless of the hardness, the maximum modeled cadmium concentration is orders of magnitude below the SWQS.
- In addition, for the ecological evaluation, Gradient conservatively assumed all constituents to be 100% bioavailable. Modeled COI concentrations in surface water are considered total COI concentrations. In addition, the measured surface water data used in this report represent total concentrations. US EPA recommends using dissolved metals as a measure of exposure to ecological receptors because it represents the bioavailable fraction of metal in water (US EPA, 1993). Therefore, the modeled surface water COI concentrations may be an overestimation of exposure concentrations to ecological receptors.

- In general, it is important to appreciate that the human health toxicity factors used in this risk evaluation are developed to account for uncertainties, such that safe exposure levels used as benchmarks are often many times lower (even orders of magnitude lower) than the levels that cause effects that have been observed in human or animal studies. For example, toxicity factors incorporate a 10-fold safety factor to protect sensitive subpopulations. This means that a risk exceedance does not necessarily equate to actual harm.

4 Summary and Conclusions

A screening-level risk evaluation was performed for Site-related constituents in groundwater at the MGS in Marion, Illinois. The CSM developed for the Site indicates that groundwater beneath the facility may flow into the Lake of Egypt to the east of the Site, or into Little Saline Creek to the north of the Site, and may potentially impact surface water.

CEMs were developed for human and ecological receptors. In the Lake of Egypt, the complete exposure pathways for humans include recreators (boaters) in the who are exposed to surface water, and anglers who consume locally caught fish. The use of surface water from the Lake of Egypt as a drinking water source was also evaluated as a complete pathway. The complete exposure pathway for humans in Little Saline Creek includes anglers who consume locally caught fish. Based on the local hydrogeology, residential exposure to groundwater used for drinking water or irrigation is not a complete pathway and was not evaluated. The complete exposure pathways for ecological receptors include aquatic life (including aquatic and marsh plants, amphibians, reptiles, and fish) exposed to surface water; benthic invertebrates exposed to sediment; and avian and mammalian wildlife exposed to bioaccumulative COIs in surface water, sediment, and dietary items.

Groundwater data collected from 2018 to 2023 were used to estimate exposures. The surface water data collected from the Lake of Egypt (in 2020) were also evaluated. Surface water concentrations were modeled in Little Saline Creek using the maximum detected groundwater concentration in the S-wells from the northern portion of the Site. Surface water exposure estimates were screened against benchmarks protective of human health and ecological receptors for this risk evaluation.

US EPA has established acceptable risk metrics. Risks above these US EPA-defined metrics are termed potentially "unacceptable risks." Based on the evaluation presented in this report, no unacceptable risks to human or ecological receptors resulting from CCR exposures associated with the Site were identified. This means that the risks from the Site are likely indistinguishable from normal background risks. Specific risk assessment results include the following:

- For recreators exposed to surface water, all COIs were below the conservative risk-based screening benchmarks. Therefore, none of the COIs evaluated in surface water are expected to pose an unacceptable risk to recreators in the Lake of Egypt.
- For anglers consuming locally caught fish, the modeled concentrations of all COIs in surface water (as well as the measured data) were below conservative benchmarks protective of fish consumption. Therefore, none of the COIs evaluated are expected to pose an unacceptable risk to anglers consuming fish caught from the Lake of Egypt or Little Saline Creek.
- For Lake of Egypt surface water used as a public drinking water supply, all COIs were below the Illinois Class I GWPS, thus no unacceptable risks were identified for the use of Lake of Egypt surface water as drinking water.
- Groundwater downgradient of the Site is not being used as a drinking water, thus the use of groundwater is not a complete exposure pathway.
- Ecological receptors exposed to surface water in Little Saline Creek include aquatic and marsh plants, amphibians, reptiles, and fish. The risk evaluation showed that none of the modeled COIs in Little Saline Creek exceeded protective screening benchmarks. Ecological receptors exposed to

sediment include benthic invertebrates. The modeled sediment COIs did not exceed the conservative screening benchmarks; therefore, none of the COIs evaluated in sediment are expected to pose an unacceptable risk to ecological receptors in Little Saline Creek.

- Ecological receptors were also evaluated for exposure to bioaccumulative COIs. This evaluation considered higher trophic level wildlife with direct exposure to surface water and sediment and secondary exposure through the consumption of dietary items (*e.g.*, plants, invertebrates, small mammals, fish). None of the ecological COIs were identified as having potential bioaccumulative effects. Overall, this evaluation demonstrated that none of the COIs evaluated are expected to pose an unacceptable risk to ecological receptors.

It should be noted that this evaluation incorporates a number of conservative assumptions that tend to overestimate exposure and risk. The risk evaluation was based on the maximum detected COI concentration; however, US EPA guidance states that risks should be based on a representative average concentration such as the 95% upper confidence limit on the mean; thus, using the maximum concentration tends to overestimate exposure. Although the COIs identified in this evaluation also occur naturally in the environment, the contributions to exposure from natural background sources and nearby industry were not considered; thus, CCR-related exposures were likely overestimated. Exposure estimates assumed 100% metal bioavailability, which likely results in overestimates of exposure and risks. Exposure estimates were based on inputs to evaluate the "reasonable maximum exposure"; thus, most individuals will have lower exposures than those estimated in this risk assessment.

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Appendix A

Surface Water Modeling

List of Tables

Gradient modeled concentrations of constituents of interest (COIs) in the Little Saline Creek surface water based on available groundwater data. First, we estimated the flow rate of COIs flowing into the Little Saline Creek *via* groundwater. Then, we adapted United States Environmental Protection Agency (US EPA) indirect exposure assessment methodology (US EPA, 1998) in order to model surface water concentrations in the Little Saline Creek.

Model Overview

The groundwater flow to the creek is represented by a one-dimensional, steady-state model. In this model, the groundwater plume from the northern portion of the Site migrates horizontally in the uppermost water-bearing unit prior to flowing to Little Saline Creek. The groundwater flow entering the creek is the flow going through a cross-sectional area that has a length equal to the length of the creek adjacent to the Site with potential impacts from the ponds system and a height equal to the thickness of the uppermost water-bearing unit. It was assumed that all the groundwater flowing through this layer would ultimately discharge to Little Saline Creek. The length of the groundwater discharge zone was estimated using Google Earth Pro (Google, LLC, 2022).

The groundwater flow to Little Saline Creek mixes with the surface water in the creek. The COIs entering the creek *via* groundwater dissolve into the water column, sorb to suspended sediments, or sorb to benthic sediments. Using US EPA's indirect exposure assessment methodology (US EPA, 1998), the model evaluates the surface water COI concentrations at a location downstream of the groundwater discharge point, assuming a well-mixed water column.

Groundwater Discharge Rate

The groundwater flow rate was evaluated using conservative assumptions. Gradient conservatively assumed that the groundwater concentrations were uniformly equal to the maximum detected concentration of each individual COI. Further, Gradient ignored adsorption by subsurface soil and assumed that all the groundwater flowing through the aquifer and intersecting the creek was flowing into the creek.

For each groundwater unit, the groundwater flow rate into the creek was derived using Darcy's Law:

$$\mathrm{Q} = \mathrm{K} \times \mathrm{i} \times \mathrm{A}$$

where:

Q = Groundwater flow rate (m^3/s)
K = Hydraulic conductivity (m/s)
i = Hydraulic gradient (m/m)
A = Cross-sectional area (m^2)

For each COI, the mass discharge rate into the creek was then calculated by:

$$\mathrm{m_c} = \mathrm{C_c} \times \mathrm{Q} \times \mathrm{CF}$$

where:

m_c = Mass discharge rate of the COI (mg/year)
C_c = Maximum groundwater concentration of the COI (mg/L)
Q = Groundwater flow rate (m^3/s)
CF = Conversion factors: 1,000 L/m^3 and 31,557,600 s/year

The values of the aquifer parameters used for these calculations are provided in Table A.1. The calculated mass discharge rates were then used as inputs for the surface water model.

The length of the discharge zone was estimated to be approximately 840 m and the height of the discharge zone was estimated to be 3 m; thus, the cross-sectional area was estimated to be 2,560 m^2 (SIPC, 2021). The average horizontal hydraulic gradient was 0.019 m/m (estimated using groundwater elevation in wells S3 and S6; SIPC, 2007). The average horizontal hydraulic conductivity was 1.5×10^{-4} cm/s (Golder Associates Inc., 2021).

Surface Water Concentration

Groundwater that flows into the creek will be diluted with the surface water flow. Constituents transported by groundwater into the surface water migrate into the water column and the bed sediments. The surface water model Gradient used to estimate the surface water concentrations is a steady-state model described in US EPA's indirect exposure assessment methodology (US EPA, 1998) and also used in US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals," referred to herein as the CCR risk assessment (US EPA, 2014). This model describes the partitioning of constituents between surface water, suspended sediments, and benthic sediments based on equilibrium partition coefficients (K_d values). It estimates the concentrations of constituents in surface water, suspended sediments, and benthic sediments at steady-state equilibrium at a theoretical location downstream of the discharge point after complete mixing of the water column. In our analysis, we used the K_d values provided in the US EPA CCR risk assessment for all of the COIs (US EPA, 2014, Table J1). These coefficients are presented in Table A.2.

To be conservative, Gradient assumed that the constituents were not affected by dissipation or degradation once they entered the water body. The total water body concentration of the COI was calculated as follows (US EPA, 1998):

$$C_{wtot} = \frac{m_c}{V_f \times f_{water}}$$

where:

C_{wtot} = Total water body concentration of the COI (mg/L)
m_c = Mass discharge rate of the COI (mg/year)
V_f = Water body annual flow (L/year)
f_{water} = Fraction of the COI in the water column (unitless)

For the Little Saline Creek annual flow rate, Gradient used the average peak-flow discharge rate of about 279 cubic feet per second (cfs), or 2.5×10^{11} L/year, based on the discharge rates measured at the United States Geological Survey (USGS) gauging station near Goreville, Illinois (USGS Station 03382025) between 1959 and 1980[7] (USGS, 2024a). The surface water parameters are presented in Table A.3.

The fraction of COIs in the water column was calculated for each COI using the sediment/water and suspended solids/water partition coefficients (US EPA, 2014). The fraction of COIs in the water column is defined as follows (US EPA, 2014):

$$f_{water} = \frac{(1 + [K_{dsw} \times TSS \times 0.000001]) \times \frac{d_w}{d_z}}{\left([1 + (K_{dsw} \times TSS \times 0.000001)] \times \frac{d_w}{d_z}\right) + ([bsp + K_{dbs} \times bsc] \times \frac{d_b}{d_z})}$$

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[7] The available data were for the years 1959 to 1980.

where:

K_{dsw} = Suspended sediment-water partition coefficient (mL/g)
K_{dbs} = Sediment-water partition coefficient (mL/g)
TSS = Total suspended solids in the surface water body (mg/L). Assumed equal to 49 mg/L based on the average suspended sediment concentration measured in South Fork Saline River at the USGS gauging station at Carrier Mills, Illinois (USGS Station 03382100) between 1976 and 1997 (USGS, 2024b).
0.000001 = Units conversion factor
d_w = Depth of the water column (m). The depth of the water column was estimated as 1.52 m from Google Earth photos.
d_b = Depth of the upper benthic layer (m). Set equal to 0.03 m (US EPA, 2014).
d_z = Depth of the water body (m). Calculated as $d_w + d_b$. Set equal to 1.55 m.
bsp = Bed sediment porosity (unitless). Set equal to 0.6 (US EPA, 2014).
bsc = Bed sediment particle concentration (g/cm^3). Set equal to 1.0 g/cm^3 (US EPA, 2014).

The fraction of COIs dissolved in the water column (f_d) is calculated as follows (US EPA, 2014):

$$f_d = \frac{1}{1 + K_{dsw} \times \mathrm{TSS} \times 0.000001}$$

The values for the fraction of COI in the water column and other calculated parameters are presented in Table A.4.

The total water column concentration (C_{wcTot}) of the COIs, comprising both the dissolved and suspended sediment phases, is then calculated as follows (US EPA, 2014):

$$C_{wcTot} = C_{wtot} \times f_{water} \times \frac{d_z}{d_w}$$

Finally, the dissolved water column concentration (C_{dw}) for the COIs is calculated as follows (US EPA, 2014):

$$C_{dw} = f_d \times C_{wcTot}$$

The dissolved water column concentration (C_{dw}) was then used to calculate the concentration of COIs sorbed to suspended solids in the water column (US EPA, 1998):

$$C_{sw} = C_{dw} \times K_{dsw}$$

where:

C_{sw} = Concentration sorbed to suspended solids (mg/kg)
C_{dw} = Concentration dissolved in the water column (mg/L)
K_{dsw} = Suspended solids/water partition coefficient (mL/g)

In the same way, using the total water body concentration and the fraction of COI in the benthic sediments, the model derives the total concentration in benthic sediments (US EPA, 2014):

$$C_{bstot} = f_{benth} \times C_{wtot} \times \frac{d_z}{d_b}$$

where:

C_{bstot} = Total COI concentration in bed sediment (mg/L or g/m^3)
C_{wtot} = Total water body COI concentration (mg/L)
f_{benth} = Fraction of COI in benthic sediments (unitless)
d_b = Depth of the upper benthic layer (m)
d_z = Depth of the water body (m). Calculated as $d_w + d_b$.

This value can be used to calculate dry weight sediment concentration as follows:

$$C_{seddw} = \frac{C_{bstot}}{bsc}$$

where:

C_{seddw} = Dry weight sediment concentration (mg/kg)
C_{bstot} = Total sediment concentration (mg/L)
bsc = Bed sediment bulk density. Used the default value of 1 g/cm^3 from US EPA (2014).

The total sediment concentration is composed of the sum of the COI concentration dissolved in the bed sediment pore water (equal to the concentration dissolved in the water column) and the COI concentration sorbed to benthic sediments (US EPA, 1998).

The COI concentration sorbed to benthic sediments was calculated as follows (US EPA, 1998):

$$C_{sb} = C_{dbs} \times K_{dbs}$$

where:

C_{sb} = Concentration sorbed to bottom sediments (mg/kg)
C_{dbs} = Concentration dissolved in the sediment pore water (mg/L)
K_{dbs} = Sediments/water partition coefficient (mL/kg)

For each COI, the modeled total water column concentration and concentration sorbed to sediment are presented in Table A.5.

Table A.1 Parameters Used to Estimate Groundwater Discharge to Surface Water

Parameter	Name	Value	Unit
A	Cross-Sectional Area	2,560	m^2
i	Hydraulic Gradient	0.019	m/m
K	Hydraulic Conductivity	1.50E-04	cm/s

Sources: SIPC, 2021; SIPC, 2007; Golder Associates Inc., 2021.

Table A.2 Partition Coefficients

Constituent	Mean Sediment-Water Partition Coefficient (K_{dbs})		Mean Suspended Sediment-Water Partition Coefficient (K_{dsw})	
	Value ($\log_{10}$) (mL/g)	Value (mL/g)	Value ($\log_{10}$) (mL/g)	Value (mL/g)
Metals				
Arsenic	2.4	2.51E+02	3.9	7.94E+03
Beryllium	2.8	6.31E+02	4.2	1.58E+04
Boron	0.8	6.31E+00	3.9	7.94E+03
Cadmium	3.3	2.00E+03	4.9	7.94E+04
Cobalt	3.1	1.26E+03	4.8	6.31E+04
Lead	4.6	3.98E+04	5.7	5.01E+05
Thallium	1.3	2.00E+01	4.1	1.26E+04

Notes:
mL/g = Milliliters per Gram.
Source: US EPA, 2014.

Table A.3 Surface Water Parameters

Parameter	Name	Value	Unit
TSS	Total Suspended Solids	49	mg/L
V_{fx}	Surface Water Flow Rate	2.5×10^{11}	L/year
d_b	Depth of Upper Benthic Layer (default)	0.03	m
d_w	Depth of Water Column	1.52	m
d_z	Depth of Water Body	1.55	m
bsc	Bed Sediment Bulk Density (default)	1	g/cm^3
bsp	Bed Sediment Porosity (default)	0.6	–
M_{TSS}	TSS Mass per Unit Area[a]	0.075	kg/m^2
M_S	Sediment Mass per Unit Area[b]	30	kg/m^2

Notes:
CF = Conversion Factor.
Source of default values: US EPA, 2014.
(a) $M_{TSS} = TSS \times d_w \times CF1 \times CF2$.
(b) $M_S = d_b \times bsc \times CF3 \times CF4$.
CF1 = 1,000 L/m^3; CF2 = 1E06 mg/kg; CF3 = 1E+06 cm^3/m^3; CF4 = 0.001 kg/g.

Table A.4 Calculated Parameters

COI	Fraction of COI in the Water Column (f_{water})	Fraction of COI in the Benthic Sediments ($f_{benthic}$)	Fraction of COI Dissolved in the Water Column ($f_{dissolved}$)
Metals			
Arsenic	0.219	0.781	0.720
Beryllium	0.1250	0.8750	0.5629
Boron	0.9108	0.0892	0.7198
Cadmium	0.1107	0.8893	0.2044
Cobalt	0.142	0.858	0.244
Lead	0.032	0.968	0.039
Thallium	0.800	0.200	0.618

Note:
COI = Constituent of Interest.

Table A.5 Surface Water and Sediment Modeling Results for Little Saline Creek

COI	Maximum Measured Groundwater Concentration (mg/L)	Modeled Surface Water Concentration (mg/L)	Modeled Sediment Concentration (mg/kg)
Arsenic	1.20E-01	1.15E-06	2.09E-04
Beryllium	8.10E-03	7.79E-08	2.77E-05
Boron	3.10E+00	2.98E-05	1.35E-04
Cadmium	5.50E-02	5.29E-07	2.16E-04
Cobalt	5.40E-02	5.19E-07	1.60E-04
Lead	8.00E-02	7.69E-07	1.20E-03
Thallium	4.60E-02	4.42E-07	5.46E-06

Notes:
COI = Constituent of Interest; mg/L = Milligrams per Liter.

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Appendix B

Screening Benchmarks

Table B.1 Calculated Water Quality Standards Protective of Incidental Ingestion and Fish Consumption

Human Health COI	Bioconcentration Factor (BCF)		Average Daily Intake (ADI)			Human Threshold Criteria (HTC)		
	BCF[a] (L/kg-tissue)	Basis	MCL (mg/L)	RfD (mg/kg-d)	ADI[b] (mg/day)	Water & Fish (mg/L)	Water Only (mg/L)	Fish Only (mg/L)
Arsenic	44	NRWQC (2002)	0.01	0.0003	0.02	0.022	2.0	0.023
Beryllium	19	NRWQC (2002)	0.004	0.002	0.008	0.021	0.80	0.021
Boron	1	(d)	NC	0.2	14	467	1400	700
Cadmium	270	US EPA (2014)	0.005	0.0001	0.01	0.0018	1.0	0.0019
Cobalt	300	ORNL (2023)	NC	0.0003	0.021	0.0035	2.1	0.0035
Lead	46	US EPA (2014)	0.01	NC	0.02	0.01	0.01	0.01
Thallium	116	NRWQC (2002)	0.002	0.00001	0.004	0.0017	0.40	0.0017

Notes:

ADI = Average Daily Intake; BCF = Bioconcentration Factor; COI = Constituent of Interest; F = Fish Consumption Rate; HTC = Human Threshold Criteria; MCL = Maximum Contaminant Level; NA = BCF Not Available and Therefore, WQC for Fish Only Not Calculated; NC = No Criterion Available; NRWQC = National Recommended Water Quality Criteria; ORNL = Oak Ridge National Laboratory; RfD = Reference Dose; W = Water Consumption Rate; WQC = Water Quality Criteria; SWQC = Surface Water Quality Criteria; US EPA = United States Environmental Protection Agency.

(a) BCFs from the following hierarchy of sources:

NRWQC (2002). National Recommended Water Quality Criteria: 2002. Human Health Criteria Calculation Matrix.
US EPA (2014). Human and Ecological Risk Assessment of Coal Combustion Residuals.
ORNL (2023). Risk Assessment Information System (RAIS) Chemical Toxicity Values.

(b) ADI based on the MCL is calculated as the MCL (mg/L) multiplied by a water ingestion rate of 2 L/day. In the absence of an MCL, the ADI was calculated as the RfD (mg/kg-d) multiplied by the body weight (70 kg).

(c) SWQC based on US EPA's action level.

(d) BCF of 1 was used as a conservative assumption, due to lack of published BCF.

Consumption of Water and Fish

$$\text{HTC} = \frac{\text{ADI}}{\text{W} + (\text{F} \times \text{BCF})}$$

Consumption of Water Only

$$\text{HTC} = \frac{\text{ADI}}{\text{W}}$$

Consumption of Fish Only

$$\text{HTC} = \frac{\text{ADI}}{\text{F} \times \text{BCF}}$$

Where:

Human Threshold Criteria (HTC)	Chemical-specific	mg/L
Acceptable Daily Intake (ADI)	Chemical-specific	mg/day
Fish Consumption Rate (F)	0.02	kg/day
Bioconcentration Factor (BCF)/ Bioaccumulation Factor (BAF)	Chemical-specific	L/kg-tissue
Water Consumption Rate (W)	0.01	L/day
Body Weight	70	kg
Target Cancer Risk (TCR)	1.0E-05	unitless

Attachment B

Curriculum Vitae of Ari Lewis, M.S.

Ari S. Lewis, M.S.
Principal
Ari.Lewis@gradientcorp.com

Areas of Expertise

Human health risk assessment, hazard assessment, product safety evaluations, metals toxicology, molecular toxicology, natural product toxicity assessment.

Education

M.S., Environmental Toxicology (Cellular and Molecular Toxicology and Risk Analysis), Cornell University, 2002

B.A., Biology and Environmental Sciences, University of Pennsylvania, 1995

Professional Experience

2002 – Present GRADIENT, Boston, MA
Provides expertise in toxicology to oversee projects evaluating potential human health hazards and risks from environmental and product exposures, with an emphasis on risks from industrial chemicals.

1999 – 2002 CORNELL UNIVERSITY, Ithaca, NY
Research Assistant. Developed an *in vivo* system to study the developmental toxicity of environmental agents at the cellular and molecular level. Investigated the tissue-specific responses to sodium arsenite and heat shock by examining the associations between stress protein induction, molecular signal transduction, and sensitivity to stress-induced cell death.

2001 – 2002 ASSOCIATION OF COMPARATIVE AND ENVIRONMENTAL TOXICOLOGY, Ithaca, NY
President. Organized educational and social events to promote the integration of Cornell graduate students within the research-diverse program of Environmental Toxicology.

1994 – 1995 UNIVERSITY OF PENNSYLVANIA, Philadelphia, PA
Research Assistant. Designed and executed a clinical research project to collect, clone, and express Canine Tumor Necrosis Factor (TNF) protein for the purpose of developing an Enzyme-linked Immunosorbent Assay (ELISA) to evaluate TNF levels in septic canines.

Awards/Honors

Society of Chemical Hazard Communication Outstanding Volunteer Award, 2023
National Institute of Environmental Health Sciences, Research Training Fellowship, 1999-2002
Cornell Institute of Comparative and Environmental Toxicology, Travel Award, 2001

1/17/2025

Professional Affiliations

US EPA Science Advisory Board Environmental Justice Science and Analysis Review Panel (Member), 2024
US EPA Science Advisory Board EJScreen Review Panel (Member), 2023
Society for Chemical Hazard Communication (Program Committee)
Product Stewardship Society (Program Committee)
Society of Toxicology (Associate Member)
Past GreenScreen Advanced Training (Guest Lecturer, Acute Mammalian Toxicity and Systemic Toxicity)

Testimony

Lewis, AS. "Comments on H.R. Bill 1391 on Recycling Coal Combustion Residuals Accessibility Act of 2011." Presented to the House Subcommittee on Energy and the Environment, Washington, DC, April 14, 2011.

Example Projects

Environmental Justice Screening Analysis in Canada: For a multi-national food manufacturer, Gradient researched available socioeconomic, health, and environmental justice (EJ) screening factors for Ontario, Canada.

Propylene Glycol Scientific Review: On behalf of a trade organization, Gradient derived an acceptable daily intake (ADI) of propylene glycol by proposing a mode of action of toxicity.

Survey of Exposure to Quantify General Population Exposure: On behalf of a trade organization, developed state-of-the-science report regarding assessment of human far-field exposures to chemicals in commerce (including fenceline exposures) in the context of TSCA risk evaluations.

Data Availability and Initial Screening Assessment of Endocrine Disruption Properties for Petroleum-Related Substances: Gradient compiled relevant information regarding the endocrine disruption potential of hydrocarbons and petroleum substances, following guidance from the European Chemicals Agency (ECHA)/European Food Safety Authority (EFSA).

Toxicology Screening of Constituents Associated with Post-Combustion, Amine-Based Carbon Capture: Used toxicity and regulatory databases to screen chemicals in carbon capture waste streams for potential human health and environmental risk concerns. Intended to further research and data gaps for future risk assessment.

Recommended Best Practices for Assessing Risks in Baby Products: On behalf of a personal care product company, partnered with a global safety certification company to develop recommended best practices for assessing chemical risks associated with personal care products, focusing on those used in infant care.

State of Environmental Justice Screening Tools: Provided comprehensive assessment of EJSCREEN and other state environmental justice screening tools. Also included assessment of current environmental justice initiatives and intersection with chemical industry.

TSCA Fenceline Risk Assessment Comments: Provided comments on EPA's proposed approach to assess fenceline risks from facilities manufacturing or using priority chemicals.

Hazard and Risk Assessment of Surface Coating: On behalf of chemical working group, conducted weight-of-evidence evaluation of compound with suspected reproductive toxicity potential. Also conducted risk assessment for downstream workers and consumers.

1,4- Dioxane Assessment: For consumer product company evaluated presence of 1,4-dioxane in US groundwater and surface water supplies.

GHS Hazard Assessment: On behalf of a global oil and gas company, led project conducting GHS-based hazard assessments for a chemical portfolio consisting of more than 1,600 chemicals used in the formulation of tens of thousands of products. The hazard assessments were used to understand product-level hazards and update US and international Safety Data Sheets (SDSs) to meet GHS compliance requirements.

Risk Assessment of Contaminant in Baby Formula: On behalf of consumer products company, performed a risk assessment of cleaning fluids that accidentally leaked into powdered infant formula during the formulation process.

Development of Occupational Exposure Limits: After a change in harmonized hazard assignment, led project developing safe worker exposure levels to several fragrance substances for global fragrance company.

Risk Assessment for Hazardous Food Ingredient: On behalf of a food service client, Gradient evaluated the safety of a flavoring ingredient. We conducted a comprehensive hazard and risk assessment using data reported in the scientific literature and accepted risk assessment methodologies to determine whether there could be health risks for children or adults from regular consumption of food products containing this ingredient. The clients used our reports for their risk communication efforts.

Toxicity and Epidemiology of a Commercial Product: Provided litigation support for project involving the safety of a commercial product. Primary efforts included evaluating the toxicological and epidemiologic information of several different compounds used in commercial products.

Green Chemistry Assessment: Led toxicology of an alternatives assessment for a product using criteria outlined in US EPA's Design for the Environment (DfE) program. The assessment was submitted to US EPA for acceptance under this "green" chemistry program.

State-of-Knowledge Assessment of Hazards of New Technologies for Grid-Scale Battery Storage: Identified and evaluated potential health risks associated with the life cycle of batteries used for energy storage applications. We examined the chemical composition and life cycle risks associated with the production and disposal of a variety of battery types (*e.g.*, lithium ion, nickel cadmium, vanadium redox).

Risk Assessment Workshop: Invited instructor for risk assessment workshop focused on the derivation of health-based benchmarks for contaminants in drinking water. Workshop conducted for the utility industry.

Safety Data Sheet (SDS) for Metal Industry: On behalf of a trade association led a project developing a detailed, OSHA-compliant safety data sheet (SDS) for the manufacture and use of a metal in the United States (US). We performed a comprehensive toxicological and ecological hazard review of the metal and incorporated US-specific regulatory information.

Product Safety: Provided an in-depth review of lead exposure and toxicology issues. Findings were presented in a report that was used by the industry group as a basis to make informed decisions about design modification and safety testing of plumbing products.

Review of Antimicrobials: Oversaw project involving the extensive toxicology and regulatory review of various anti-microbial substances that are banned or under consideration for banning by the US Food and Drug Administration (US FDA).

Chemical Compliance: For a multinational chemicals company, led project registering and classifying hazards of chemical products to satisfy global regulatory requirements.

Product Stewardship: Led project providing ongoing support for a printer ink company. Work involves hazards assessment, registration support, and internal product standard development.

TSCA Support (PMN): For a large multinational chemicals company, led project providing technical expertise to fulfill regulatory requirements under the Toxic Substances Control Act (TSCA). Our expertise in read-across and complex chemistries, thorough analysis of exemptions, and careful documentation helped the client avoid unnecessary PMNs and create sustainable compliance strategies.

TSCA Support (Test Waivers): Oversaw project evaluating the scientific credibility of a US EPA Significant New Use Rule (SNUR) for a chemical of interest to an advanced materials manufacturer. The collective toxicity dataset and in silico models were used to support an argument against the scientific need for the EPA SNUR toxicity test requests.

Toxicity Assessment using Predictive Toxicology: On behalf of an office supply company, led project assessing toxicity of a newly developed compound. Because no existing toxicity information was available on the compound, we identified chemical surrogates expected to have a similar toxicological profile and conducted a structural alert analysis to better understand potential human health hazards.

Safety Data Sheet for Flavor Manufacturer: Led project involving SDS Requirements for natural food colorant products according to OSHA 2012 Haz Com Standard.

Coal Ash Regulatory Comment: In response to a Notice of Data Availability (NODA), Gradient assessed the potential impact of new data on US EPA's draft risk assessment of coal combustion waste (CCW). Our assessment was used by the client to propose revisions and additions to the US EPA's analysis.

Assessment of Coal Ash Surface Impoundment Closure Options: As a form of reliance material for a legal action, led an assessment of two closure scenarios for surface impoundments containing coal combustion residual (CCR) at an electric power utility.

Development of Coal Ash Surface Impoundment Closure Decision Framework: Served a principal investigation on project for Electric Power Research Institute supporting development of a comprehensive Framework that enables coal-fired utilities to evaluate the potential human health and environmental impacts associated with two closure options for surface impoundments (SI) containing coal combustion residual (CCR).

Constituent Profiles and Risk Issues: On behalf of a research organization sponsored by the power utility companies, oversaw a series of technical briefing documents providing an overview of the environmental fate and transport, human health and ecological risks associated with arsenic and selenium.

Development of a No Significant Risk Level: To comply with provisions of California's Proposition 65, developed a no significant risk level (NSRL) for an animal carcinogen that could volatilize from a consumer product.

Inhalation Criteria Development: Developed a series of health-based inhalation criteria (HBIC) for several different organic compounds present in printer cartridges. In some cases, derivation of the HBIC required surrogate selection, route-to-route extrapolation, and animal-to-human pharmacokinetic adjustments.

Risk Assessment of Emerging Chemicals: Provided technical oversight of a large risk assessment evaluating potential drinking water risks for emerging contaminants, a majority of which did not have established toxicity criteria. Researched and developed quantitative toxicity information that could be used to estimate potential risks.

Toxicity and Epidemiology of a Commercial Product: Provided litigation support for project involving the safety of a commercial product. Primary efforts included evaluating the toxicological and epidemiologic information of several different compounds used in commercial products.

Regulatory Comment on Coal Combustion Product Risk Assessment: Led evaluation of US EPA's technical approach for assessing human health and ecological risks associated with the storage of coal combustion products. Evaluations occurred in 2007 and on an updated version of the risk assessment in 2010. Our evaluations were provided to US EPA during a public comment period.

Overview Reports on Chemical Constituents in Coal Combustion Products: Lead author on a series of chapters summarizing the human health and ecological health effects of several metals found in coal combustion products, focusing on the use of this information in risk assessment and current regulatory standards and criteria. Metals included arsenic, thallium, selenium, and molybdenum.

Molybdenum Groundwater Limit: For an on-going project, leading effort to develop an alternative health-based guideline for molybdenum in drinking water.

Ecological Effects of Coal Combustion Products: Conducted literature review to evaluate the ecological effects of unintended releases of coal combustion products (CCPs), focusing effects on the growth, survival, reproduction, and population characteristics of aquatic and terrestrial organisms.

Mercury Risks from the Use of Coal Ash in Building Materials: Evaluated potential inhalation risks from mercury associated with the beneficial use of coal combustion products in wallboard, concrete, and structural fill.

Arsenic Content in Dietary Supplement: Evaluated whether the amount of inorganic arsenic in a dietary supplement product line would constitute an unacceptable inorganic arsenic exposure if products were taken individually or as part of a multi-product program. Estimated exposure from supplements and compared to international guidelines for arsenic in food, typical inorganic arsenic exposure in the US diet, and levels that are known to cause adverse effects in humans.

History of Use of a Dietary Ingredient (Toxic Tort): In the absence of extensive information on the toxicology of the ingredient *Hoodia gordonii*, researched its history of safe use as an appetite suppressant to refute a claim that a particular dietary supplement caused adverse health effects in an individual.

Toxic Tort Involving Dietary Supplement: Managed toxic tort project evaluating the claim that a dietary supplement containing multiple herbal ingredients was the cause of a stroke. Reviewed the health effects literature on the ingredients in the supplement, medical records of the plaintiff, and the risk factors for stroke.

Toxic Tort Involving Dietary Supplement: For a litigation project, assessed likelihood that a multi-ingredient dietary supplement was the cause of elevated liver enzymes and migraine headaches in a plaintiff. The evaluation involved examination of health information on the various ingredients in the product and examination of the plaintiff's medical records.

Evaluation of Structure-Function Claims: Evaluated several different structure-function claims for a product line for a major dietary supplement company. Activities included a comprehensive literature search, article summary, and a weight-of-evidence evaluation to determine if available science supported structure-function claims.

Toxic Tort Involving Pesticide Exposure: In the context of litigation, analyzed whether pesticide exposure was the cause of a specific birth defect. The evaluation involved a review of toxicological and epidemiological literature, as well as a reconstruction of potential dose *via* complex exposure pathways.

Arsenic Bioavailability Assessment: Led project providing input on a university study to evaluate the bioavailability of arsenic in soil with and without soil amendments aimed at reducing bioavailability.

PFC Regulatory Comments: Provided comments to a state agency regarding the toxicological significance of exposure to PFOA and PFOS *via* drinking water.

Class Action Determination for PFC Exposure: Assisted law firm to assess validity of a class action involving perfluorinated chemical exposure.

Residential Exposure Evaluation: Performed a risk evaluation in a community claiming that illegally disposed manufactured gas plant waste was a public health concern and decreased property values. The analysis was used as part of expert testimony.

Arsenic Exposure Assessment: Performed in-depth review of the relationship between exposure to arsenic in soil and the effect on arsenic body burden and health. Results were provided to client as part of a litigation effort.

Metal Risk Assessment: Interpreted the results of a metal bioassay and potential regulatory implications. Proposed experimental approach to establish chemical mode of action and human relevance of rodent bioassay results.

Human Health Risk Assessment: Provided input as a third-party consultant on a risk assessment of former chemical manufacturing plant. Role also included responding to community concerns.

Pesticide Re-registration of an Arsenic-based Pesticide: Managed a multi-faceted project in support of the re-registration of organic arsenic herbicides. This project included several presentations and technical submissions to US EPA regarding relevance of cancer data from animals to human risk, as well as directed responses to US EPA-issued risk assessments.

Lead Exposure and Toxicology: Assessed the validity of a tax allocation based on the contribution of historic gasoline emissions to current lead exposures in California. The findings were presented in a report that described the relative contribution of various lead sources to children's blood lead levels.

Arsenic Risk Assessment: Contributed to an expert report in a toxic tort case involving exposure to arsenic in a residential area. The report critically evaluated toxicological information regarding the carcinogenic effects of arsenic and the plausibility of health claims.

Arsenic Risk Assessment: Provided litigation support in lawsuit alleging that the presence of arsenic in a residential town caused a decrease in property value. The evaluation involved comparing levels of arsenic found in the town (in soil, water, dust, *etc.*) and arsenic exposures associated with adverse health effects.

Evaluation of Chemical Toxicity: Contributed to a weight-of-evidence evaluation of the low dose effects of Bisphenol A (BPA). The results were published in a peer-reviewed journal.

Arsenic Risk Assessment: Provided litigation support by evaluating the biological plausibility of the association between low level arsenic exposure and various health endpoints.

Manufactured Gas Plants: Contributed to an expert report that assessed the state of toxicological knowledge of contaminants released at a former MGP site.

Chromium Risk Assessment: Evaluated the feasibility of a nonlinear dose-response relationship between chromium and adverse health effects in litigation that involved occupational exposure to chromium(III).

Arsenic Risk Assessment: Provided litigation support in toxic tort case involving exposure to arsenic in a residential area. Assessed the strength of an association between arsenic exposure and several different health endpoints.

Regulatory Comment for Arsenic Risk Assessment: Contributed to an evaluation of the technical soundness of US EPA's risk assessment of chromated copper arsenate (CCA) treated wood.

Regulatory Comment for Arsenic Risk Assessment: Provided technical support to a consortium of registrants evaluating the technical validity of US EPA's approach to develop a cancer potency factor (CPF) for inorganic arsenic. The evaluation was presented in a technical white paper submitted to US EPA.

Human Health Risk Assessment: Prepared Method 3 risk characterizations in accordance with Massachusetts Contingency Plan (MCP) regulations for petroleum-impacted sites in Massachusetts.

Arsenic Risk Assessment: Provided information on inorganic arsenic's nonlinear dose-response relationship in response to a US EPA risk assessment of an industrial site with arsenic contamination.

Articles

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Publications

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Hower, JC; Granite, EJ; Mayfield, DB; Lewis, AS; Finkelman, RB. 2016. "Notes on contributions to the science of rare earth element enrichment in coal and coal combustion byproducts." *Minerals* 6(2):32.

Lewis, A; Seeley, M; Pizzurro, D; Sharma, M; Flewelling, S. 2015. "A hierarchical framework for the selection and development of toxicity criteria for the evaluation of potential drinking water risks from hydraulic fracturing fluids." *Toxicologist* 144(1):49. Presented at the Society of Toxicology (SOT) 54th Annual Meeting, San Diego, CA, March 22-26.

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Lewis, AS; Beyer, LA; Zu, K. 2015. "Considerations in deriving quantitative cancer criteria for inorganic arsenic exposure *via* inhalation." *Environ. Int*. 74:258-273.

Mayfield, DB; Lewis, AS; Bailey, LA; Beck, BD. 2014. "Properties and effects of metals." In *Principles of Toxicology: Environmental and Industrial Applications Third Edition*. (Eds.: Roberts, SM; James, RC; Williams, PL), Wiley, p283-307.

Lynch, HN; Greenberg, GI; Pollock, MC; Lewis, AS. 2014. "A comprehensive evaluation of inorganic arsenic in food and considerations for dietary intake analyses." *Sci. Total Environ*. 496:299-313.

Lewis, AS; Reid, KR; Pollock, MC; Campleman, SL. 2012. "Speciated arsenic in air: Measurement methodology and risk assessment considerations." *J. Air Waste Manage. Assoc.* 62(1):2-17.

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****Awarded Top 10 Best Published Paper Demonstrating Application of Risk Assessment by the Society of Toxicology Risk Assessment Specialty Section.**

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Kondziolka, JM; Lewis, AS. 2024. "Corrective Action Sustainability: Holistic Decision Support Tool." Presented at Southern Company Professional Development Meeting, Birmingham, AL, October 24.

Lewis, AS. 2024. "The Intersection of Environmental Justice Initiatives Coal Combustion Products." Presented at Southern Company Professional Development Meeting. 22p. September 26.

Lewis, AS. 2024. "Screening, Testing, and Assessing Ingredient Portfolios for Endocrine Disruption." Presented at the 2024 Society for Chemical Hazard Communication (SCHC) Annual Meeting, Charlotte, NC. 30p. September 24.

Lewis, AS. 2024. "Coal Transport and Environmental Justice: Two Trains on the Same Track." Presented at the National Coal Transportation Association (NCTA) 50th Annual Business Meeting and Conference, Tucson, AZ. 22p. September 11.

Kondziolka, J; Lewis, A. 2024. "Corrective Action Sustainability: Holistic Decision Support Tool." Presented at World of Coal Ash (WOCA) 2024, Grand Rapids, MI, May 14.

Lewis, A; Kondziolka, J; Biega, M; Tentori, E; Zhang, Q; Shrivastava, I; Hensel, B. 2024 "Example Application of a Holistic Decision Support Tool Used for Selecting Corrective Actions at Coal Combustion Product Sites." Abstract/Poster #: 182. Presented at World of Coal Ash (WOCA) 2024, Grand Rapids, MI, May 13-16.

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Slagowski, NL; Lemay, JC; Lewis, AS. 2023. "Evaluating Exposure and Risk in Communities with EJ Concerns: Uses and Limitations of Publicly Available Geographic Information System (GIS)-Based Tools." Presented at ACE 2023: Air & Waste Management Association (A&WMA)'s 116th Annual Conference & Exhibition, Orlando, FL, June 6, 20p.

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* Ari S. Lewis formerly Ari S. Schoen.

CORRECTED
EXHIBIT 37

Human Health and Ecological Risk Assessment
Marion Power Station
Southern Illinois Power Cooperative
Marion, Illinois

Prepared by

Ari Lewis

Ari S. Lewis, M.S.
Principal

December 20, 2024
Corrected on January 29, 2025

GRADIENT

www.gradientcorp.com
One Beacon Street, 17th Floor
Boston, MA 02108
617-395-5000

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Abbreviations

ADI	Acceptable Daily Intake
BCF	Bioconcentration Factor
CCR	Coal Combustion Residuals
CEM	Conceptual Exposure Model
COI	Constituent of Interest
COPC	Constituent of Potential Concern
CSM	Conceptual Site Model
GWPS	Groundwater Protection Standard
GWQS	Groundwater Quality Standard
HTC	Human Threshold Criteria
ID	Identification
IEPA	Illinois Environmental Protection Agency
ISGS	Illinois State Geological Survey
K_d	Equilibrium Partitioning Coefficient
MCL	Maximum Contaminant Level
MGS	Marion Power Generating Station
NRWQC	National Recommended Water Quality Criteria
ORNL RAIS	Oak Ridge National Laboratory's Risk Assessment Information System
pCi/L	Picocuries per Liter
PRG	Preliminary Remediation Goal
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SIPC	Southern Illinois Power Cooperative
SWQS	Surface Water Quality Standard
US EPA	United States Environmental Protection Agency

1 Introduction

Southern Illinois Power Cooperative (SIPC) owns and operates the Marion Power Generating Station (MGS), a gas and coal-fired electric power generating facility in Marion, Illinois. The MGS is located in Williamson County, approximately eight miles south of Marion, Illinois, on the northwestern bank of the Lake of Egypt (Figure 1.1). The MGS began operation in 1963. The area surrounding the facility is a rural agricultural community (Kleinfelder, 2013). The MGS has several surface impoundments that have been used for storage of coal combustion residuals (CCR) and several impoundments that were used to support other operational purposes (*e.g.*, wastewater storage, surface water run-off collection). This report addresses potential impacts from the surface impoundments (*i.e.*, storage ponds) that did not routinely receive CCRs and consequently contain a *de minimis* amount of CCRs. These storage ponds include:

- Pond 4
- Pond 3 and Pond 3A
- Pond S-6
- Pond B-3
- South Fly Ash Pond

This report presents the results of an evaluation that characterizes potential risk to human and ecological receptors that may be exposed to CCR constituents in environmental media originating from the storage ponds listed above. This risk evaluation was performed to support a petition for relief from the closure schedule required under the Illinois coal ash rule (IEPA, 2021). Human health and ecological risks were evaluated for Site-specific constituents of interest (COIs). The conceptual site model (CSM) assumed that Site-related COIs in groundwater may migrate to the Lake of Egypt or to Little Saline Creek and affect surface water in the vicinity of the Site.

Consistent with United States Environmental Protection Agency (US EPA) guidance (US EPA, 1989), this report used a tiered approach to evaluate potential risks, which included the following steps:

1. Identify complete exposure pathways and develop a conceptual exposure model (CEM).
2. Identify Site-related COIs: Constituents detected in groundwater were considered COIs if their maximum detected concentration over the period from 2018 to 2023 exceeded a groundwater protection standard (GWPS) identified in Part 845.600 (IEPA, 2021), or a relevant surface water quality standard (SWQS) (IEPA, 2019).
3. Perform screening-level risk analysis: Compare maximum measured or modeled COI concentrations in surface water and sediment to conservative, health-protective benchmarks in order to determine constituents of potential concern (COPCs).
4. Perform refined risk analysis: If COPCs are identified, perform a refined analysis to evaluate potential risks associated with the COPCs.
5. Formulate risk conclusions and discuss any associated uncertainties.

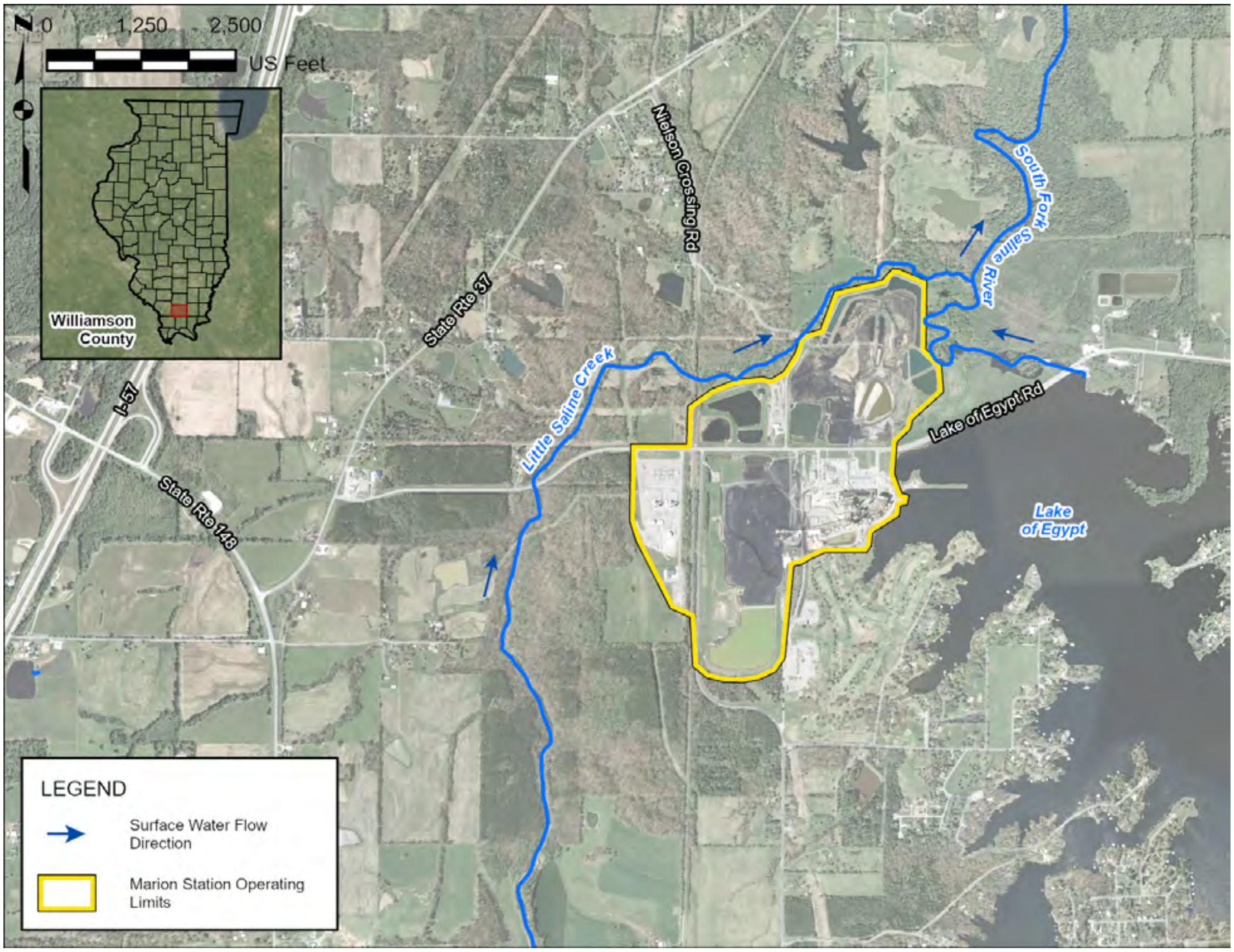

Figure 1.1 Site Location Map. Sources: Golder Associates Inc., 2021; USGS, 2022; US Census Bureau, 2016; USGS, 2011.

This assessment relies on a conservative (*i.e.*, health-protective) approach and is consistent with the risk approaches outlined in US EPA guidance (US EPA, 1989; US EPA, 2004; US EPA [Region IV], 2018). Specifically, we considered evaluation criteria detailed in Illinois Environment Protection Agency (IEPA) guidance documents (*e.g.*, IEPA, 2013, 2019), incorporating principles and assumptions consistent with the Federal CCR Rule (US EPA, 2015a) and US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals" (US EPA, 2014).

US EPA has established acceptable risk metrics. Risks above these US EPA-defined metrics are termed potentially "unacceptable risks." Based on the evaluation presented in this report, no unacceptable risks to human or ecological receptors resulting from CCR exposures associated with the ponds listed above were identified. This means that the risks from the Site are likely indistinguishable from normal background risks. Specific risk assessment results include the following:

- No completed exposure pathways were identified for any groundwater receptors; consequently, no risks were identified relating to the use of groundwater for drinking water and other household purposes.
- No unacceptable risks were identified for the use of Lake of Egypt surface water as drinking water.
- No unacceptable risks were identified for recreators boating in Lake of Egypt.

- No unacceptable risks were identified for anglers consuming locally-caught fish.
- No unacceptable risks were identified for ecological receptors exposed to surface water or sediment.
- No bioaccumulative ecological risks were identified.

It should be noted that this evaluation incorporates a number of conservative assumptions that tend to overestimate exposure and risk (discussed in Section 3.5).

2 Site Overview

2.1 Site Description

The MGS is located in Williamson County, approximately eight miles south of Marion, Illinois, on the northwestern bank of the Lake of Egypt. The MGS facility is bordered to the east by Lake of Egypt, to the southeast by a golf course (Lake of Egypt Country Club), and to the south, west, and north by farmland (Figure 2.1). Little Saline Creek is located just north of the MGS facility boundary; it flows northeast and joins the South Fork Saline River about 600 feet east of the facility boundary (Figure 2.1).

Only "relatively small amounts of fly ash" were produced at the Site (SIPC, 2021a). Fly ash that was generated was transported and stored in the Initial Fly Ash Holding Area, Replacement Fly Ash Holding Area, Pond A-1, or the Former On-Site Landfill (SIPC, 2021a). The former Fly Ash Holding Areas are within the cover area for the Former On-Site Landfill (SIPC, 2021a). Other ponds located on Site (Figure 2.1) and a description of their historic and current operation are described below.

- Ponds 1 and 2 received sluiced bottom ash from power generation units 1, 2, 3, and 4 (Figure 1.1; SIPC, 2021a). During the entire pond operational life, bottom ash was removed from Ponds 1 and 2, and sold for beneficial reuse to shingle manufacturers, grit blasting companies, and local highway departments. Decanted water from Ponds 1 and 2 flowed into Pond 4.
- The Former Emery Pond was constructed in the late 1980s to hold stormwater drainage from the generating station (Figure 1.1; SIPC, 2021a). All CCRs in Emery Pond have been removed and the pond has been closed (SIPC, 2021a). Groundwater corrective action is currently on-going (Hanson Professional Services Inc., 2021).
- South Fly Ash Pond was constructed in 1989 and was originally intended to be a replacement for Pond A-1 (Figure 1.1; SIPC, 2021a). Ultimately, Pond A-1 did not need to be replaced. Thus, the South Fly Ash Pond was only used to receive decant water from the Former Emery Pond while it was operational. No CCRs were ever directly sent to or disposed of in the South Fly Ash Pond (SIPC, 2021a).
- Ponds 3 and 3-A were secondary ponds that received overflow from the fly ash holding areas (Figure 1.1; SIPC, 2021a). They also received storm water runoff, coal pile runoff, and water from the facility floor drains. In approximately 1982, Pond 3-A was separated from Pond 3 by construction of an internal berm. All sediment and debris were removed from Pond 3 in 2006 and 2011. All sediment and debris were removed from Pond 3-A in 2014. Subsequently, no CCRs were ever directly sent to or disposed in Ponds 3 or 3-A. Currently, water from the South Fly Ash Pond flows into Pond 3 (SIPC, 2021a).
- Pond S-6 was originally built to manage stormwater associated with the Former Landfill (Figure 1.1; SIPC, 2021b). Initially, water in Pond S-6 discharged to Little Saline Creek through Outfall 001; however, in approximately 1993, water from Pond S-6 was pumped to Pond 4. No CCRs were ever directly sent to or disposed in the Pond S-6 (SIPC, 2021a).
- Pond B-3 was built in 1985 and was primarily used as a secondary pond that received water from Pond A-1 (Figure 1.1; SIPC, 2021a). During periodic shutdowns of Pond A-1, Pond B-3 may have received some short-term discharges of fly ash from Unit 1, 2, and 3 prior to their shutdown (SIPC, 2021a). In 2017, Pond B-3 was dewatered and all sediment and CCR were excavated.

- Pond 4 was built in 1979 and historically received decant water from Ponds 1 and 2 for secondary treatment and received runoff from the coal pile (Figure 1.1; Kleinfelder, 2013; SIPC, 2021 a,b). No CCRs were ever directly sent to or disposed in the Pond 4. All sediment and debris were removed from Pond 4 in 2012. Currently, Pond 4 receives overflow from Pond S-6; water in Pond 4 discharges into the Little Saline Creek *via* Outfall 002 (Kleinfelder, 2013; SIPC, 2021a).

The ponds are shown in Figure 2.1. This Risk Assessment focuses on the storage ponds that supported operations but never directly received CCRs on a routine basis. These storage ponds include: Pond 4, Pond 3 and 3A, Pond S-6, Pond B-3, and the South Fly Ash Pond.

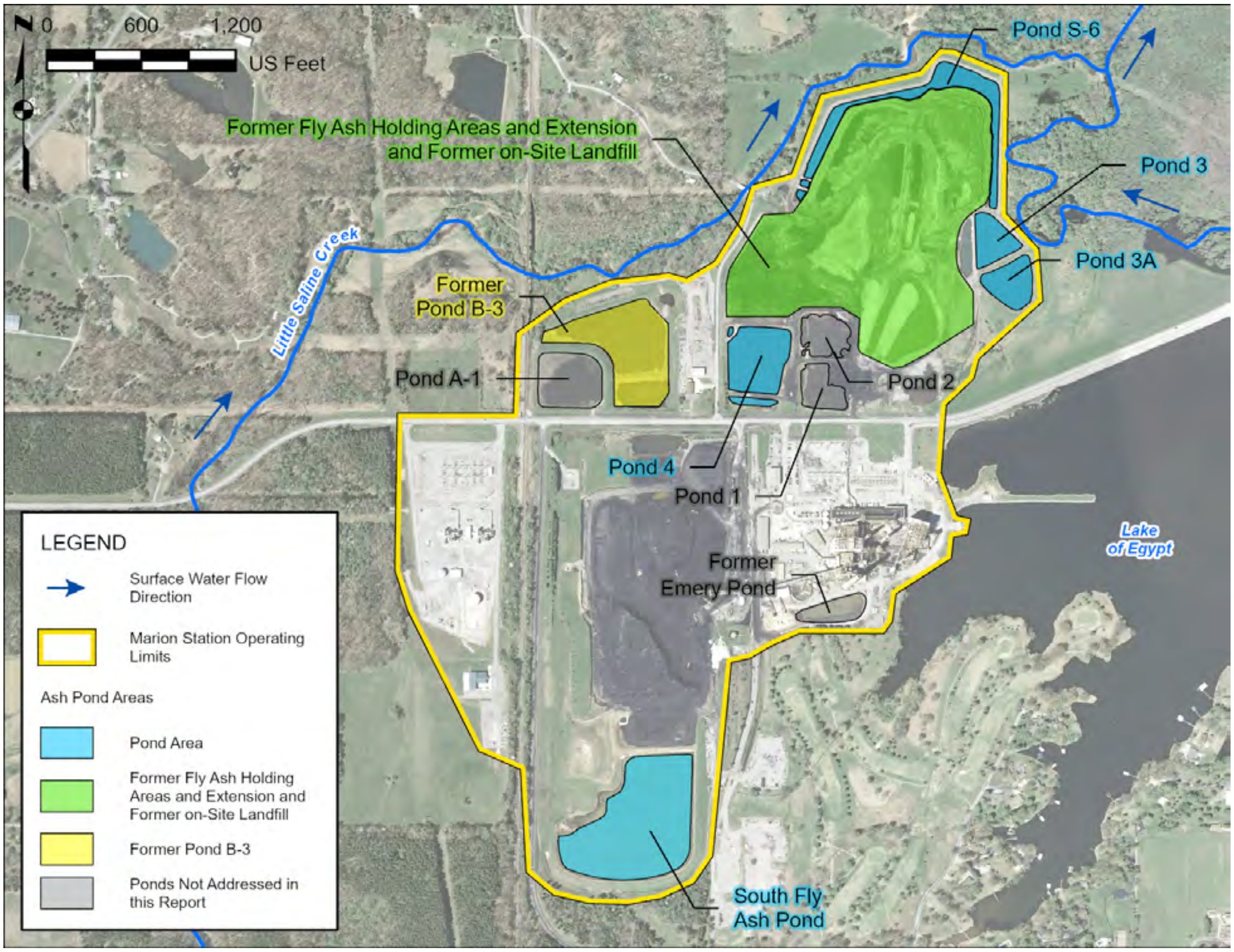

Figure 2.1 Site Layout. Sources: Golder Associates Inc., 2021; USGS, 2022; Andrews Engineering, 2021; SIPC, 2021a; USGS, 2011.

2.2 Geology/Hydrogeology

The Site is located at the southern edge of the Illinois Basin in the Shawnee Hills Section of the Interior Low Plateaus physiographic province (Golder Associates Inc., 2021). The Illinois Basin is a depositional and structural basin composed of sedimentary rocks ranging in age from Cambrian to Permian. The southern portion of the basin is characterized by extensive faulting, and some of these faults host commercially significant fluorite vein deposits (Golder Associates Inc., 2021). The regional stratigraphic sequence includes the following, from the surface downward (Golder Associates Inc., 2021):

- The Caseyville/Tradewater Formation: consists of lenticular, vertically and horizontally interbedded layers of sandstone, siltstone, and shale beneath a relatively thin layer of unconsolidated materials. It ranges from 190 to 500 feet in thickness.
- The Kinkaid Formation: consists of limestone, shale, claystone, and sandstone. It is separated from the overlying Pennsylvanian rocks of the Caseyville Formation by a laterally extensive unconformity. It ranges from 120 to 160 feet in thickness.
- The Degonia Formation: consists of thin, very-fine grained sandstone, siltstone, shale, and irregular chert beds. It ranges from 20 to 64 feet in thickness.
- The Clore Formation: consists of sandstone, shale and limestone, which sporadically outcrops at the surface. It ranges from 110 to 155 feet in thickness.

On Site, soils overlying the Caseyville/Tradewater Formation consist of glacial and alluvial deposits including layers of silty clay, clayey silt, silty sand and clayey sand (Kleinfelder, 2013). Table 2.1 provides a detailed summary of the Site lithology for the upper 50 feet (Golder Associates Inc., 2021).

Table 2.1 Site Geology

Lithology	Description
Peoria/Roxana Silt	Light yellow-tan to gray, fine sandy silt
Glasford Formation	Silty/sandy diamictons with thin lenticular bodies of silt, sand, and gravel
Caseyville Formation/Bedrock	Sedimentary rocks including sandstone, limestone, and shales

Source: Golder Associates, Inc., 2021; Kleinfelder, 2013.

The Site is located within the South Fork Saline River/Lake Egypt watershed. Groundwater in the southern/eastern portion of the Site flows toward and discharges into the Lake of Egypt; groundwater throughout the rest of property flows in a northeasterly direction toward Little Saline Creek (Figure 3.3; SIPC, 2007). The uppermost water-bearing zone (*i.e.*, the Unlithified Unit) is a shallow, hydraulically perched layer consisting of fill and residuum (silts and clays), with a saturated thickness of approximately up to 10 feet (Hanson Professional Services Inc., 2021). The average horizontal hydraulic conductivity is estimated to be approximately 1.5×10^{-4} cm/s in the Unlithified Unit (Golder Associates Inc., 2021). The hydraulic gradient was estimated to be 0.019 based on measured groundwater elevations at monitoring wells S-3 and S-6 (SIPC, 2007).

2.3 Conceptual Site Model

A CSM describes sources of contamination, the hydrogeological units, and the physical processes that control the transport of water and solutes. In this case, the CSM describes how groundwater underlying the MGS migrates and potentially interacts with surface water and sediment in the Lake of Egypt and Little

Saline Creek. The CSM was developed using site-specific hydrogeologic data, including information on groundwater flow and surface water characteristics.

Groundwater (and CCR-related constituents originating from the MGS) may migrate vertically downward through the Unlithified Unit. As noted in Section 2.2, the dominant groundwater flow direction at the Site is to the northeast toward Little Saline Creek. However, south of Lake of Egypt Road, groundwater has an eastern flow component toward the Lake of Egypt (SIPC, 2007). Dissolved constituents in groundwater that flows into these two water bodies may partition between sediment and surface water.

2.4 Groundwater Monitoring

Data from the following monitoring wells were included in this risk assessment, as they are used to monitor groundwater quality downgradient and upgradient of the MGS (Figure 2.3):

- Wells C-1, C-2, C-3 and Well EBG; these wells were used to characterize groundwater quality near the South Fly Ash Pond.
- Wells S-1, S-2, S-3, S-4, S-5, S-6; these wells were used to characterize groundwater quality near the Pond 4, Pond 3 and 3A, Pond S-6, and Pond B-3.

The monitoring well construction details are presented in Table 2.2. The analyses presented in this report rely on the available data from these wells collected between 2018 and 2023. Groundwater samples were analyzed for a suite of total metals, specified in Illinois CCR Rule Part 845.600 (IEPA, 2021),[1] as well as general water quality parameters (pH, chloride, fluoride, sulfate, and total dissolved solids). A summary of the groundwater data used in this risk evaluation is presented in Tables 2.3a and 2.3b. The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with operations at MGS or that they have been identified as potential groundwater exceedances.

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[1] Samples were analyzed for a longer list of inorganic constituents and general water quality parameters (chloride, fluoride, sulfate, and total dissolved solids), but these constituents were not evaluated in the risk evaluation.

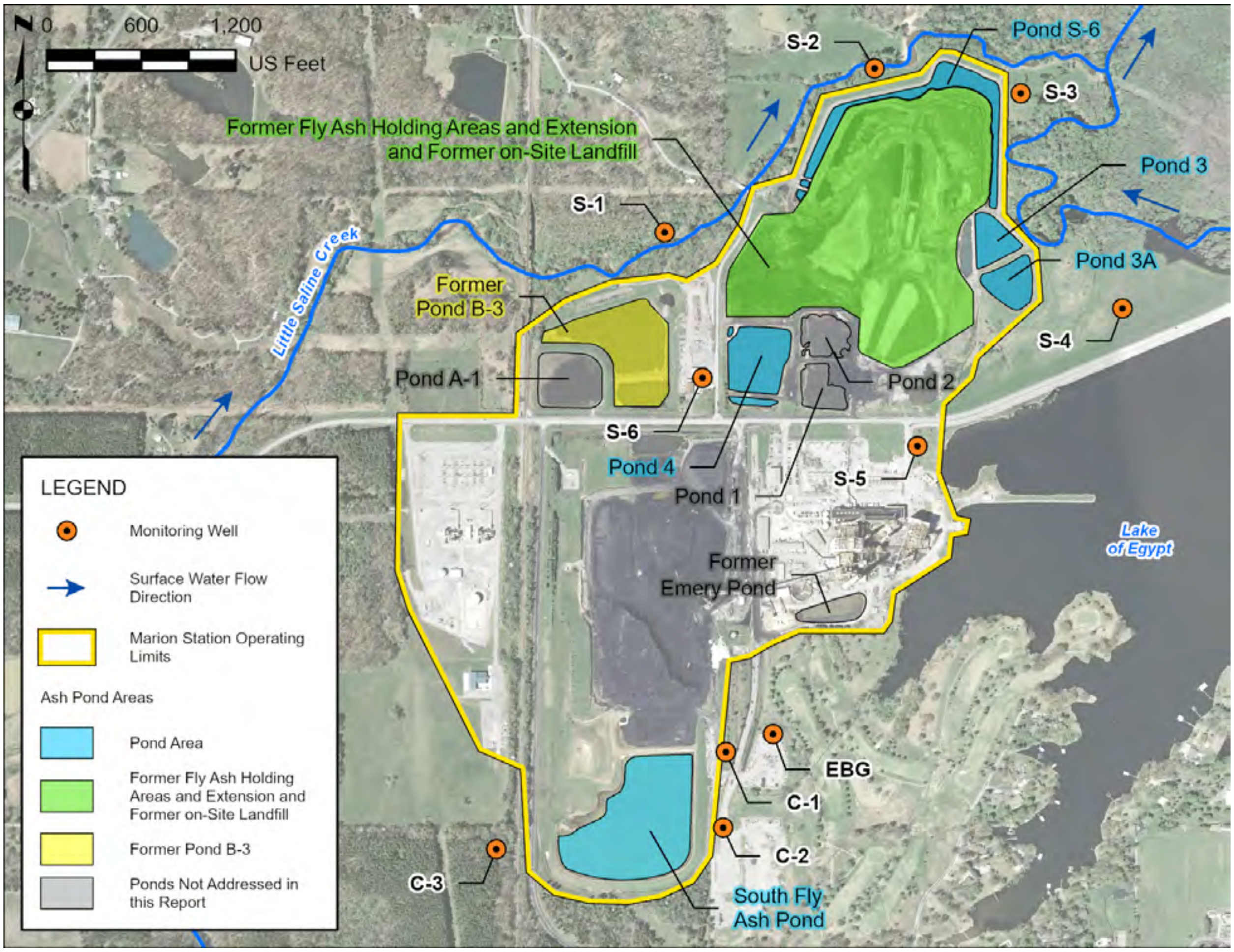

Figure 2.2 Monitoring Well Locations. Sources: Golder Associates Inc., 2021; USGS, 2022; SIPC, 2007; Andrews Engineering, 2021; SIPC, 2021a; USGS, 2011.

Table 2.2 Groundwater Monitoring Wells

Well	Date Constructed	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Well Depth (ft bgs)	Hydrostratigraphic Unit (Screened Interval)
C-1	2/16/2010	5	15	15	Unlithified Unit/Bedrock
C-2	2/16/2010	2	12	12	Unlithified Unit/Bedrock
C-3	(no info)	(no info)			Unlithified Unit/Bedrock
EBG	2/8/2017	18	28	28	Unlithified Unit/Bedrock
S-1	9/20/1993	15	25	25	Unlithified Unit/Bedrock
S-2	2/18/2010	16	26	27.5	Unlithified Unit/Bedrock
S-3	9/20/1993	15	25	25	Unlithified Unit/Bedrock
S-4	9/21/1993	8	18	18	Unlithified Unit/Bedrock
S-5	9/20/1993	12	22	22	Unlithified Unit/Bedrock
S-6	9/20/1993	12	22	22	Unlithified Unit/Bedrock

Notes:
bgs = Below Ground Surface; ft = Feet; EBG = Emery Pond Background Well.

Table 2.3a Groundwater Data Summary (2018-2023) for C-Wells + EBG

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	0	20	ND	ND	0.030
Arsenic	7	20	0.00040	0.0075	0.10
Barium	19	20	0.012	0.20	0.0050
Beryllium	3	21	0.00038	0.00060	0.020
Boron	36	81	0.011 J	12 J	0.50
Cadmium	5	77	0.00066	0.013	0.020
Chromium	8	21	0.00070	0.0042	0.030
Cobalt	13	21	0.00020 J	0.29 J	0.020
Lead	3	21	0.0011	0.0031	0.050
Lithium	8	13	0.014	0.024	0.060
Mercury	1	19	0.000070	0.000070	0.00020
Molybdenum	8	14	0.0012 J	0.015	0.040
Selenium	11	21	0.00060	0.033	0.025
Thallium	2	21	0.0012	0.031	0.040
Dissolved Metals (mg/L)					
Boron	12	24	0.040	0.92	0.50
Cadmium	0	24	ND	ND	0.0010
Radionuclides (pCi/L)					
Radium 226 + 228	9	11	0.12	2.7	0.33
Other (mg/L or SU)					
Chloride	61	63	2.4	570	20
Fluoride	19	24	0.10	0.68	0.50
pH	47	47	5.8	7.0	0
Sulfate	81	81	49	670	123
Total Dissolved Solids	51	51	100	4000	16

Notes:

EBG = Emery Pond Background Well; J = Estimated Value; mg/L = Milligrams per Liter; ND = Not Detected; pCi/L = Picocuries per Liter; SU = Standard Unit.

Blank cells indicate constituent not detected.

Table 2.3b Groundwater Data Summary (2018-2023) for S-Wells

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	0	12	ND	ND	0.0050
Arsenic	3	12	0.0089	0.12	0.050
Barium	12	12	0.020	1.5	NA
Beryllium	1	12	0.0081	0.0081	0.0050
Boron	35	126	0.0041	2.8	0.50
Cadmium	12	126	0.00068	0.055	0.002
Chromium	9	12	0.0014	0.069	0.0050
Cobalt	5	12	0.0012	0.054	0.010
Lead	7	12	0.0027	0.080	0.0050
Mercury	0	12	ND	ND	0.00020

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Selenium	3	12	0.0021	0.017	0.025
Thallium	1	12	0.046	0.046	0.025
Dissolved Metals (mg/L)					
Boron	14	48	0.0051	3.1	0.50
Cadmium	0	48	ND	ND	0.001
Other (mg/L or SU)					
Chloride	88	90	6.1	480	20
Fluoride	6	12	0.062	0.18	0.50
pH	66	66	5.7	6.9	NA
Sulfate	122	126	2.6	310	20
Total Dissolved Solids	66	66	78	4500	NA

Notes:
mg/L = Milligrams per Liter; NA = Not Available; ND = Not Detected; SU = Standard Unit.
Blank cells indicate constituent not detected.

2.5 Surface Water Monitoring

Surface water samples were collected by MGS from five locations in Lake of Egypt in June 2020. The sample locations are listed in Table 2.4, are shown in Figure 2.2, and the sampling results are summarized in Table 2.5. Surface water data are also available from the Lake of Egypt public water district as part of routine monitoring. The data used in this report were collected 2018-2023, and the sampling results are summarized in Table 2.6.

Table 2.4 Lake of Egypt Sample Locations

Sample ID	Description
LE-u	Upstream sample
LE-d	Spillway sample
LE-in	Public water supply intake
LE-b1	Bay sample #1
LE-b2	Bay sample #2

Figure 2.3 Surface Water Sample Locations. Source: Hanson (2021)

Table 2.5 Surface Water Data Summary for Lake of Egypt Samples

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Arsenic	0	5	ND	ND	0.025
Barium	5	5	0.00227	0.00265	NA
Boron	0	5	ND	ND	0.02
Cadmium	0	5	ND	ND	0.001
Chromium	0	5	ND	ND	0.005
Cobalt	0	5	ND	ND	0.005
Lead	0	5	ND	ND	0.001
Mercury	0	5	ND	ND	0.2
Selenium	0	5	ND	ND	0.001
Thallium	0	5	ND	ND	0.002
Other (mg/L)					
Chloride	1	5	4	4	4
Fluoride	0	5	ND	ND	0.1
pH	5	5	6.57	7.25	NA
Sulfate	5	5	16	17	NA
Total Dissolved Solids	5	5	44	60	NA

Notes:
mg/L = Milligrams per Liter; NA = Not Available; ND = Not Detected; SU = Standard Unit.
Blank cells indicate constituent was not detected.
Data collected on 6/1/2020.

Table 2.6 Surface Water Data Summary for Lake of Egypt Public Water District Data

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	0	6	ND	ND	0.003
Arsenic	0	6	ND	ND	0.001
Barium	6	6	0.021	0.0263	NA
Beryllium	0	6	ND	ND	0.001
Cadmium	0	6	ND	ND	0.003
Chromium	0	6	ND	ND	0.005
Mercury	0	6	ND	ND	0.0002
Selenium	1	6	0.0024	0.0024	0.002
Thallium	0	6	ND	ND	0.002
Radionuclides (pCi/L)					
Radium 226 + 228	1	1	1.03	1.03	NA
Other (mg/L)					
Chloride	6	6	10.4	23	NA
Fluoride	6	6	0.553	0.73	NA
Sulfate	6	6	34.6	51.7	NA
Total Dissolved Solids	6	6	87	158	NA

Notes:
mg/L = Milligrams per Liter; NA = Not Available; ND = Not Detected; pCi/L = Picocuries per Liter.
Data collected 2018-2023.

3 Risk Evaluation

3.1 Risk Evaluation Process

A risk evaluation was conducted to determine whether constituents present in groundwater underlying and downgradient of the MGS have the potential to pose adverse health effects to human and ecological receptors. The risk evaluation is consistent with the principles of risk assessment established by US EPA and has considered evaluation criteria detailed in Illinois guidance documents (*e.g.*, IEPA, 2013, 2019).

The general risk evaluation approach is summarized in Figure 3.1 and discussed below.

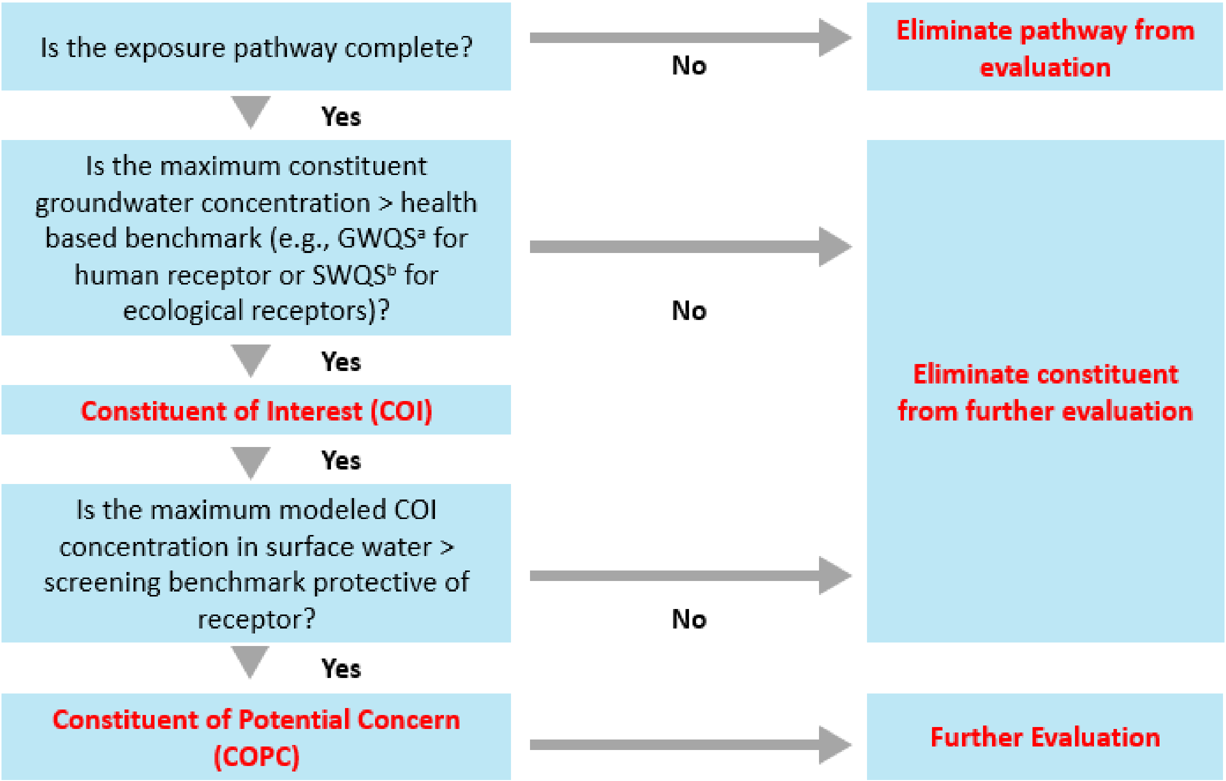

Figure 3.1 Overview of Risk Evaluation Methodology. IEPA = Illinois Environmental Protection Agency; GWQS = IEPA Groundwater Quality Standards; SWQS = IEPA Surface Water Quality Standards. (a) The IEPA Part 845 Groundwater Protection Standards (GWPS) were used to identify COIs. (b) IEPA SWQS protective of chronic exposures to aquatic organisms were used to identify ecological COIs. In the absence of an SWQS, US EPA Region IV Ecological Screening Values (ESVs) were used.

The first step in the risk evaluation was to develop the CEM and identify complete exposure pathways. All potential receptors and exposure pathways based on groundwater use and surface water use in the vicinity of the Site were considered. Exposure pathways that are incomplete were excluded from the evaluation.

Groundwater data were used to identify COIs. COIs were identified as constituents with maximum concentrations in groundwater in excess of groundwater quality standards (GWQS)[2] for human receptors, and SWQS for ecological receptors. Based on the CSM (Section 2.2), groundwater in the south half of the Site, on the west side of the South Fly Ash Pond, has the potential to interact with surface water in the Lake of Egypt. Therefore, potential facility-related constituents in groundwater may potentially flow toward and into surface water in the Lake of Egypt. Surface water samples have been collected from the Lake of Egypt adjacent to the Site, and Gradient used the measured surface data to evaluate potential risks to receptors in using the lake for recreation and as a source of drinking water.

Groundwater in the northern portion of the Site, near Pond 4, Pond 3 and 3A, Pond S-6, and Pond B-3 and in the northern portion of the South Fly Ash pond has the potential to interact with surface water in Little Saline Creek. No surface water has been collected from Little Saline Creek, therefore, Gradient modeled the COI concentrations in Little Saline Creek based on the groundwater data from the groundwater monitoring wells located in this portion of the Site (*i.e.*, S-wells). The measured and modeled COI concentrations in surface water and sediment were compared to conservative, generic risk-based screening benchmarks for human health and ecological receptors. These generic screening benchmarks rely on default assumptions with limited consideration of site-specific characteristics. Human health benchmarks are receptor-specific values calculated for each pathway and environmental medium that are designed to be protective of human health. Human health and ecological screening benchmarks are inherently conservative because they are intended to screen out chemicals that are of no concern with a high level of confidence. Therefore, a measured or modeled COI concentration exceeding a screening benchmark does not indicate an unacceptable risk, but only that further risk evaluation is warranted. COIs with maximum concentrations exceeding a conservative screening benchmark are identified as COPCs requiring further evaluation.

As described in more detail below, this evaluation relied on the screening assessment to demonstrate that constituents present in groundwater underlying the facility do not pose an unacceptable human health or ecological risk. That is, after the screening step, no COPCs were identified and further assessment was not warranted.

3.2 Human and Ecological Conceptual Exposure Models

A CEM provides an overview of the receptors and exposure pathways requiring risk evaluation. The CEM describes the source of the contamination, the mechanism that may lead to a release of contamination, the environmental media to which a receptor may be exposed, the route of exposure (exposure pathway), and the types of receptors that may be exposed to these environmental media.

3.2.1 Human Conceptual Exposure Model

The human CEM for the Site depicts the relationships between the off-Site environmental media potentially impacted by constituents in groundwater and human receptors that could be exposed to these media. Figure 3.2 presents a human CEM for the Site. It considers a human receptor who could be exposed to COIs hypothetically released into groundwater and surface water. The following human receptors and exposure pathways were evaluated for inclusion in the Site-specific CEM.

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[2] As discussed further in Section 3.3.2, GWQS are protective of human health and not necessarily of receptors. While receptors are not exposed to groundwater, groundwater can potentially enter into the adjacent surface water and impact receptors. Therefore, two sets of COIs were identified: one for humans and another for receptors.

- Residents – exposure to groundwater/surface water as drinking water;
- Residents – exposure to groundwater/surface water used for irrigation;
- Recreators in the Lake of Egypt to the east of the Site:
  - Boaters – exposure to surface water while boating;
  - Swimmers – exposure to surface water while swimming;
  - Anglers – exposure to surface water and consumption of locally caught fish.
- Recreators in Little Saline Creek to the north of the Site:[3]
  - Anglers – exposure to surface water and consumption of locally caught fish.

All of these exposure pathways were considered to be complete, except for residential exposure to groundwater used for drinking water or irrigation, and exposure to sediment. Section 3.2.1.1 explains why the residential drinking water and irrigation pathways are incomplete for groundwater. Section 3.2.1.2 discusses the use of surface water as a drinking water source. Section 3.2.1.3 provides additional description of the recreational exposures.

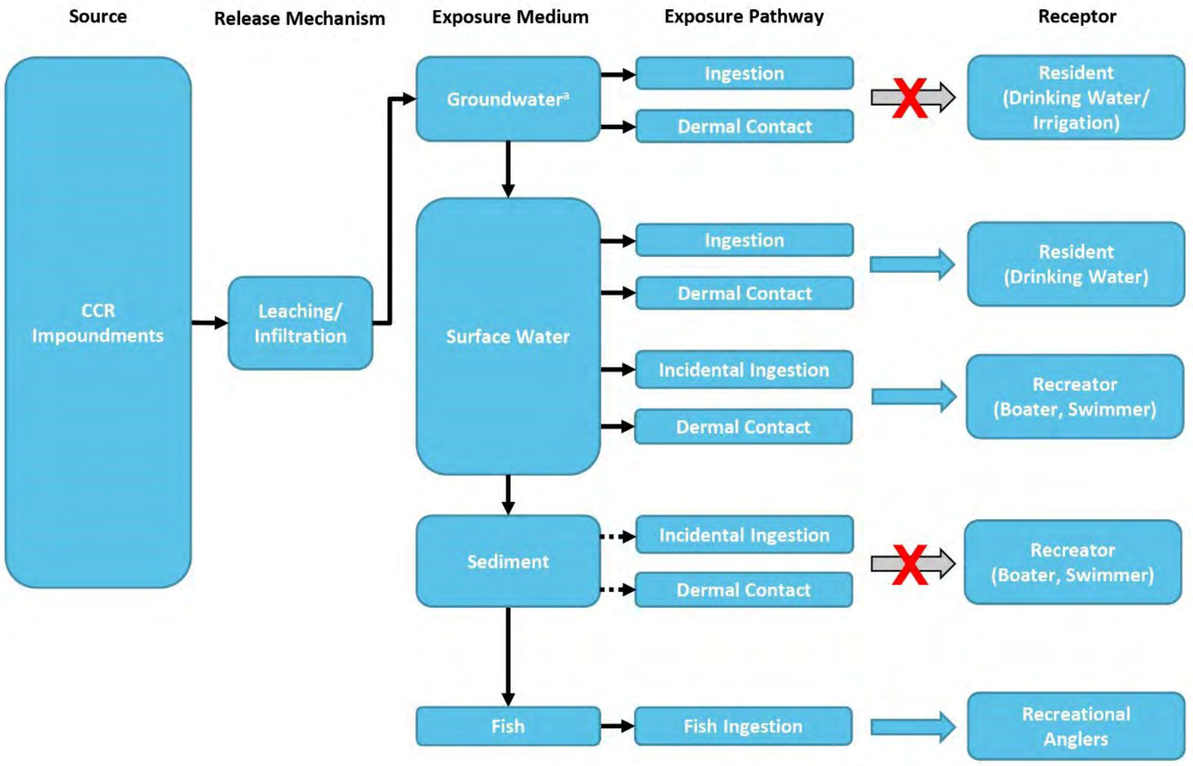

Figure 3.2 Human Conceptual Exposure Model. CCR = Coal Combustion Residuals. Dashed line/Red X = Incomplete or insignificant exposure pathway. (a) Groundwater in the vicinity of the Site is not used as a drinking water or irrigation source.

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[3] Boating and swimming are assumed not to occur in Little Saline Creek due to its small size.

3.2.1.1 Groundwater as a Drinking Water/Irrigation Source

Groundwater beneath the facility generally flows northeast towards the Little Saline Creek (SIPC, 2007). However, in the southern section of the Site, there is a component of groundwater flow that is to the east toward the Lake of Egypt (SIPC, 2007). Gradient conducted a receptor survey in 2024 to identify potential users of groundwater in the vicinity of the facility. Specific sources that were used in this survey include the Illinois State Geological Survey (ISGS) ILWATER database (ISGS, 2024). Four private water wells were identified within 1,000 meters of the facility (Table 3.1, Figure 3.3). One private well (121990235000) is upgradient of the facility, and the other three wells are sidegradient of the facility, such that these wells are not expected to be impacted by any CCR constituents in groundwater that originate from any of the ponds that are being evaluated (Figure 3.3). Further, wells are screened in the sandstone or lime sandstone water bearing unit and range in depth from 95 to 260 ft bgs, far below the depths of the monitoring wells at the site (12-28 feet bgs) where impacts, if any, from site-related activities would be observed. Moreover, three of the private wells are on the opposite side of Little Saline Creek, which provides hydraulic separation from any potential impacts at the site since shallow groundwater is likely to discharge into the creek rather than flow underneath it.

Table 3.1 Summary of Water Wells Within 1,000 Meters of the MGS

Well Number	Type	Date Drilled	Owner	Depth (ft)	Formation	Latitude	Longitude
121990235000	Water Well	2/29/1968	Morganthaler, Carrol	95	Sandstone	37.612148	-88.968285
121990235100	Water Well	4/30/1968	Propes, Charlie	98	Sandstone	37.611752	-88.950049
121990252500	Water Well	10/31/1971	Fisher, William	150	Sandstone	37.628378	-88.962144
121992397400[a]	Water Well	7/20/2003	Gordon, Steve	260	Lime Sandstone	37.628378	-88.962144

Notes:
ft = Feet; MGS = Marion Power Generating Station..
(a) This well, drilled in 2003, listed a pumping rate of 20 gallons per minute (gpm), while the well at the same location (121990252500), drilled in 1971 listed a pumping rate of 7 gpm. It is not known whether the 1971 is still in use.
Source: ISGS (2024).

3.2.1.2 Surface Water as a Drinking Water Source

The Lake of Egypt is used as a public water supply (IEPA, 2024a). The intake for the Lake of Egypt Public Water District (Facility ID IL1995200) is located at the northeast corner of the Lake of Egypt (Figure 3.3). The Lake of Egypt Public Water District serves a population of 11,368 (IEPA, 2024a) and supplies "approximately 1 million gallons per day of drinking water to Union, Jackson, and Williamson Counties" (SIPC, 2018a).

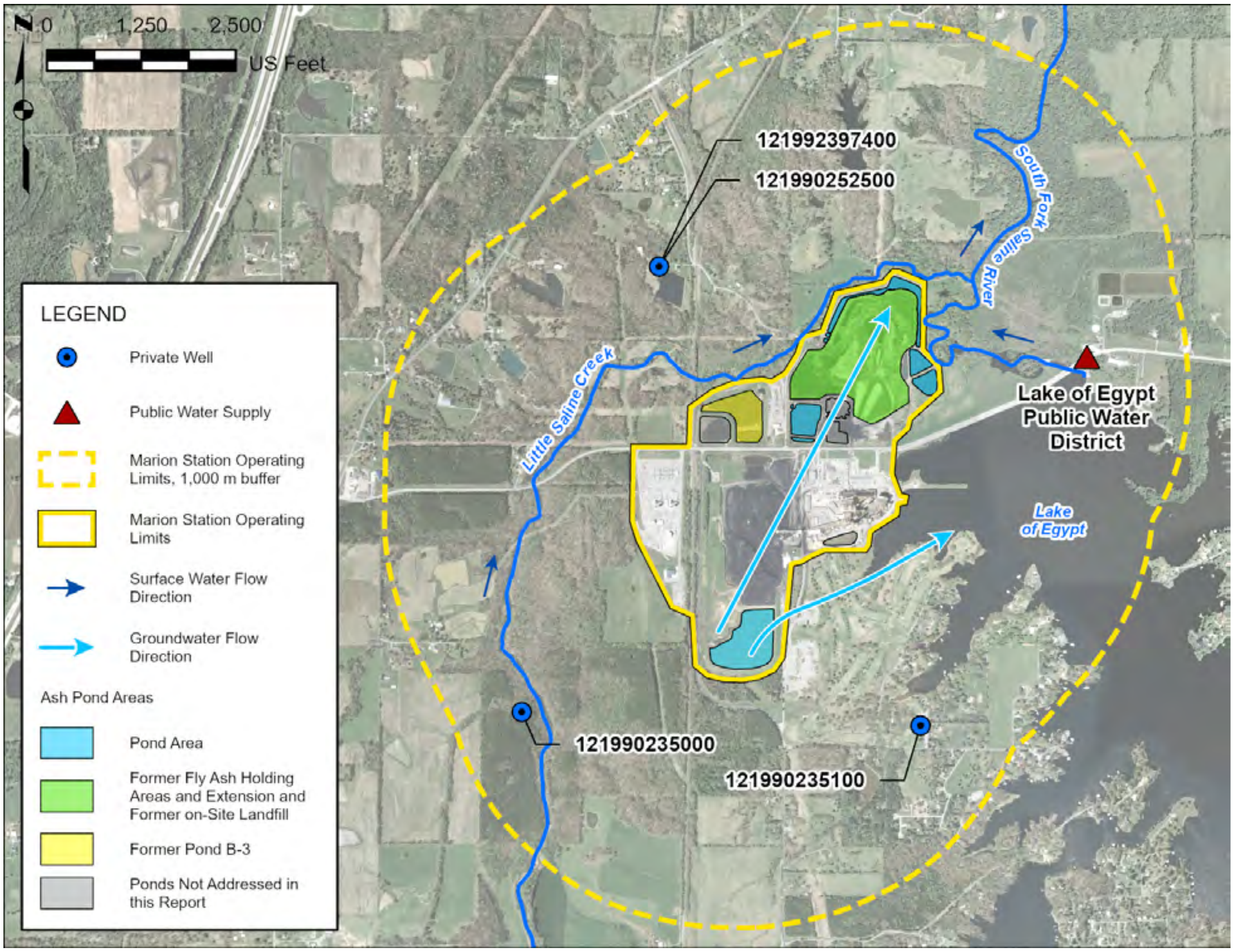

Figure 3.3 Water Wells Within 1,000 Meters of the Facility. Sources: Golder Associates Inc., 2021; USGS, 2022; Andrews Engineering, 2021; ISGS, 1909-2023; IEPA, 2024b; SIPC, 2007; USGS, 2011.

3.2.1.3 Recreational Exposures

Lake of Egypt, located to the east of the MGS facility, is a private lake owned by SIPC which allows the lake to be used for recreation. The lake is approximately 2,300 acres in size, and has an average depth of 18 feet and a maximum depth of 52 feet (SIPC, 2018a). The recreational uses of the Lake of Egypt include fishing, boating, swimming, and water sports such as water skiing (SIPC, 2018b). SIPC notes that "swimming is prohibited except at approved beaches marked by buoys" (SIPC, 2018b). Recreational exposure to surface water may occur during activities such as boating or fishing in the lake. Recreational anglers may also consume locally caught fish from the lake. The northwest bay of the lake (nearest the MGS) is a restricted area (SIPC, 2018b). Due to the depth of the lake, sediment exposure was not evaluated in Lake of Egypt.

Little Saline Creek is located immediately to the north of the Site. Gradient estimated the average creek width as 26 feet (based on measurements from an aerial photo), and the depth to be approximately 5 feet (based on a Google Earth photo from February 2020 in which bottom sediments were visible). Recreators in the Little Saline Creek may include anglers who could be exposed to surface water and consume locally caught fish. It is assumed that boating and swimming do not occur in Little Saline Creek due to its small size, and the availability of recreation areas at Lake of Egypt to the east.

3.2.2 Ecological Conceptual Exposure Model

The ecological CEM for the Site depicts the relationships between off-Site environmental media (surface water and sediment) potentially impacted by COIs in groundwater and ecological receptors that may be exposed to these media. The ecological risk evaluation considered both direct toxicity as well as secondary toxicity *via* bioaccumulation. Due to the fact that the dominant groundwater flow direction is to the northeast, and the relatively small size of Little Saline Creek, this surface waterbody has a higher potential to be influenced by CCR constituents. Given these factors, Little Saline Creek was identified as the primary focus for evaluating environmental risks for ecological receptors. Figure 3.4 presents the ecological CEM for the Site. The following ecological receptor groups and exposure pathways were considered:

- **Ecological Receptors Exposed to Surface Water:**
  - Aquatic plants, amphibians, reptiles, and fish.
- **Ecological Receptors Exposed to Sediment:**
  - Benthic invertebrates (*e.g.*, insects, crayfish, mussels).
- **Ecological Receptors Exposed to Bioaccumulative COIs:**
  - Higher trophic level wildlife (avian and mammalian) *via* direct exposures (surface water and sediment exposure) and secondary exposures through the consumption of prey (*e.g.*, plants, invertebrates, small mammals, fish).

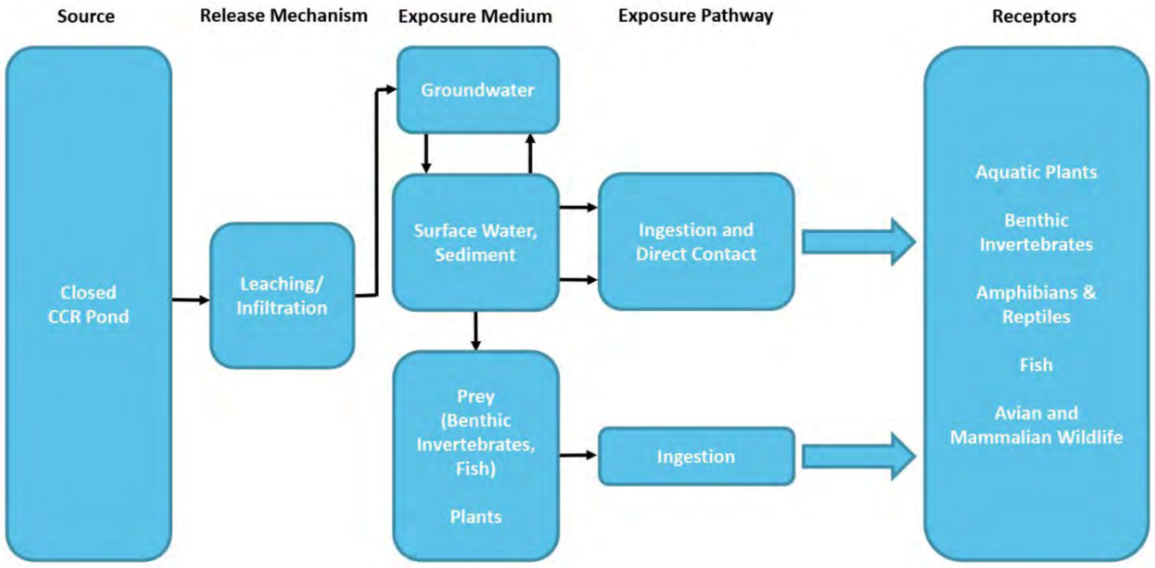

Figure 3.4 Ecological Conceptual Exposure Model. CCR = Coal Combustion Residuals.

3.3 Identification of Constituents of Interest

Risks were evaluated for COIs. A constituent was considered a COI if the maximum detected constituent concentration in groundwater exceeded a health-based benchmark. According to US EPA risk assessment guidance (US EPA, 1989), this screening step is designed to reduce the number of constituents carried through the risk evaluation that are anticipated to have a minimal contribution to the overall risk.

Identified COIs are the constituents that are most likely to pose a risk concern in the surface water adjacent to the Site.

3.3.1 Human Health Constituents of Interest

For the human health risk evaluation, COIs were conservatively identified as constituents with maximum concentrations in groundwater above the GWPS listed in the Illinois CCR Rule Part 845.600 (IEPA, 2021). The COIs were determined separately for the wells monitoring north and south of Lake of Egypt Road (the S-wells in the north that characterize groundwater quality near Pond 4, Pond 3 and 3A, Pond S-6, and Pond B-3, and the C-wells plus EBG well in the south that characterize groundwater quality near the South Fly Ash Pond). Gradient used the maximum detected concentrations from groundwater samples collected from these two groups of wells, regardless of hydrostratigraphic unit. The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with the facility or that they have been identified as potential groundwater exceedances. Using this approach, the COIs that were identified from the S-wells included arsenic, beryllium, boron, cadmium, cobalt, lead, and thallium (Table 3.2). For the S-wells, the maximum concentrations for arsenic, beryllium, cadmium, cobalt, and lead were detected in well S-1; the maximum concentrations for boron and thallium were detected in well S-2. The COIs that were identified from the C-wells+EBG included boron, cadmium, cobalt, and thallium (Table 3.3). For the C-wells, the maximum concentrations were detected in well EBG for boron and cobalt, well C-3 for cadmium, and well C-2 for thallium. Although these constituents were identified as COIs, it's important to re-emphasize that this identification was based solely on whether their maximum concentration exceeded the GWPS. We did not take into account overall temporal or spatial patterns, nor did we consider how these concentrations related to natural background levels or potential contamination from non-CCR sources.

The water quality parameters that exceeded the GWPS included chloride and total dissolved solids in the S-wells, and chloride, sulfate, and total dissolved solids in the C-wells. However, these constituents were not included in the risk evaluation because the GWPS is based on aesthetic quality and there is an absence of studies regarding toxicity to human health. The US EPA secondary maximum contaminant levels (MCLs) for chloride, sulfate, and total dissolved solids are based on aesthetic quality. The secondary MCLs for chloride and sulfate (250 mg/L) are based on salty taste (US EPA, 2021). The secondary MCL for total dissolved solids (500 mg/L) is based on hardness, deposits, colored water, staining, and salty taste (US EPA, 2021). Given that these parameters are not likely to pose a human health risk concern in the event of exposure, they were not considered to be human health COIs.

Table 3.2 Human Health Constituents of Interest Based on Groundwater for S-Wells - Near Pond 4, Pond 3 and 3A, Pond S-6, and Pond B-3 (2018-2022)

Constituent[a]	Detected Maximum[b]	GWPS[c]	Human Health COI[d]
Total Metals (mg/L)			
Antimony	*0.0050*	0.0060	No
Arsenic	0.12	0.010	Yes
Barium	1.5	2.0	No
Beryllium	0.0081	0.0040	Yes
Boron	2.8	2.0	Yes
Cadmium	0.055	0.005	Yes
Chromium	0.069	0.10	No
Cobalt	0.054	0.0060	Yes
Lead	0.080	0.0075	Yes
Mercury	*0.0002*	0.0020	No
Selenium	0.017	0.050	No
Thallium	0.046	0.0020	Yes
Dissolved Metals (mg/L)			
Boron	3.1	2.0	Yes
Cadmium	*0.001*	0.005	No
Other (mg/L or SU)			
Chloride	480	200	No[e]
Fluoride	0.18	4.0	No
pH	6.9	9.0	No
Sulfate	310	400	No
Total Dissolved Solids	4500	1200	No[e]

Notes:

COI = Constituent of Interest; GWPS = Groundwater Protection Standard; IL = Illinois; mg/L = Milligrams per Liter; SU = Standard Units.

Italics indicate constituent was not detected; the value reported is the maximum detection limit.

Shaded cell indicates a compound identified as a COI.

(a) The constituents are those listed in the IL Part 845.600 GWPS (IEPA, 2021).

(b) The maximum detected groundwater concentration was used to identify COIs.

(c) The IL Part 845.600 GWPS (IEPA, 2021) were used to identify COIs.

(d) COIs are constituents for which the maximum concentration exceeds the groundwater standard.

(e) Maximum exceeds the GWPS but analyte is not considered to be a COI because the GWPS is based on aesthetic quality.

Table 3.3 Human Health Constituents of Interest Based on Groundwater for C-Wells - Near the South Fly Ash Pond (2018-2023)

Constituent[a]	Maximum Groundwater Concentration[b]	GWPS[c]	Human Health COI[d]
Total Metals (mg/L)			
Antimony	*0.030*	0.0060	No[e]
Arsenic	0.0075	0.010	No
Barium	0.20	2.0	No
Beryllium	0.00060	0.0040	No
Boron	12	2.0	Yes
Cadmium	0.013	0.0050	Yes
Chromium	0.0042	0.10	No
Cobalt	0.29	0.0060	Yes
Lead	0.0031	0.0075	No
Lithium	0.024	0.040	No
Mercury	0.000070	0.0020	No
Molybdenum	0.015	0.10	No
Selenium	0.033	0.050	No
Thallium	0.031	0.0020	Yes
Dissolved Metals (mg/L)			
Boron	0.92	2.0	No
Cadmium	*0.0010*	0.0050	No
Radionuclides (pCi/L)			
Radium 226 + Radium 228	2.7	5.0	No
Other (mg/L or SU)			
Chloride	570	200	No[f]
Fluoride	0.68	4.0	No
pH	7.0	9.0	No
Sulfate	670	400	No[f]
Total Dissolved Solids	4000	1200	No[f]

Table 3.3 Notes:

COI = Constituent of Interest; GWPS = Groundwater Protection Standard; IL = Illinois; mg/L = Milligrams per Liter; pCi/L = Picocuries per Liter; SU = Standard Units.

Italics indicate constituent was not detected; the value reported is the maximum detection limit.

Shaded cell indicates a compound identified as a COI.

(a) The constituents are those listed in the IL Part 845.600 GWPS (IEPA, 2021).

(b) The maximum detected groundwater concentration was used to identify COIs.

(c) The IL Part 845.600 GWPS (IEPA, 2021) were used to identify COIs.

(d) COIs are constituents for which the maximum concentration exceeds the groundwater standard.

(e) Antimony was not detected in 32 groundwater samples. Only 2 of the 32 samples had detection limits above the GWPS; most of the DLs ranged from 0.001 to 0.005 mg/L and thus were below the GWPS of 0.006 mg/L. Thus antimony was not considered a COI.

(f) Maximum exceeds the GWPS but analyte is not considered to be a COI because the GWPS is based on aesthetic quality.

3.3.2 Ecological Constituents of Interest

The Illinois GWPS, as defined in IEPA's guidance, were developed to protect human health but not necessarily ecological receptors. While ecological receptors are not exposed to groundwater, groundwater can potentially migrate into the adjacent surface water and impact ecological receptors. Therefore, to identify ecological COIs, the maximum concentrations of constituents detected in groundwater were compared to ecological surface water benchmarks protective of aquatic life.

The surface water screening benchmarks for freshwater organisms were obtained from the following hierarchy of sources:

- IEPA (2019) SWQS. IEPA SWQS are health-protective benchmarks for aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). The SWQS for several metals are hardness dependent (cadmium, chromium, and lead). Screening benchmarks for these constituents were calculated assuming US EPA's default hardness of 100 mg/L (US EPA, 2022), due to an absence of hardness data for Little Saline Creek.[4]
- US EPA Region IV (2018) surface water Ecological Screening Values (ESVs) for hazardous waste sites.

Consistent with the human health risk evaluation, Gradient used the maximum detected concentrations from groundwater samples collected from the S-wells without considering spatial or temporal representativeness for ecological receptor exposures. The use of the maximum constituent concentrations in this evaluation is designed to conservatively identify COIs that warrant further investigation. The COIs identified for ecological receptors include cadmium, cobalt, lead, and thallium (Table 3.4).

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[4] Hardness data are available from the South Fork Saline River near Carrier Mills, Illinois (USGS Site No. 03382100), approximately 26 miles downstream of the MGS. Based on 208 samples collected from October 1976 to April 1997, the average hardness at this location was 438 mg/L (USGS, 2024c). Due to the age of the samples and the distance from the site, the US EPA (2022) default hardness of 100 mg/L was used. Use of a higher hardness value would result in less stringent screening values, thus, use of the US EPA default hardness is conservative.

Table 3.4 Ecological Constituents of Interest Based on Groundwater for S-Wells (2018-2022)

Constituent[a]	Maximum Detected Groundwater Concentration	Ecological Benchmark[b]	Basis	Ecological COI[c]
Total Metals (mg/L)				
Antimony	ND	0.19	EPA R4 ESV	No
Arsenic	0.12	0.19	IEPA SWQC	No
Barium	1.5	5.0	IEPA SWQC	No
Beryllium	0.0081	0.064	EPA R4 ESV	No
Boron	2.8	7.6	IEPA SWQC	No
Cadmium	0.055	0.0011	IEPA SWQC	Yes
Chromium	0.069	0.21	IEPA SWQC	No
Cobalt	0.054	0.019	EPA R4 ESV	Yes
Lead	0.080	0.020	IEPA SWQC	Yes
Mercury	ND	0.0011	IEPA SWQC	No
Selenium	0.017	1.0	IEPA SWQC	No
Thallium	0.046	0.0060	EPA R4 ESV	Yes
Dissolved Metals (mg/L)				
Boron	3.1	7.6	IEPA SWQC	No
Cadmium		0.00093	IEPA SWQC	No
Other (mg/L or SU)				
Chloride	480	500	IEPA SWQC	No
Fluoride	0.18	4.0	IEPA SWQC	No
Sulfate	310	NA	NA	No
Total Dissolved Solids	4500	NA	NA	No
pH	6.9	NA	NA	No

Notes:
Blank cells indicate constituent was not detected.
Shaded cell indicates a compound identified as a COI.
COI = Constituent of Interest; EPA R4 = United States Environmental Protection Agency Region IV; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; NA = Not Applicable; ND = Not Detected; SWQC = Surface Water Quality Criteria.
(a) The constituents are those listed in the IL Part 845.600 GWPS (IEPA, 2021) that were detected in at least one groundwater sample from the S-wells.
(b) Ecological benchmarks are from: IEPA SWQC (IEPA, 2019); EPA R4 ESV (US EPA Region IV, 2018).
(c) Constituents with maximum detected concentrations exceeding a benchmark protective of surface water exposure are considered ecological COIs.

3.3.3 Surface Water and Sediment Modeling

Surface water sampling has not been conducted in Little Saline Creek to the north of the Site. To estimate the potential contribution to surface water from groundwater specifically associated with the Site, Gradient modeled concentrations in Little Saline Creek surface water from groundwater flowing into the Creek for the detected human and ecological COIs. This is because the constituents detected in groundwater above a health-based benchmark are most likely to pose a risk concern in the adjacent surface water. Gradient modeled COI concentrations in the surface water using a mass balance calculation based on the surface water and groundwater mixing. The model assumes a well-mixed groundwater-surface water location.

The maximum detected concentrations in groundwater from the S-wells from 2018 to 2022 were conservatively used to model COI concentrations in surface water. For COIs that were measured as both total and dissolved fractions, we used the maximum of the total and dissolved COI concentrations for the modeling. For most metals, the maximum concentration was from the total fraction. Use of the total metal concentration for these COIs may overestimate surface water concentrations because dissolved concentrations, which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow into and mix with surface water.

The modeling approach does not account for geochemical transformations that may occur during groundwater mixing with surface water. Gradient assumed that predicted surface water concentrations were influenced only by the physical mixing of groundwater as it enters the surface water and were not further influenced by the geochemical reactions in the water and sediment, such as precipitation. In addition, the model only predicts surface water concentrations as a result of the potential migration of COIs in Site-related groundwater and does not account for background concentrations in surface water.

For this evaluation, Gradient adapted a simplified and conservative form of US EPA's indirect exposure assessment methodology (US EPA, 1998) that was used in US EPA's coal combustion waste risk assessment (US EPA, 2014). The model is a mass balance calculation based on surface water and groundwater mixing and the concept that the dissolved and sorbed concentrations can be related through an equilibrium partitioning coefficient (K_d). The model assumes a well-mixed groundwater-surface water location, with partitioning among total suspended solids, dissolved water column, sediment pore water, and solid sediments.

Sorption to soil and sediment is highly dependent on the surrounding geochemical conditions. To be conservative, we ignored the natural attenuation capacity of soil and sediment and estimated the surface water concentration based only on the physical mixing of groundwater and surface water (*i.e.*, dilution) at the point where groundwater flows into surface water.

The aquifer properties used to estimate the volume of groundwater flowing into Little Saline Creek and surface water concentrations are presented in Table 3.5. The surface water and sediment properties used in the modeling are presented in Tables 3.6 and 3.7. In the absence of Site-specific information for Little Saline Creek, Gradient used default assumptions (*e.g.*, depth of the upper benthic layer and bed sediment porosity) to model sediment concentrations. The modeled surface water and sediment concentrations are presented in Table 3.8. These modeled concentrations reflect conservative contributions from groundwater. A description of the modeling and the detailed results are presented in Appendix A.

Table 3.5 Groundwater Properties Used in Modeling

Parameter	Value	Units	Notes
Aquifer thickness	3	m	Thickness of the groundwater unit at the interface of unlithified deposits and bedrock (10 ft or 3 m) (SIPC, 2021b).
Length of River	840	m	Length of river receiving potentially-impacted groundwater (estimated using Google Earth).
Cross-Sectional Area	2560	m^2	Length × thickness
Hydraulic Gradient	0.019	m/m	Average hydraulic gradient (estimated using groundwater elevation in wells S3 and S6; SIPC, 2007).
Hydraulic Conductivity	1.50E-04	cm/sec	Average hydraulic conductivity (assumed to be the same as that for Emery Pond wells; Golder Associates Inc., 2021).
COI Concentration	Constituent specific	mg/L	Maximum detected concentration in groundwater.

Notes:
COI = Constituent of Interest
(a) The cross-sectional area represents the area through which groundwater flows from the unlithified unit to Little Saline Creek.

Table 3.6 Surface Water Properties Used in Modeling

Parameter	Value	Unit	Notes/Source
Flow rate in little saline creek	2.5×10^{11}	L/yr	Average of peak flows 1959-1980 for Little Saline Creek Tributary Near Goreville, IL (USGS, 2024a)
Total suspended solids (TSS)	49	mg/L	Average TSS concentration for South Fork Saline River, Carrier Mills, IL (USGS, 2024b)
Depth of water column	1.5	m	Mean depth of Little Saline Creek estimated from Google Earth photos.
Suspended Sediment to Water Partition Coefficient	Constituent specific	mg/L	Values based on US EPA (2014).

Notes:
IL = Illinois; US EPA = United States Environmental Protection Agency; USGS = United States Geological Survey.

Table 3.7 Sediment Properties Used in Modeling

Parameter	Value	Unit	Notes/Source
Depth of Upper Benthic Layer	0.03	m	Default (US EPA, 2014).
Depth of Water Column	1.5	m	Mean depth of Little Saline Creek estimated from Google Earth photos.
Bed Sediment Particle Concentration	1	g/cm^3	Default (US EPA, 2014).
Bed Sediment Porosity	0.6	–	Default (US EPA, 2014).
Total Suspended Solids (TSS) Mass per Unit Area	0.075	kg/m^2	Depth of water column × TSS × conversion factors (10^{-6} kg/mg and 1,000 L/m^3).
Sediment Mass per Unit Area	30	kg/m^2	Depth of upper benthic layer × bed sediment particulate concentration × conversion factors (0.001 kg/g and 10^6 cm^3/m^3).
Sediment to Water Partitioning Coefficients	Constituent specific	mg/L	Values based on US EPA (2014).

Note:
US EPA = United States Environmental Protection Agency.

Table 3.8 Surface Water and Sediment Modeling Results for Little Saline Creek

COI	Maximum Measured Groundwater Concentration (mg/L)	Modeled Surface Water Concentration (mg/L)	Modeled Sediment Concentration (mg/kg)
Arsenic	0.12	1.15E-06	2.09E-04
Beryllium	0.0081	7.79E-08	2.77E-05
Boron	3.1	2.98E-05	1.35E-04
Cadmium	0.055	5.29E-07	2.16E-04
Cobalt	0.054	5.19E-07	1.60E-04
Lead	0.08	7.69E-07	1.20E-03
Thallium	0.046	4.42E-07	5.46E-06

Notes:
COI = Constituent of Interest; mg/L = Milligrams per Liter.

3.4 Human Health Risk Evaluation

The section below presents the results of the human health risk evaluation for recreators (boaters, swimmers, and anglers) in the Lake of Egypt to the east of the Site, and anglers in the Little Saline Creek to the north of the Site. Risks were assessed using the maximum measured COIs in Lake of Egypt, and the modeled COIs in the Little Saline Creek.

3.4.1 Recreators Exposed to Surface Water

Screening Exposures: In Lake of Egypt, recreators could be exposed to surface water *via* incidental ingestion and dermal contact while boating or swimming, and anglers could consume fish caught in the lake. In Little Saline Creek, it is assumed that anglers could consume fish caught in the creek. Measured concentrations were used in Lake of Egypt, and modeled concentrations were used for Little Saline Creek due to lack of sampling data. The maximum measured or modeled COI concentrations in surface water were used as conservative upper-end estimates of the COI concentrations to which a recreator might be exposed directly (incidental ingestion of COIs in surface water while boating) and indirectly (consumption of locally caught fish exposed to COIs in surface water).

Screening Benchmarks: Illinois surface water criteria (IEPA, 2019), known as human threshold criteria (HTC), are based on incidental exposure through contact or ingestion of small volumes of water while swimming or during other recreational activities, as well as the consumption of fish. The HTC values were calculated from the following equation (IEPA, 2019):

$$\mathrm{HTC} = \frac{\mathrm{ADI}}{\mathrm{W} + (\mathrm{F} \times \mathrm{BCF})}$$

where:

HTC = Human health protection criterion in milligrams per liter (mg/L)
ADI = Acceptable daily intake (mg/day)
W = Water consumption rate (L/day)
F = Fish consumption rate (kg/day)
BCF = Bioconcentration factor (L/kg tissue)

Illinois defines the acceptable daily intake (ADI) as the "maximum amount of a substance which, if ingested daily for a lifetime, results in no adverse effects to humans" (IEPA, 2019). US EPA defines its chronic reference dose (RfD) as an "estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure for a chronic duration (up to a lifetime) to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime" (US EPA, 2011). Illinois lists methods to derive an ADI from the primary literature (IEPA, 2019). In accordance with Illinois guidance, Gradient derived an ADI by multiplying the MCL by the default water ingestion rate of 2 L/day (IEPA, 2019). In the absence of an MCL, Gradient applied the RfD used by US EPA to derive its Regional Screening Levels (RSLs) (US EPA, 2024) as a conservative estimate of the ADI. The RfDs are given in mg/kg-day, while the ADIs are given in mg/day; thus, Gradient multiplied the RfD by a standard body weight of 70 kg to obtain the ADI in mg/day. The calculation of the HTC values is shown in Appendix B, Table B.1.

Gradient used bioconcentration factors (BCFs) from a hierarchy of sources. The primary BCFs were those that US EPA used to calculate the National Recommended Water Quality Criteria (NRWQC) for human health (US EPA, 2002). Other sources included BCFs used in the US EPA coal combustion ash risk assessment (US EPA, 2014) and BCFs reported by Oak Ridge National Laboratory's Risk Assessment Information System (ORNL RAIS) (ORNL, 2020).[5] Lithium did not have a BCF value available from any authoritative source; therefore, the water quality criterion for lithium was calculated assuming a BCF of 1. This is a conservative assumption, as lithium does not readily bioaccumulate in the aquatic environment (ECHA, 2020a,b; ATSDR, 2010).

Illinois recommends a fish consumption rate of 0.020 kg/day (20 g/day) for an adult weighing 70 kg (IEPA, 2019). Illinois recommends a water consumption rate of 0.01 L/day for "incidental exposure through contact or ingestion of small volumes of water while swimming or during other recreational activities" (IEPA, 2019). Appendix B, Table B.1 presents the calculated HTC for fish and water and for fish consumption only.

The HTC for fish consumption for radium 226+228 was calculated as follows:

$$\mathrm{HTC} = \frac{\mathrm{TCR}}{(\mathrm{SF} \times \mathrm{BAF} \times \mathrm{F})}$$

where:

HTC = Human health protection criterion in picoCuries per liter (pCi/L)
TCR = Target cancer risk (1×10^{5})
SF = Food ingestion slope factor (risk/pCi)
BAF = Bioaccumulation factor (L/kg tissue)
F = Fish consumption rate (kg/day)

The food ingestion slope factor (lifetime excess total cancer risk per unit exposure, in risk/pCi) used to calculate the HTC was the highest value of those for radium 226 (Ra226), radium 228 (Ra228), and "Ra228+D" (US EPA, 2001). According to US EPA (2001), "+D" indicates that "the risks from associated short-lived radioactive decay products (*i.e.,* those decay products with radioactive half-lives less than or equal to 6 months) are also included."

Screening Risk Evaluation, Lake of Egypt: The four COIs were not detected in the surface water data available from Lake of Egypt, therefore, Gradient used half of the maximum detection limit as the exposure concentration. The COI concentrations in surface water were compared to the calculated Illinois HTC values (Table 3.8). All surface water concentrations, all of which were non-detect, were below their respective benchmarks. The HTC values are protective of recreational exposure *via* water and/or fish ingestion and do not account for dermal exposures to COIs in surface water while boating. However, given that the measured COI surface water concentrations are well below HTC protective of water and/or fish ingestion, dermal exposures to COIs are not expected to be a risk concern. Moreover, the dermal uptake of metals is considered to be minimal and only a small proportion of ingestion exposures. Thus, none of the COIs evaluated pose an unacceptable risk to recreators exposed to surface water while boating and anglers consuming fish caught in the Lake of Egypt.

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[5] Although recommended by US EPA (2015b), US EPA EpiSuite 4.1 (US EPA, 2019) was not used as a source of BCFs because inorganic compounds are outside the estimation domain of the program.

Table 3.9 Risk Evaluation for Recreators Exposed to Surface Water in Lake of Egypt

COI	Maximum Surface Water Concentration (Measured)[a]	HTC for Water and Fish	HTC for Water Only	HTC for Fish Only	COPC
Total Metals (mg/L)					
Boron	*0.01*	467	1400	700	No
Cadmium	*0.0015*	0.0019	1.0	0.0019	No
Cobalt	*0.0025*	0.0035	2.1	0.0035	No
Thallium	*0.001*	0.0017	0.40	0.0017	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria; mg/L = Milligrams per Liter.
Concentrations are listed only for the constituents identified as COIs in the C-wells.
(a) Concentrations in italics were not detected; half the detection limit was used for non-detects.

Screening Risk Evaluation, Little Saline Creek: The modeled COI concentrations in surface water were compared to the calculated Illinois HTC values (Table 3.10). All surface water concentrations were below their respective benchmarks. Thus, none of the COIs evaluated pose an unacceptable risk for anglers consuming fish caught in Little Saline Creek.

Table 3.10 Risk Evaluation for Recreators Exposed to Surface Water in Little Saline Creek

COI	Maximum Surface Water Concentration (Modeled)	HTC for Water and Fish	HTC for Water Only	HTC for Fish Only	COPC
Total Metals (mg/L)					
Arsenic	1.15E-06	2.25E-02	2.00E+00	2.27E-02	No
Beryllium	7.79E-08	2.05E-02	8.00E-01	2.11E-02	No
Boron	2.98E-05	4.67E+02	1.40E+03	7.00E+02	No
Cadmium	5.29E-07	1.85E-03	1.00E+00	1.85E-03	No
Cobalt	5.19E-07	3.49E-03	2.10E+00	3.50E-03	No
Lead	7.69E-07	1.00E-02	1.00E-02	1.00E-02	No
Thallium	4.42E-07	1.72E-03	4.00E-01	1.72E-03	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria; mg/L = Milligrams per Liter.
Concentrations are listed only for the constituents identified as COIs in the S-wells.
Modeled concentrations represent the potential effect on surface water quality resulting from the measured groundwater concentrations.

3.4.2 Use of Surface Water as Drinking Water

The Lake of Egypt is used as a public water supply (IEPA, 2024a). Gradient compared the maximum detected concentrations (or the maximum detection limit) from the available public water supply data (2018-2023) to the Illinois Class I GWPS (Table 3.11). There were no exceedances of the IL GWPS, therefore the use of surface water from the Lake of Egypt for residential drinking water does not pose an unacceptable risk to residents.

Table 3.11 Lake Public Water Supply Data Compared to GWPS (2018-2023)

Constituent[a]	Number of Detects	Number of Samples	Detected Minimum	Detected Maximum[b]	Maximum Laboratory Detection Limit	GWPS[c]	Exceedance
Total Metals							
Antimony	0	6			0.003	0.006	No
Arsenic	0	6			0.001	0.01	No
Barium	6	6	0.021	0.0263	NA	2	No
Beryllium	0	6			0.001	0.004	No
Cadmium	0	6			0.003	0.005	No
Chromium	0	6			0.005	0.1	No
Mercury	0	6			0.0002	0.002	No
Selenium	1	6	0.0024	0.0024	0.002	0.05	No
Thallium	0	6			0.002	0.002	No
Other							
Chloride	6	6	10.4	23	NA	200	No
Fluoride	6	6	0.553	0.73	NA	4	No
Sulfate	6	6	34.6	51.7	NA	400	No
Total Dissolved Solids	6	6	87	158	NA	1200	No
Radionuclides							
Radium 226 + Radium 228	1	1	1.03	1.03	NA	5	No

Notes:
GWPS = Groundwater Protection Standard; NA = Not Available.

3.5 Ecological Risk Evaluation

Based on the ecological CEM (Figure 3.4), ecological receptors could be exposed to surface water and dietary items (*i.e.*, prey and plants) potentially impacted by identified COIs.

3.5.1 Ecological Receptors Exposed to Surface Water in Little Saline Creek

Screening Exposures: The ecological evaluation considered aquatic communities in Little Saline Creek potentially impacted by identified ecological COIs. Modeled surface water concentrations were compared to risk-based ecological screening benchmarks.

Screening Benchmarks: Surface water screening benchmarks protective of aquatic life were obtained from the following hierarchy of sources:

- IEPA SWQS (IEPA, 2019), regulatory standards that are intended to protect aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). For cadmium, the surface water benchmark is hardness dependent and calculated using a default hardness of 100 mg/L (US EPA, 2022);[6]
- US EPA Region IV (2018) surface water ESVs for hazardous waste sites.

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[6] Conservatisms associated with using a default hardness value are discussed in Section 3.6.

Risk Evaluation: The maximum modeled COI concentrations in surface water were compared to the benchmarks protective of aquatic life (Table 3.12). The modeled surface water concentrations for the COIs were below their respective benchmarks. Thus, none of the COIs evaluated are expected to pose an unacceptable risk to aquatic life in Little Saline Creek.

Table 3.12 Risk Evaluation for Ecological Receptors Exposed to Surface Water in Little Saline Creek

COI	Maximum Surface Water Concentration (modeled)	Ecological Freshwater Benchmark	Basis	COPC
Cadmium	5.29E-07	1.13E-03	IEPA SWQC	No
Cobalt	5.19E-07	1.90E-02	EPA R4 ESV	No
Lead	7.69E-07	2.01E-02	IEPA SWQC	No
Thallium	4.42E-07	6.00E-03	EPA R4 ESV	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; SWQC = Surface Water Quality Criteria; US EPA = United States Environmental Protection Agency.
Criteria sources: IEPA SWQC: IEPA (2019a); EPA R4 ESV: US EPA Region IV (2018)

3.5.2 Ecological Receptors Exposed to Sediment in Little Saline Creek

Screening Exposures: COIs in impacted groundwater flowing into Little Saline Creek can sorb to sediments *via* chemical partitioning. In the absence of sediment data, sediment concentrations were modeled using maximum detected groundwater concentrations. Therefore, the modeled COI sediment concentrations reflect the potential maximum Site-related sediment concentration originating from groundwater.

Screening Benchmarks: Sediment screening benchmarks were obtained from US EPA Region IV (2018). The majority of the sediment ESVs are based on threshold effect concentrations (TECs) from MacDonald *et al.* (2000), which provide consensus values that identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. The benchmarks used in this evaluation are listed in Table 3.13.

Screening Risk Results: The maximum modeled COI sediment concentrations were below their respective sediment screening benchmarks (Table 3.13). The modeled sediment concentrations attributed to potential contributions from Site groundwater for all COIs were less than 1% of the sediment screening benchmark. Although thallium does not have an ESV, the modeled concentration is well below the soil ESV of 0.05 mg/kg (US EPA Region IV, 2018); therefore, thallium does not present an unacceptable risk to ecological receptors. Thus, the modeled sediment concentrations attributed to potential contributions from Site groundwater are not expected to significantly contribute to ecological exposures in Little Saline Creek adjacent to the Site.

Table 3.13 Risk Evaluation for Ecological Receptors Exposed to Sediment in Little Saline Creek

COI	Modeled Sediment Concentration (mg/kg)	ESV[a] (mg/kg)	COPC	% of Benchmark
Cadmium	2.16E-04	1.0E+00	No	0.02
Cobalt	1.60E-04	5.0E+01	No	0.0003
Lead	1.20E-03	3.6E+01	No	0.003
Thallium	5.46E-06	NA	No	NA

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; NA = Not Available; US EPA = United States Environmental Protection Agency.
(a) ESV from US EPA Region IV (2018).

3.5.3 Ecological Receptors Exposed to Bioaccumulative Constituents of Interest

Screening Exposures: COIs with bioaccumulative properties can impact higher trophic level wildlife exposed to these COIs *via* direct exposures (surface water and sediment exposure) and secondary exposures through the consumption of dietary items (*e.g.*, plants, invertebrates, small mammals, and fish).

Screening Benchmark: US EPA Region IV (2018) and IEPA SWQS (IEPA, 2019) guidance were used to identify constituents with potential bioaccumulative effects.

Risk Evaluation: The ecological COIs (cadmium, cobalt, lead, and thallium) were not identified as having potential bioaccumulative effects. Therefore, these COIs are not considered to pose an ecological risk *via* bioaccumulation. IEPA (2019) identifies mercury as the only metal with bioaccumulative properties, however, mercury was not considered an ecological COI. US EPA Region IV (2018) identifies selenium as having potential bioaccumulative effects; although selenium was detected in groundwater, it was not considered an ecological COI.

3.6 Uncertainties and Conservatisms

A number of uncertainties and their potential impact on the risk evaluation are discussed below. Wherever possible, conservative assumptions were used in an effort to minimize uncertainties and overestimate rather than underestimate risks.

Exposure Estimates:

- The risk evaluation included the IL Part 845.600 constituents detected in groundwater samples (above GWPS) collected from wells associated with the MGS facility. However, it is possible that not all of the detected constituents are related specifically to the MGS facility.
- The human health and ecological risk characterization was based on the maximum measured or modeled COI concentrations, rather than on averages. Thus, the variability in exposure concentrations was not considered. Assuming continuous exposure to the maximum concentration overestimates human and ecological exposures, given that receptors are mobile and concentrations change over time. For example, US EPA guidance states that risks should be estimated using average exposure concentrations as represented by the 95% upper confidence limit on the mean (US EPA, 1992). Given that exposure estimates based on the maximum concentrations did not exceed risk benchmarks, Gradient has greater confidence that there is no risk concern.

- Only constituents detected in groundwater were used to identify COIs and model COI concentrations in surface water. For the constituents that were not detected in facility groundwater, the detection limits were below the IL Part 845.600 GWPS for all constituents except antimony, and thus do not require further evaluation. (Antimony was not detected in 32 groundwater samples from 2018 to 2023; 30 of the detection limits ranged from 0.001 to 0.005 mg/L, thus were below the GWPS of 0.006 mg/L.)
- There are limited groundwater data available that have been analyzed for Appendix IV constituents to specifically characterize the ponds of interest. If additional data are collected, the new data could lead to different risk estimates (either increased or decreased risk).
- COI concentrations in Little Saline Creek were modeled using the maximum detected total COI concentrations in groundwater from the S-wells. Modeling surface water concentrations using total metal concentrations may overestimate surface water concentrations because dissolved concentrations, which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow into and mix with surface water.
- The COIs identified in this evaluation also occur naturally in the environment. Contributions to exposure from natural or other non-MGS-related sources were not considered in the evaluation of modeled concentrations; only exposure contributions potentially attributable to Site groundwater mixing with surface water were evaluated. While not quantified, exposures from potential MGS-related groundwater contributions are likely to represent only a small fraction of the overall human and ecological exposure to COIs that also have natural or non-MGS-related sources.
- Screening benchmarks for human health were developed using exposure inputs based on US EPA's recommended values for reasonable maximum exposure (RME) assessments (Stalcup, 2014). RME is defined as "the highest exposure that is reasonably expected to occur at a site but that is still within the range of possible exposures" (US EPA, 2004). US EPA states the "intent of the RME is to estimate a conservative exposure case (*i.e.*, well above the average case) that is still within the range of possible exposures" (US EPA, 1989). US EPA also notes that this high-end exposure "is the highest dose estimated to be experienced by some individuals, commonly stated as approximately equal to the 90th percentile exposure category for individuals" (US EPA, 2015c). Thus, most individuals will have lower exposures than those presented in this risk assessment.

Toxicity Benchmarks:

- Screening-level ecological benchmarks were compiled from IEPA and US EPA guidance and designed to be protective of the majority of Site conditions, leaving the option for Site-specific refinement. In some cases, these benchmarks may not be representative of the Site-specific conditions or receptors found at the Site, or may not accurately reflect concentration-response relationships encountered at the Site. For example, the ecological benchmark for cadmium is hardness dependent, and Gradient relied on US EPA's default hardness of 100 mg/L. Use of a higher hardness value would increase the cadmium SWQS because benchmarks become less stringent with higher levels of hardness. Regardless of the hardness, the maximum modeled cadmium concentration is orders of magnitude below the SWQS.
- In addition, for the ecological evaluation, Gradient conservatively assumed all constituents to be 100% bioavailable. Modeled COI concentrations in surface water are considered total COI concentrations. In addition, the measured surface water data used in this report represent total concentrations. US EPA recommends using dissolved metals as a measure of exposure to ecological receptors because it represents the bioavailable fraction of metal in water (US EPA, 1993). Therefore, the modeled surface water COI concentrations may be an overestimation of exposure concentrations to ecological receptors.

- In general, it is important to appreciate that the human health toxicity factors used in this risk evaluation are developed to account for uncertainties, such that safe exposure levels used as benchmarks are often many times lower (even orders of magnitude lower) than the levels that cause effects that have been observed in human or animal studies. For example, toxicity factors incorporate a 10-fold safety factor to protect sensitive subpopulations. This means that a risk exceedance does not necessarily equate to actual harm.

4 Summary and Conclusions

A screening-level risk evaluation was performed for Site-related constituents in groundwater at the MGS in Marion, Illinois. The CSM developed for the Site indicates that groundwater beneath the facility may flow into the Lake of Egypt to the east of the Site, or into Little Saline Creek to the north of the Site, and may potentially impact surface water.

CEMs were developed for human and ecological receptors. In the Lake of Egypt, the complete exposure pathways for humans include recreators (boaters) in the who are exposed to surface water, and anglers who consume locally caught fish. The use of surface water from the Lake of Egypt as a drinking water source was also evaluated as a complete pathway. The complete exposure pathway for humans in Little Saline Creek includes anglers who consume locally caught fish. Based on the local hydrogeology, residential exposure to groundwater used for drinking water or irrigation is not a complete pathway and was not evaluated. The complete exposure pathways for ecological receptors include aquatic life (including aquatic and marsh plants, amphibians, reptiles, and fish) exposed to surface water; benthic invertebrates exposed to sediment; and avian and mammalian wildlife exposed to bioaccumulative COIs in surface water, sediment, and dietary items.

Groundwater data collected from 2018 to 2023 were used to estimate exposures. The surface water data collected from the Lake of Egypt (in 2020) were also evaluated. Surface water concentrations were modeled in Little Saline Creek using the maximum detected groundwater concentration in the S-wells from the northern portion of the Site. Surface water exposure estimates were screened against benchmarks protective of human health and ecological receptors for this risk evaluation.

US EPA has established acceptable risk metrics. Risks above these US EPA-defined metrics are termed potentially "unacceptable risks." Based on the evaluation presented in this report, no unacceptable risks to human or ecological receptors resulting from CCR exposures associated with the Site were identified. This means that the risks from the Site are likely indistinguishable from normal background risks. Specific risk assessment results include the following:

- For recreators exposed to surface water, all COIs were below the conservative risk-based screening benchmarks. Therefore, none of the COIs evaluated in surface water are expected to pose an unacceptable risk to recreators in the Lake of Egypt.
- For anglers consuming locally caught fish, the modeled concentrations of all COIs in surface water (as well as the measured data) were below conservative benchmarks protective of fish consumption. Therefore, none of the COIs evaluated are expected to pose an unacceptable risk to anglers consuming fish caught from the Lake of Egypt or Little Saline Creek.
- For Lake of Egypt surface water used as a public drinking water supply, all COIs were below the Illinois Class I GWPS, thus no unacceptable risks were identified for the use of Lake of Egypt surface water as drinking water.
- Groundwater downgradient of the Site is not being used as a drinking water, thus the use of groundwater is not a complete exposure pathway.
- Ecological receptors exposed to surface water in Little Saline Creek include aquatic and marsh plants, amphibians, reptiles, and fish. The risk evaluation showed that none of the modeled COIs in Little Saline Creek exceeded protective screening benchmarks. Ecological receptors exposed to

sediment include benthic invertebrates. The modeled sediment COIs did not exceed the conservative screening benchmarks; therefore, none of the COIs evaluated in sediment are expected to pose an unacceptable risk to ecological receptors in Little Saline Creek.

- Ecological receptors were also evaluated for exposure to bioaccumulative COIs. This evaluation considered higher trophic level wildlife with direct exposure to surface water and sediment and secondary exposure through the consumption of dietary items (*e.g.*, plants, invertebrates, small mammals, fish). None of the ecological COIs were identified as having potential bioaccumulative effects. Overall, this evaluation demonstrated that none of the COIs evaluated are expected to pose an unacceptable risk to ecological receptors.

It should be noted that this evaluation incorporates a number of conservative assumptions that tend to overestimate exposure and risk. The risk evaluation was based on the maximum detected COI concentration; however, US EPA guidance states that risks should be based on a representative average concentration such as the 95% upper confidence limit on the mean; thus, using the maximum concentration tends to overestimate exposure. Although the COIs identified in this evaluation also occur naturally in the environment, the contributions to exposure from natural background sources and nearby industry were not considered; thus, CCR-related exposures were likely overestimated. Exposure estimates assumed 100% metal bioavailability, which likely results in overestimates of exposure and risks. Exposure estimates were based on inputs to evaluate the "reasonable maximum exposure"; thus, most individuals will have lower exposures than those estimated in this risk assessment.

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Appendix A

Surface Water Modeling

List of Tables

Gradient modeled concentrations of constituents of interest (COIs) in the Little Saline Creek surface water based on available groundwater data. First, we estimated the flow rate of COIs flowing into the Little Saline Creek *via* groundwater. Then, we adapted United States Environmental Protection Agency (US EPA) indirect exposure assessment methodology (US EPA, 1998) in order to model surface water concentrations in the Little Saline Creek.

Model Overview

The groundwater flow to the creek is represented by a one-dimensional, steady-state model. In this model, the groundwater plume from the northern portion of the Site migrates horizontally in the uppermost water-bearing unit prior to flowing to Little Saline Creek. The groundwater flow entering the creek is the flow going through a cross-sectional area that has a length equal to the length of the creek adjacent to the Site with potential impacts from the ponds system and a height equal to the thickness of the uppermost water-bearing unit. It was assumed that all the groundwater flowing through this layer would ultimately discharge to Little Saline Creek. The length of the groundwater discharge zone was estimated using Google Earth Pro (Google, LLC, 2022).

The groundwater flow to Little Saline Creek mixes with the surface water in the creek. The COIs entering the creek *via* groundwater dissolve into the water column, sorb to suspended sediments, or sorb to benthic sediments. Using US EPA's indirect exposure assessment methodology (US EPA, 1998), the model evaluates the surface water COI concentrations at a location downstream of the groundwater discharge point, assuming a well-mixed water column.

Groundwater Discharge Rate

The groundwater flow rate was evaluated using conservative assumptions. Gradient conservatively assumed that the groundwater concentrations were uniformly equal to the maximum detected concentration of each individual COI. Further, Gradient ignored adsorption by subsurface soil and assumed that all the groundwater flowing through the aquifer and intersecting the creek was flowing into the creek.

For each groundwater unit, the groundwater flow rate into the creek was derived using Darcy's Law:

$$Q = K \times i \times A$$

where:

Q = Groundwater flow rate (m^3/s)
K = Hydraulic conductivity (m/s)
i = Hydraulic gradient (m/m)
A = Cross-sectional area (m^2)

For each COI, the mass discharge rate into the creek was then calculated by:

$$m_c = C_c \times Q \times CF$$

where:

m_c = Mass discharge rate of the COI (mg/year)
C_c = Maximum groundwater concentration of the COI (mg/L)
Q = Groundwater flow rate (m^3/s)
CF = Conversion factors: 1,000 L/m^3 and 31,557,600 s/year

The values of the aquifer parameters used for these calculations are provided in Table A.1. The calculated mass discharge rates were then used as inputs for the surface water model.

The length of the discharge zone was estimated to be approximately 840 m and the height of the discharge zone was estimated to be 3 m; thus, the cross-sectional area was estimated to be 2,560 m^2 (SIPC, 2021). The average horizontal hydraulic gradient was 0.019 m/m (estimated using groundwater elevation in wells S3 and S6; SIPC, 2007). The average horizontal hydraulic conductivity was 1.5×10^{-4} cm/s (Golder Associates Inc., 2021).

Surface Water Concentration

Groundwater that flows into the creek will be diluted with the surface water flow. Constituents transported by groundwater into the surface water migrate into the water column and the bed sediments. The surface water model Gradient used to estimate the surface water concentrations is a steady-state model described in US EPA's indirect exposure assessment methodology (US EPA, 1998) and also used in US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals," referred to herein as the CCR risk assessment (US EPA, 2014). This model describes the partitioning of constituents between surface water, suspended sediments, and benthic sediments based on equilibrium partition coefficients (K_d values). It estimates the concentrations of constituents in surface water, suspended sediments, and benthic sediments at steady-state equilibrium at a theoretical location downstream of the discharge point after complete mixing of the water column. In our analysis, we used the K_d values provided in the US EPA CCR risk assessment for all of the COIs (US EPA, 2014, Table J1). These coefficients are presented in Table A.2.

To be conservative, Gradient assumed that the constituents were not affected by dissipation or degradation once they entered the water body. The total water body concentration of the COI was calculated as follows (US EPA, 1998):

$$C_{wtot} = \frac{m_c}{V_f \times f_{water}}$$

where:

C_{wtot} = Total water body concentration of the COI (mg/L)
m_c = Mass discharge rate of the COI (mg/year)
V_f = Water body annual flow (L/year)
f_{water} = Fraction of the COI in the water column (unitless)

For the Little Saline Creek annual flow rate, Gradient used the average peak-flow discharge rate of about 279 cubic feet per second (cfs), or 2.5×10^{11} L/year, based on the discharge rates measured at the United States Geological Survey (USGS) gauging station near Goreville, Illinois (USGS Station 03382025) between 1959 and 1980[7] (USGS, 2024a). The surface water parameters are presented in Table A.3.

The fraction of COIs in the water column was calculated for each COI using the sediment/water and suspended solids/water partition coefficients (US EPA, 2014). The fraction of COIs in the water column is defined as follows (US EPA, 2014):

$$f_{water} = \frac{(1 + [K_{dsw} \times TSS \times 0.000001]) \times \frac{d_w}{d_z}}{\left([1 + (K_{dsw} \times TSS \times 0.000001)] \times \frac{d_w}{d_z}\right) + ([bsp + K_{dbs} \times bsc] \times \frac{d_b}{d_z})}$$

---

[7] The available data were for the years 1959 to 1980.

where:

K_{dsw} = Suspended sediment-water partition coefficient (mL/g)
K_{dbs} = Sediment-water partition coefficient (mL/g)
TSS = Total suspended solids in the surface water body (mg/L). Assumed equal to 49 mg/L based on the average suspended sediment concentration measured in South Fork Saline River at the USGS gauging station at Carrier Mills, Illinois (USGS Station 03382100) between 1976 and 1997 (USGS, 2024b).
0.000001 = Units conversion factor
d_w = Depth of the water column (m). The depth of the water column was estimated as 1.52 m from Google Earth photos.
d_b = Depth of the upper benthic layer (m). Set equal to 0.03 m (US EPA, 2014).
d_z = Depth of the water body (m). Calculated as $d_w + d_b$. Set equal to 1.55 m.
bsp = Bed sediment porosity (unitless). Set equal to 0.6 (US EPA, 2014).
bsc = Bed sediment particle concentration (g/cm^3). Set equal to 1.0 g/cm^3 (US EPA, 2014).

The fraction of COIs dissolved in the water column (f_d) is calculated as follows (US EPA, 2014):

$$f_d = \frac{1}{1 + K_{dsw} \times TSS \times 0.000001}$$

The values for the fraction of COI in the water column and other calculated parameters are presented in Table A.4.

The total water column concentration (C_{wcTot}) of the COIs, comprising both the dissolved and suspended sediment phases, is then calculated as follows (US EPA, 2014):

$$C_{wcTot} = C_{wtot} \times f_{water} \times \frac{d_z}{d_w}$$

Finally, the dissolved water column concentration (C_{dw}) for the COIs is calculated as follows (US EPA, 2014):

$$C_{dw} = f_d \times C_{wcTot}$$

The dissolved water column concentration (C_{dw}) was then used to calculate the concentration of COIs sorbed to suspended solids in the water column (US EPA, 1998):

$$C_{sw} = C_{dw} \times K_{dsw}$$

where:

C_{sw} = Concentration sorbed to suspended solids (mg/kg)
C_{dw} = Concentration dissolved in the water column (mg/L)
K_{dsw} = Suspended solids/water partition coefficient (mL/g)

In the same way, using the total water body concentration and the fraction of COI in the benthic sediments, the model derives the total concentration in benthic sediments (US EPA, 2014):

$$C_{bstot} = f_{benth} \times C_{wtot} \times \frac{d_z}{d_b}$$

where:

C_{bstot} = Total COI concentration in bed sediment (mg/L or g/m^3)
C_{wtot} = Total water body COI concentration (mg/L)
f_{benth} = Fraction of COI in benthic sediments (unitless)
d_b = Depth of the upper benthic layer (m)
d_z = Depth of the water body (m). Calculated as $d_w + d_b$.

This value can be used to calculate dry weight sediment concentration as follows:

$$C_{seddw} = \frac{C_{bstot}}{bsc}$$

where:

C_{seddw} = Dry weight sediment concentration (mg/kg)
C_{bstot} = Total sediment concentration (mg/L)
bsc = Bed sediment bulk density. Used the default value of 1 g/cm^3 from US EPA (2014).

The total sediment concentration is composed of the sum of the COI concentration dissolved in the bed sediment pore water (equal to the concentration dissolved in the water column) and the COI concentration sorbed to benthic sediments (US EPA, 1998).

The COI concentration sorbed to benthic sediments was calculated as follows (US EPA, 1998):

$$C_{sb} = C_{dbs} \times K_{dbs}$$

where:

C_{sb} = Concentration sorbed to bottom sediments (mg/kg)
C_{dbs} = Concentration dissolved in the sediment pore water (mg/L)
K_{dbs} = Sediments/water partition coefficient (mL/kg)

For each COI, the modeled total water column concentration and concentration sorbed to sediment are presented in Table A.5.

Table A.1 Parameters Used to Estimate Groundwater Discharge to Surface Water

Parameter	Name	Value	Unit
A	Cross-Sectional Area	2,560	m^2
i	Hydraulic Gradient	0.019	m/m
K	Hydraulic Conductivity	1.50E-04	cm/s

Sources: SIPC, 2021; SIPC, 2007; Golder Associates Inc., 2021.

Table A.2 Partition Coefficients

Constituent	Mean Sediment-Water Partition Coefficient (K_{dbs})		Mean Suspended Sediment-Water Partition Coefficient (K_{dsw})	
	Value ($\log_{10}$) (mL/g)	Value (mL/g)	Value ($\log_{10}$) (mL/g)	Value (mL/g)
Metals				
Arsenic	2.4	2.51E+02	3.9	7.94E+03
Beryllium	2.8	6.31E+02	4.2	1.58E+04
Boron	0.8	6.31E+00	3.9	7.94E+03
Cadmium	3.3	2.00E+03	4.9	7.94E+04
Cobalt	3.1	1.26E+03	4.8	6.31E+04
Lead	4.6	3.98E+04	5.7	5.01E+05
Thallium	1.3	2.00E+01	4.1	1.26E+04

Notes:
mL/g = Milliliters per Gram.
Source: US EPA, 2014.

Table A.3 Surface Water Parameters

Parameter	Name	Value	Unit
TSS	Total Suspended Solids	49	mg/L
V_{fx}	Surface Water Flow Rate	2.5×10^{11}	L/year
d_b	Depth of Upper Benthic Layer (default)	0.03	m
d_w	Depth of Water Column	1.52	m
d_z	Depth of Water Body	1.55	m
bsc	Bed Sediment Bulk Density (default)	1	g/cm^3
bsp	Bed Sediment Porosity (default)	0.6	–
M_{TSS}	TSS Mass per Unit Area[a]	0.075	kg/m^2
M_S	Sediment Mass per Unit Area[b]	30	kg/m^2

Notes:
CF = Conversion Factor.
Source of default values: US EPA, 2014.
(a) $M_{TSS} = TSS \times d_w \times CF1 \times CF2$.
(b) $M_S = d_b \times bsc \times CF3 \times CF4$.
CF1 = 1,000 L/m^3; CF2 = 1E06 mg/kg; CF3 = 1E+06 cm^3/m^3; CF4 = 0.001 kg/g.

Table A.4 Calculated Parameters

COI	Fraction of COI in the Water Column (f_{water})	Fraction of COI in the Benthic Sediments ($f_{benthic}$)	Fraction of COI Dissolved in the Water Column ($f_{dissolved}$)
Metals			
Arsenic	0.219	0.781	0.720
Beryllium	0.1250	0.8750	0.5629
Boron	0.9108	0.0892	0.7198
Cadmium	0.1107	0.8893	0.2044
Cobalt	0.142	0.858	0.244
Lead	0.032	0.968	0.039
Thallium	0.800	0.200	0.618

Note:
COI = Constituent of Interest.

Table A.5 Surface Water and Sediment Modeling Results for Little Saline Creek

COI	Maximum Measured Groundwater Concentration (mg/L)	Modeled Surface Water Concentration (mg/L)	Modeled Sediment Concentration (mg/kg)
Arsenic	1.20E-01	1.15E-06	2.09E-04
Beryllium	8.10E-03	7.79E-08	2.77E-05
Boron	3.10E+00	2.98E-05	1.35E-04
Cadmium	5.50E-02	5.29E-07	2.16E-04
Cobalt	5.40E-02	5.19E-07	1.60E-04
Lead	8.00E-02	7.69E-07	1.20E-03
Thallium	4.60E-02	4.42E-07	5.46E-06

Notes:
COI = Constituent of Interest; mg/L = Milligrams per Liter.

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Appendix B

Screening Benchmarks

Table B.1 Calculated Water Quality Standards Protective of Incidental Ingestion and Fish Consumption

Human Health COI	**Bioconcentration Factor (BCF)**		**Average Daily Intake (ADI)**			**Human Threshold Criteria (HTC)**		
	BCF[a] (L/kg-tissue)	**Basis**	**MCL (mg/L)**	**RfD (mg/kg-d)**	**ADI[b] (mg/day)**	**Water & Fish (mg/L)**	**Water Only (mg/L)**	**Fish Only (mg/L)**
Arsenic	44	NRWQC (2002)	0.01	0.0003	0.02	0.022	2.0	0.023
Beryllium	19	NRWQC (2002)	0.004	0.002	0.008	0.021	0.80	0.021
Boron	1	(d)	NC	0.2	14	467	1400	700
Cadmium	270	US EPA (2014)	0.005	0.0001	0.01	0.0018	1.0	0.0019
Cobalt	300	ORNL (2023)	NC	0.0003	0.021	0.0035	2.1	0.0035
Lead	46	US EPA (2014)	0.01	NC	0.02	0.01	0.01	0.01
Thallium	116	NRWQC (2002)	0.002	0.00001	0.004	0.0017	0.40	0.0017

Notes:

ADI = Average Daily Intake; BCF = Bioconcentration Factor; COI = Constituent of Interest; F = Fish Consumption Rate; HTC = Human Threshold Criteria; MCL = Maximum Contaminant Level; NA = BCF Not Available and Therefore, WQC for Fish Only Not Calculated; NC = No Criterion Available; NRWQC = National Recommended Water Quality Criteria; ORNL = Oak Ridge National Laboratory; RfD = Reference Dose; W = Water Consumption Rate; WQC = Water Quality Criteria; SWQC = Surface Water Quality Criteria; US EPA = United States Environmental Protection Agency.

(a) BCFs from the following hierarchy of sources:

NRWQC (2002). National Recommended Water Quality Criteria: 2002. Human Health Criteria Calculation Matrix.
US EPA (2014). Human and Ecological Risk Assessment of Coal Combustion Residuals.
ORNL (2023). Risk Assessment Information System (RAIS) Chemical Toxicity Values.

(b) ADI based on the MCL is calculated as the MCL (mg/L) multiplied by a water ingestion rate of 2 L/day. In the absence of an MCL, the ADI was calculated as the RfD (mg/kg-d) multiplied by the body weight (70 kg).

(c) SWQC based on US EPA's action level.

(d) BCF of 1 was used as a conservative assumption, due to lack of published BCF.

Consumption of Water and Fish

$$\text{HTC} = \frac{\text{ADI}}{\text{W} + (\text{F} \times \text{BCF})}$$

Consumption of Water Only

$$\text{HTC} = \frac{\text{ADI}}{\text{W}}$$

Consumption of Fish Only

$$\text{HTC} = \frac{\text{ADI}}{\text{F} \times \text{BCF}}$$

Where:

Human Threshold Criteria (HTC)	Chemical-specific	mg/L
Acceptable Daily Intake (ADI)	Chemical-specific	mg/day
Fish Consumption Rate (F)	0.02	kg/day
Bioconcentration Factor (BCF)/ Bioaccumulation Factor (BAF)	Chemical-specific	L/kg-tissue
Water Consumption Rate (W)	0.01	L/day
Body Weight	70	kg
Target Cancer Risk (TCR)	1.0E-05	unitless

CORRECTED
EXHIBIT 38

Closure Impact Assessment
Pond 4
Marion Generating Station,
Marion, Illinois

Prepared by

Andrew Bittner, M.Eng., P.E.

Prepared for

Southern Illinois Power Company
11543 Lake of Egypt Rd
Marion, IL 62959

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GRADIENT

www.gradientcorp.com
One Beacon Street, 17th Floor
Boston, MA 02108
617-395-5000

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Abbreviations

BMP	Best Management Practice
CBR	Closure-by-Removal
CCR	Coal Combustion Residual
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CY	Cubic Yards
EJ	Environmental Justice
FEMA	Federal Emergency Management Agency
GHG	Greenhouse Gas
GWPS	Groundwater Protection Standard
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
N_2O	Nitrous Oxide
NO_x	Nitrogen Oxide
NPDES	National Pollutant Discharge Elimination System
PM	Particular Matter
SIPC	Southern Illinois Power Cooperative
TDS	Total Dissolved Solids
US	United States
US DOT	United States Department of Transportation
VOC	Volatile Organic Compound

Executive Summary

Southern Illinois Power Cooperative (SIPC) owns and operates the Marion Generating Station (Site), a gas and coal-fired power generating station. The station is located approximately eight miles south of Marion, Illinois, on the northwestern bank of the Lake of Egypt. The facility began operation in 1963. The area surrounding the facility is a rural agricultural community (Kleinfelder and Wendland, 2013).

The Site has several surface impoundments that have been used for storage of coal combustion residuals (CCR) and impoundments that were used to support other operational purposes (*e.g.*, wastewater storage, surface water run-off collection). The focus of my analysis in this report is Pond 4. Pond 4 was built in 1979 and is in the central portion of the Site. Historically, Pond 4 received decant water from other ponds that received bottom ash, and it has been used to receive runoff from the coal pile (Kleinfelder, 2013; SIPC, 2021a). No CCRs were ever directly sent to or disposed in Pond 4. Currently, Pond 4 receives overflow from Pond S-6. Water in Pond 4 discharges into the Little Saline Creek *via* Outfall 002 (Kleinfelder, 2013; SIPC, 2021a).

The goal of this Closure Impact Assessment was to holistically evaluate a closure scenario with respect to a wide range of factors, including risks to human health and the environment, risks of future releases, effects on groundwater, surface water, and air quality, impacts to the local community, and impacts on worker safety. Specifically, I evaluated the impacts and potential benefits associated with one specific closure scenario at Pond 4: closure-by-removal (CBR). CBR would include dewatering of the pond and excavation of sediment in the pond; it may also include either on-Site disposal or off-Site disposal of the excavated sediment. Post-excavation, this scenario could also include a retrofit of Pond 4 with an impermeable bottom liner to allow for continued operation and use of the pond. Results of the closure impact assessment were compared to the impacts associated with current operational conditions at Pond 4.

Based on the assessment, CBR does not lead to greater environmental benefit as compared to continued operation of Pond 4. Specifically, CBR will not result in any reduction in risks to human health or the environment and will not result in any improvement to groundwater or surface water quality. However, implementing CBR may have several adverse effects compared to the continued operation of Pond 4. Specifically, closure may cause short-term impacts to air quality, result in increased greenhouse gas (GHG) emissions and increased energy consumption, cause an increase in worker injuries, and result in increased accidents, traffic, and noise to nearby communities.

1 Introduction

Southern Illinois Power Cooperative (SIPC) owns and operates the Marion Generating Station (Site), a gas and coal-fired power generating station. The station is located approximately eight miles south of Marion, Illinois, on the northwestern bank of the Lake of Egypt (Figure 1.1). Power generation Units 1, 2, and 3 started operating in 1963; Unit 4 started operating in 1978. Unit 123 replaced the retired Units 1, 2, and 3 in the early 2000s, and Unit 4 ceased operation in 2020 (Kleinfelder, 2013; SIPC, 2021b).

The Site has several surface impoundments that have been used for storage of CCR and impoundments that were used to support other operational purposes (*e.g.*, wastewater storage, surface water run-off collection). Only "relatively small amounts of fly ash" were ever produced at the Site (SIPC, 2021b). Fly ash that was generated was transported and stored in the Initial Fly Ash Holding Area, Replacement Fly Ash Holding Area, Pond A-1, or the Former On-Site Landfill (SIPC, 2021b). The former Fly Ash Holding Areas are within the cover area for the Former On-Site Landfill (SIPC, 2021b). Other ponds located on Site (Figure 1.1) and a description of their historic and current operation are described below.

- Ponds 1 and 2 received sluiced bottom ash from power generation units 1, 2, 3, and 4 (Figure 1.1; SIPC, 2021b). During the entire pond operational life, bottom ash was removed from Ponds 1 and 2 and sold for beneficial reuse to shingle manufacturers, grit blasting companies, and local highway departments. Decanted water from Ponds 1 and 2 flowed into Pond 4. Ponds 1 and 2 are no longer in operation and are currently being closed (SIPC, 2021b).
- The Former Emery Pond was constructed in the late 1980s to hold stormwater drainage from the generating station (Figure 1.1; SIPC, 2021b). All CCRs in Emery Pond have been removed and the pond has been closed (SIPC, 2021b). Groundwater corrective action is currently on-going (Hanson Professional Services Inc., 2021).
- South Fly Ash Pond was constructed in 1989 and was originally intended to be a replacement for Pond A-1 (Figure 1.1; SIPC, 2021b). Ultimately, Pond A-1 did not need to be replaced. Thus, the South Fly Ash Pond was only used to receive decant water from the Former Emery Pond while it was operational. No CCRs were ever directly sent to or disposed of in the South Fly Ash Pond (SIPC, 2021b).
- Ponds 3 and 3-A were secondary ponds that received overflow from the fly ash holding areas (Figure 1.1; SIPC, 2021b). They also received storm water runoff, coal pile runoff, and water from the facility floor drains. In approximately 1982, Pond 3-A was separated from Pond 3 by construction of an internal berm. All sediment and debris were removed from Pond 3 in 2006 and 2011. All sediment and debris were removed from Pond 3-A in 2014. Subsequently, no CCRs were ever directly sent to or disposed in Ponds 3 or 3-A. Currently, water from the South Fly Ash Pond flows into Pond 3 (SIPC, 2021b).
- Pond S-6 was originally built to manage stormwater associated with the Former Landfill (Figure 1.1; SIPC, 2021a. Initially, water in Pond S-6 discharged to Little Saline Creek through Outfall 001; however, in approximately 1993, water from Pond S-6 was pumped to Pond 4. No CCRs were ever directly sent to or disposed in the Pond S-6 (SIPC, 2021b).
- Pond B-3 was built in 1985 and was primarily used as a secondary pond that received water from Pond A-1 (Figure 1.1; SIPC, 2021b). During periodic shutdowns of Pond A-1, Pond B-3 may have received some short-term discharges of fly ash from Unit 1, 2, and 3 prior to their shutdown (SIPC,

2021b). Pond A-1 was taken off-line approximately 3 to 4 times between 1985 and 2003, each lasting about 2 weeks. In 2017, Pond B-3 was dewatered and all sediment and CCR were excavated.

- Pond 4 was built in 1979 and historically received decant water from Ponds 1 and 2 for secondary treatment and received runoff from the coal pile (Figure 1.1; Kleinfelder, 2013; SIPC, 2021a,b). No CCRs were ever directly sent to or disposed of in Pond 4. All sediment and debris were removed from Pond 4 in 2012. Currently, Pond 4 receives overflow from Pond S-6; water in Pond 4 discharges into the Little Saline Creek *via* Outfall 002 (Kleinfelder, 2013; SIPC, 2021b).

This Closure Impact Assessment is focused solely on Pond 4 (Figure 1.1).

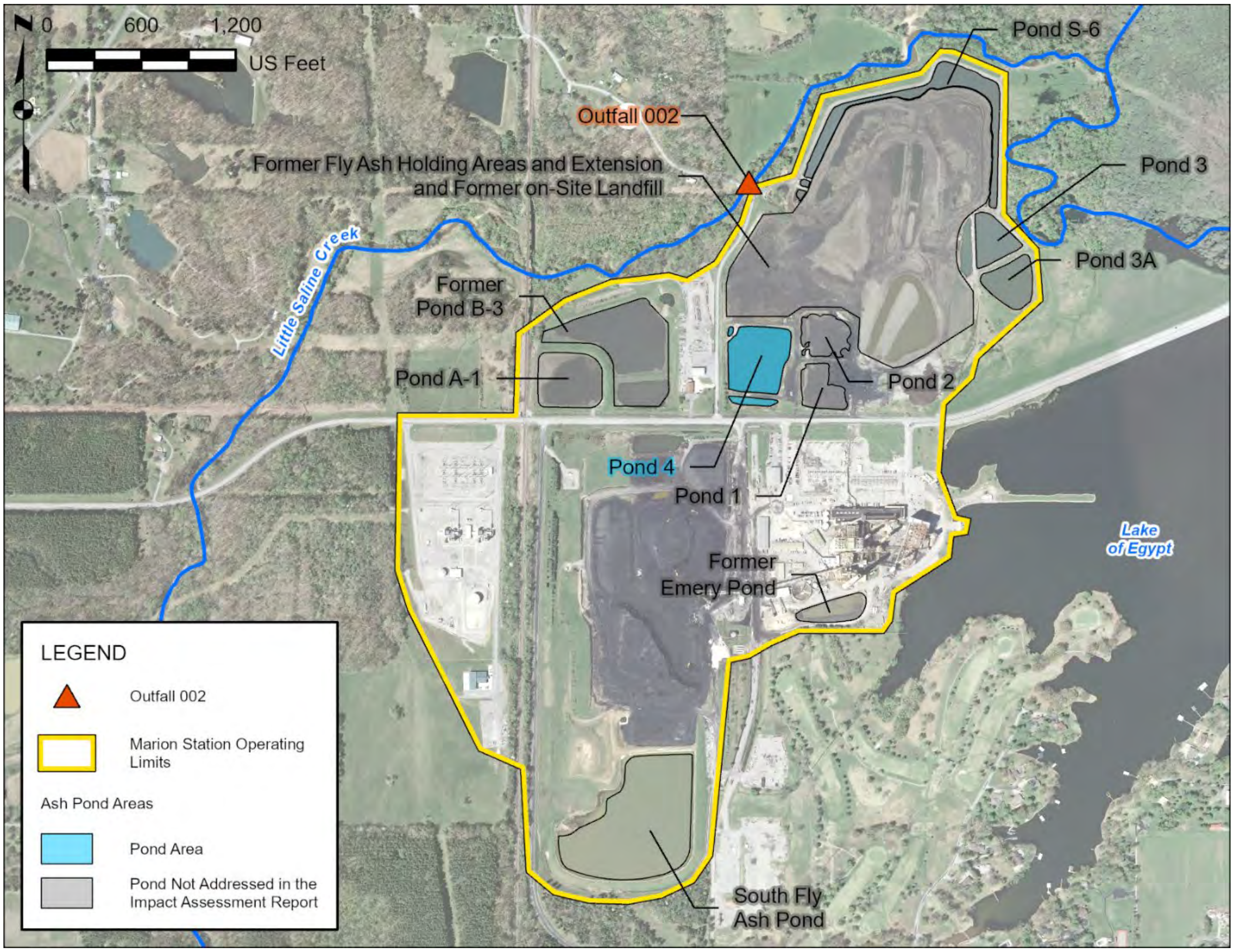

Figure 1.1 Site Location Map. Sources: Golder Associates, 2021; Andrews Engineering, 2021; USGS, 2011.

Based on the Human Health and Ecological Risk Assessment conducted for the Site (Gradient, 2024), there are no current risks to human health or the environment due to CCR-related constituents associated with Pond 4. As a result, closing Pond 4 would not result in any reduction of risk to human health or the environment. In this report, I evaluate the potential impacts that would be incurred if Pond 4 were to be closed. The Pond 4 closure scenario was assumed to be CBR. This closure scenario would include dewatering of the pond and excavation of sediment in the pond; CBR may include either on-Site disposal or off-Site disposal of the excavated sediment. Post-excavation, this scenario could also include a retrofit of Pond 4 with an impermeable bottom liner to allow for continued operation and use of the pond. This impact assessment holistically assesses the CBR closure scenario based on a series of metrics, including the efficiency, reliability, and ease of implementation of the closure scenario, as well as its potential positive and negative short- and long-term impacts on human health and the environment. These metrics are largely consistent with factors that are recommended for consideration in a closure alternatives evaluation specified in Section 845.710 of Title 35, Part 845 of the Illinois Administrative Code (IAC Part 845; IEPA, 2021).

2 Qualifications

I am a Principal at Gradient, an environmental consulting firm located in Boston, Massachusetts, and a licensed professional engineer. During my 26 years of professional experience, I have consulted and testified on a variety of projects related to the fate and transport of constituents in the environment, hydrogeology, groundwater and surface water modeling, site characterization, and remediation system design. I have a master's degree in environmental engineering from the Massachusetts Institute of Technology and bachelor's degrees in environmental engineering and physics from the University of Michigan. A copy of my *curriculum vitae* is provided in Appendix A.

I have applied my knowledge to address a range of complex challenges in the electric power, oil and gas, chemical manufacturing, pharmaceutical, mining, agrichemical, and waste disposal sectors. Related to CCRs, my experience includes projects involving regulatory comment, closure alternatives analysis, corrective action alternatives analysis, relative impact assessments, and fate and transport modeling. I have worked on projects at approximately 75 CCR coal ash landfills and surface impoundments. Additionally, I have published and presented on a variety of topics, including fate and transport of coal ash constituents in groundwater and surface water, closure evaluations at coal ash disposal facilities, groundwater and surface water modeling, remedial system optimization, and the impact of environmental regulations in the United States (US) and abroad.

3 Site Overview

3.1 Site Description

The Marion Generating Station is located in Marion, Illinois, on the west shores of the Lake of Egypt. The Site is bounded by Lake of Egypt to the east, Lake of Egypt Country Club to the southeast, Little Saline Creek to the north, and agricultural fields to the west and south (Figure 3.1). Little Saline Creek flows to the northeast (USGS, 2022). This Closure Impact Assessment addresses potential impacts associated with closure of Pond 4 by CBR.

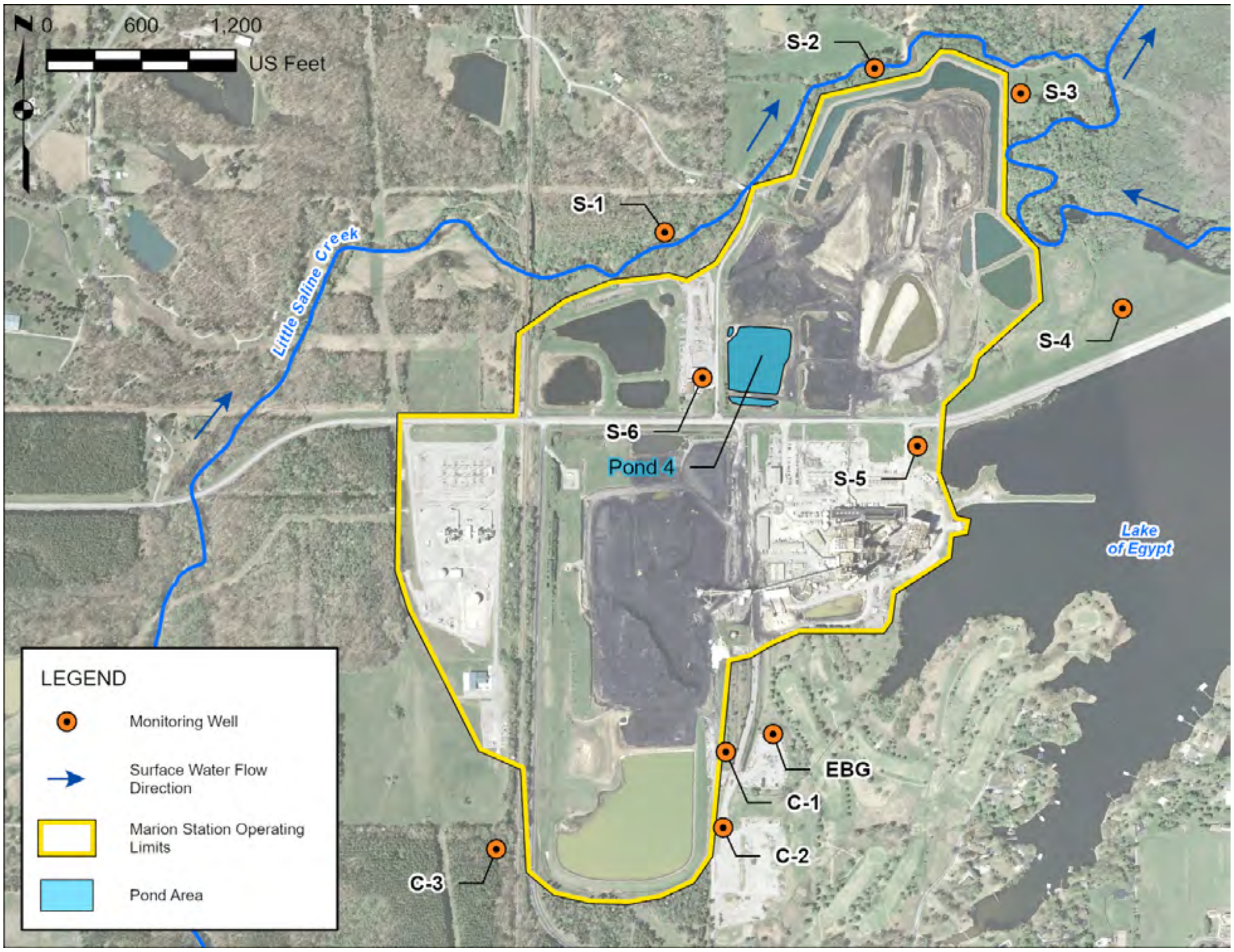

Figure 3.1 Site Location Map with Groundwater Monitoring Well Locations. Sources: USGS, 2022; Golder Associates, 2021; Andrews Engineering, 2021; USGS, 2011). Note: Monitoring Wells associated with the Former Emery Pond are not shown on this map.

Pond 4 was built in 1979 (Kleinfelder, 2013). It is approximately 3.7 acres in size with a total volume of approximately 1,370,059 ft^3 (50,743 cubic yards [CY]; Haley & Aldrich, 2021). Pond 4 is located in the central portion of the Site (Figure 3.1; SIPC, 2021a). During operation, bottom ash from power generating units 1, 2, 3 and 4 was sluiced to Ponds 1 and 2 (SIPC, 2021a). Pond 4 received decant water from Ponds 1 and 2 for secondary treatment prior to the shutdown of Unit 4. Pond 4 also received runoff from the coal pile area. Pond 4 never received direct discharge of CCRs. Around 1993, following the requirements of an Illinois Environmental Protection Agency (IEPA)-issued permit, SIPC installed pumps to transfer water from Pond S-6 to Pond 4 (SIPC, 2021a). In 2012, Pond 4 was excavated to the clay layer underlying the pond, removing all plant debris and any accumulated CCR or coal fines. Since 2012, Pond 4 has only received overflow from Pond S-6 and stormwater runoff. Water in Pond 4 is discharged into the Little Saline Creek *via* Outfall 002 (Kleinfelder, 2013; SIPC, 2021a). Figures 3.2-3.5 show the Site conditions of Pond 4 in 2011 prior to the excavation.

Figure 3.2 2011 Photographs of Pond 4 – General Conditions. Source: Kleinfelder, 2013.

Figure 3.3 2011 Photographs of Pond 4 – (a) Discharge Pipe from Pond 1 into Pond 4; (b) Discharge Pipe from Pond 2 into Pond 4. Source: Kleinfelder, 2013.

Figure 3.4 2011 Photographs of Pond 4 – (a) Intake from Pond 4 to Outlet Structure (pipe submerged); (b) Outlet Structure from Pond 4. Source: Kleinfelder, 2013**.**

Based on a 2021 Pond Investigation Report by Haley & Aldrich, the average sediment thickness in Pond 4 is approximately 1.67 feet, which means that sediment is currently less than 10% of the total volume in Pond 4[1] (Haley & Aldrich, 2021). Sediment samples collected from Pond 4 had low concentrations of sulfate and calcium which suggests there is minimal CCR in the pond (Haley & Aldrich, 2021). Shake test concentrations of Pond 4 sediments were all below Class I groundwater standards. Based on these results, the limited amount of CCR materials that may be present in Pond 4 sediment "are not expected to result in groundwater impacts above the Part 620 Class I groundwater standards" (Haley & Aldrich, 2021).

3.2 Hydrogeology

The Site is located on the southern edge of the Illinois Basin in the Shawnee Hills Section of the Interior Low Plateaus physiographic province (Golder, 2021). The Illinois Basin is a depositional and structural basin composed of sedimentary rocks ranging in age from Cambrian to Permian. The southern portion of the basin is characterized by extensive faulting, and some of these faults host commercially significant fluorite vein deposits (Golder, 2021). The regional stratigraphic sequence includes the following, from the surface downward (Golder, 2021):

- The Caseyville/Tradewater Formation: consists of lenticular, vertically and horizontally interbedded layers of sandstone, siltstone, and shale beneath a relatively thin layer of unconsolidated materials. It ranges from 190 to 500 feet in thickness.
- The Kinkaid Formation: consists of limestone, shale, claystone, and sandstone. It ranges from 120 to 160 feet in thickness.
- The Degonia Formation: consists of thin, very-fine grained sandstone, siltstone, shale, and irregular chert beds. It ranges from 20 to 64 feet in thickness.
- The Clore Formation: consists of sandstone, shale and limestone, which sporadically outcrops at the surface. It ranges from 110 to 155 feet in thickness.

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[1] Based on the sediment and pond volumes reported by Haley & Aldrich, Inc. (2021), the sediment volume in Pond 4 is approximately 6.6% of its total volume; however, Haley & Aldrich, Inc. (2021) reported a value of 10.9% instead.

On Site, soils overlying the Caseyville/Tradewater Formation consist of glacial and alluvial deposits including layers of silty clay, clayey silt, silty sand and clayey sand (Kleinfelder, 2013). Table 3.1 provides a detailed summary of the Site lithology for the upper 50 feet (Golder, 2021).

Table 3.1 Site Geology

Lithology	Description
Peoria/Roxana Silt	Light yellow-tan to gray, fine sandy silt
Glasford Formation	Silty/sandy diamictons with thin lenticular bodies of silt, sand, and gravel
Caseyville Formation/Bedrock	Sedimentary rocks including sandstone, limestone, and shales

Sources: Golder, 2021; Kleinfelder, 2013.

The Site is located within the South Fork Saline River/Lake Egypt watershed. Groundwater in the southern/eastern portion of the Site flows toward and discharges into the Lake of Egypt; groundwater throughout the rest of property flows in a northeasterly direction toward Little Saline Creek (Figure 3.5; SIPC, 2007). The uppermost water-bearing zone (*i.e.*, the Unlithified Unit) is a shallow, hydraulically perched layer consisting of fill and residuum (silts and clays), with a saturated thickness of approximately up to 10 feet (Hanson Professional Services Inc., 2021). The average horizontal hydraulic conductivity is estimated to be approximately 1.5×10^{-4} cm/s in the Unlithified Unit (Golder, 2021). The hydraulic gradient was estimated to be 0.019 based on measured groundwater elevations at monitoring wells S-3 and S-6 (SIPC, 2007).

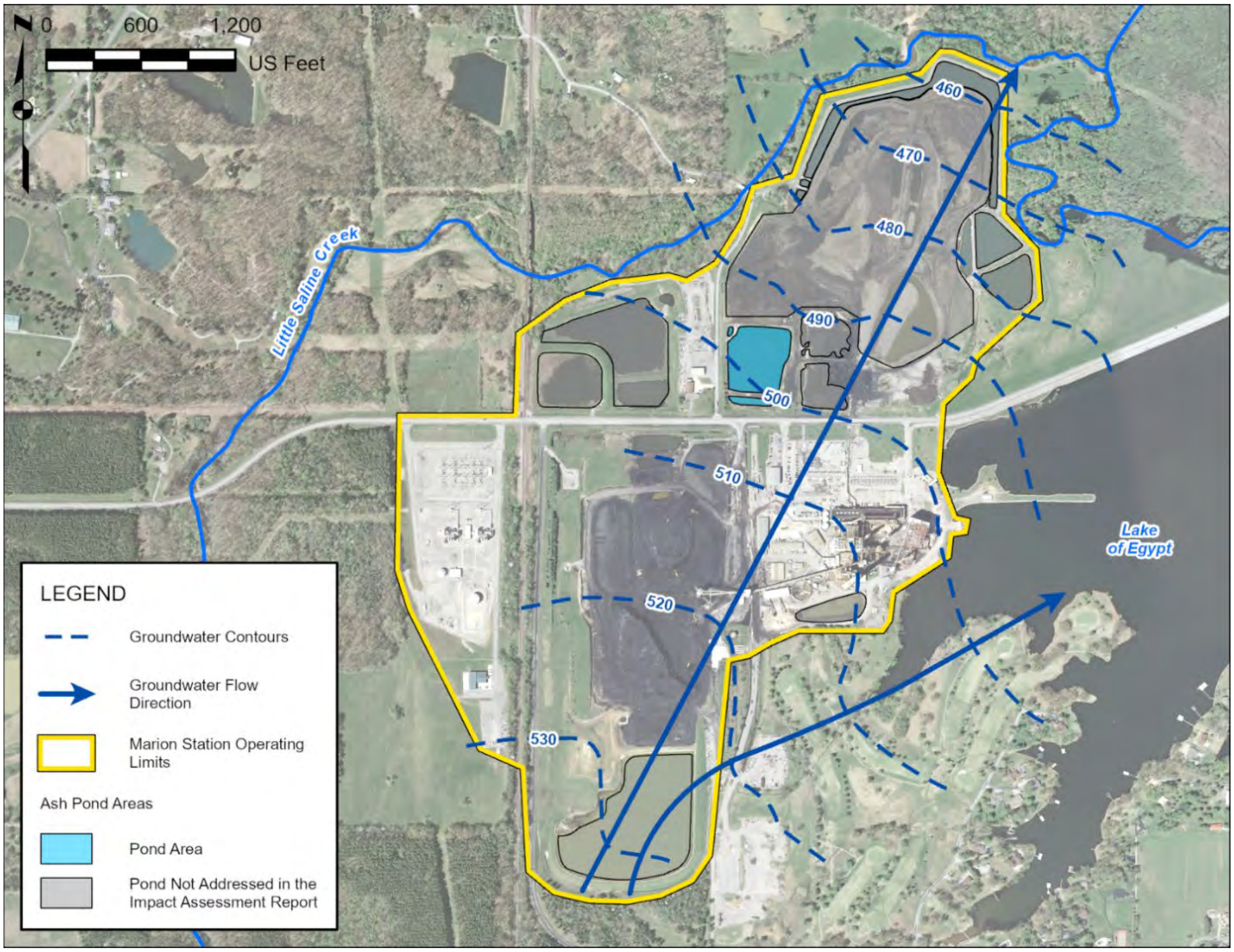

Figure 3.5 2007 Groundwater Elevations, Contours, and Flow Direction at the Site. Source: SIPC, 2007.

3.3 Groundwater Monitoring

Groundwater samples have been collected from a series of monitoring wells to monitor groundwater quality near Pond 4 ("S" series wells; Figure 3.1). Groundwater samples were analyzed for a suite of total metals, specified in IAC 845.600 (IEPA, 2021),[2] as well as general water quality parameters (pH, chloride, fluoride, sulfate, and total dissolved solids). Groundwater quality data from samples collected at "S" wells over the past five years are summarized in Table 3.2.

Table 3.2 Groundwater Data Summary (2018-2023) from Monitoring Wells ("S" Wells) Located Near Pond 4

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	0	12	ND	ND	0.0050
Arsenic	3	12	0.0089	0.12	0.050
Barium	12	12	0.020	1.5	NA
Beryllium	1	12	0.0081	0.0081	0.0050
Boron	35	126	0.0041	2.8	0.50
Cadmium	12	126	0.00068	0.055	0.002
Chromium	9	12	0.0014	0.069	0.0050
Cobalt	5	12	0.0012	0.054	0.010
Lead	7	12	0.0027	0.080	0.0050
Mercury	0	12	ND	ND	0.00020
Selenium	3	12	0.0021	0.017	0.025
Thallium	1	12	0.046	0.046	0.025
Dissolved Metals (mg/L)					
Boron	14	48	0.0051	3.1	0.50
Cadmium	0	48	ND	ND	0.001
Other (mg/L or SU)					
Chloride	88	90	6.1	480	20
Fluoride	6	12	0.062	0.18	0.50
pH	66	66	5.7	6.9	NA
Sulfate	122	126	2.6	310	20
Total Dissolved Solids	66	66	78	4500	NA

Notes:
mg/L = Milligrams per Liter; NA = Not Available; ND = Not Detected; SU = Standard Unit.
Source: Gradient (2024).

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[2] Samples were analyzed for a longer list of inorganic constituents and general water quality parameters (chloride, fluoride, sulfate, and total dissolved solids), but these constituents were not evaluated in the risk evaluation.

4 Closure Impact Assessment

The goal of this Closure Impact Assessment was to holistically evaluate a closure scenario with respect to a wide range of factors, including risks to human health and the environment, risks of future releases, effects on groundwater, surface water, and air quality, impacts to the local community, and impacts on worker safety. Specifically, I evaluated the impacts and potential benefits associated with one specific closure scenario at Pond 4: CBR. Results of the closure impact assessment were compared to the impacts associated with current operational conditions at Pond 4.

4.1 Introduction

For this report, the Pond 4 closure scenario was assumed to be CBR. This scenario would include dewatering of the pond and excavation of sediment in the pond; CBR may include either on-Site disposal or off-Site disposal of the excavated sediment. Post-excavation, this scenario could also include a retrofit of Pond 4 with an impermeable bottom liner to allow for continued operation and use of the pond. This impact assessment holistically assesses the CBR closure scenario based on a series of metrics, described below.

- **Risks to Human Health and the Environment:** This metric evaluates the impact of closure by CBR on the reduction of risks to human health and the environment due to exposure to CCR-related constituents in groundwater and surface water.
- **Risks of Potential Future CCR Releases:** This metric evaluates the residual risk of potential CCR releases. Sub-categories include CCR releases due to a dike failure event and CCR releases under flood conditions.
- **Groundwater Quality:** This metric describes the likelihood of groundwater concentration exceedances of relevant regulatory standards.
- **Surface Water Quality:** This metric describes the likelihood of surface water concentration exceedances of relevant regulatory standards.
- **Air Quality:** This metric describes the air quality impacts of closure activities under CBR, including the generation of fugitive dust and emissions from diesel-powered construction equipment.
- **Climate Change and Sustainability:** This metric describes sustainability and climate change-related aspects of CBR, including GHG emissions and energy consumption during closure activities.
- **Worker Safety:** This metric describes potential for worker fatalities and injuries to occur during closure activities, either on-Site or off-Site (*i.e.*, due to haul truck accidents).
- **Community Impacts:** This metric describes potential for fatalities and injuries to occur in the community due to off-Site haul truck accidents. It also includes the nuisance impacts that may arise from closure activities, including traffic and noise.
- **Environmental Justice (EJ):** This metric evaluates the possible impacts of the closure activities on EJ communities.

- **Recreational Value:** This metric evaluates the potential impacts resulting from noise and visual disturbances to recreators during closure activities.

Section 4.2 summarizes the CBR scenario that I evaluated as part of this assessment. Section 4.3 presents my analysis of the various closure alternatives with respect to the metrics listed above, and Section 4.4 summarizes the conclusions of this Closure Impact Assessment.

4.2 Summary of Closure Approach

For this report, I assumed the closure scenario was CBR, which may include the following elements:

- Removal of liquids. Water would be managed in accordance with the National Pollutant Discharge Elimination System (NPDES) permit for the facility;
- Excavation of sediments;
- Site restoration such as placement of topsoil along the side slopes and bottom of Pond 4 and revegetation with native grasses;
- Disposal of the excavated sediments at either an on-Site area or an off-Site landfill; and
- Post-excavation, this scenario may also include a retrofit of Pond 4 with an impermeable bottom liner to allow for continued operation and use of the pond.

Based on a 2021 report, the total sediment volume in Pond 4 was estimated to be approximately 91,077 ft^3 (*i.e.*, 3,373 CY; Haley & Aldrich, 2021). On-Site disposal may be feasible if there is an existing on-Site landfill or construction of a new on-Site landfill is demonstrated to be viable. For this report, I assumed that that excavated sediments from Pond 4 would be transported to the West End Disposal Facility located in Thompsonville, Illinois (1710 McFarland Road), which is approximately 35 road miles from the Site. Excavated sediments could be hauled to the off-Site landfill using haul trucks with an assumed capacity of 16.5 CY.

Based on my previous experience for similarly sized units, I assumed that CBR-related closure activities would take approximately 2-4 months. Key parameters for the CBR scenario are shown in Table 4.1.

Table 4.1 Key Parameters for the CBR Scenario

Parameter	Value
Size of Pond 4 (acres)	3.7
Volume of sediments (yd^3)	3,373
Estimated duration of construction activities (months)	2 - 4
Truckloads required	205
Length of the haul route between Pond 4 and disposal area (mi)	35
Total vehicle miles traveled (mi)	14,350

Source: Haley & Aldrich, 2021.

4.3 Closure Impact Assessment

4.3.1 Risks to Human Health and the Environment

A Human Health and Ecological Risk Assessment (Gradient, 2024) concluded that, under current conditions at the Site, there are no unacceptable risks to human health or the environment associated with the use of groundwater or the discharge of groundwater to surface water. Because the current operational conditions in Pond 4 do not present a risk to human health or the environment, there are not likely to be any unacceptable risks after Pond 4 is closed. As a result, there is no risk reduction achieved by closing Pond 4.

4.3.2 Risks of Potential Future CCR Releases

Environmental impacts can occur at coal ash impoundments due to the sudden release of CCR during infrastructure failures and flooding events. This section evaluates the risk of CCR releases resulting from a dike failure or flood event.

Releases Due to Dike Failure

Sites in Illinois may be subject to seismic risks arising from the Wabash Valley Seismic Zone and the New Madrid Seismic Zone (IEMA, 2020). Specifically, the Wabash Valley Fault System is approximately 85 miles northeast of the Site, the New Madrid fault zone is located approximately 80 miles southwest of the Site, and the St. Genevieve fault zone is approximately 40 miles west of the Site (Hanson Professional Services Inc., 2019a). Although the Marion Generating Station property is located within a seismic impact zone (Hanson Professional Services Inc., 2019a), the Site does not lie within 200 feet of an active fault or fault damage zone at which displacement has occurred in Holocene time (Hanson Professional Services Inc., 2019b). As a result, there is minimal risk of dike failure under current conditions due to seismic impact. Furthermore, because there are currently only negligible amounts of CCR related materials in Pond 4, there is very little risk of a release of CCR due to a seismic event. Under the CBR scenario, all of the sediments in Pond 4 will be excavated and relocated, which would eliminate the risk of a future CCR release.

Flood-Related Releases

Based on the effective Federal Emergency Management Agency (FEMA) Flood Map for the Site, Pond 4 is not located within the 100-year flood zone (*i.e.*, Zone A) for the Lake of Egypt (FEMA, 2024). For this reason and because there are currently only negligible amounts of CCR related materials in Pond 4, there is very little risk of a flood-related CCR release at Pond 4. Under the CBR scenario, all sediments in Pond 4 would be excavated and disposed, eliminating the risk of any flood-related CCR releases.

4.3.3 Groundwater Quality

Concentrations of constituents detected in groundwater near Pond 4 were compared to the relevant groundwater protection standards (GWPSs) and to a Site-specific background concentration (Table 4.2; "S" Wells on Figure 3.1). GWPSs were defined based on IAC 845.600. The site-specific background concentration was estimated based on the maximum concentration detected at monitoring well C-3 which is located upgradient of the power generation station (Figure 3.1). Exceedances were identified when the constituent concentrations exceed either the corresponding GWPS or the background concentration, whichever is higher.

Table 4.2 Groundwater Exceedances Summary for (2018-2023) - Monitoring Wells ("S" Wells) Located Near Pond 4

Constituent[a]	Maximum Concentration Detected	Groundwater Protection Standard (GWPS; IAC 845.600)	Background Concentration (Well C-3)[b]	Exceedance of Benchmark Identified (Location of Exceedance)[c]
Total Metals (mg/L)				
Antimony	--	0.0060	--	No
Arsenic	0.12	0.010	0.0033	Yes (S-1)
Barium	1.5	2.0	0.23	No
Beryllium	0.0081	0.0040	--	Yes (S-1)
Boron	2.8	2.0	0.414	Yes (S-2)
Cadmium	0.055	0.005	0.013	Yes (S-1, S-2, S-3, S-4, S-5, and S-6)
Chromium	0.069	0.10	0.0029	No
Cobalt	0.054	0.0060	0.0072	Yes (S-1 and S-6)
Lead	0.080	0.0075	0.0062	Yes (S-1, S-2, and S-6)
Mercury	--	0.0020	--	No
Selenium	0.017	0.050	0.012	No
Thallium	0.046	0.0020	--	Yes (S-2)
Dissolved Metals (mg/L)				
Boron	3.1	2.0	0.031	Yes (S-2)
Cadmium	--	0.005	--	No
Other (mg/L or SU)				
Chloride	480	200	570	No
Fluoride	0.18	4.0	0.19	No
pH	6.9	9.0	7	No
Sulfate	310	400	414	No
Total Dissolved Solids	4,500	1,200	4,000	Yes (S-4)

Notes:

COI = Constituent of Interest; GWPS = Groundwater Protection Standard; IL = Illinois; mg/L = Milligrams per Liter; SU = Standard Units.

"--" indicate constituent was not detected

(a) The constituents are those listed in the IL Part 845.600 GWPS (IEPA, 2021).

(b) Well C-3 (Figure 3.1) is located upgradient of the Site and the maximum level of concentrations identified at C-3 were used to represent the Site background concentrations.

(c) Exceedances were identified when the constituent concentrations exceed either the GWPS or the background concentrations, whichever is higher.

Source: Gradient (2024).

The "S" series monitoring wells are located in close proximity to other historic ponds and disposal areas that received CCR during their operation, including Ponds 1 and 2, the Initial Fly Ash Holding Area, Replacement Fly Ash Holding Area, Pond A-1, and the Former On-Site Landfill. Moreover, Shake Tests performed on Pond 4 sediments did not identify concentrations of any constituents in excess of Class I groundwater standards (Haley & Aldrich, 2021). Because of this, and since CCRs were never directly sent to or disposed in Pond 4, GWPS and background concentration exceedances that have been observed at the "S" series monitoring wells are likely the result of other nearby historic ponds and disposal areas that received CCR during their operation. Thus, closure of Pond 4 by CBR is not likely to result in any improvement in groundwater quality.

4.3.4 Surface Water Quality

The impacts to surface water quality from groundwater adjacent to Pond 4 flowing into the Little Saline Creek was estimated by modeling the mixing of groundwater flowing into the stream (Gradient, 2024). Even using a conservative methodology,[3] modeling results concluded that surface water concentrations potentially attributable to groundwater discharges in the area near Pond 4 are below all relevant human health and ecological surface water screening benchmarks. The model predicted surface water concentrations in Little Saline Creek are presented in Table 4.3a and 4.3b. Consequently, closure of Pond 4 by CBR is not likely to affect surface water quality in Little Saline Creek resulting from groundwater discharges into the creek. However, construction activity associated with the closure and/or pond retrofit may result in exposed terrain which could increase the potential for surface runoff and increased sedimentation in the creek.

Table 4.3a Surface Water Modeling Results for the Little Saline Creek – Human Health Benchmarks

COI	Maximum Surface Water Concentration (Modeled)	HTC for Water and Fish	HTC for Water Only	HTC for Fish Only	Exceedance of Benchmarks
Total Metals (mg/L)					
Arsenic	1.15E-06	2.25E-02	2.00E+00	2.27E-02	No
Beryllium	7.79E-08	2.05E-02	8.00E-01	2.11E-02	No
Boron	2.98E-05	4.67E+02	1.40E+03	7.00E+02	No
Cadmium	5.29E-07	1.85E-03	1.00E+00	1.85E-03	No
Cobalt	5.19E-07	3.49E-03	2.10E+00	3.50E-03	No
Lead	7.69E-07	1.00E-02	1.00E-02	1.00E-02	No
Thallium	4.42E-07	1.72E-03	4.00E-01	1.72E-03	No

Notes:
COI = Constituent of Interest; HTC = Human Threshold Criteria; mg/L = Milligrams per Liter.
Concentrations are listed only for the constituents identified as COIs in the "S" Wells.
Modeled concentrations represent the potential effect on surface water quality resulting from the measured groundwater concentrations.
Source: Gradient (2024).

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[3] The maximum detected concentrations in groundwater from the "S" Wells from 2018 to 2023 were conservatively used to model constituents of interest (COI) concentrations in surface water.

Table 4.3b Surface Water Modeling Results for the Little Saline Creek – Ecological Benchmarks

COI	Maximum Surface Water Concentration (modeled)	Ecological Freshwater Benchmark	Basis	Exceedance of Benchmark
Total Metals (mg/L)				
Cadmium	5.29E-07	1.13E-03	IEPA SWQC	No
Cobalt	5.19E-07	1.90E-02	EPA R4 ESV	No
Lead	7.69E-07	2.01E-02	IEPA SWQC	No
Thallium	4.42E-07	6.00E-03	EPA R4 ESV	No

Notes:
COI = Constituent of Interest; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; SWQC = Surface Water Quality Criteria; EPA = United States Environmental Protection Agency; R4 = Region 4; mg/L = Milligrams per Liter.
Concentrations are listed only for the constituents identified as COIs in the "S" Wells.
Modeled concentrations represent the potential effect on surface water quality resulting from the measured groundwater concentrations.
Sources: Gradient (2024); IEPA SWQC: IEPA (2019a); EPA R4 ESV: US EPA Region IV (2018).

4.3.5 Air Quality

Construction activities can adversely impact air quality. Air pollution due to construction and/or pond retrofit occurs both on-Site and off-Site (*i.e.*, along haul routes). For this analysis, two categories of air pollution are of primary concern: equipment emissions and fugitive dust. The equipment emissions of greatest concern are those found in diesel exhaust. Most construction equipment is diesel-powered, including the dump trucks used to haul material to and from the Site. Diesel exhaust contains air pollutants, including nitrogen oxides (NO_x), particular matter (PM), carbon monoxide (CO), and volatile organic compounds (VOCs) (Hesterberg *et al*., 2009; Mauderly and Garshick, 2009). Fugitive dust, another major air pollutant at construction sites, is generated by earthmoving operations and other soil- and sediment-handling activities. Along haul routes, an additional source of fugitive dust is road dust along unpaved dirt roads. Careful planning and the use of Best Management Practices (BMPs) such as wet suppression are used to minimize and control fugitive dust during construction activities; however, it is not possible to prevent dust generation entirely.

During closure, air quality impacts would be expected both near the Pond 4 construction and retrofit area and along haul roads for off-Site disposal.

4.3.6 Climate Change and Sustainability

In addition to the air pollutants listed above in Section 4.3.5, construction equipment emits GHGs, including carbon dioxide (CO_2) and possibly nitrous oxide (N_2O). Moreover, construction activities have high energy demands. The energy for construction comes from the burning of fossil fuels (*e.g.*, the diesel used to power construction equipment). This section describes the impact of closure on two metrics related to climate change and sustainable construction: GHG emissions and energy consumption.

GHG Emissions

The potential impact of the CBR scenario associated with GHG emissions from construction equipment is proportional to the vehicle miles required. The off-Site disposal of Pond 4 sediments would require a total of 14,350 vehicle miles, which would result in higher GHG emissions than the current Pond 4 operation.

Energy Consumption

Energy consumption at a construction site is synonymous with fossil fuel consumption, because the energy to power construction vehicles and equipment comes from the burning of fossil fuels. The potential energy consumption impact associated with the CBR scenario is proportional to the vehicle miles required. Off-Site disposal of Pond 4 sediments would require a total of 14,350 vehicle miles. This would result in higher energy consumption/fossil fuel consumption than the current Pond 4 operation.

4.3.7 Worker Safety

Best practices would be employed during construction and/or pond retrofit in order to ensure worker safety and comply with all relevant regulations, permit requirements, and safety plans. However, it is impossible to completely eliminate the risk of accidents occurring during construction activities.

Accidents may occur either on-Site or off-Site. On-Site accidents include injuries and deaths arising from the use of heavy equipment and/or earthmoving operations. Off-Site accidents include injuries and deaths due to haul truck accidents.

Table 4.4 shows the expected number of accidents and injuries to vehicle occupants (workers) and non-occupants (community members) due to the hauling of sediments from the Site under the CBR scenario assuming off-Site disposal. Values in Table 4.4 are based on the "per vehicle mile traveled" crash rates reported by United States Department of Transportation (US DOT) for large trucks in the US (US DOT, 2023) and total vehicle miles estimated in Table 4.1.

Table 4.4 Expected Injuries and Fatalities Under the CBR Scenario

Factor	Value
Worker Injuries	0.003
Worker Fatalities	2.3×10^{-4}
Community Injuries	0.0037
Community Fatalities	2.78×10^{-5}

4.3.8 Community Impacts

Closure activities can impact communities near the Site as well as communities located along trucking routes. Community impacts may include air pollution, haul truck accidents, and nuisance impacts from traffic and noise.

Accidents

Haul truck accidents have the potential to injure or kill community members as well as workers. Table 4.4 (above) shows the number of community injuries and fatalities that would be expected under the CBR scenario due to off-Site hauling of sediments from the Site.

Traffic

Haul routes are expected to use major arterial roads and highways, if possible, which will reduce the incidence of traffic. However, heavy use of local roads for construction operations may result in traffic near the Site. Potential sources of traffic include the mobilization of equipment and materials, the daily arrival and departure of the workforce, and transport of the excavated sediment (TVA, 2015).

For the CBR scenario (assuming off-Site disposal of sediment), approximately 205 truckloads would be required to transport excavated sediments to the off-Site landfill (Table 4.1). Therefore, some traffic would be expected adjacent to the Site during the 2-4 month construction period.

Noise

Construction generates a great deal of noise, both in the vicinity of the Site and along haul routes. However, in a similar closure impact analysis performed by TVA (2015), the authors found that "[T]ypical noise levels from construction equipment used for closure are expected to be 85 dBA or less when measured at 50 ft. These types of noise levels would diminish with distance…at a rate of approximately 6 dBA per each doubling of distance and therefore would be expected to attenuate to the recommended EPA noise guideline of 55 dBA at 1,500 ft." As identified in Google Street View (Google LLC, 2024), there are no residences located within 1,500 ft of Pond 4 of the Site and, thus, closure will not cause any adverse noise impacts.

Haul routes are expected to use major arterial roads and highways, if possible, which would reduce the noise impacts on nearby communities. However, local roads near the Site may experience noise pollution under the CBR scenario due to high volumes of truck traffic. Notably, dump trucks generate significant noise pollution, with noise levels of approximately 88 decibels or higher expected within a 50 ft radius of the truck (Exponent, 2018). This noise level is similar to the noise level of a gas-powered lawnmower or a leaf blower (CDC NCEH, 2019). Decibel levels above 80 can damage hearing after two hours of exposure (CDC NCEH, 2019).

4.3.9 Environmental Justice

The State of Illinois defines environmental justice (EJ) communities to be those communities with a minority population above twice the state average and/or a total population below twice the state poverty rate (IEPA, 2019b). Relative to other communities, EJ communities experience an increased risk of adverse health impacts due to environmental pollution (US EPA, 2016).

As shown in a map of EJ communities throughout the state (US EPA, 2024), the nearest EJ community (Marion) lies approximately 6 miles from the Site to the north (Figure 4.1). As described above, noise impacts due to CBR-related construction are expected to be limited to potential receptors located within 1,500 feet (or 0.28 miles) of the Site. Similarly, the air quality impacts of construction are expected to be limited to potential receptors located within 1,000 feet (or 0.19 miles) of the Site (CARB, 2005; BAAQMD, 2017). The EJ community near Marion is therefore unlikely to be affected by impacts to on-Site air emissions and noise pollution.

EJ communities located along the potential haul routes to the off-Site landfills may be negatively impacted throughout the excavation period by the air pollution, noise, traffic, and accidents generated by hauling activities. A review of the EJ communities in Illinois (Figure 4.1) reveals that the off-Site landfill (*i.e.*, the West End Disposal Facility in Thompsonville, Illinois) is not located within the 1-mile buffer zone of an EJ community. Moreover, none of the three major haul routes suggested by Google Maps (Figure 4.1; Google LLC, 2024) would require hauling sediment through any EJ communities or buffer zones. Therefore, no EJ impacts would be expected to occur under this disposal scenario.

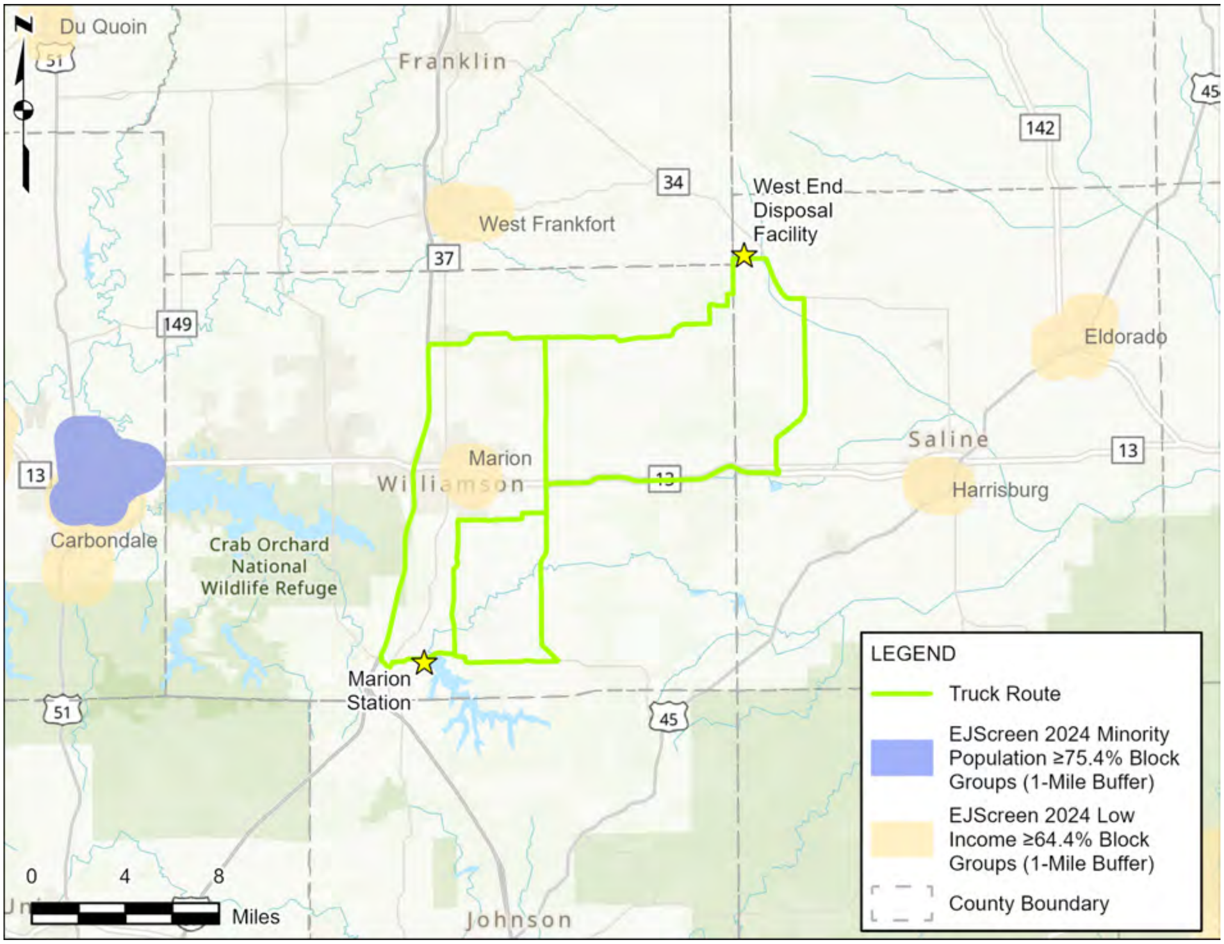

Figure 4.1 EJ Communities in the Vicinity of the Site and the Off-Site Landfill. Sources: US EPA (2024); IEPA (2019b); Google LLC (2024).

4.3.10 Scenic, Recreational, and Historical Value

During construction activities, negative impacts on scenic and recreational value may occur along the Lake of Egypt. Construction activities at the Pond 4 may not be visible to recreators given the separation between Pond 4 and the lake. Based on a review of the Illinois Department of Natural Resources (IDNR) Historic Preservation Division database and the Illinois State Archaeological Survey database, there are no historic sites located within 1,000 meters of Pond 4 (IDNR, 2023; ISAS, 2023). Thus, no impacts on historical sites would be expected under the CBR scenario.

4.4 Summary

The impacts associated the potential closure scenario, (*i.e.*, CBR) at Pond 4 were analyzed. CBR does not lead to greater environmental or human health benefit as compared to continued operation of Pond 4. Specifically, CBR will not result in any reduction in risks to human health or the environment and will not result in any improvement to groundwater quality or surface water quality. However, implementing CBR will have several adverse effects compared to the continued operation of Pond 4. Specifically, closure may cause short-term impacts to air quality, result in increased GHG emissions and increased energy consumption, cause an increase in worker injuries, and result in increased accidents, traffic, noise to nearby communities.

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Appendix A

Curriculum Vitae of Andrew Bittner, M.Eng., P.E.

GRADIENT

Andrew B. Bittner, M.Eng., P.E.
Principal
(he/him)
Andy.Bittner@gradientcorp.com

Areas of Expertise

Contaminant fate and transport in porous and fractured media, migration of coal ash combustion products in groundwater and surface water, non-aqueous phase liquid (NAPL) transport, surface water and groundwater hydrology, groundwater and surface water modeling, remedial investigation design, remedy evaluation and optimization, cost allocation, international regulatory compliance and remediation.

Education & Certifications

M.Eng., Environmental Engineering and Water Resources, Massachusetts Institute of Technology, 2000

B.S.E., Environmental Engineering, University of Michigan, 1997

B.S., Physics, University of Michigan, 1997

Licensed Professional Engineer: Idaho, New Hampshire, Nevada

Professional Experience

2000 – Present GRADIENT, Boston, MA
Environmental Engineer. Specializes in the fate and transport of contaminants in groundwater and surface water, coal combustion products, groundwater hydrology, groundwater flow and contaminant transport modeling, NAPL transport, and remedial investigation and design. Has served as principal-in-charge, testifying expert, and consulting expert on large, multi-disciplinary projects at coal combustion product surface impoundments and landfills, pharmaceutical facilities, automotive facilities, manufacturing plants, dry cleaning facilities, and Superfund sites. Extensive experience in South America and at other international sites.

1997 – 1999 PARSONS ENGINEERING SCIENCE, Canton, MA
Environmental Engineer. Specialized in industrial wastewater treatability. On-site supervisor for bioremediation bench scale treatment and laboratory study for a major pharmaceutical company. Built hydraulic models for pharmaceutical wastewater treatment facilities. Designed hazardous waste treatment systems for a major pharmaceutical company. Performed site investigations to delineate NAPL plumes and design remedial recovery plans.

10/15/2024

Professional Affiliations

National Ground Water Association; Chi Epsilon – Environmental Engineering Honor Society

Technical Session Chair:

- World of Coal Ash Conference. Lexington, KY. May 8-11, 2017. Session title: "Groundwater."
- Battelle Conference on Remediation of Chlorinated and Recalcitrant Compounds. Palm Springs, CA. May 23-26, 2016. Session title: "Coal Ash Facility Restoration."
- Battelle Conference on Remediation of Chlorinated and Recalcitrant Compounds. Monterey, CA. May 21-24, 2012. Session title: "Environmental Remediation in Emerging Markets."
- Defense Research Institute. Panelist for session titled "Groundwater-Surface Water Connectivity and the Clean Water Act." New Orleans, LA. May 13-14, 2019.
- World of Coal Ash Conference. St. Louis, MO. May 13-16, 2019. Session title: "Project-Specific Case Studies."
- World of Coal Ash Conference. Covington, KY. May 16-19, 2022. Session title: "Regulatory."

Projects – *Coal Combustion Products*

Industry Research Group: Reviewed and submitted comments related to US EPA's proposed legacy impoundment rule. The review focused both on US EPA's risk models, fate and transport models, and their conceptual site model for both legacy impoundments and coal combustion residual management units (CCRMUs).

Utility Client: Evaluated the amount of greenhouse gas emissions that would be generated during the potential hauling of coal ash from surface impoundments to off-site landfills. Used SiteWise, a tool developed by US ACE, to determine the amount PM10, SOx, NOx, and CO2 generated during the transportation process. Our analysis supported communications with the public and regulators regarding different surface impoundment closure alternatives.

Utility Client: Conducted a relative impact assessment of potential closure options at a former CCR disposal facility in Illinois. Ranked each closure option based on 10 different metrics including human health and environmental risks, water and air quality, safety, community and habitat impacts, risk of potential release, climate change and sustainability, and cost.

Electric Power Research Institute: Modeled groundwater impacts from coal combustion product (CCP) surface impoundments with intersecting groundwater conditions and evaluated hydrogeological factors and other characteristics that influence risks to human health and the environment (HHE).

Utility Client: Served as litigation consulting expert regarding the fate and transport of metal constituents in groundwater from 18 different coal combustion residual (CCR) disposal facilities at 7 sites in the Midwest.

Utility Client: Prepared expert report and provided testimony related to the fate and transport of metal constituents in groundwater from 11 different coal combustion residual (CCR) disposal facilities at 6 sites in West Virginia, Virginia, and Ohio.

Utility Client: Prepared expert report in support of "Petition for a Finding of Inapplicability or, in the Alternative, an Adjusted Standard from 35 ILL. Admin. Code Part 845." Report assessed current risks to human and environmental receptors and evaluated net environmental benefits (*i.e.*, NEBA) of potential closure options at a former CCR disposal facility.

Utility Client: Prepared Closure Alternatives Assessment (CAA), Corrective Measures Assessment (CMA), and Corrective Action Alternatives Analysis (CAAA) reports for multiple CCR surface impoundments located at a series of midwestern power plants. Reports were prepared consistent with requirements of 35 ILL. Admin. Code Part 845.

Utility Client: Evaluated risks to human health and the environment associated with CCR surface impoundments at six coal fired power plants in the southern US. Evaluations included assessing CCR constituent migration in groundwater and the flux of constituents into nearby surface waters.

Utility Client: Calculated alternative groundwater protection standards (GWPSs) at a coal fired power plant facility in the midwestern US. Alternative standards were calculated based on site-specific human and ecological receptors and attenuation factors.

Utility Client: Prepared expert report and testified before state pollution control board regarding proposed coal ash disposal regulations.

Electric Power Research Institute: Evaluated the performance of alternative liners, including engineered clay liners, natural clay liners, and geomembrane composite-lined systems at CCP impoundments. Used a probabilistic approach to model the flux of CCP constituents through each liner and the subsequent transport of constituents through the underlying vadose and saturated zone.

Industry Research Group: Developed methodology to evaluate performance equivalency of various surface impoundment liner systems. The methodology, which was submitted to US EPA in order to inform future rulemakings, presented a process to evaluate and compare hydraulic flux and travel times through different liner systems including geocomposite, compacted clay, and natural clay liners.

Confidential Client: Developed a screening-level risk assessment for a manufacturing facility beneficially using coal fly ash as a soil stabilizer. The risk assessment compared estimated coal ash constituent exposure concentrations in soil, groundwater, and surface water to relevant benchmarks protective of human health and the environment.

Manufacturing Client: Performed beneficial use risk assessments consistent with US EPA Federal Coal Combustion Residual (CCR) Rule and Secondary Use Guidance for multiple commercial and construction products containing coal ash – including carpet backing, interior and exterior trim, and backer board. Analysis evaluated risks to groundwater, surface water, indoor air, and soil. Evaluation also considered exposure pathways for residents, construction workers, and landfill workers associated with installation of products, active life of the installed products, and post-life disposal in a landfill.

Electric Power Research Institute: Developed framework for creating alternative groundwater standards at CCP storage sites. The framework considers the development of alternative standards for the protection of human health and the environment, current and future uses of groundwater near CCP management units, and potential attenuation that may occur between the current point of compliance and a relevant point of exposure.

Utility Client: Prepared expert report and provided testimony related to the fate and transport of metal constituents in groundwater, including sulfate, boron, and arsenic, from over 30 different coal combustion residual surface impoundments at 15 sites in North Carolina and South Carolina.

Industry Research Group: Prepared technical comments regarding proposal to add boron to list of Appendix IV constituents to the Federal CCR Rule. Evaluated technical practicability and cost implications associated with the potential boron addition.

Industry Research Group: Prepared technical comments regarding portion of Federal CCR Rule that requires the groundwater protection standard (GWPS) of Appendix IV constituents with no MCL to be the background concentration. Evaluated technical practicability, cost implications, and potential benefits associated with the requirement for the four current Appendix IV constituents with no established MCL – cobalt, lithium, molybdenum, and lead.

Confidential Client: Developed a screening-level risk assessment for a steel production and recycling facility that is beneficially using coal fly ash as a soil stabilizer. The risk assessment addressed a requirement in the Federal Coal Combustion Residuals (CCR) Disposal Rule for a characterization of risk from unencapsulated beneficial use of CCR. Used the Industrial Waste Evaluation Model (IWEM) to evaluate potential transport of coal ash constituents, including arsenic, in groundwater as a result of the beneficial reuse.

Utility Client: Prepared expert report interpreting data produced during a field investigation performed at a large midwestern coal ash landfill.

Utility Client: For litigation support, modeled the fate and transport of arsenic and other coal ash related constituents in groundwater and surface water downgradient of a large midwestern coal ash surface impoundment located in a karst environment. Model simulations compared potential impacts to groundwater and surface water resulting from potential surface impoundment closure scenarios.

Manufacturing Client: Performed beneficial use risk assessments consistent with US EPA Federal Coal Combustion Residual (CCR) Rule and Secondary Use Guidance for multiple commercial and construction products containing coal ash. Analysis evaluated risks to groundwater, surface water, indoor air, worker safety, and residential safety. Evaluation also considered exposure pathways associated with installation of products, active life of the installed products, and post-life disposal in a landfill. Used the Industrial Waste Evaluation Model (IWEM) to evaluate potential transport of coal ash constituents, including arsenic, in groundwater as a result of the beneficial reuse.

Industry Research Group: Developed a groundwater fate and transport model to evaluate the level of groundwater protection provided by various coal ash surface impoundment closure options, including closure in place and closure by removal. Model simulated transport of arsenic (III) and arsenic (V) in groundwater downgradient of coal ash disposal facilities. Model results are being used by utilities in support of closure planning which is required by Federal Coal Combustion Residual Rule.

Confidential Client: Prepared expert report on human health and ecological risks due to a potential spill of barged coal combustion byproducts (CCBs) on a large midwestern river. Modeled the fate and transport of key CCB constituents, including arsenic, in surface water for a range of spill scenarios and river flow conditions and estimated potential downstream concentrations at drinking water intake locations.

Industry Research Group: Evaluated technical approach used by United States Environmental Protection Agency (US EPA) to simulate the migration of arsenic, selenium, and other metals in groundwater from overlying coal combustion storage units. Model analyses were included in regulatory comments submitted in response to US EPA's 2010 Coal Combustion Product Risk Assessment.

Industry Research Group: Developed relative risk framework to assess impacts to groundwater associated coal combustion product (CCP) surface impoundment closure scenarios. Framework identified potential deterministic and probabilistic modeling approaches to simulate potential migration of CCP constituents, including arsenic, boron, selenium, and molybdenum through the vadose and saturated zones for each closure alternative.

Industry Research Group: Modeled the downward migration of leachate from unlined coal combustion product surface impoundments using a probabilistic framework for a wide range of climatic and site conditions. Model results provided estimated durations for interactions between the impoundment leachate and nearby surface and groundwater.

Industry Research Group: As part of a relative risk framework, performed detailed sensitivity analysis of all factors associated with a coal ash surface impoundment closure that may impact the fate and transport of constituents in groundwater. Factors analyzed included surface impoundment characteristics (*e.g.*, volume, depth, and leachate quality), hydrogeological conditions (*e.g.*, hydraulic conductivity, hydraulic gradient, soil type, depth to groundwater, and surface water proximity), climatic characteristics (*e.g.*, precipitation), and closure details (*e.g.*, closure type and duration).

Projects – *Fate & Transport and Modeling*

Confidential Client, New Hampshire: Prepared expert report regarding the source of MTBE detected in a private, residential well and evaluated the timing of potential MTBE releases at an upgradient retail fuel dispensing station.

Confidential Client: Provided environmental site management and risk communication support for a property developer at a former Superfund site. Presented at public meetings with local officials, led discussions with state environmental agencies, conducted a public site visit, prepared a site investigation work plan, analyzed environmental data, proposed a low-impact remediation approach in collaboration with the stormwater design team, and submitted an environmental impact report.

Mining Client: Prepared expert report regarding the fate and transport of metal constituents in soils and groundwater from various sources at 4 different mining sites located in Ontario and Manitoba, Canada.

Manufacturing Client: Provided oral testimony related to the fate and transport of dioxins and furans in the environment resulting from waste disposal and wastewater treatment lagoons at a paper mill in South Carolina.

PRP Group: Reviewed hydrogeological characteristics and evaluated potential off-site migration of contaminants at a former industrial site in Nevada. Presented the findings of our assessment to the Nevada Division of Environmental Protection (NDEP) and to representatives of the neighboring property to support discussions relating to a groundwater remedial alternatives study.

Manufacturing Client: Consulting expert for a class certification case. Evaluated PFAS transport from known and potential sources.

Natural Gas Processing Facility: Prepared an expert report evaluating the hydrogeological conditions at and downgradient of a natural gas processing plant and provided assessment of the fate and transport over time of light non-aqueous phase liquids (LNAPLs) released from the plant and associated pipelines.

Confidential Client, Rhode Island: Designed and calibrated a groundwater flow and solute transport model for multiple chlorinated organic constituents at a northeastern Superfund site. Used one-year long tracer test to calibrate model. Model was used to predict the future effectiveness of various remedial alternatives.

Confidential Client: Designed and calibrated a groundwater flow and solute transport model for a Superfund site that has groundwater impacted with volatile organic compounds including benzene, tetrachloroethylene, trichloroethylene, and vinyl chloride. The model was used successfully to present the case to US EPA for shutting down the source remedy.

Confidential Client, Brazil: Developed 3-D numerical groundwater and solute transport model using MODFLOW and MT3D for volatile organic compounds and pesticides. Used model to evaluate and design remediation alternatives. Managed multiple site investigation and characterization studies. Projects involved calculation of risks to human health from exposure to soils, groundwater, indoor air, and outdoor air.

Savage Well Superfund Site: For a potentially responsible party (PRP) group, managed the development of a 3-D numerical groundwater and solute transport model for tetrachloroethylene (PCE) at a Superfund site in New Hampshire. Calibrated the model using approximately 10 years of data with review and oversight by US EPA and United States Geological Survey (USGS). Designed an optimization algorithm to develop the optimal groundwater pump and treat system.

Confidential Client, Massachusetts: Developed a 2-D contaminant transport model for PCE to demonstrate that contaminant contribution from a dry-cleaning operation to the town water supply wells was insignificant compared to contribution from other potential sources. Managed the installation and operation of a pump and treat system at the site.

Confidential Client, Argentina: Developed a 2-D numerical groundwater and solute transport model using MODFLOW and MT3D. Used the calibrated model to design a hydraulic barrier system to control off-site migration.

Confidential Client: Performed site-specific vapor intrusion modeling using the Johnson-Ettinger model at a pharmaceutical facility. Performed a detailed sensitivity analysis for each model input parameter.

Confidential Client: Performed NAPL transport and travel time calculations through porous media vadose and saturated zones and clay confining layers.

Confidential Client: Wrote critique of US EPA geochemistry model.

Projects – *Remediation*

Confidential Client: Developed a remedial strategy at a former mining site contaminated with metals located in Brazil. Evaluated historical constituent concentrations in soil, surface water, and sediment, developed a conceptual site model, and designed a site-characterization sampling program to define whether remediation was warranted.

Confidential Client: Evaluated potential liabilities related to range of issues including waste surface impoundment closure, groundwater remediation, and regulatory compliance at sites around the world that were involved in a corporate transaction.

Manufacturing Client, New Hampshire: Served as consulting expert for a case related to a failed groundwater remedy. Evaluated remedy design and installation and performed probabilistic modeling to determine appropriate design factors.

PRP Group, Nevada: Provided hydrogeological support at an industrial site with groundwater impacts due to benzene, chlorobenzene, chloroform, perchlorate, and chromium. Evaluated and critiqued a remedial investigation (RI) report related to a neighboring property and developed a conceptual site model (CSM) describing the fate and transport mechanisms of constituents in groundwater. Prepared submittals and presented conclusions at meetings with the state environmental agency.

Confidential Client, Brazil: Designed and implemented nanoscale zero valent iron remedy to prevent off-site arsenic migration. Upon completion of remedy, negotiated site closure with state of Rio de Janeiro environmental agency.

Confidential Client, Brazil: Designed and implemented a pilot scale enhanced *in-situ* bioremediation remedy for groundwater impacted with chlorinated organic compounds at a former agricultural product manufacturing facility.

Confidential Client, New Hampshire: As an independent third party, performed a review of a proposed Electrical Resistive Heating remedy for a chlorinated solvent dense non-aqueous phase liquid (DNAPL) source zone.

Confidential Client, New York: Provided regulatory comments regarding a US EPA Proposed Remedial Action Plan at a Region II Superfund site on Long Island. Provided support during mediation and during negotiations with US EPA.

Confidential Client, New Jersey: Provided regulatory comments regarding a US EPA Proposed National Priorities List (NPL) listing at a Region II Superfund site.

Confidential Client, Brazil: Managed multiple conceptual and detailed engineering remedial design projects for a soil vapor extraction system, dual-phase extraction system, and a pump and treat system. Remediation efforts focused on soil and groundwater contamination by pesticides and chlorinated solvents.

Confidential Client, Brazil: Managed site remediation projects to operate and maintain a soil vapor extraction system, dual-phase extraction system, and a hydraulic barrier system.

Confidential Client, Argentina: Managed conceptual and detailed engineering remedial design project for dual-phase extraction system focused on the remediation of volatile organic compounds in soil and groundwater.

Confidential Client: On-site supervisor for bioreactor bench scale study at a pharmaceutical wastewater treatment plant. Performed an in-depth investigation on the bio-inhibitory effects due to the chronic exposure of biomass to manganese. Performed laboratory work required to support the bioreactors including tests for mixed liquor volatile suspended solids (MLVSS), total suspended solids (TSS), chemical oxygen demand (COD), dissolved oxygen (DO), ammonia (NH_3), and respirometry.

Confidential Client: Lead environmental engineer for a belt filter press replacement project for a pharmaceutical company wastewater treatment plant. Designed and sized polymer addition system.

Projects – *Site Characterization*

Confidential Client, Brazil: Provided strategic oversight for a series of environmental investigations, remedial actions, and agency negotiations for an automotive facility located in São Paolo.

Confidential Client: Managed large-scale cost allocation at a midwestern Superfund site. Forensically evaluated the sources of tar to river sediments considering site industrial operational history, contaminant fate and transport, chemistry, site modification and filling history, and observed contaminant patterns. Calculated the mass of tar present in the environment using both visual observations and analytical data.

Confidential Client, Brazil: Managed large-scale site investigations and human health risk assessment projects at a former pharmaceutical facility located in São Paulo. Key compounds were petroleum hydrocarbons and volatile organic compounds.

Confidential Client, New York: Served as consulting expert for large cost allocation involving over 16 responsible parties and chlorinated organic groundwater plumes extending for nearly 2 miles. Evaluated lateral and vertical groundwater flow direction, chemical usage history, and groundwater chemistry to support a *de minimis* contribution argument for our client.

Confidential Client, Ohio: Served as consulting expert for cost allocation project at a midwestern landfill. Evaluated differences in toxicity and risk associated with municipal solid waste and industrial hazardous waste. Used data to devise risk-weighted allocation approach for remedy costs.

Confidential Client, Brazil: Managed site investigation to evaluate groundwater responses due to seasonal precipitation events and their effect on potential contaminant fate and transport.

Confidential Client: Managed site investigation project identifying sources of PCE present at a former electrical resistor manufacturing facility. Soil, groundwater, and soil gas data were evaluated and used to identify individual sources of PCE to the subsurface. The impact of each source on remediation costs related to the site was evaluated and successfully used as a tool to mediate between responsible parties. Served as consulting expert during mediation between responsible parties.

Confidential Client, New Jersey: Delineated NAPL plumes and investigated spill history, sewer maps, and gas chromatography fingerprint results at an East Coast Superfund site. Designed French Drain to recover NAPL from subsurface.

City of Pittsfield, Massachusetts: Technical consultant to the city for mediation between General Electric (GE) and governmental agencies. Evaluated reports and clean-up standards and attended mediation sessions on behalf of the city.

Projects – *Clean Water Act*

Municipal Client, Ohio: Consulting expert for significant nexus evaluation to determine whether wetlands and surface water tributaries are jurisdictional waters of the United States.

Publications

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Lewis, AS; Dube, EM; Bittner, A. 2017. "Key role of leachate data in evaluating CCP beneficial use." *ASH at Work* 1:32-34.

Lewis, A; Bittner A; Radloff, K; Hensel, B. 2017. "Storage of coal combustion products in the United States: Perspectives on potential human health and environmental risks." In *Coal Combustion Products (CCPs): Characteristics, Utilization and Beneficiation, 1st Edition*. Woodhead Publishing, May 2.

Bittner, AB. 2014. "Evolving environmental regulations in Brazil." *Gradient Trends: Risk Science and Application* 59:4. Winter.

Bittner, AB. 2013. "Evolving methods for evaluating vapor intrusion." *Gradient Trends: Risk Science and Application* 57:4. Spring.

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Bittner, AB. 2006. "M&A emerging issues and requirements." *Gradient Trends: Risk Science & Application* 36:4. Spring.

Bittner, AB; Halsey, P; Khayyat, A; Luu, K; Maag, B; Sagara, J; Wolfe, A. 2002. "Drinking water quality assessment and point-of-use treatment in Nepal." *Civil Eng. Practice* 17:5-24.

Bittner, AB. 2000. "Drinking Water Quality Assessment in Nepal: Nitrates and Ammonia [Thesis]." Submitted to Massachusetts Institute of Technology.

Presentations

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Radloff, KA; Lewis, AS; Bittner, AB; Zhang Q; Minkara, R. 2022. "A Risk Evaluation of Controlled Low-Strength Materials (CLSM) Containing Coal Combustion Products (CCPs) in Construction Projects." Presented at the World of Coal Ash (WOCA) Conference, Covington, KY, May 17.

Kondziolka, J; Radloff, KA; Bittner, AB. 2022. "Emerging Clean Water Act Issues for CCR Surface Impoundments." Presented at the World of Coal Ash (WOCA) Conference, Covington, KY, May 17.

Bittner, AB; Kondziolka, J. 2022. "Alternative Liner Performance Demonstrations – A Science-Based Approach to Inform Policy Development." Presented at the World of Coal Ash (WOCA) Conference, Covington, KY, May 18.

Bittner, AB. 2022. "Decision Analysis Applied to CCR Surface Impoundment Closure and Corrective Action." Presented at the World of Coal Ash (WOCA) Conference, Covington, KY, May 18.

Lewis, AS; Bittner, AB; Radloff, KA. 2022. "Using Human Health and Ecological Risk Assessment at Coal Combustion Product (CCP) Sites to Meet Closure Objectives." Presented at the World of Coal Ash (WOCA) Conference, Covington, KY, May 18.

Radloff, KA; Lewis, AS; Bittner, AB. 2021. "Challenges Using Data Generated by LEAF Methods in Risk Evaluations." Presented at the USWAG CCR Webinar, August 5.

Register, JR; Bittner A. 2020. "USEPA Reconsideration of CCR Regulations Impacting the Geosynthetic Industry." Presented to the Fabricated Geomembrane Institute, October 8.

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Lewis, A. Bittner, A. 2019. "Risk-Based Considerations for Establishing Alternative Groundwater Standards at Coal Combustion Product Sites." Presented at the World of Coal Ash (WOCA) Conference, St. Louis, MO, May 15.

Lewis, AS; Bittner, A. 2018. "Risk-Based Approaches for Establishing Alternative Standards at Coal Combustion Sites." Presented at the World of Coal Ash (WOCA) Ponded Ash Workshop, Louisville, KY, October 30-31.

Lewis, AS; Bittner, AB; Lemay, JC. 2017. "Achieving Groundwater Protection Standards for Appendix IV Constituents: The Problem with Using Background Concentrations in the Absence of Maximum Contaminant Levels (MCLs)." Presented at the 2017 World of Coal Ash Conference (WOCA), Lexington, KY, May 8-11.

Bittner, A. 2017. "Evaluation of Groundwater Protectiveness of Potential Surface Impoundment Closure Options." Presented at the American Coal Ash Association's 7th Annual World of Coal Ash Conference, Lexington, KY, May 11.

Bittner, AB; Kondziolka, JM; Lewis, A; Hensel, B; Ladwig, K. 2016. "Groundwater Assessment Framework for Evaluating the Relative Impacts of Coal Ash Surface Impoundment Closure Options." Presented at Battelle's Tenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Palm Springs, CA, May 22-26.

Bittner, AB; Kondziolka, JM; Sharma, M; Nangeroni, P; McGrath, R. 2016. "Using Tracer Test Data to Calibrate a Groundwater Flow and Solute Transport Model." Presented at Battelle's Tenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Palm Springs, CA, May 22-26.

Bittner, A. 2016. "A Retrospective Look at Remediation in the State of Rio de Janeiro, Brazil: And What Lessons We Can Apply to Remediation Projects in Other Emerging International Markets." Presented at Battelle's Tenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Palm Springs, CA, May 22-26. 17p.

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Lewis, A; Bittner, AB; Herman, K; Dubé, E; Long, C; Hensel, B; Ladwig, K. 2015. "Framework for Evaluating Relative Impacts for Surface Impoundment Closure Options." Presented at the 2015 World of Coal Ash Conference, Nashville, TN, May 8.

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Bittner, AB. 2013. "Modeling Mass Discharge from the Source Zone." Presented at Second International Symposium on Bioremediation and Sustainable Environmental Technologies, Jacksonville, FL, June 11.

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Bittner, A. 2010. "A Weight-of-Evidence Approach to Assess NAPL Mobility." Presented at the 7th International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 27.

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Bittner, AB; Baffrey, RN; Esakkiperumal, C. 2006. "Using Sediment Transport Modeling to Support Environmental Forensic PCB Analyses." Presented at Society of Environmental Toxicology and Chemistry Conference, Montreal, Canada, November 8.

Bittner, AB. 2006. "Groundwater and Air Modeling Used to Support Forensic Analyses." Presented at the Gradient Breakfast Seminar Titled: Forensic Chemistry – The Intersection of Science and Law, May 16.

Sharma, M; Saba, T; Bittner, A. 2003. "Optimization of Groundwater Pump and Treat Systems." Presented at the 19th Annual International Conference on Contaminated Soil, Sediments and Water, Amherst, MA, October 23.

Sharma, M; Saba, T; Bittner, A. 2003. "Optimization of Groundwater Pump and Treat Systems Using Numerical Modeling and the Monte Carlo Approach." Presented at the National Ground Water Association Mid-South Focus Conference, Nashville, TN, September 19.