Managing Springs Emanating from Coal Combustion Residual Disposal Impoundments

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ABSTRACT

Affected springs emanating from coal combustion residual (CCR) disposal impoundments where “wet disposal” methods were employed is a typical issue that frequently needs to be addressed during operation and management of these facilities. Identifying potential effects on a spring is typically accomplished through regularly scheduled field reconnaissance and laboratory analyses. Analytical testing is performed to characterize the chemical constituents present in the spring water. The management approach employed for specific springs is developed on the basis of several factors, including chemical composition and flow rate of the spring water, regulatory requirements and discharge standards, available treatment technologies, facility operations, site topography, economic feasibility, and constructability issues. Management strategies may include permitting through a National Pollutant Discharge Elimination System outfall, treatment in-place, collection and conveyance to a centralized treatment facility, collection and conveyance to a publicly owned treatment works, or collection and return to the CCR disposal impoundment. Spring management will often include a combined approach that uses several methods. Examples of the selection and implementation of spring collection and conveyance system designs and their subsequent construction are presented in this article.

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1. Introduction

Springs are locations where groundwater emanates from the ground. Seeps are a variety of spring that yield lesser amounts of water and may emanate through the pores of the ground over a considerable area instead of a distinct opening (Bryan, 1919). Springs can be perennial, flowing throughout the year, or intermittent, flowing only during wet seasons. Figure 1 presents a photograph of two closely spaced springs. The flows from the two distinct springs converge and form a tributary stream. Figure 2 presents a photograph of a seep. The ground in the foreground is wet over a large area, supporting a wetland in the center of the photograph. The ephemeral stream present in the background only flows during wetter times of the year or during rain events.

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Topographic depressions provide a common mechanism for the formation of springs. These depression springs form when the water table reaches the surface (Fetter, 1988). As such, depression springs often form the headwaters of streams. The elevation and location of these springs may vary throughout the year with a seasonal rise and fall of the water table.

Contact springs often form a spring line where groundwater emanates over an area following the contact of more permeable rocks overlying rocks with lower permeabilities (Fetter, 1988). Contact springs may manifest as a long continuous spring or a series of smaller, discontinuous springs separated by drier soils.

Water monitoring programs for coal combustion residual (CCR) disposal sites often require identification, sampling, and analysis of springs in areas downgradient of the disposal facility. Spring identification is most commonly performed through site reconnaissance. Sampling of the identified springs is typically incorporated into the disposal facility’s water monitoring program. Potential effects from...
CCR disposal can be qualified by parameter concentrations, time trends, and major ion chemistry in the spring discharge.

Once a spring is determined to be affected by CCR disposal, a management approach is developed on the basis of several factors, including chemical composition and flow rate of the spring water, regulatory requirements and discharge standards, available treatment technologies, facility operations, site topography, economic feasibility, and constructability issues.

Management strategies may include permitting the discharge through a National Pollutant Discharge Elimination System (NPDES) outfall, treatment in-place, collection and conveyance to a centralized treatment facility, collection and conveyance to a publicly owned treatment works (POTW), or collection and return to the CCR disposal impoundment. Spring management often includes a combined approach utilizing several methods. The strategies described herein address springs as point source discharges and are not intended to address diffuse groundwater discharge to surface water. Examples of the selection and implementation of spring collection and conveyance system designs and their subsequent construction are presented below.

2. Collection Strategies

2.1. Discrete spring collection

Discrete spring collection refers to collecting the source water for the identified spring while allowing surface water to bypass the collection system.

The example setting in Figure 3 shows a series of five distinct springs that occur along the crop line of a coal seam (contact springs) along a stream valley. Figure 4 shows a close-up of water emanating from the coal seam at one of these five distinct springs. Each of these springs may be collected individually by intercepting the groundwater that supports the spring with the installation of subsurface spring collectors placed immediately upgradient of where the spring expresses at the ground surface.

Figure 5 shows an example of a subsurface spring collector that collects the groundwater immediately upgradient of the spring. The
Fig. 3. Springs emanating along a similar elevation from a coal seam.

subsurface spring collector is a groundwater interceptor trench lined at the bottom and along the downgradient face with a geomembrane before placing a perforated pipe along the length of the bottom of the trench. The geomembrane prevents groundwater from bypassing the system. The perforated pipe is bedded and covered in aggregate, which is covered by a nonwoven geotextile. The remainder of the trench is backfilled with soil. Groundwater enters the perforated collector pipe through the stone pipe bedding. The spring collector is covered at the surface with compacted soil to promote storm water to run off and pass over the system.

The combined flow from the five spring collectors in the example is conveyed to drop inlets installed along an underground header pipe. The drop inlets allow for flow measurement and water sample collection at each individual spring. Each drop inlet is connected to a header pipe and the combined flow is directed into a collection pipe and routed to a collection manhole that houses pumps. Collected water is pumped via a force main, combined with other spring collectors in the area, and ultimately pumped back to the CCR disposal impoundment.

2.2. In-stream spring collection

The example setting in Figure 6 shows a spring that is the headwaters to a perennial stream. The elevation of the spring varies with seasonal fluctuations of the water table. During wetter seasons of the year, the groundwater table is higher and the spring emanates from a higher elevation than during drier times of the year. Figure 6 shows the approximate range within the stream valley where the spring expresses according to the elevation of the water table.

The example setting in Figure 7 shows two springs that emanate from two different coal seams along a small gaining stream. Figure 7 is a generalized section along the path of a small tributary stream. The bedrock in this area consists of a series of coal seams separated by various thicknesses of sandstones, siltstones, and shales. The spring that emanates from the uppermost coal seam in the section forms the headwater of the small stream. The stream gains flow along its path in response to groundwater discharges at lower elevations—most notably from the sandstone unit and the lower coal seam, which are more permeable units.

Discrete spring collection is not ideal for the example in Figure 6 because the elevation and location of the spring are not fixed and vary seasonally. Similarly, discrete spring collection is not ideal for the example in Figure 7 because the stream receives additional flow of affected groundwater along its flow path.

2.3. In-stream surface collection

Figure 8 shows a typical in-stream spring collector that consists of a drop inlet to collect the flow within the stream bed up to a specified design storm, with no segregation of storm water runoff from the springs and groundwater. Therefore, sizing the pumps to manage peak flows during the design storm is necessary. Flow is directed into a collection pipe and routed to a collection manhole that houses pumps. Collected water is pumped via a force main, combined with other spring collectors in the area, and ultimately pumped back to the CCR impoundment. Alternatively, the water could be pumped to a centralized treatment facility or permitted NPDES outfall.

2.3.1. Bypassing diluted flows

The example setting in Figure 9 shows an area where multiple springs flow into a perennial stream. Springs that display the effects of CCR disposal impoundment are shown in red. Springs that are not affected are shown in green. The springs in this area have low flow rates of typically less than 2 L/min (½ gallon/min). The
flow in the stream consists of spring flow, groundwater contributions, and surface runoff from precipitation events. Therefore, the total stream varies greatly and can range from 15 to 23,000 L/min (4–6100 gallons/min) at the base of the valley before discharging into a larger stream. In this example, the state permitting agency allowed the operator to collect water at the base of the valley before the waters entered the larger stream. The system is allowed to bypass during higher flows when the constituents are diluted with unaffected storm water runoff.

Figure 10 is a cross section of an in-stream collection system that collects stream flow behind a check dam. Ponded water is directed to a collection manhole through a perforated riser pipe and underground pipe. The collection manhole is equipped with an outlet to the pump station. Collected water is pumped by a force main back to the CCR impoundment. Alternatively, the water could be pumped to a centralized treatment facility or permitted NPDES outfall.

The pumps and discharge pipe are sized to handle the amount of flow that is agreeable to the state permitting agency for collection. When flows exceed the agreed upon collection design criteria, water is discharged from the collection manhole overflow pipe into the stream. During greater stream flows, water simply overtops the check dam.

2.4. In-stream subsurface collection

Figure 11 shows a typical in-stream spring collector installed in the subsurface that collects groundwater, yet allows surface water to bypass the collection. This design consists of trenching along the stream channel to install a perforated pipe bedded in aggregate and wrapped in geotextile. The remainder of the trench is backfilled with compacted soil, and the stream channel is reconstructed. The reconstructed stream channel may be lined with a geosynthetic clay liner or geomembrane to limit surface water infiltrating into the perforated collection pipe. The collected groundwater (intercepted spring water) would be directed to a drop inlet where flow rates and water quality may be monitored. From there, the water would be directed to a pump station or permitted NPDES outfall, depending on site-specific water management strategies.

The construction of a subsurface in-stream collector does pose additional permitting issues because of the extensive work and related effects within the stream.

2.5. Area-wide seep collection

A different strategy may be used in areas outside of stream channels where a seep emanates over an area with no distinct flow channel. Figure 12 presents a typical design to collect water immediately downhill from a seep. In this scenario, a trench is excavated downhill of the seep perpendicular to the direction of water flow. Geomembrane is installed along the bottom and downgradient side of the trench to prevent groundwater and infiltrating surface water from bypassing the system. A perforated pipe is placed in the bottom of the trench and the trench is filled to the surface with permeable aggregate. This design allows the seep water and shallow groundwater to flow into the perforated pipe and to a drop inlet, where flow rates and water quality may be monitored. From there, the water would be directed to a pump station or permitted NPDES outfall depending on site-specific water management strategies. This design does not allow for the segregation of storm water runoff from the seep flow.

3. Conveyance of Collected Seeps and Springs

3.1. Conveyance to a POTW

An additional alternative for management of CCR-affected seeps and springs includes collecting and conveying the water to a POTW. This alternative may be achieved by constructing collection systems similar to those described above to convey flow to a POTW. This option requires a contractual agreement with the POTW for receiving and treating the affected water. Certain constituents of CCR-affected water may restrict or prohibit treatment by the POTW,
require upgrades to POTW treatment capabilities, or both. This alternative will also likely require additional costs associated with land acquisition and easement agreements for routing of the conveyance pipeline system from the collection location to the POTW, as well as engineering design, permitting, and construction costs associated with installation of the conveyance piping systems.

3.2. Conveyance to a centralized treatment facility

Construction of on-site treatment facilities is also a potentially viable management alternative for affected seeps and springs. On the basis of chemical composition of the CCR-affected water, an on-site treatment facility may be constructed to treat the collected water and achieve applicable regulatory discharge limits. This alternative may be achieved by constructing collection systems similar to those described above and constructing pipe and pump systems or gravity systems to convey flow to the on-site treatment facility. The required treatment technologies can be expensive, and the degree of constituent removal required will create additional waste streams that will also need to be managed through alternative approved disposal methodologies. This alternative will also likely require additional costs associated with land acquisition and easement agreements for routing of the conveyance pipeline system.
system from the collection location to the treatment facility, as well as real estate for the treatment facility footprint. Costs will also be incurred for engineering design, permitting, and construction associated with installation of the conveyance piping systems; design and construction of the treatment facilities; and associated ongoing operation and maintenance of the facility, including costs for transportation and disposal of wastes generated during the treatment process.
4. Summary

Several options for the collection and conveyance of CCR-affected springs to a permitted NPDES outfall, centralized treatment facility, POTW, or the CCR disposal impoundment are available. The selected approach employed for specific springs is developed on the basis of several factors, including chemical composition and flow rate of the spring water, regulatory requirements and discharge standards, available treatment technologies, facility operations, site topography, economic feasibility, and constructability issues.

Discrete spring collection, which allows surface water to bypass the collection system, reduces the amount of water that is transferred to the discharge location. The reduced volume of water will result in cost savings for water that is being transported to a treatment facility or POTW.

The amount of water managed by an in-stream spring and surface water collection system, which also captures storm water runoff, will increase during rain events and periods of snow melt. The amount of water that will be managed will be directly proportional to the size of the drainage area captured by the system. This method of spring management is more appealing if the water is being returned to the impoundment or if no treatment is necessary before discharge.

Spring management will often include a combined approach that uses several methods discussed in this article. There is no “one size fits all” for the design and the authors recommend working closely with the state permitting agency to gain an understanding of the collection system goals and future compliance obligations.

References