Economic Value of Protecting Groundwater: A Response to EPA

Technical Comments Submitted to the U.S. Environmental Protection Agency on Behalf of the Natural Resources Defense Council

In Response to EPA's Economic Analysis for Revised Uranium Mill Tailings Standards (EPA 402-R-14-003)

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Comments on EPA's Draft Economic Analysis of Groundwater and Uranium ISR Rule Revisions

1. Introduction

EPA has recently released a draft economic analysis for proposed revisions to protection standards for uranium mill tailings.[1] With uranium mining operations transitioning from open pit and surface mining to in-situ recovery (ISR) operations taking place below ground, EPA has issued a subpart F to revise 40 CFR Part 192 by adding monitoring requirements to help protect groundwater. EPA's economic analysis (hereafter Economic Analysis) assesses the costs (Section 3), benefits (Section 4), and economic impacts (Section 5) of the proposed rule.

We applaud the EPA for exploring much needed updates to health and environmental standards for uranium operations and for proposing extensive groundwater monitoring before operations begin (baseline data), during operations, and for longer periods after operations are completed. Likewise, the EPA's Economic Analysis of the proposed rule offers a number of clear economic perspectives on the costs and benefits of groundwater protection. However, we see a number of areas where EPA's Economic Analysis could be improved and where economic valuation of protecting groundwater can be incorporated more universally in EPA's rulemaking and in environmental impact assessments.

Below, we provide economic perspective and recommendations for EPA's valuation of groundwater. Our comments relate to the section 4 "Benefits Analysis" (pp. 4-1 – 4-11) of the Economics Analysis. The Benefits Analysis provides a qualitative discussion and a partially quantified description of expected benefits of the proposed rule in two main sections: the first is a broader discussion of conceptual frameworks for valuing groundwater and the second section is an application of valuation methods to the proposed rule.

We organized our two primary sections to assess the quality of conceptual frameworks and methods presented and to assess the quality of the benefits estimates applied to the proposed rule. Our comments are intended to help inform future groundwater protection policy development and analysis. We submit these comments to EPA in an effort to bring awareness to the unique economic characteristics of groundwater and ultimately to facilitate greater protection of our groundwater resources.

2. Conceptual Framework and Methods for Groundwater Valuation

Economically speaking, groundwater is a unique natural resource with distinct attributes (Young and Loomis 2014). Groundwater is connected to surface waters in myriad pathways and time scales. Total stocks and loss and return rates of aquifers are not easily ascertained. Groundwater is a public good, without associated property rights, leading to externalities associated with the tragedy of the commons.

[1] Economic Analysis: Proposed Revisions to the Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings Rule (40 CFR Part 192). Draft Report: EPA 402-R-14-003, November 2014.

In many places, there is no extraction fee for groundwater. These attributes of groundwater lead to an undervaluation of its importance to society (NAS 1997) and a need to economically acknowledge, if not capture, downstream externalities of using groundwater resources (Koundouri 2004).

The first section of the Benefits Analysis is Section 4.1 (p. 4-1), where background economic methodologies for groundwater resources and protection are discussed. EPA provides a good overview of various values and valuation methods for groundwater resources and changes to the quality and quantity of groundwater. EPA's starting point of a Total Economic Value (TEV) perspective is commendable, and supported by the groundwater economics literature (e.g., NAS 1997, Young and Loomis 2014). TEV frameworks have been used to value the benefits of wilderness areas as well as the negative externalities from oil and gas development (Morton 1999, Morton et al 2004, see Appendix A for example categories for oil and gas development). The TEV framework is widely used as a starting valuation framework and has been recommended by the U.S. Department of the Interior[2]. In this section we discuss the importance of incorporating a TEV approach to EPA groundwater valuation.

2.1. Total Economic Value (TEV)

The majority of economic valuation of groundwater has come from the extraction and production perspective for industrial and agricultural development. The Total Economic Value (TEV) framework, however, provides for a more holistic valuation approach to the many beneficial uses of groundwater, along with the many beneficial *in-situ* values of keeping groundwater in the ground. As discussed in the Benefits Analysis (p. 4-2), TEV includes both use and non-use, or passive use, values. Use values include the extraction of groundwater for drinking, irrigation, aesthetics, and recreation. Passive use values include the existence and bequest values for protection of groundwater. Methods for valuing use and passive use values under a TEV framework are illustrated on p. 4-3 of the Benefits Analysis, and include revealed preference methods, stated preference methods, and avoided cost methods.

While we are encouraged to see more mainstreaming of the TEV framework in conceptual economic discussions for EPA groundwater protection policies, we recommend that EPA should actually incorporate more components of TEV in their calculations of benefits for all groundwater policy (e.g., greater accounting for changes in *in-situ* use values, option values, and passive use values). There are also other economic frameworks and filters with which to assess the economic ramifications of groundwater contamination and protection.

All valuation frameworks have overlap, but each one typically highlights particular areas of economic importance. Below, we highlight two important valuation frameworks for groundwater protection policy currently missing from the EPA's Benefits Analysis: ecosystem service valuation and natural resource damage assessments. These frameworks can be conducted under the umbrella TEV approach recommended by EPA and can shed light on groundwater values typically not assessed in traditional benefit-cost analysis (BCA). Individual valuation methods that comprise these frameworks are largely the same, various revealed and stated preference methods, along with avoided cost analyses.

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[2] For example, see USDOI Instruction Memo for BLM nonmarket valuation at: http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_instruction/2013/IM_2013-131__Ch1.print.html

Synthesizing a number of individual valuation studies can be done statistically via meta-analysis (for an example valuing ecosystem conservation see Hjerpe et al. 2015). Additionally, benefits transfer techniques can be used to apply relevant individual studies, or a synthesized set of studies, directly to the policy site under question.

2.2 Ecosystem Service Framework

Recent developments in the valuation of nature's goods and services provided to humans have been advanced under the Ecosystem Services (ES) framework. Ecosystem services are the benefits from natural capital provided to mankind (Daily 1997 and Costanza et al. 1997) and can be classified as final services (e.g. provisioning services such as drinking water) and intermediate services necessary to produce final services (e.g., regulating services such as recharging surface water).

While the value of many of these ecosystem services may be captured in other economic valuation methods already included in EPA's economic analysis guidance, an ES framework provides a useful, alternative filter with which to view groundwater protection. In particular, an ES framework is well suited to identifying intermediate services related to *in-situ* value, or the value of water remaining in place within the aquifer,[3] such as buffering water supplies, preventing land subsidence, and supporting ecological habitats. These environmental benefits provided by groundwater are most often public goods. Without specific property rights on ecosystem goods (exhibiting economic characteristics of being nonexclusive and nonrival) to allocate prices to *in-situ* values of groundwater, changes in these ecosystem services are the externalities generated from groundwater injury. We recommend EPA incorporate an ES framework for their Benefits Analysis, in addition to the identification of other economic costs, benefits, and impacts.

A recent case study on valuing groundwater resources in South Africa by Bann and Wood (2012) show a number of potential ecosystem services associated with groundwater. Services include provisioning services such as the supply of water for drinking, and a number of regulating services such as the dilution of pollutants, a sink for CO_2, and a recharge for surface waters. Bann and Wood (2012) also outline steps for incorporating groundwater values into decision making by including benefit transfer methods. Table 1 below is the list of potential groundwater services and benefits from Bann and Wood (2012). Additionally, many of these services are discussed in EPA's framework for groundwater benefits (EPA 1995).

2.3. Natural Resource Damage Assessments

From the public's perspective, the benefits of groundwater protection can be viewed as damage avoided from groundwater contamination (Abdallah 1994). Natural resource damage assessments (NRDA) are another framework that can highlight potential damages resulting from groundwater contamination. NRDAs are measures of liability, or damage estimates to be paid to replace, offset, or mitigate lost economic values. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), or Superfund, provided for liability of polluters of hazardous waste. Interestingly, the first legislation to identify injuries to natural resources as compensable damages was the Clean Water Act

[3] *In-situ* values are discussed In EPA's Economic Analysis on p. 4-2.

(Kopp and Smith 2013). After these provisions were enacted, the federal government, states, and others filed legal claims to recoup damages from environmental contaminators and utilized natural resource damage assessments to estimate the value of the damages.

Table 1
Potential groundwater services and benefits

Ecosystem service category	Service	Benefit / outcome
Provisioning services	Water supply	Public water supply
		Private / community water supply
		Agriculture
		Industrial abstraction
	Habitat for hypogean species	Species diversity and potential genetic/scientific value
	Sink/source of energy	Energy provision
Regulating services	Recharge to surface waters (rivers, lakes, springs, wetlands, transitional waters)	Protecting the benefits of surface water for consumptive and non-consumptive use (e.g. water abstraction, recreation and tourism, non-use)
	Flood risk regulation	Flood risk reduction (protection of property, agricultural land, human lives)
	Sink for atmospheric carbon dioxide	Carbon capture
	Dilution of pollutants	Reduced impact of contaminants
	Attenuation of pollutants	Reduced impact of contaminants
	Prevents subsidence	Avoidance of subsidence
	Sustains habitats	Reduction of irrigation requirement
Cultural services	Biodiversity non-use	Biological diversity, species, habitat
	Tourism, spiritual, religious, educational experiences	Tourism, spiritual, religious, educational experiences

Source: Bann and Wood 2012. Table 1, p. 463.

Habitat-equivalency analysis (HEA) is an often-used method for determining the magnitude, or scale, of compensatory-restoration actions needed to compensate the public for the losses resulting from natural resource damage (Dunford et al. 2004). HEA consists of a couple basic components to determine NRDAs: estimate the cost of restoring the damaged resource, and estimate the lost values in the interim (NOAA 2006). NRDAs are valuable for determining potential contamination of groundwater, though there are always concerns with whether or not complete restoration of the damaged resource is fully feasible.

Concerning aquifers, Ando et al. (2004) provide a comprehensive review of economic methods and values used for assessing groundwater damage. While the context of their review is framed around natural resource damage assessments (NRDA) available to states under the CERCLA and other statutes, the concepts for understanding degradation to groundwater and its associated economic effects provides valuable information that can be incorporated into EPA's Benefits analysis of the proposed rule. Prevention of groundwater contamination from uranium ISR sites via the proposed rule provide much greater benefits than those outlined in Section 4.

Damage assessments are sometimes included in stated preference studies (i.e., WTP studies) for groundwater protection (Young and Loomis 2014), but it depends on which damages were introduced to survey respondents and whether or not specific damages were used as an attribute by primary research authors. The most publicized NRDA was conducted to determine compensation from damages from the Exxon Valdez oil spill to the Prince William Sound ecosystem in Alaska. These compensatory damages included lost use and passive use values to local and Native peoples.

Both the Ecosystem Service framework and Natural Resource Damage Assessments have been utilized for estimating TEV of groundwater resources. We recommend that EPA incorporate additional groundwater valuation frameworks and suggest that many of the values pursued may be able to be incorporated into agency BCA of policy changes.

3. Economic Benefits of the Revised Uranium ISR Rulemaking

Section 4.2 (p.4-4) of the Benefits Analysis provides a specific application of the benefits of proposed changes in monitoring requirements. The Benefits Analysis focuses on three main areas of potential benefits, or avoided damages, associated with preventing groundwater contamination: reducing human health risks, protecting groundwater for future generations, and avoiding future remediation costs (pp. 4-5 – 4-7). Of these three, only the avoided future remediation costs are quantified. Human health risks are qualitatively discussed and focus on the "value of statistical life" (VSL) approach, whereas bequest values for future generations are not estimated at all.

To determine potentially avoided remediation costs due to the proposed rule, EPA utilized a "modeled facility" approach to estimate costs of varying uranium contamination scenarios on a modeled mine unit. Estimated avoided remediation costs for a modeled contamination due to the proposed rule range from $8 million to $560 million. The extensive sensitivity analysis in this section, along with the incorporation of the modeled facility approach is laudable and provides quantified estimates that illustrate one category of potential benefits from the proposed rule.

The qualitative discussions on the monetary value of health benefits and bequest values for future generations are a good starting point for examining additional benefits of the proposed rule, but we recommend more rigorous exploration of these categories. Likewise, there are a number of additional benefit categories that are missing from the Benefits Analysis. In this section we examine the primary missing benefit categories and provide recommendations for furthering estimates of the health and bequest benefits from the proposed rule.

3.1 Missing Economic Spillover Damages

Groundwater contamination, especially when involving radioactive heavy metals, creates numerous adverse economic effects. These adverse effects are incurred on site, and spill over to adjacent communities and environments. However, most avoided spillover effects from groundwater contamination across time and space are noticeably absent from the Benefit Analysis. A review of the literature shows additional categories of critical benefits associated with groundwater protection (Spofford et al. 1989, Abdallah 1994, NAS 1997). In addition to the three avoided damages included in the estimated benefits of the proposed rule (human health, bequest values, and remediation costs), spillover effects include damages to adjacent and existing (if leasing) property owners, associated fear and anxiety from communities near contaminated aquifers, and ecological/biophysical damages.

Properties adjacent to groundwater contamination sites lose value. This is a negative externality of extractive development and of uranium ISR operations. For example Muehlenbachs et al. (2012) found a 26 percent reduction in property values just from the risk of groundwater contamination from shale gas development. Likewise, Boxall et al. (2005) found that the risk of health hazards from oil and natural gas facilities had a significant negative association with adjacent property values. Similar cases have been illustrated for the risk of groundwater contamination from other forms of energy development such as coal ash[4] and uranium production[5]. Given recent trends of migrants relocating to regions with greater natural amenities and public lands, particularly in the West where the majority of uranium reserves are located, communities may suffer from macro spillover effects that make them less attractive and ultimately may see affected property values and tax bases.

While fear and anxiety are economic costs to societal well-being in their own right, they can also lead to broader property stigma effects for communities with publicized groundwater contamination. Groundwater contamination from uranium mining, or even the risk of groundwater contamination, can also affect public lands and tourism and recreation regional economic impacts. For example, longstanding issues over uranium mining on public lands adjacent to Grand Canyon National Park[6] create concern among visitors wanting to enjoy the Colorado River and potentially affected tributaries. These community effects are different from the regional economic impacts presented in Section 5, and should be acknowledged in the Benefits Analysis.

Finally, the spillover damages from groundwater contamination on the environment can harm ecological receptors and the biophysical structure that supports natural capital. These environmental damages can affect human health (e.g., consumption of livestock that has ingested pollutants) and can have cascading effects on ecological communities. For a detailed examination of environmental impacts

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[4] For coal ash waste contamination and groundwater effects see LA Times story on May 4, 2015, available at: http://www.latimes.com/nation/la-na-coal-ash-pollution-20150504-story.html#page=1

[5] Poisoning the well: how the Feds let industry pollute the nation's underground water supply. ProPublica. 12/11/12. Article available at: http://www.propublica.org/article/poisoning-the-well-how-the-feds-let-industry-pollute-the-nations-undergroun

[6] Science still developing on uranium's environmental impact. AZ Daily Sun. 4/20/15. Article available at: http://azdailysun.com/news/local/science-still-developing-on-uranium-s-environmental-impact/article_108aa9e0-da62-578d-869f-404b427b21c3.html

stemming from uranium ISR operations see Fettus and McKinzie (2012). Environmental damage to ecological receptors and biophysical supporting services are largely ignored in the Benefits Analysis.

Recommendations:

We recommend that EPA include partially quantified descriptions of these missing economic spillover effects in their final Benefits Analysis of proposed monitoring requirements (Section 4.2, pp 4-4 – 4-10). Valuation methods identified in the Conceptual Framework (Section 4.1, p 4-3), such as revealed preference methods like hedonic pricing are available for measuring groundwater pollution effects on property values. However, estimates of these economic effects stemming from groundwater protection are not included in specific Benefits Analysis in Section 4.2. While economic data for uranium pollution of groundwater, or the preferences for preventing uranium groundwater pollution are extremely limited, we recommend EPA provide surrogate estimates (as recommended in NAS 1997) for these spillover effects that have been identified in research on other forms of anthropogenic water pollution, such as effects from fertilizers, pesticides, other heavy metals, bacteria, sediment, and temperature. Incorporating estimates from economic valuations of various types of water pollution will strengthen the Benefits Analysis and would provide greater context to the conceptual scoping exercise.

3.2. Greater Incorporation of Stated Preference Methods Needed

Stated preference methods are useful for measuring willingness to pay (WTP) for nonmarket goods and services. Stated preference methods include contingent valuation techniques and choice experiments, where a hypothetical market is created and executed by relevant stakeholders. These contingent valuation methods are particularly well suited for ascribing value for passive uses, such as existence and bequest values. Thus, research on willingness to pay (WTP) for protecting and improving groundwater quality provide additional means of quantifying the economic values of protecting groundwater.

The Benefits Analysis of the proposed rule includes a discussion of society’s nonmarket values for groundwater and highlights a meta-analysis conducted by Poe et al. (2001) that illustrates substantial WTP for groundwater protection. However, in Section 4.2 (pp 4-4 – 4-10), where EPA outlines the benefits of the proposed changes in monitoring requirements, the latest synthesis of nonmarket values for groundwater protection (Poe et al. 2001) are only nominally included in two places and have not been included in the overall benefit aggregation. The two ad-hoc inclusions note that: 1) the value of groundwater protection increases when cancer risks from contamination are involved; and 2) the value of groundwater protection increases when including use and passive use values.

The majority of studies analyzed by Poe et al. (2001) and previously by Boyle et al. (1994) are east of the Mississippi River and focus on nitrates and pesticides as potential groundwater pollutants. However, this rulemaking is concerned with uranium recovery, a potential pollutant with a much greater half-life than nitrates and pesticides. And, as illustrated in Table 2-7, all operating and non-operation ISR plants in the U.S. are located in the West and the Southwest, arid regions where water is more scarce and thus has greater economic value.

One of the three main groups of explanatory variables for overall WTP for groundwater protection as modeled by Boyle et al. (1994) and Poe et al. (2001) is the "environmental commodity." Environmental commodities include the type and scale of groundwater contamination, the local price of potable water, and the availability and price of substitutes. Since uranium ISR plants are clustered in arid geographies, local prices of potable water are generally higher than those found in primary studies incorporated in Boyle et al. (1994) and Poe et al. (2001), and available substitutes (e.g., surface water) are drastically lower. Given the increased water scarcity in typical geographies where ISR operations are taking place, overall WTP for groundwater protection in these regions is likely to be much higher than average WTP estimated in Poe et al. (2001).

Recommendations:

We recommend that synthesized WTP estimates for groundwater protection be included in the benefit calculations of the proposed rule. The "modeled facility" approach used to calculate avoided remediation costs can include a modeled affected population with which to apply individual and/or household WTP estimates. While bequest values may not be able to be isolated, providing surrogate estimates of broad WTP would be inclusive of bequest and other passive use values.

Benefits transfer of this type can be problematic due to the numerous differences between sampled study sites and the proposed policy site, and we recommend extensive caution when illustrating estimates from various locations and various groundwater pollutants. But, in the same vein as the modeled facility approach for avoided remediation costs (Section 4.2.3), acknowledging and applying a modeled WTP estimate provides a point of reference and further illustration of the true benefits of the proposed rule. Currently, the draft Benefits Analysis treats these significant nonmarket values as zero, which greatly undervalues the affected resource----scarce Western groundwater.

Inclusion of WTP estimates and nonmarket values in general, through benefit transfer techniques, would generally be applied to policy sites using the aggregated mean WTP found in synthesized WTP estimates from primary studies. However, application of WTP estimates for groundwater protection in this case deserve special treatment given the unique pollutant of concern under consideration and the distinct geographic locations of ISR. Given the influence of these independent variables on the overall WTP for groundwater protection, we recommend using WTP estimates well above the mean as found in Poe et al. (2001) for any proposed rulemaking focused on uranium ISR. Additionally, WTP extends beyond just the local affected populations, especially when considering ISR on or adjacent to aquifers in public lands. Thus, we recommend a broader and more inclusive framing of WTP for groundwater protection.

3.3. Interim Lost Use, Averting Behavior, and Additional Health Costs

There are a number of other damages, beyond those detailed in the benefits application of the proposed rule (Section 4.2), that occur when groundwater becomes contaminated or even has the risk of contamination. Only three main types of benefits are included in Section 4: reducing human health risks, protecting groundwater for future generations, and avoided remediation costs. But groundwater contamination results in numerous damages and extensive liabilities for responsible parties that go far beyond those outlined in Section 4. Standard economic theory treats avoided costs as benefits. And while much caution should be taken to prevent double counting and to accurately assess who is benefitting (e.g. operators, individuals, or society), we recommend greater acknowledgement of avoided costs. Along with human health, environmental costs, and remediation costs, these costs should include the value of interim lost use (Ando et al. 2004).

We recommend including the value of interim lost use, which is currently missing from Section 4. For example, groundwater contamination from a uranium ISR operator would generate human health and spillover effects discussed above, but would also result in the potential loss of other production uses of the contaminated groundwater such as for irrigation. Similar to interim lost uses are other costs incurred during the contamination period such as averting behaviors by affected populations (e.g., purchasing bottled water), mobilization costs of communities to access new water sources, medical costs for treatment that society would likely bear the brunt of, and lost utility/labor of sickened people (NAS 1997). These are real economic ramifications of contaminating groundwater with mobile uranium and should be acknowledged. The duration of the injury to contaminated aquifers is a critically important valuation concept and is often underestimated due to the slow-moving nature of groundwater and the irreversibility of some contamination (Ando and Khanna 2004).

3.4 Other Recommendations for Estimating the Benefits of the Proposed Rule

The Benefits Analysis (Section 4) provides a cursory introduction to groundwater economics and a partial application of the benefits of the proposed rule, but falls short of fully accounting for the benefits of avoiding groundwater contamination from uranium ISR operations. In this section, we have illustrated economic effects of groundwater pollution that are largely missing from the Benefits Analysis and suggest greater quantification of with/without scenarios.

Other recommendations for a more comprehensive Benefits Analysis section include:

- Emphasize the importance of site and geographic variation in benefits analysis;
- Incorporate findings from avoided costs and environmental damages estimated in other forms of groundwater contamination resulting from fracking techniques for oil and gas;
- Include greater sensitivity analysis for quantification of benefits. EPA does extensive sensitivity analysis for illustrating costs to ISR operators of the proposed rule (e.g. ES-5) and for avoided remediation costs. We feel that other benefit categories should also be subjected to extensive sensitivity analysis (recommended in NAS 1997).
- Incorporate more of the EPA's own guidance on economic analysis and groundwater. Specifically, EPA (1995) cautions managers not to overlook indirect effects of groundwater contamination when conducting regulatory impact analysis. Similarly, EPA (2014) advocates for an "effect by effect" approach in assessing benefits to ensure all effects are included.

4. Broad Recommendations for Groundwater Valuation

Beyond the economic analysis discussed for a uranium ISR rulemaking, we encourage EPA to add greater economic investigation for all groundwater protection policy. EPA has presented the economic characteristics of groundwater thoroughly in the Section 1 Introduction of the Economic Analysis, particularly in the outlining of market failures of not fully accounting for groundwater pollution from industrial development and the justification for regulatory intervention (p. 1-2). But, EPA largely fails to acknowledge or capture these externalities in their regulatory impact analyses. Further regulatory adjustments are needed to fully account for these negative externalities.

Much of the EPA economic analysis is predicated on benefit cost analysis (BCA) and economic impact analysis. Economic impact analysis (EIA) evaluates the changes in macro regional market indicators of output, employment, income, and taxes. Economic impacts are traditionally not considered as benefits or costs, as they do not represent changes in societal welfare but rather geographic transfers of income and capital. The benefits and costs in BCA are representative of changes in well being and utility, but can vary based on the perspective of an individual, a business, a community, a country, and even a future generation. These various views on whose welfare is being affected are problematic for comparing apples to apples in BCA. In an attempt to avoid double counting, it seems as if EPA too often errs on the side of leaving out many benefits of regulatory revisions, leaving many BCAs of water resources light on the full accounting of costs and benefits. Not all benefits or avoided costs can be incorporated into BCA due to various perspectives on who is benefiting and who will pay for damages. Instead of boiling down all economic welfare effects into inputs for BCA, we recommend that some be included and others be acknowledged as economic effects unable to be combined with others.

Uranium, and associated radioactive metals, are unique pollutants of concern for groundwater and need special treatment given their extremely slow rate of decay and the intense toxicity and radioactive nature of exposing these elements. Combining the longevity of exposed uranium with the slow rate of travel for groundwater in many aquifers limits the dispersal and dilution effectiveness found in surface waters. Because groundwater contamination can be hidden and undiscovered for long periods of time, and ISR operations represent newer technology, the Benefits Analysis of the proposed rule has a limited set of information and data on the risk of groundwater contamination from uranium ISR.

In cases where there is lack of quantitative data, EPA's economic guidance suggests the following approach. "Thus, even when data are insufficient to support particular types of economic analysis, the conceptual scoping exercise can provide useful insights" (p. 1-2, EPA Guidelines for Economic Analysis 2014). We agree that scoping in these cases provides valuable information, but recommend more comprehensive scoping when dealing with such uncertainty and with pollutants of such high concern.

4.1. Accounting for Groundwater-Associated Negative Externalities

Most EPA economic analysis fails to fully account for the spillover effects, or negative externalities, that occur when groundwater becomes contaminated from subsurface mining. Many of these spillover effects are not easily categorized as either a cost or a market impact, as they often illustrate characteristics of both. For example, adverse effects on adjacent property values stemming from subsurface mining operations and potential groundwater pollution have both a regional market effect (pulling down entire community property values and attractiveness) and personal costs for individual properties owners that experience before-and-after subsurface mining changes. Yet, these effects are often missing from any of the economic analyses (even the Socioeconomic Affected Environment sections).

Other indirect effects, such as the burden on societal health care costs, stemming from adverse human health effects from groundwater contamination are generally not included in the full accounting of costs. While accounting for the full suite of negative externalities from exposing groundwater to potential contamination requires greater analysis and greater resources for monitoring socioeconomic effects, EPA's current treatment of these externalities is extremely limited, treating them as zero cost to society well-being. We recommend greater qualitative acknowledgment of these groundwater-associated negative externalities at a minimum, and encourage EPA to attempt quantification of these costs in many cases (even as a scoping exercise).

Full evaluation of marginal effects of policy changes requires extensive knowledge of the type and size of goods and services provided by groundwater under current conditions, along with knowledge of the type and size of changes to these services under policy revision. With myriad groundwater goods and services and limited existing data, we understand that it is often impossible to accurately account for all impacts or changes to ecosystem services. But, in these cases, we recommend greater acknowledgement of the diverse array of services and at a minimum, a checklist and identification of suspected direction of change in these services under policy revision. For example, under a modeled groundwater contamination scenario we would expect the drinking water service to decrease in quality. A compiled list of anticipated enhancement (positive effect) of the quantity and quality of services, or anticipated degradation (negative effect) of individual services, would provide greater information for policy analysis and a more complete scoping exercise.

4.2. Strengthening Standards for Aquifer Exemptions

The Underground Injection Control (UIC) program under the Safe Drinking Water Act (SWDA) allows for certain cases of wastewater injection into groundwater for oil and gas production facilities. These "Aquifer Exemptions" have also been utilized by uranium ISR operators (Noël 2015). The aquifer exemptions have recently come under greater scrutiny as the exemption applications have greatly increased and tracking of exemptions has been haphazard,[7] and there has been a systematic failure to study the long term cumulative effects of sacrificing aquifers to uranium mining and other forms of resource extraction (Fettus and McKinzie 2012).

There are a number of economic considerations for the aquifer exemption program, but most policy revisions by EPA in this area have been reactionary and with little thought to long term groundwater values and scarcity. The three primary criteria for receiving aquifer exemptions most relevant for economic considerations include: 1) the aquifer is currently not used for drinking water, 2) the aquifer is not reasonably expected to serve as a source of drinking water in the future, 3) the aquifer has a dissolved solids count between 3,000 and 10,000 mg/l (Noël 2015).

Many of these aquifer exemptions are occurring in the arid West, where water scarcity is increasing dramatically. The arbitrary criteria for exemptions are unable to keep pace with rapidly expanding groundwater demand and with technological advancements. Groundwater with heavy sediment that

[7] Poisoning the well: how the Feds let industry pollute the nation's underground water supply. ProPublica. 12/11/12. Article available at: http://www.propublica.org/article/poisoning-the-well-how-the-feds-let-industry-pollute-the-nations-undergroun

was unable to be technically treated a couple decades ago are now a possibility for drinking water sources. Similarly, aquifers that were cost prohibitive to utilize as drinking water a couple of decades ago, are now potentially cost effective to access given increasing scarcity and increasing prices for groundwater. Given rapidly changing technology, demands, and demographics, we recommend the EPA strengthen the standards for aquifer exemptions based on economic realities.

5. Summary

Groundwater is the "hidden old growth" of water resources, and should be treated with special attention. We are encouraged to see EPA tackle long overdue revisions to monitoring requirements for uranium ISR operations. We commend EPA for acknowledging the holistic economic values at stake with groundwater degradation and protection. In particular, we commend EPA for advocating for a Total Economic Value framework and for clearly articulating the externalities and market failures associated with the development of groundwater resources. However, we recommend that EPA incorporate these economic concepts more fully when conducting benefits analysis of the proposed rule.

There are numerous economic values affected by water policy, and numerous valuation methods to account for changes in values generated by policy revisions.[8] The myriad values and measurement techniques can lead to double counting of benefits, but can also lead to being too cautious and settling for partial lists of values. EPA's own guidance on preparing economic analyses (EPA 2014, p. 7-3) advocates an "effect-by-effect" approach for benefits analysis and encourages the use of multiple valuation methods. Given that uranium pollution to groundwater resources can be irreversible and permanent, we recommend following the Precautionary Principle and erring on the side of limiting overall risk whenever possible. We believe that in addition to the groundwater monitoring components included in the proposed rule, the EPA should consider adding socioeconomic monitoring programs as necessary protocol for uranium ISR operators as well.

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[8] For exhaustive lists of economic services, effects, and valuation methods for estimating effects of groundwater policy changes see Tables 1 and 2 in EPA 1995. For a complete list of economic valuation methods for all water resources, see Table 2.1 in Young and Loomis 2014.

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Appendix A: TEV Framework for the Hidden Costs from Oil and Natural Gas Drilling that Spillover into our Communities and Environment

Direct use costs – displacement or loss of land for habitat, recreation opportunities, hunting, farmland, grazing, reclamation costs, water quantity and drought

Community concerns – NOx, VOCs, ozone and kids health, truck traffic and infrastructure costs, property values, loss of local control, displaced jobs and revenues due to "crowding out", natural amenities and quality of life issues, loss of retirement income, displaced farming due to competition for water, boom-bust cycles, revenue lag and fiscal risks, water treatment plants and recycled fracking water, draining of reservoirs for fracking water and the loss of fishing and recreation revenue

Science benefits foregone -- loss of natural areas for scientific study

Off-site damages – fugitive methane emissions, water pollution from spills, noise pollution from compressor stations, visual impacts, erosion from well pads and roads, pipeline explosion risks, road dust on petroglyphs and snowpack, seismic activity from injection wells

Biodiversity impacts – loss and fragmentation of wildlife habitat by roads and well pads, pipelines are conduits for invasive weeds, endocrine disrupters impact to amphibians and fish, produced water holding ponds and bird deaths

Ecosystem service costs – water lost to fracking, impacts to aquifer re-charge and wetland function, carbon lost via land use change, fossil fuels and climate change

Passive use benefits foregone -- loss of option, bequest and existence benefits generated by open space, parks and wildlands.

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