Kimberly MacMillan

From: **Jerry H. Smit** <Smit.Jerry@azdeq.gov>
Date: Wed, May 4, 2011 at 6:17 PM
Subject: Comments from the State of Arizona to the Northern Arizona Proposed Withdrawal DEIS
To: NAZproposedwithdrawal@azblm.org, azaasminerals@blm.gov
Cc: Monica Hart <Hart.Monica@azdeq.gov>, Henry Darwin <Darwin.Henry@azdeq.gov>, "Michael A. Fulton" <Fulton.Michael@azdeq.gov>

Dear Mr. Florence,

Please find attached comments from the State of Arizona regarding the Northern Arizona Proposed Withdrawal Draft Environmental Impact Statement (DEIS). A hard copy of these comments has also been mailed to your office.

Sincerely,

Jerry Smit

Jerry H. Smit, RG, Manager

Groundwater Section

Water Quality Division

602-771-4827

Janice K. Brewer
Governor

Arizona Department of Environmental Quality

1110 West Washington Street • Phoenix, Arizona 85007
(602) 771-2300 • www.azdeq.gov

Henry R. Darwin
Director

May 4, 2011

Northern Arizona Proposed Withdrawal Project
ATTN: Mr. Scott Florence, District Manager,
Bureau of Land Management Arizona Strip District Office
345 East Riverside Drive, St. George, UT 84790-6714

Re: ADEQ Comments to U.S. Bureau of Land Management (BLM) Northern Arizona Proposed Withdrawal Draft Environmental Impact Statement (DEIS).

Dear Mr. Florence:

The Arizona Department of Environmental Quality (ADEQ) respectfully submits the following observations and comments in response to the U.S. Bureau of Land Management (BLM) Northern Arizona Proposed Withdrawal Draft Environmental Impact Statement (DEIS).

The BLM prepared this DEIS in response to the Secretary of Interior's proposed 20-year withdrawal of approximately 1,000,000 acres of federal lands in northern Arizona from new mining claims under the General Mining Law of 1872. Specifically, the DEIS evaluates four alternatives ranging from no action (no withdrawal) to withdrawal of approximately 300,000, 700,000 or 1,000,000 acres respectively.

As the lead regulatory agency responsible for the protection of Arizona's environment, ADEQ closely regulates uranium mining activities in Northern Arizona. The environmental risks posed by mining in Arizona have been successfully managed by both State and federal environmental requirements currently in place. The State of Arizona has adopted the Aquifer Protection Permit program specifically designed to protect its precious groundwater resources. This State program provides added protection to the federal environmental laws. It is important that the BLM consider not only the federal programs, but also Arizona's unique environmental requirements when making its decision. ADEQ's issuance of both federal and State environmental permits is done so with the highest regard for environmental protection, but also allows access to natural resources that are vital to Arizona's economy.

The DESI does not give full consideration to modern uranium mining technology or ADEQ issued permits that require environmental controls, financial assurance, and reclamation. These modern technologies and permits ensure that new and reactivated mining claims can be safely worked with minimal environmental impact. A broad withdrawal of federal lands in response to concerns that new mining operations will pose unacceptable environmental risk is unwarranted. Rather than a blanket prohibition of new claims, proposed new mining facilities should continue to be evaluated on a case-by-case basis under existing federal and State environmental permitting programs.

In addition to these fundamental issues, the DEIS makes a number of assumptions regarding water quality and recharge of the R-aquifer at current and potential mines that are not consistent with actual conditions or permits issued for operation and reclamation of new mines. Specifically:

1) The DEIS states that the potential for impacts to local perched aquifers is dependent on their presence and location with respect to uranium ore within a particular breccia pipe. Under the DEIS assumption that future mines would be evenly spaced and that perched aquifers are not continuous, BLM estimates that impacts would range from "none" to "major" and such impacts would occur due to mobilization of chemical constituents and handling of waste rock.

ADEQ has not observed a wide-spread presence of perched aquifers at any of the ADEQ permitted mining sites in/near the DEIS study area. Only one minor perched aquifer has been identified, and its presence can be attributed to an overlying stock watering pond. In all known cases, ore bodies have been located far below the elevation of any potential perched aquifer, rendering any potential perched aquifer impacts negligible.

2) The DEIS assumes that one gallon per minute (gpm) of drainage containing 400 μg/l of uranium would be passing through each mine and would eventually reach the R-aquifer. 400 μg/l is described as the highest concentration detected in water from below the historic (and unreclaimed) Orphan Lode Mine. This theoretical concentration of uranium in water was then applied to all potential mines in the area for purposes of estimating potential impacts to R-Aquifer water quality. These assumptions grossly overestimate potential impacts to the R-aquifer as:

- all mines would need to be continually exposed to percolating groundwater (an unrealistic assumption);
- each mine would need to contribute one gpm (or about 650,000 gallons per year) of high-uranium drainage to the R-aquifer; and,
- no mines are assumed subject to dewatering or reclamation (sealing) to prevent water percolation during or subsequent to operation as is required by current permits.

3) The DEIS acknowledges that "It is assumed for the purposes of this impact analysis that the impact to surface streams is equivalent to the impact on the springs supplying discharge. This assumption could lead to a conservative overestimation of impacts if a stream is fed by multiple springs that are not all impacted and because in-stream attenuation is ignored."

In addition to this acknowledged overestimation of surface water impacts, the analysis of potential impacts to surface waters would be further overestimated due to the overly conservative assumptions made during the assessment of R-aquifer water quality discussed above.

4) The DEIS cites United States Geological Survey, in its 2010 publication *Hydrological, Geological, and Biological Site Characterization of Breccia Pipe Uranium Deposits in Northern Arizona:*

"Water migrating from the surface to the subsurface is an important transport mechanism for the remobilization of trace and radiochemical elements. Since most of the orebodies associated with breccia pipes are located several hundred to more than 1,000 ft above the regional groundwater flow systems of northern Arizona, natural recharge of water from the surface through these orebodies is one of the few ways of naturally adding to the radiochemistry of the regional groundwater flow systems." (Page 9)

Though the USGS believes natural recharge occurs through breccia pipes and adds radionuclides to the R-aquifer, the DEIS does not appear to differentiate between such natural recharge and potential recharge through mining activity.

In addition, the Arizona Geological Survey (AGS), who worked with the BLM as a cooperating agency during development of the DEIS, has completed a study of the amount of naturally-occurring uranium in the Colorado River and the possible impacts of additional uranium entering the river as a result of accidental discharge from current and potential uranium mining in northern Arizona (attached). The AGS concluded that even under hypothetical worst-case scenarios of releases of uranium ore directly to the Colorado River, uranium concentrations would not exceed applicable regulatory standards.

None of these comments is intended to diminish the concerns expressed by the public regarding uranium mining in northern Arizona. However, I do strongly feel that the inherent environmental risks associated with mining have and will be properly managed through existing environmental regulation and that a strict prohibition of new mining claims unnecessary and counter to the interests of Arizona.

Sincerely,

Henry R. Darwin
Director

cc:
M. Lee Allison
Arizona State Geologist and Director
Arizona Geological Survey

Attachment:

Transmittal Letter dated April 27, 2011 - "Breccia-pipe Uranium Mining in the Grand Canyon Region and Implications for Uranium Levels in Colorado River Water", AZGS Open-file Report 2011-4

State of Arizona
Arizona Geological Survey
416 W. Congress St, Suite 100
Tucson, Arizona 85701
(520) 770-3500

Janice K. Brewer
Governor

M. Lee Allison, Ph.D., P.G.
Director & State Geologist

April 28, 2011

Honorable Janice Brewer
Governor of Arizona
1700 W. Washington Ave.
Phoenix, Arizona 85007

Dear Gov. Brewer:

The Arizona Geological Survey has completed a study of the amount of naturally-occurring uranium in the Colorado River and the possible impacts of additional uranium entering the river as a result of accidental discharge from current and potential uranium mining in northern Arizona.

This new report addresses one of the primary concerns raised by Interior Secretary Ken Salazar in implementing the temporary federal land segregation in northern Arizona.

We conclude that even the most implausible accident would increase the amount of uranium in the Colorado River by an amount that is undetectable over amounts of uranium that are normally carried by the river from erosion of geologic deposits. Even if the entire annual uranium production from an operating mine were somehow implausibly dumped into the river, the resulting increase in uranium concentration in river water would increase from 4.0 to 12.8 parts per billion (ppb) for one year, which is still far below the 30 ppb EPA Maximum Contaminant Level.

Therefore, we believe the fears of uranium contamination of the Colorado River from mining accidents are minor and transitory compared to the amounts of uranium that are naturally and continually eroded into the river.

Our report is being released as "Breccia-pipe Uranium Mining in the Grand Canyon Region and Implications for Uranium Levels in Colorado River Water", AZGS Open-file Report 2011-4 by Jon Spencer and Karen Wenrich.

We initiated this study in our role as a Cooperator in the Bureau of Land Management's EIS for the proposed withdrawal of federal lands in northern Arizona from mineral exploration and mining, and in response to the fears raised that mining could contaminate the water supplies for millions of people downstream.

Drs. Spencer and Wenrich used data published by the U.S. Geological Survey[1] to find that 40 to 80 tonnes of dissolved uranium (not uranium ore) are currently being carried by the Colorado River through northern Arizona and the Grand Canyon every year. The area has one of the highest concentrations of naturally-occurring uranium in the world with many deposits exposed in the walls of canyons across the area. Even without this, the volume of water carried by the river is adequate to carry large amounts of uranium and other minerals from just average concentrations in the rocks. Uranium has been eroding out of these deposits into the Colorado River and other streams and creeks for millions of years and will continue to do so for millions more.

They considered a hypothetical, worst-case accident in which a truck hauling thirty metric tons (66,000 pounds) of ore containing one-percent uranium is overturned by a flash flood in Kanab Creek and its entire ore load is washed into the Colorado River where it is pulverized and dissolved during a one-year period to become part of the dissolved uranium content of the river (such a scenario is extremely unlikely if not impossible). This addition of 300 kilograms (660 pounds) of uranium over one year would increase uranium in river water from 4.00 ppb to 4.02 ppb, an increase of one-half of one percent. This would be undetectable against much larger natural variation in river-water uranium content.

The authors of the study note that our deliberately exaggerated, worst-case scenario for a uranium-ore spill into the Colorado River can be applied to even more unlikely environmental situations. Consider the entire 13,200 tonnes of uranium ore production from the currently operating "Arizona 1" mine that occurred during 13 months in 2009-2010. Then consider that, for some reason, this ore was not trucked to a distant uranium mill, but was stockpiled on site in a location vulnerable to flash flooding. At a grade of 1 percent uranium, this stockpile would contain 132 tonnes of uranium. If a flash flood washed the entire 13,200 tonnes of uranium ore into the Colorado River, and all of the ore was pulverized and its 132 tonnes of uranium dissolved in the river over one year, then the annual uranium flux in the Colorado River would increase from approximately 60 tonnes to 192 tonnes. Uranium concentration in river water would increase from 4.0 to 12.8 ppb for one year, which is still far below the 30 ppb EPA Maximum Contaminant Level for uranium.

We recognize the very serious issues to be considered regarding any development in the Grand Canyon region and we will continue to work with the BLM and other stakeholders to bring objective, unbiased scientific results to the discussion.

Sincerely,

M. Lee Allison
State Geologist and Director

[1]"Hydrological, Geological, and Biological Site Characterization of Breccia Pipe Uranium Deposits in Northern Arizona, U.S. Geological Survey SIR 2010-5025, 2010

STATE OF ARIZONA

JANICE K. BREWER
GOVERNOR

EXECUTIVE OFFICE

October 30, 2009

Honorable Kenneth L. Salazar
Secretary
U.S. Department of the Interior
1849 C Street, N.W.
Washington, DC 20240

RE: Notice of Proposed Withdrawal

Dear Secretary Salazar:

On behalf of the State of Arizona, I am pleased to take this opportunity to provide comments on the proposed withdrawal of 993,549 acres of Bureau of Land Management and U.S. Forest System lands in northern Arizona. The stated purpose of the Department of the Interior's proposed withdrawal of these lands is "to protect the Grand Canyon watershed from adverse effects of locatable hardrock mineral exploration and mining." This withdrawal is unnecessary to protect the Grand Canyon region and Colorado River, and in many ways would have an adverse impact on the State of Arizona. As a steward of Arizona's tremendous natural resources, economic well being, and the public trust, I object to this proposal, and request that the Department take action to remove the proposed burdensome restrictions on federal and state lands in the Northern Arizona Uranium District.

Uranium mining exploration and production operations already exist on the Colorado Plateau and in the Grand Canyon region. Various federal and state laws heavily regulate these mining operations. Additionally, only a small fraction of the land is impacted by these activities.

Existing Federal law requires mining operations to comply with the National Environmental Policy Act, Clean Air Act, Clean Water Act, Federal Land Policy and Management Act, Endangered Species Act, National Historic Preservation Act and various rules, regulations and policies established by the U.S. Forest Service and Bureau of Land Management. These regulations require all mining activities on federal lands minimize, prevent or mitigate adverse environmental impacts, and a plan of operations subject to the NEPA process, for any operation likely to cause a significant disturbance.

Moreover, the Arizona Department of Environmental Quality (ADEQ) enforces federal and state laws protecting public health and the environment. ADEQ ensures air and water quality permits are obtained prior to starting mining operations to ensure clean air and clean water in the Grand Canyon region and in the Colorado River. Together, these various safeguards protect the air, water, cultural resources, wilderness, and wildlife habitat in areas affected by mining operations.

In the Colorado Plateau region of northern Arizona that includes the proposed withdrawal area, ore extraction and production at existing uranium mines has minimal environmental impact on the surrounding land, water, and wildlife because of modern environmental laws. The uranium deposits in these breccia pipes are typically dry and located several hundred feet above the underlying aquifer. Mining of uranium ore in Arizona requires an Aquifer Protection Permit (APP) to ensure there are no adverse effects on the underlying aquifer. Further, since *in situ* mining of uranium is not planned or envisioned for northern Arizona deposits, the risk of contamination of underground water sources is significantly reduced. Finally, clean closure, which is required under the APP, involves returning the land to background radiation levels consistent with those naturally occurring in the area.

As you are aware, exploratory uranium activities do not involve extraction or transporting of uranium ore for processing. Exploratory activities create minimal impact to the land. Mining explorations frequently use existing roads, utilize a small drill pad, achieve zero discharge, drill small boreholes, return drillings to the borehole and reclaim the disturbed areas. Due to the limited activity and drilling material "containment", exploratory activities generate no discharge to waters of the United States or the state under the Clean Water Act because the operations typically contain all drill materials onsite. While not specifically regulated by Arizona's state APP Program, returning drill cuttings including drill fluids after exploration is consistent with ADEQ's general APP requirements. Even in full-scale uranium mining, due to the use of underground mining methods and the utilization of waste rock as backfill, the surface footprint is small, ranging from ten to twenty acres.

Most environmental concerns raised by the legacy of uranium mining in Arizona and the southwest United States are the result of activities that occurred prior to the existence of modern environmental laws and generally resulted from detonation, disposal, ore-processing (milling) and weapons manufacturing sites; activities not associated with modern uranium extraction. Even so, as is the case with the recently permitted Arizona uranium activities, further mitigation measures could be undertaken to address concerns raised during any permitted activities. ADEQ recently issued two permits with enforceable permit conditions including mine permeability testing and monitoring to ensure fluids are not conveyed out of the mine, ground water monitoring, mine water monitoring and financial assurances for clean closure.

Proposed uranium mining activities in northern Arizona are located completely outside of Grand Canyon National Park. Since most sites are far away from the National Park boundary, there is no expected impact on the quality of Park visitors' experiences. Wildlife would also be unaffected by mining operations. At existing uranium mines in northern Arizona, the mine site is completely fenced off so that no ground animal or human can enter the property without the knowledge of the workers or guards. Each mine only operates for less than 10 years, which time frame includes reclamation activities to restore the area for wildlife to inhabit.

As expressed in Arizona State Land Commissioner Maria Baier's September 24, 2009 letter to you, the state is also very concerned about Arizona State Trust land encompassed in the proposed closure area. Significant portions of the 85,673 acres of non-federal lands within the closure area are Arizona State Trust lands. Potential loss of mining royalties to the 13 public beneficiaries, the largest of which is K-12 education, from even a single breccia pipe on trust lands could range from $1.5 to $18.5 million.

In terms of the economic impacts of uranium mining activities on federal land in northern Arizona, we estimate that the industry will generate more than $10 billion to the local economy over the life of these mines. This will include hundreds of high-paying jobs in a rural economy that desperately needs employment opportunities. We envision that local residents from nearby areas where unemployment rates remain far above the state and national averages will fill many of these jobs.

Finally, I must urge the Department to consider national security and energy independence as an additional basis to vacate its proposed withdrawal of lands for uranium mining. Arizona and the United States have a tremendous national security resource in northern Arizona. Although various types of uranium deposits occur within Arizona, breccia pipes in the Grand Canyon region contain the highest-grade uranium ore in the United States and some of the highest in the world. The United States imports over 90% of the needed uranium for nuclear-powered electrical energy production. A secure domestic supply of uranium is a crucial element for continued use of this energy source. According to the United States Geological Survey, the Arizona Strip holds 42% of the nation's estimated undiscovered uranium. Generally, nuclear energy is cheaper than coal and natural gas, and cleaner in that it doesn't contribute global warming gases to the atmosphere. To remove this source of energy forces our nation to rely more heavily on foreign nations to meet growing energy needs. Without this nuclear energy, we would be forced to look toward other sources of power that have a much higher carbon footprint and a detrimental impact on climate change.

In conclusion, I urge you to consider the overwhelming evidence that responsible uranium mining can be both safe for public health and the environment and compatible with the Grand Canyon region and its watershed. This is an opportunity to provide access to one of the richest deposits of high-grade ore in the world while creating the smallest possible mining impact. Canceling the proposed withdrawal and allowing the market to provide this commodity will promote the economy both in Arizona and nationally; will fuel carbon-neutral nuclear power; and support energy independence in an environmentally safe and protective manner. The withdrawal proposal is overly broad and unnecessary because of the protections offered by state and federal laws that will ensure mining operations will be protective of the Grand Canyon region and the Colorado River.

Sincerely,

Janice K. Brewer

Janice K. Brewer
Governor

JB:MA:njw

cc: Scott Florence, District Manager
Bureau of Land Management

STATE OF ARIZONA

JANICE K. BREWER
GOVERNOR

EXECUTIVE OFFICE

May 4, 2011

Mr. Scott Florence, District Manager
Bureau of Land Management
Arizona Strip District Office
345 East Riverside Drive
St. George, UT 84790-6714

RE: Northern Arizona Proposed Withdrawal Draft Environmental Impact Statement (DEIS)

Dear Mr. Florence:

On behalf of the State of Arizona, I am respectfully submitting the following comments on the Withdrawal DEIS because of the negative impacts it would have on our state. Enclosed are my comments that I submitted to you on October 30, 2009 in opposition to this proposed Withdrawal and the comments being submitted to you by the Arizona Department of Environmental Quality.

In addition, the Arizona Geologic Survey, in a role as a Cooperator in the Bureau of Land Management's EIS, has completed a study that finds uranium mining would have little impact on the Colorado River. I am including this study for your consideration.

I strongly encourage you to not move forward with this withdrawal. Arizona is a highly mineralized state and the withdrawal would significantly impact the economy of northern Arizona at a time when our economy and specifically this region are struggling.

Sincerely,

Janice K. Brewer

Janice K. Brewer
Governor

Enclosure (3)

1700 WEST WASHINGTON STREET, PHOENIX, ARIZONA 85007
602-542-4331 • FAX 602-542-7602

OPEN-FILE REPORT OFR-11-04 V1.0

Arizona Geological Survey

www.azgs.az.gov

BRECCIA-PIPE URANIUM MINING IN THE GRAND CANYON REGION AND IMPLICATIONS FOR URANIUM LEVELS IN COLORADO RIVER WATER

Jon E. Spencer (AZGS) and Karen Wenrich (Consulting Geologist)

April 2011

ARIZONA GEOLOGICAL SURVEY

Breccia-pipe uranium mining in the Grand Canyon region and implications for uranium levels in Colorado River water

April, 2011

Arizona Geological Survey, Open-File Report OFR-11-04, version 1.0, 13 p.

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Abstract

The Grand Canyon region contains over 1300 known or suspected breccia pipes, which are vertical, pipe-shaped bodies of highly fractured rock that collapsed into voids created by dissolution of underlying rock. Some breccia pipes were mineralized with uranium oxide as well as sulfides of copper, zinc, silver, and other metals. Renewed exploration during and following a steep rise in uranium prices during 2004-2007 led some to concerns about contamination of the Colorado River related to uranium mining and ore transport. Total breccia-pipe uranium production as of Dec. 31, 2010 has been more than 10,700 metric tons (23.5 million pounds) from nine underground mines, eight of which are north of Grand Canyon near Kanab Creek. Colorado River water in the Grand Canyon region currently contains about 4 μg/l (micrograms per liter) of uranium (equivalent to 4 ppb [parts per billion by mass]), with approximately 15 cubic kilometers annual discharge. Thus, approximately 60 metric tons of dissolved uranium are naturally carried by the Colorado River through the Grand Canyon in an average year. We consider a hypothetical, worst-case accident in which a truck hauling thirty metric tons (66,000 pounds) of one-percent uranium ore is overturned by a flash flood in Kanab Creek and its entire ore load is washed into the Colorado River where it is pulverized and dissolved during a one-year period to become part of the dissolved uranium content of the river (such a scenario is extremely unlikely if not impossible). This addition of 300 kilograms (660 pounds) of uranium over one year would increase uranium in river water from 4.00 ppb to 4.02 ppb. Given that the EPA maximum contaminant level for uranium in drinking water is 30 ppb, this increase would be trivial. Furthermore, it would be undetectable against much larger natural variation in river-water uranium content.

Breccia-pipe uranium deposits

Paleozoic strata of the southwestern Colorado Plateau are spectacularly exposed in the walls of the Grand Canyon. This approximately 1 km-thick sedimentary sequence rests on Proterozoic schist, granite, and tilted sedimentary rocks visible in the bottom of the eastern Grand Canyon. The Mississippian Redwall Limestone, one of the cliff-forming Paleozoic sedimentary rock units exposed in the Canyon, is located several hundred meters (up to several thousand feet) below the Canyon rim. After the Redwall Limestone was deposited (between about 359 and 318 million years ago), it was slightly elevated above sea level, leading to dissolution of the limestone and formation of a rubble zone called a dissolution breccia (McKee and Gutschick, 1969; Beus, 1989; Troutman, 2004). Some of these breccias remained highly porous and permeable while overlying strata were deposited, and are now an excellent source of potable groundwater in some areas, and contain significant dissolved solids in others.

A breccia pipe is a vertical, pipe-like mass of broken rock (breccia), typically a few tens of meters across and hundreds of meters in vertical extent (Fig. 1). Breccia pipes formed within Paleozoic and Triassic strata over a broad area around the Grand Canyon. They were created when groundwater, flowing through Redwall Limestone dissolution breccias and along fracture zones, dissolved more limestone, causing collapse of overlying rocks and possibly creating sink holes. Some pipes extend many hundreds of meters upward into the Chinle Group (formerly Chinle Formation; Heckert and Lucas, 2003), indicating that some pipes are at least as young as this Upper Triassic rock unit (Brown and Billingsley, 2010). Some pipes are blind and never broke through to the surface. Breccia pipes are abundant in the Grand Canyon region, with approximately 1300 pipes or suspected pipes identified (Fig. 2; Sutphin and Wenrich, 1989; Brown and Billingsley, 2010).

Cover Illustration. The high plateaus above Kanab Creek are barren of most vegetation except sagebrush. Within these plateaus lie thousands of breccia pipes. Some of them contain the highest grade uranium in the U.S. and some are dissected by the canyons and tributaries of northern Arizona, exposing them to oxidation and weathering. The Kanab North breccia pipe, which contains high-grade ore and is incised along the west wall of Kanab Creek, is shown in the center of this aerial view over Kanab Creek (see insert). Note the small area of red Moenkopi Sandstone within the amphitheater eroded into the breccia pipe. Much of the ore from this dissected breccia pipe has been mined (2.7 million pounds of U_3O_8) through the shaft below the headframe in photo. This block of sandstone was downdropped 700 feet into the pipe during breccia-pipe collapse over 200 million years ago. Photos by K. Wenrich.

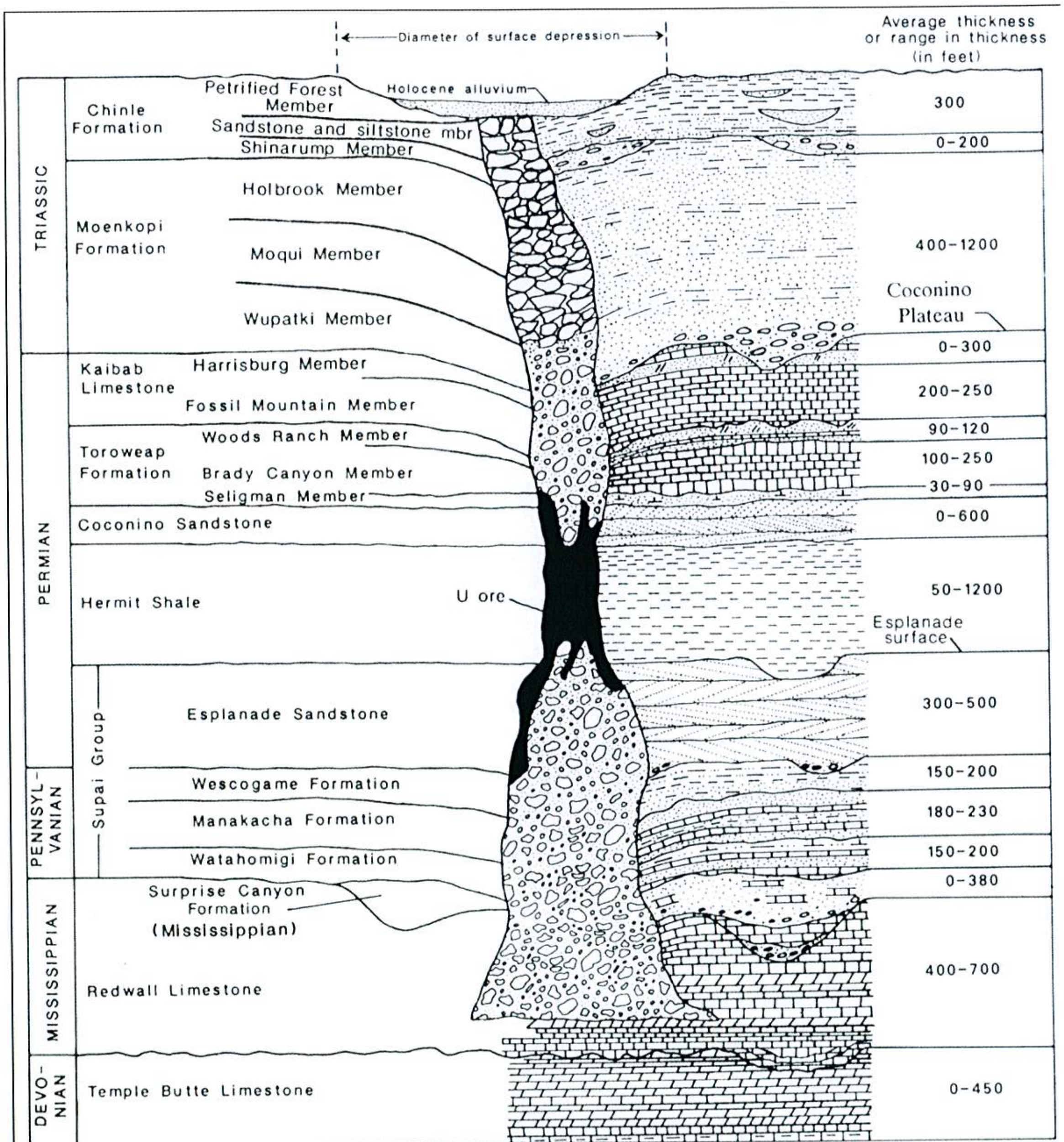
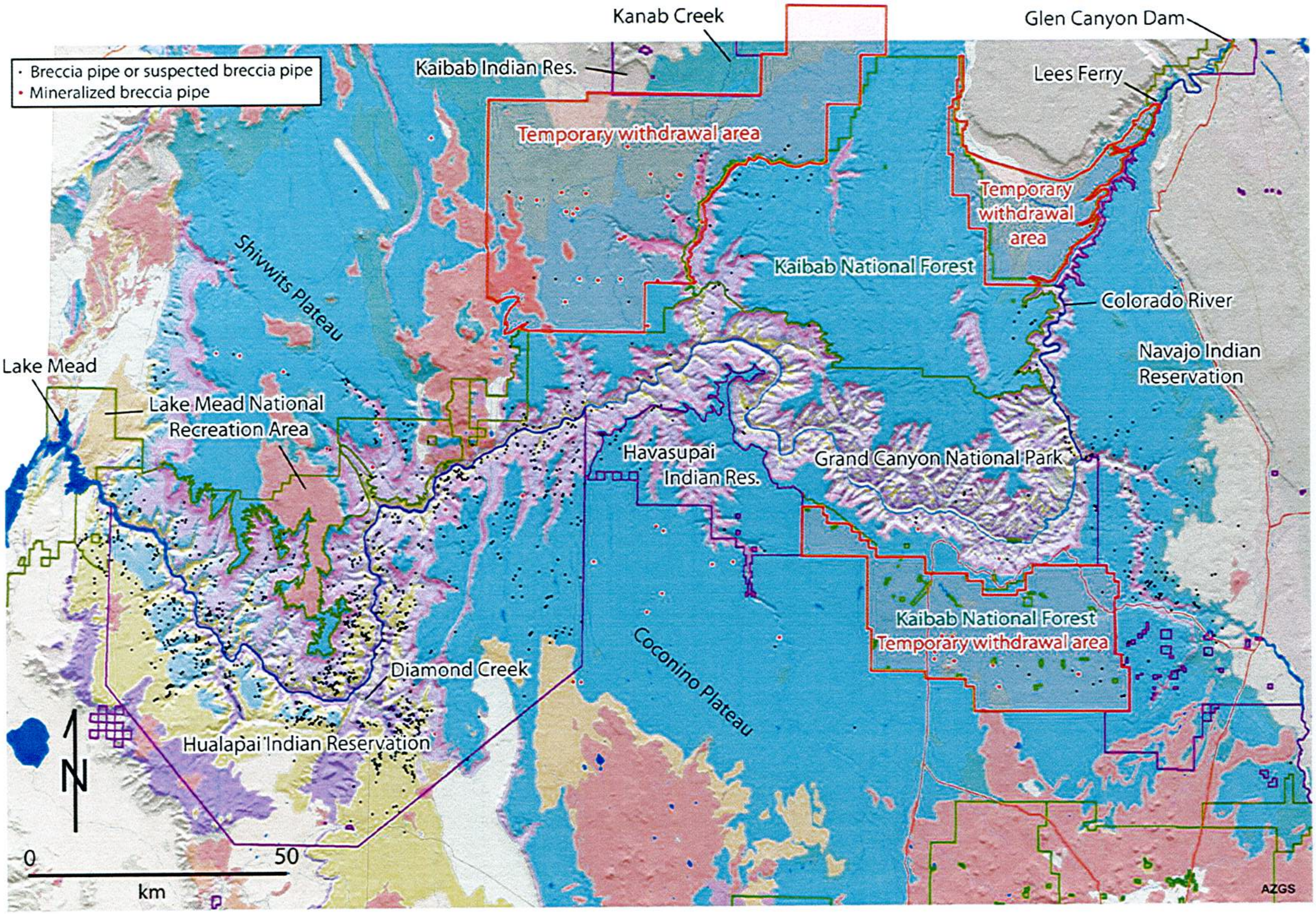


Figure 1. Simplified cross section of a breccia pipe and host uranium mineralization (modified from Finch et al., 1990).

Figure 2 (next page). Geologic map of the Grand Canyon area in northwestern Arizona showing the many areas that are off-limits to uranium mining (all labeled areas except parts of the Shivwits and Coconino Plateaus), including the three 2009 temporary withdrawal areas. Blue represents the Kaibab Limestone that forms most of the rim of the Grand Canyon and surrounding plateaus. Red represents late Cenozoic volcanic rocks. Thin red lines represent highways.



Breccia pipe or suspected breccia pipe
Mineralized breccia pipe
Kanab Creek
Kaibab Indian Res.
Glen Canyon Dam
Lees Ferry
Temporary withdrawal area
Temporary withdrawal area
Kaibab National Forest
Colorado River
Navajo Indian Reservation
Shivwits Plateau
Lake Mead
Lake Mead National Recreation Area
Havasupai Indian Res.
Grand Canyon National Park
Kaibab National Forest
Temporary withdrawal area
Coconino Plateau
Diamond Creek
Hualapai Indian Reservation
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AZGS

Warm to hot brines migrated through the Redwall solution breccia and up the breccia pipes at about the time, or shortly after, the pipes formed, and may have contributed to some late-stage pipe dissolution and collapse. Abundant sulfide minerals were precipitated from these brines, including pyrite (FeS), chalcopyrite ($CuFeS_2$), galena (PbS), and sphalerite (ZnS), and a great variety of other minerals, including Ni-Co sulfides. Fluid-inclusion analysis of some of the precipitated minerals indicates that mineralizing solutions were brines with salinities commonly >18 wt% NaCl equivalent and homogenization temperatures of, generally, 80° to 173°C (Wenrich and Sutphin, 1989).

Uranium, in the form of uraninite (UO_2), is abundant in some breccia pipes. Because uranium is soluble and hence mobilized by oxidizing aqueous solutions, such as most shallow groundwater, and is immobile in reducing aqueous solutions, such as those associated with sulfide mineral precipitation, it is generally believed that breccia-pipe uraninite was derived from different solutions than were the sulfide minerals. This inference is supported by the observation that uranium minerals were precipitated after most sulfide minerals. Most likely, oxidizing aqueous solutions carrying dissolved uranium flowed laterally through the Esplanade Sandstone Member of the Supai Group, entered the breccia pipes, and mixed with ascending, reducing brines (Wenrich and Titley, 2008). Mixing of solutions caused chemical reduction of the uranium and immediate precipitation of uraninite, typically in the pipe breccia adjacent to the Hermit Shale or Coconino Sandstone (Fig. 1). Alternatively, oxidizing, uranium-bearing solutions reacted with previously precipitated sulfide minerals, similarly causing prompt uraninite precipitation (oxidation/reduction front in figure 19 of Wenrich and Titley, 2008). Uranium-lead isotopic analysis of uraninite indicates uraninite precipitation at 200-260 Ma (Ludwig and Simmons, 1992).

Breccia-pipe uranium exploration and mining

As noted above, the Grand Canyon region contains at least 1300 known or suspected breccia pipes (Sutphin and Wenrich, 1989; Wenrich and Titley, 2008). Exploration for mineralized breccia pipes over the flat to gently sloping plateaus around the Grand Canyon is directed at finding a set of features, as follows: (1) a circular depression a hundred meters to 1.5km across, (2) inward-dipping beds that may indicate collapse into an underlying pipe, (3) brecciated rock, (4) sulfide minerals or altered sulfide minerals, and (5) radioactivity anomalies. In most cases, it is necessary to drill into the underlying rock to determine if a breccia pipe is mineralized, and necessary to drill hundreds of meters to determine if the breccia pipe contains uraninite ore. Electromagnetic techniques that identify electrically conductive minerals deep below the surface have been successfully used in the search for uranium ore.

By 1989, over 71 breccia pipes had been drilled and were found to contain ore-grade mineralized rock (Sutphin and Wenrich, 1989). As of 2010, nine of these breccia pipes had yielded approximately 10,653 metric tons (23.5 million pounds) of uranium. Eight of these breccia pipes produced approximately 10,522 metric tons (23.2 million pounds) of uranium between 1980 and 1994 (Wenrich and Titley, 2008). The ninth has produced an additional 132 metric tons (0.29 million lbs.) of uranium over a 13-month period between Dec. 1, 2009 until Dec. 31, 2010 (Harold Roberts, Denison Mines (USA), written communication, 2011). These small, deep uranium deposits are mined by way of conventional underground mining rather than by open-pit methods. Generally, two shafts are used, with a second shaft to provide ventilation and an alternative escape route in case of emergency. Remediation and mine closure are done by filling the shafts with waste rock and re-grading and re-vegetating the land. This can be, and has been, done with essentially no long-term environmental consequences.

Dissolved uranium in the Colorado River

Concerns about adverse environmental consequences of uranium mining led to temporary withdrawal from mineral entry of approximately one million acres of public land in the Grand Canyon region encompassing three different sub-areas ("Temporary withdrawal area" on Figure 2). This was done in spite of the fact that there had been no environmental accidents or significant events during the 1980-1995 period of breccia-pipe mining, nor during the following 15 years of mining inactivity. This temporary withdrawal was placed into effect on July 21, 2009, by the U.S. Secretary of the Interior, Ken Salazar, for period of time "up to two years". During this time the U.S. Bureau of Land Management (BLM) was instructed to prepare an Environmental Impact Statement (EIS) evaluating the consequences of various alternatives for a 20-year withdrawal period. BLM retained SWCA Environmental Consultants (SWCA) to prepare the EIS under BLM's direction. The Arizona Geological Survey is one of the many Cooperating Agencies in the EIS development process.

One concern about adverse environmental consequences of uranium mining was expressed by then Governor of Arizona Janet Napolitano in a letter, dated March 6, 2008, to U.S. Secretary of the Interior Dirk Kempthorne (Appendix 1). That letter stated that "the dramatic rise in prices for uranium over the last three years has created a 'boom' that has the potential to seriously harm the Grand Canyon National Park and the water quality of the lower Colorado River." Concern about contamination to the Colorado River was reiterated by environmental groups such as the Sierra Club: "Mining would have ... threatened to contaminate the Colorado River, the source of drinking water for tens of millions of people." (http://sierraclub.typepad.com/scrapbook/2008/10/club-allies-sto.html, accessed Dec. 10, 2010 under the heading "Club, Allies Stop Uranium Mining Next to Grand Canyon").

An evaluation of potential contamination of the Colorado River due to uranium mining requires consideration of the natural uranium concentration in river water. Two hundred and seventy uranium analyses of river water from three sites along the Colorado River between Glen Canyon Dam and Lake Mead, summarized by Bills et al. (2010, Figure 15 and Appendix 4), indicate average dissolved uranium concentration of generally between three and eight parts per billion (ppb), with significant variability (Fig. 3; Table 1). One hundred measurements during a nine-year period (1963-1972) from a site below Page, Arizona, show decreasing dissolved uranium concentrations after the first ~1.5 years, possibly because of increasingly significant effects of water impoundment by Glen Canyon dam directly upstream (Fig. 3). Dissolved uranium concentration during this initial measurement period varied from six to twelve ppb, but then dropped below approximately eight ppb. The average concentration for the entire nine year measurement period was 6.46 ppb uranium (U) (n=100), while the average concentration following the first 18 months of the measurement period was 5.57 ppb U (n=73) (Table 1). Measurements at Lees Ferry during 1996 to 1998 averaged 3.24 ppb U (n=19), while measurements near Peach Spring (1997-2007), near the head of Lake Mead, averaged 3.57 ppb U (n=78). On the basis of these data sets, we consider modern Colorado River water to have a dissolved uranium concentration of 4±1 ppb uranium.

Table 1. Uranium concentration in Colorado River water, Grand Canyon area*

site	time period of survey	n	average U (ppb)	standard deviation	source
Page	5-1963 to 5-1972	100	6.46	2.24	USEPA (1973)
Page	7-1965 to 4-1972	73	5.57	1.49	USEPA (1973)
Lees Ferry	1-1996 to 8-1998	19	3.24	0.38	USGS (2009)
Near mouth of Diamond Creek	11-1996 to 8-2007	78	3.57	0.46	USGS (2009)

*table derived from Bills et al., 2010, Appendix 4

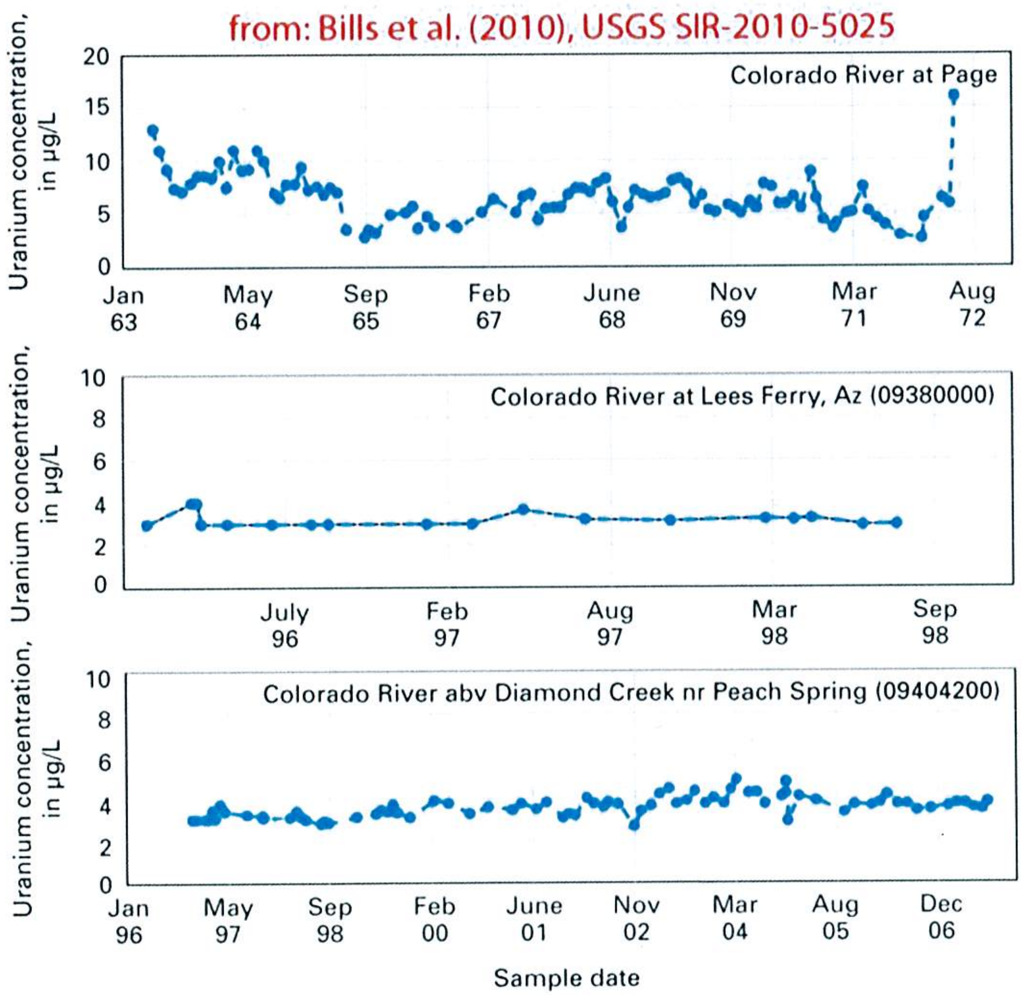

Figure 3. Dissolved uranium concentration in Colorado River water from measurements at three sites in the Grand Canyon area (modified from Bills et al., 2010, Figure 15). Sample locations are shown in Figure 2 (Page locality is just below Glen Canyon dam).

The 4±1 ppb uranium level considered to be representative of Colorado River water is below the 5.57 ppb average for a long set of measurements made during the period 1965-1972 (Table 1; Fig. 3). We consider this acceptable partly because analytical methods improved considerably by the time later measurements yielded generally lower levels, and consider it likely that earlier measurements were less accurate. This is indicated by much greater variability of earlier measurements, with a standard deviation of the older data set that is considerably higher than for later data sets (Table 1).

The 4±1 ppb uranium level estimated for the modern Colorado River probably underestimates natural Colorado River water conditions, as indicated by higher levels recorded below Glen Canyon dam immediately after initial water impoundment. We speculate that Colorado River uranium levels were naturally higher before river water was impounded and suspended sediment removed by settling to the reservoir floor. While 4±1 ppb uranium in Colorado River water may be an underestimate of pre-reservoir, natural water conditions, it is more relevant to evaluating potential contamination from future mining.

Colorado River water flux in the Grand Canyon region averages 13 to 16 cubic kilometers per year (km^3/yr), depending on the measurement site and set of years over which measurements were made (Table 2, note that 1.29E+07 = 1.27×10^7). A cubic kilometer of water, corresponding to a cube of water 1000 m along each side, contains a billion cubic meters, each of which has a mass of one metric ton (a tonne). Thus, if one cubic kilometer of water contains one ppb of uranium, it contains one tonne of uranium (one tonne = 1000 kg = 2205 lbs). As outlined above, uranium concentration of Colorado River water is estimated at 4±1 ppb. Thus, 13 to 16 km^3/yr of river water carrying 4±1 ppb dissolved uranium correspond to a uranium flux of 39 to 80 tonnes (86,000 to 176,400 lbs.) carried by the Colorado River each year. We represent this as 60±20 tonnes/year uranium.

Table 2. Colorado River water volume, Grand Canyon area

Source	ac-ft / yr	gal / ac-ft	m^3/gal	m^3/yr	km^3/yr
Smith et al., 1997, p. 49*	1.29E+07	325851	0.003785	1.59E+10	15.95
Irelan, 1971, p. E9**	1.21E+07	325851	0.003785	1.50E+10	14.96
Anning, 2002, Table 3***	1.08E+07	325851	0.003785	1.33E+10	13.26

*Discharge at Lees Ferry (1912-1962) before Lake Powell began filling in March, 1963
**Discharge at Grand Canyon 1926-1962
***Discharge at Davis Dam, 1995-1999

A worst-case uranium-ore spill

We now consider a maximum credible uranium-ore spill into the Colorado River that assumes a sequence of worst-case events. We consider this scenario as bordering on impossible, but consider it nevertheless in order to address concerns about contamination of a vast and enormously valuable water resource. Any real uranium spill is likely to be much smaller than the scenario outlined here.

Uranium ore is hauled in trucks with loads up to 30 tons (about 27.2 tonnes), usually in a 20 ton trailer with a second trailer containing 10 tons (Kris Hefton, Vane Minerals LLC, personal communication, 2010). We represent this as 30 tonnes of ore, recognizing that this is slightly larger than a likely real full load. Most breccia-pipe uranium ore varies from 0.4 to 0.8% uranium oxide, but we represent this as 1.0% uranium for analytical simplicity (again, recognizing that this is a modest overestimate). Consider a hypothetical truck hauling 30 tonnes of uranium ore at 1% uranium grade (300 kg U). If this ore truck was overturned by a flash flood while crossing Kanab Creek, and its entire load of uranium ore was washed 60 km down Kanab Creek, completely pulverized in the riverbed, and dissolved into Colorado River water over a one-year period, then 0.3 tonnes of uranium would be added to the river over this time period. Against a natural background of 60±20 tonnes/year of uranium dissolved in the Colorado River, this amounts to an approximately 0.5% increase in river-water uranium concentration, or a change from 4.00 ppb to 4.02 ppb (an increase of 0.02 ppb, or 20 parts per trillion). This change would be trivial, especially when considered in light of the EPA Maximum Contaminant Level for drinking water of 30 ppb uranium.

Standard deviation of uranium measurements at Lees Ferry and near Peach Spring is 0.38 and 0.46 ppb, respectively (Table 1). Thus, in our worst-case uranium-spill scenario, uranium concentration in the Colorado River would be increased by about one twentieth of one standard deviation of uranium measurements in these two data sets. If deviation primarily represents natural variation, which seems likely, then uranium added to the Colorado River in this hypothetical situation would be undetectable against much larger natural variation.

Our deliberately exaggerated, worst-case scenario for a uranium-ore spill into the Colorado River can be applied to even more unlikely environmental situations. Consider the entire 132 tonnes of uranium production from the Arizona 1 mine that occurred during 13 months in 2009-2010. Then consider that, for some reason, the ore containing this uranium was not trucked to a distant uranium mill, but was stockpiled on site in a location vulnerable to flash flooding. At a grade of 1% uranium, this stockpile would consist of 13,200 tonnes of uranium ore. If a flash flood washed the entire 13,200 tonnes of uranium ore into the Colorado River, and all of the ore was pulverized and its 132 tonnes of uranium dissolved in the Colorado River over one year, then the annual uranium flux in the Colorado River would increase from approximately 60 tonnes to 192 tonnes. Uranium concentration in river water would increase from 4.0 to 12.8 ppb for one year, which is still far below the 30 ppb EPA Maximum Contaminant Level. Thus, even in this implausible scenario, with approximately 20% of the entire ore body washed into the Colorado River and completely dissolved in river water, the water would still be considered safe to drink by the EPA under current regulations. In reality, any such flash-flood mobilization of uranium ore would result in mixing of ore with stream-bed sediment, in the Colorado River as well as in tributaries, and a much more gradual addition of uranium to river water.

Conclusion

Uranium, present in typical crustal rock at about 3 ppm (Spencer, 2002), is one of the many chemical elements in Earth's crust that are gradually washed away by weathering and erosion and dissolved in very small concentrations in river water and groundwater. The seemingly large amount of naturally occurring uranium in the Colorado River (tens of tonnes per year) reflects the large water flux in the river, not unusually high uranium concentration. Colorado River water is consumed by millions of people in Arizona, California, and Nevada. Uranium concentration in river water, at about 4 ppb, has been consistently well below the EPA Maximum Contaminant Level (MCL) of 30 ppb for drinking water. Under the conditions modeled here for a uranium ore-truck accident, designed to represent an extremely unlikely, worst-case, mining-related uranium spill into the Colorado River, an increase of 0.02 ppb uranium would be trivial in comparison to the EPA drinking water MCL of 30 ppb uranium. Furthermore, such an increase of uranium in river water would be undetectable against natural variation as revealed by variability in past uranium measurements of river water.

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APPENDIX A: Letter from Arizona Governor Janet Napolitano regarding uranium mining

STATE OF ARIZONA

JANET NAPOLITANO
GOVERNOR

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MAIN PHONE: 602-542-4331
FACSIMILE: 602-542-7601

March 6, 2008

The Honorable Dirk Kempthorne
Secretary of the Interior
Department of the Interior
1849 C Street, N.W.
Washington DC 20240

Dear Mr. Secretary:

I am writing to you on behalf of the citizens of the State of Arizona to express concerns regarding the impact of uranium development on the Grand Canyon National Park. As you know, the Grand Canyon is not only an Arizona treasure, it is a National one and we must fully understand environmental impacts before moving forward with uranium mining or millsite activities. Therefore, I request that you exercise your emergency withdrawal authority under the Federal Land Policy and Management Act (FLPMA), 43 U.S.C. Section 1714 to stop new claimstaking and conduct an overall environmental impact analysis of uranium development around the Grand Canyon. It is imperative that we fully understand impacts to the land and water in the Canyon region before moving forward with mining and millsite activities. Should the analysis determine a negative impact to the Canyon, you should exercise your authority to withdraw the lands from mineral entry for twenty years. The attached map shows the areas of concern.

As you may be aware, the dramatic rise in prices for uranium over the last three years has created a "boom" that has the potential to seriously harm the Grand Canyon National Park and the water quality of the lower Colorado River. According to a report by The Environmental Working Group, 2,215 new mining claims have been filed within 10 miles of Grand Canyon National Park since 2003, and that 805 of those claims are within 5 miles of the Grand Canyon National Park. As those claims are further developed, the industrial development in the vicinity of the Park and along its watersheds would have significant negative economic, cultural, and environmental repercussions for the residents of Northern Arizona and for the citizens of the State of Arizona.

On Tuesday, February 5, 2008 the Board of Supervisors for Coconino County passed a resolution opposing uranium development in the vicinity of the Grand Canyon National Park and its watershed. The resolution reflects the sentiment of citizens in the local communities around the Grand Canyon and calls for the withdrawal of mineral entry that I am now requesting.

These efforts have resulted in stories and editorials in the New York Times and other newspapers. These reflect the high level of public concern, both here in Arizona, and nationally, about the prospect of uranium mines opening on the rim of the Grand Canyon. This is not just an Arizona concern; this has national implications.

There are places where uranium might be appropriately mined, but I think that almost every American can agree that the Grand Canyon is not one of those places. As President Theodore Roosevelt, who created what is now Grand Canyon National Park, said:

> *In the Grand Canyon, Arizona has a natural wonder which, so far as I know, is in kind absolutely unparalleled throughout the rest of the world...*
>
> *Leave it as it is. You can not improve on it. The ages have been at work on it, and man can only mar it. What you can do is to keep it for your children, your children's children, and for all who come after you...*

In 1906, President Roosevelt put his words into action and removed the land from mineral entry that is now largely encompassed by the North Kaibab Ranger District of the Kaibab National Forest. Since that time, additional lands in the region, including those that fall within the boundaries of the Grand Canyon Parashant and Vermillion Cliffs National Monuments were protected from new mineral entry. The Navajo Nation has prohibited uranium development on their tribal lands bordering the Grand Canyon and other tribes are considering doing the same. Indeed, the Navajo Nation just passed Tribal Superfund legislation to specifically help address the large number of abandoned and unreclaimed uranium sites on their land.

The withdrawal from mineral entry of the three areas that I have indicated will complete the process of protecting the Grand Canyon from the adverse affects of mineral development that President Roosevelt began more than a century ago. On behalf of the citizens of the state of Arizona, I, therefore, petition and request that you remove those federal lands identified on the attached map. Should you need additional information, please contact Lori Faeth, Sr. Policy Advisor for Natural Resources, Agriculture and Environment at 602-542-1334, lfaeth@az.gov.

I thank you for your consideration of this very important issue.

Yours very truly,

Janet Napolitano
Governor

cc: Congressman Rick Renzi
Congressman Raul Grijalva
Congressman Nick Rahall
Senator John McCain
Senator John Kyl
Senator Jeff Bingaman
The Honorable Ed Schafer Secretary U.S. Department of Agriculture
Chairwoman Ono Segundo, The Kaibab Paiute Tribe
Chairman Don Watahomigie, The Havasupai Tribe
Chairman Ben Nuvamsa, The Hopi Tribe
Chairman Charles Vaughn Sr., The Hualapai Tribe
President Joe Shirley Jr., The Navajo Nation