ROCKY FLATS STEWARDSHIP COUNCIL

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Board of Directors Meeting – Agenda

Monday, June 4, 2012, 8:30 AM – 11:30 AM

Rocky Mountain Metropolitan Airport, Terminal Building, Mount Evans Room
11755 Airport Way, Broomfield, Colorado

8:30 AM Convene/Introductions/Agenda Review

8:35 AM Chairman's Review of May 7th Executive Committee meeting

8:40 AM Business Items (briefing memo attached)

1. Consent Agenda
   - o Approval of meeting minutes and checks

2. Executive Director's Report

8:50 AM Public Comment

9:00 AM Receive Stewardship Council 2011 Financial Audit (briefing memo attached)
- o At this meeting the Board will be briefed on the results of the audit.
- o No material problems were found, and the Stewardship Council was found to be in compliance with all applicable laws and regulations.

Action item: Accept Stewardship Council 2011 Financial Audit

9:15 AM Host DOE Annual Meeting (briefing memo attached)
- o DOE will brief on site activities for calendar year 2011.
- o DOE has posted the report on its website and will provide a summary of its activities to the Stewardship Council.
- o Activities included surface water monitoring, groundwater monitoring, ecological monitoring, and site operations (inspections, maintenance, etc.).

10:30 AM Briefing on the Actinide Migration (briefing memo attached)
- o Actinide migration concerns the movement of plutonium, americium and uranium in the environment at Rocky Flats.
- o The Actinide Migration Evaluation (AME) projects were commissioned at Rocky Flats in 1995 to address how actinide elements move in the environment.

- Initially, AME advisors were recruited to evaluate and provide guidance on environmental conditions (including actinide chemistry, geochemistry, migration, and erosion) at Rocky Flats. The charter was expanded to include recommendations of paths forward for long-term protection of surface-water quality as the primary technical and regulatory measure of remedial action quality.
- Understanding how actinides move in the environment is central to the cleanup and long-term protection strategies.

11:15 AM Public comment

11:25 PM Big Picture Review/Updates

1. Review Big Picture
2. Member Updates

Adjourn

Next Meetings: September 10 (second Monday)
November 5

Rocky Flats Acronym List
Prepared by Rik Getty, Rocky Flat Stewardship Council
March 2012

Acronym or Term	**Means**	**Definition**
Alpha Radiation		A type of radiation that is not very penetrating and can be blocked by materials such as human skin or paper. Alpha radiation presents its greatest risk when it gets inside the human body, such as when a particle of alpha emitting material is inhaled into the lungs. Plutonium, the radioactive material of greatest concern at Rocky Flats, produces this type of radiation.
Am	americium	A man-made radioactive element which is often associated with plutonium.
AME	Actinide Migration Evaluation	An exhaustive years-long study by independent researchers who studied how actinides such as Pu, Am, and U move through the soil and water at Rocky Flats
AMP	Adaptive Management Plan	Additional analyses that DOE is performing beyond the normal environmental assessment for breaching the remaining site dams.
AOC well	Area of Concern well	A particular type of groundwater well
B	boron	Boron has been found in some surface water and groundwater samples at the site
Be	beryllium	A very strong and lightweight metal that was used at Rocky Flats in the manufacture of nuclear weapons. Exposure to beryllium is now known to cause respiratory disease in those persons sensitive to it
Beta Radiation		A type of radiation more penetrating than alpha and hence requires more shielding. Some forms of uranium emit beta radiation.
BMP	best management practice	A term used to describe actions taken by DOE that are not required by regulation but warrant action.
BZ	Buffer Zone	The majority of the Rocky Flats site was open land that was added to provide a "buffer" between the neighboring communities and the industrial portion of the site. The buffer zone was approximately 6,000 acres. Most of the buffer zone lands now make up the Rocky Flats National Wildlife Refuge.
CAD/ROD	corrective action decision/record of	The complete final plan for cleanup and closure for Rocky Flats. The Federal/State

	decision	laws that governed the cleanup at Rocky Flats required a document of this sort.
CCP	Comprehensive Conservation Plan	The refuge plan adopted by the U.S. Fish and Wildlife Service in 2007.
CDPHE	Colorado Department of Public Health and Environment	State agency that regulates the site.
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act	Federal legislation that governs site cleanup. Also known as the Superfund Act
cfs	cubic feet per second	A volumetric measure of water flow.
COC	Contaminant of Concern	A hazardous or radioactive substance that is present at the site.
COU	Central Operable Unit	A CERCLA term used to describe the DOE-retained lands, about 1,500 acres comprised mainly of the former Industrial Area where remediation occurred
Cr	chromium	Potentially toxic metal used at the site.
CRA	comprehensive risk assessment	A complicated series of analyses detailing human health risks and risks to the environment (flora and fauna).
D&D	decontamination and decommissioning	The process of cleaning up and tearing down buildings and other structures.
DG	discharge gallery	This is where the treated effluent of the SPPTS empties into North Walnut Creek.
DOE	U.S. Department of Energy	The federal agency that manages portions of Rocky Flats. The site office is the Office of Legacy Management (LM).
EA	environmental assessment	Required by NEPA (see below) when a federal agency proposes an action that could impact the environment. The agency is responsible for conducting the analysis to determine what, if any, impacts to the environment might occur due to a proposed action.
EIS	environmental impact statement	A complex evaluation that is undertaken by a government agency when it is determined that a proposed action by the agency may have significant impacts to the environment.
EPA	U.S. Environmental Protection Agency	The federal regulatory agency for the site.
ETPTS	east trenches plume treatment system	The treatment system near the location of the east waste disposal trenches which treats

		groundwater contaminated with organic solvents emanating from the trenches. Treated effluent flows into South Walnut Creek.
FC	functional channel	Man-made stream channels constructed during cleanup to help direct water flow.
FACA	Federal Advisory Committee Act	This federal law regulated federal advisory boards. The law requires balanced membership and open meetings with published Federal Register meeting dates.
Gamma Radiation		This type of radiation is very penetrating and requires heavy shielding to keep it from exposing people. Am is a strong gamma emitter.
GAO	Government Accountability Office	Congressional office which reports to Congress. The GAO did 2 investigations of Rocky Flats relating to the ability to close the site for a certain dollar amount and on a certain time schedule. The first study was not optimistic while the second was very positive.
g	gram	metric unit of weight
gpm	gallons per minute	A volumetric measure of water flow in the site's groundwater treatment systems and other locations.
GWIS	groundwater intercept system	Refers to a below ground system that directs contaminated groundwater toward the Solar Ponds and East Trenches treatment systems.
IA	Industrial Area	Refers to the central core of Rocky Flats where all production activities took place. The IA was roughly 350 of the total 6,500 acres at the site.
IC	Institutional Control	ICs are physical and legal controls geared towards ensuring the cleanup remedies remain in place and remain effective.
IHSS	Individual Hazardous Substance Site	A name given during cleanup to a discrete area of known or suspected contamination. There were over two hundred such sites at Rocky Flats.
ITPH	interceptor trench pump house	The location where contaminated groundwater collected by the interceptor trench is pumped to either the Solar Ponds and East Trenches treatment systems
L	liter	Metric measure of volume, a liter is slightly larger than a quart.

LANL	Los Alamos National Laboratory	One of the US government's premier research institutions located near Santa Fe, NM. LANL is continuing to conduct highly specialized water analysis for Rocky Flats. Using sophisticated techniques, LANL is able to determine the percentages of both naturally-occurring and man-made uranium. That analysis helps inform water quality decisions.
LM	Legacy Management	DOE office responsible for overseeing activities at closed sites.
LMPIP	Legacy Management Public Involvement Plan	This plan follows DOE and EPA guidance on public participation and outlines the methods of public involvement and communication used to inform the public of site conditions and activities. It was previously known as the Post-Closure Public Involvement Plan (PCPIP).
M&M	monitoring and maintenance	Refers to ongoing activities at Rocky Flats.
MSPTS	Mound site plume treatment system	The treatment system for treating groundwater contaminated with organic solvents which emanates from the Mound site where waste barrels were buried. Treated effluent flows into South Walnut Creek.
NEPA	National Environmental Policy Act	Federal legislation that requires the federal government to perform analyses of environmental consequences of major projects or activities.
nitrates		Contaminant of concern found in the North Walnut Creek drainage derived from Solar Ponds wastes. Nitrates are very soluble in water and move readily through the aquatic environment
Np	neptunium	A man-made radioactive isotope that is found as a by-product of nuclear reactors and plutonium production.
NPL	National Priorities List	A listing of Superfund sites. The refuge lands were de-listed from the NPL while the DOE-retained lands are still on the NPL due to ongoing groundwater contamination and associated remediation activities.
OLF	Original Landfill	Hillside dumping area of about 20 acres which was used from 1951 to 1968. It

		underwent extensive remediation with the addition of a soil cap and groundwater monitoring locations.
OU	Operable Unit	A term given to large areas of the site where remediation was focused.
PCE	perchloroethylene	A volatile organic solvent used in past operations at the site. PCE is also found in environmental media as a breakdown product of other solvents.
pCi/g	picocuries per gram of soil	A unit of radioactivity measure. The soil cleanup standard at the site was 50 pCi/g of soil.
pCi/L	picocuries per liter of water	A water concentration measurement. The State of Colorado has a regulatory limit for Pu and Am which is 0.15 pCi/L of water. This standard is 100 times stricter than the EPA's national standard.
PLF	Present Landfill	Landfill constructed in 1968 to replace the OLF. During cleanup the PLF was closed under RCRA regulations with an extensive cap and monitoring system.
PMJM	Preble's Meadow Jumping Mouse	A species of mouse found along the Front Range that is on the endangered species list. There are several areas in the Refuge and COU that provide an adequate habitat for the mouse, usually found in drainages. Any operations that are planned in potential mouse habitat are strictly controlled.
POC	Point of Compliance (surface water)	A surface water site that is monitored and must be found to be in compliance with federal and state standards for hazardous constituents. Violations of water quality standards at the points of compliance could result in DOE receiving financial penalties.
POE	Point of Evaluation (surface water)	These are locations at Rocky Flats at which surface water is monitored for water quality. There are no financial penalties associated with water quality exceedances at these locations, but the site may be required to develop a plan of action to improve the water quality.
POU	Peripheral Operable Unit	A CERCLA term used to describe the Wildlife Refuge lands of about 4,000 acres.
Pu	plutonium	Plutonium is a metallic substance that was fabricated to form the core or "trigger" of a

		nuclear weapon. Formation of these triggers was the primary production mission of the Rocky Flats site. Pu-239 is the primary radioactive element of concern at the site. There are different forms of plutonium, called isotopes. Each isotope is known by a different number. Hence, there are plutonium 239, 238, 241 and others.
RCRA	Resource Conservation and Recovery Act	Federal law regulating hazardous waste. In Colorado, the EPA delegates CDPHE the authority to regulate hazardous wastes.
RFCA	Rocky Flats Cleanup Agreement	The regulatory agreement which governed cleanup activities. DOE, EPA, and CDPHE were signors.
RFCAB	Rocky Flats Citizen Advisory Board	This group was formed as part of DOE's site-specific advisory board network. They provided community feedback to DOE on a wide variety of Rocky Flats issues from 1993-2006.
RFCLOG	Rocky Flats Coalition of Local Governments	The predecessor organization of the Rocky Flats Stewardship Council
RFETS	Rocky Flats Environmental Technology Site	The moniker for the site during cleanup years.
RFLMA	Rocky Flats Legacy Management Agreement	The post-cleanup regulatory agreement between DOE, CDPHE, and EPA which governs site activities. The CDPHE takes lead regulator role, with support from EPA as required.
RFNWR	Rocky Flats National Wildlife Refuge	The approximate 4,000 acres which compose the wildlife refuge.
RFSOG	Rocky Flats Site Operations Guide	The nuts-and-bolt guide for post-closure site activities performed by DOE and its contractors.
SPPTS	solar ponds plume treatment system	System used to treat groundwater contaminated with uranium and nitrates. The nitrates originate from the former solar evaporation ponds which had high levels of nitric acid. The uranium is primarily naturally-occurring with only a slight portion man-made. Effluent flows into North Walnut Creek
SVOCs	semi-volatile organic compounds	These compounds are not as volatile as the solvent VOCs. They tend to be similar to oils and tars. They are found in many

		environmental media at the site. One of the most common items to contain SVOCs is asphalt.
TCE	trichloroethlyene	A volatile organic solvent used in past operations at the site. TCE is also found in environmental media as a breakdown product of other solvents.
U	uranium	Naturally occurring radioactive element. There were two primary isotopes of U used during production activities. The first was enriched U which contained a very high percentage (>90%) of U-235 which was used in nuclear weapons. The second isotope was U-238, also known as depleted uranium. This had various uses at the site and only had low levels of radioactivity..
USFWS	United States Fish & Wildlife Service	An agency within the US Department of the Interior that is responsible for maintaining the nation-wide system of wildlife refuges, among other duties. The regional office is responsible for the RFNWR.
VOC	volatile organic compound	These compounds include cleaning solvents that were used in the manufacturing operations at Rocky Flats. The VOCs used at Rocky Flats include carbon tetrachloride (often called carbon tet), trichloroethene (also called TCE), perchloroethylene (also called PCE), and methylene chloride.
WCRA	Woman Creek Reservoir Authority	This group is composed of the three local communities, the Cities of Westminster, Northglenn, and Thornton, who use Stanley Lake as part of their drinking water supply network. Water from the site used to flow through Woman Creek to Stanley Lake but the reservoir severed that connection. The Authority has an operations agreement with DOE to manage the Woman Creek Reservoir.
WQCC	Water Quality Control Commission	State board within CDPHE tasked with overseeing water quality issues throughout the state. DOE has petitioned the WQCC several times in the last few years regarding water quality issues.
ZVI	zero valent iron	A type of fine iron particles used to treat VOC's in the ETPTS and MSPTS.

Business Items

- April 2, 2012, draft board meeting minutes
- List of Stewardship Council checks

2011 Audit

- Cover memo
- Draft audit

ROCKY FLATS STEWARDSHIP COUNCIL
Monday, April 2, 2012, 8:30 AM – 11:30 AM
Rocky Mountain Metropolitan Airport, Terminal Building, Mount Evans Room
11755 Airport Way, Broomfield, Colorado

Board members in attendance: Shelley Cook (Director, Arvada), Jim McCarthy (Alternate, Arvada), Lisa Morzel (Director, City of Boulder), Tim Plass (Alternate, City of Boulder), Deb Gardner (Director, Boulder County), Meagan Davis (Alternate, Boulder County), Greg Stokes (Director, Broomfield), Mike Shelton (Alternate, Broomfield), David Allen (Alternate, Broomfield), Bill Fisher (Director, Golden), Kate Newman (Alternate, Jefferson County), Joyce Downing (Director, Northglenn), Shelley Stanley (Alternate, Northglenn), Joe Cirelli (Director, Superior), Eric Tade (Director, Thornton), Emily Hunt (Alternate, Thornton), Bob Briggs (Director, Westminster), Mary Fabisiak (Alternate, Westminster), Shirley Garcia (Director, Rocky Flats Cold War Museum), Ann Lockhart (Alternate, Rocky Flats Cold War Museum), Roman Kohler (Director, Rocky Flats Homesteaders), Jeannette Hillery (Director, League of Women Voters), Arthur Widdowfield (citizen).

Stewardship Council staff members and consultants in attendance: David Abelson (Executive Director), Rik Getty (Technical Program Manager), Barb Vander Wall (Seter & Vander Wall, P.C), Erin Rogers (consultant).

Attendees: Vera Moritz (EPA), Carl Spreng (CDPHE), Marilyn Null (CDPHE), Scott Surovchak (DOE-LM), Bob Darr (Stoller), Rick DiSalvo (Stoller), Stuart Feinhor (Rep. Polis).

Convene/Agenda Review

Chair Lisa Morzel convened the meeting at 8:37 a.m. She asked if there were any suggested changes to the agenda and there were not.

Chairman's Review of March 14 Executive Committee meeting

Chairman Morzel noted that an Executive Committee meeting was held on March 14, 2012. The purpose was to develop the agenda for this meeting. These meetings are always open to public.

Consent Agenda

David Allen presented one minor editing change to the February Board meeting minutes.

Bob Briggs moved to approve the February Board meeting minutes as amended and the checks. The motion was seconded by Jeannette Hillery. The motion to accept the minutes and checks passed 14-0.

Executive Director's Report

The Stewardship Council's Executive Director, David Abelson, presented an update to the Board. He noted that the Board's Intergovernmental Agreement (IGA) had been signed by all entities. He next spoke about the approval of DOE's grant to fund the Stewardship Council. For the benefit of new members, David explained how the Board's funding works. The Board receives five-year grants from DOE. During this timeframe, funding is disbursed periodically upon the Board showing cause. Annually, the Board receives roughly $130,000. Non-federal dollars, in the form of local government contributions, cover certain activities not covered by the DOE grant (such as food for meetings). David next shared that the April quarterly financial report would be distributed to Board members, and that he would be happy to answer any questions.

David next discussed an update on the Energy Employees Occupational Illness Compensation Program Act (EEIOCPA). The EEOICPA, passed in Congress in 2000, was created to compensate workers at defense nuclear facilities for illnesses sustained as direct result of working at one of these facilities. David noted that numerous problems have been encountered by former workers in getting their claims approved. The problems include inadequate record keeping, missing records, state vs. federal requirements, and the difficulties of dose reconstruction. Around 2005, there were attempts to limit program funding due to federal budget issues. David reported that, while there have been some clams paid, far too few workers had been successful with their claims. In recent years, workers at Rocky Flats began pursuing a designation of 'Special Cohort status'. With this designation, workers meeting a much more straight-forward set of criteria, such as having worked at certain facilities during certain years, would be presumed to have contracted their illnesses due to work, rather than having to prove their individual exposures. Senator Udall introduced legislation to address this issue, called the Charlie Wolf Act after a Rocky Flats worker who died while working for compensation. All members of the Colorado congressional delegation supported this legislation, with the exception of Rep. Lamborn. At this point, the legislation is basically dead, primarily due to the large costs associated with the claims. On March 1, The National Institute for Occupational Safety and Heath (NIOSH) announced it would review the Rocky Flats Special Cohort petition, covering the period from 1972. Roman Kohler noted how disappointing it was that the Charlie Wolf Act was not passed and how few workers have their claims approved. Shirley Garcia commented on how complicated the required forms are, and that workshops are being planned to assist workers with this process.

David next reported about an op-ed published recently in the New York Times, written by a former Arvada resident, Kristin Iversen. The op-ed column was based on a book she is writing that will be out later this year, and links the disaster at the Fukushima nuclear plant with Rocky Flats. David noted that some parts of her article were accurate, while some were extreme mischaracterizations. The Denver Post responded with a rebuttal. David commented that, because of the complexity of these issues, some in the media will always make stories sensational. Also, no matter how much information is released about nuclear sites, many people will never be satisfied.

Rik Getty gave an update on feedback from the Board on potential dates for the annual site tour. He said that Thursdays had the most votes currently for both main tour and backup date. Board members were asked to respond to Rik with their preferences.

Shirley Garcia noted that Kristin Iversen has a book signing scheduled in Denver. Shelley Stanley said that it would be a good idea for Board members to be prepared and available for press queries when the book is released. David Abelson commented that it will be difficult without advance copy of book, but that there are some general talking points he will provide, and perhaps discuss at the next meeting. A major theme will be that there is ongoing local oversight, and that the community has been involved for years. Ann Lockhart said that she was contacted recently by a reporter from Channel 2/Fox News who wanted to interview someone about this book.

Public Comment

There was none.

Second review of bylaws amendments

Due to changes in the Board's IGA regarding membership and voting requirements, the bylaws needed to be amended to align with the IGA. As a unit of local government, the Stewardship Council must review the changes at one meeting and then adopt the changes at a second meeting. The amendments were reviewed at the last Board meeting.

Murph Widdowfield moved to approve the bylaws amendments. The motion was seconded by Joe Cirelli. The motion to accept the minutes and checks passed 14-0.

Briefing on the history of Rocky Flats Stewardship Council

David Abelson provided a brief history of the Stewardship Council. During the cleanup of Rocky Flats, Dan Miller with the Colorado Attorney General's office repeatedly emphasized that a key component of long term oversight needed to be institutional controls. Examples such as Love Canal show how easy it can be for information about environmental dangers to be lost. David said multiple layers of control were developed at Rocky Flats. An Environmental Covenant was created, which is a land use restriction deed on file with Jefferson County. There has also been a commitment to keep the community involved with what is going on. In 2003, the parties involved in Rocky Flats developed the idea for the Stewardship Council and legislation was approved in 2004. Around this time, DOE's Office of Legacy Management was created.

More governments are involved in this group now than there were during cleanup. The Board's primary goal has always been to bring together local issues with national priorities. To do this, the group looks at facts first, and then offers opinions, if needed. Fundamentally, this group is a public forum to keep well-informed about issues. One issue that the Stewardship Council intentionally stays away from is the debate over the Jefferson Parkway. The only facet of this issue that the Board agreed to discuss at Stewardship Council meetings is the question of contamination in the eastern buffer zone where the road is planned to be built. This data can then be taken to other forums, where the Parkway discussions are occurring. David noted that there are two active lawsuits that involve entities represented on the Stewardship Council which is another reason to keep these discussions off the table in this venue.

Lisa Morzel commented that if Stewardship Council did not exist, there would be no public group overseeing the site. This forum is an opportunity for people to be able to bring up issues and discuss them in a fact-based manner. She emphasized the importance of trying to speak as one voice and being clear about a message. She said she hopes that public oversight never ends.

Jeannette Hillery said she said she was living in New York when Love Canal happened, and has always felt that one of biggest issues going forward at Rocky Flats is the need for multiple layers of control. She said that future generations need to understand exactly what went on at Rocky Flats, and that public education and understanding are extremely important. She added that the Stewardship Council has been a good venue in which to discuss thorny issues how important is was to be good stewards of the site.

Joe Cirelli asked why the Mound and Fernald sites did not establish local stakeholder organizations (LSOs). David Abelson said that at Fernald, local governments were not engaged on site issue, and instead left the issues to a citizen advisory board. At Mound, there was a very powerful mayor who entered the process. The participants were mostly interested in re-development and Mound is now a private site. DOE has very small role left. The communities at these sites were not asked if they wanted form LSO's, but were included in the legislation anyway. Both rejected forming LSOs.

Briefing on the history of Rocky Flats

Scott Surovchak gave an overview of the site that included several historical photos. He said Rocky Flats is situated on a series of mesas created by erosion from the mountains. During the production era, Rocky Flats produced variety of components, not only nuclear. It was fundamentally a state-of-the-art machining shop. Workers used gloveboxes with carefully controlled environments in which to fabricate these components. The site was split into a plutonium side and a uranium side. Plutonium work took place in the 700 area. Uranium, stainless steel, and beryllium were used in the 400 and 800 areas. Administrative buildings were in the 100 area, with support buildings in the 200-300 areas. A security area was built around the Protected Zone in 1981. This consisted of two 12-15 foot fences, motion detectors, and guard towers.

The 903 pad area is where waste drums were stored in the 1960's, and later corroded and leaked. Most of material from Rocky Flats is now in Pit 9 in Idaho. In earlier years, scientists did not recognize the impacts of certain storage practices, and thought soil prevented movement of contaminants.

The Rocky Flats closure project was defined in the 1996 Rocky Flats Cleanup Agreement (RFCA). At the time, the plan was a fairly controversial and unique way to manage nuclear cleanup process. The primary structure was a consultative process with the regulators – the EPA and the Colorado Department of Public Health and Environment (CDPHE). The cleanup took 10 years and $7 billion. Physical completion occurred in October 2005. The cleanup encompassed 385 acres, and 800 buildings and structures, including what was called the 'most dangerous building in America'. 21 tons of weapons grade material was shipped to other sites and 100 metric tons of plutonium residues were dispositioned. Of 421 potentially contaminated sites, 121 required remediation.

50 picocuries per gram (pCi/g) was set as the standard for the top three feet of soil. However, the majority of site was cleaned to below 7 pCi/g. Scott noted that some plutonium and americium contamination was fixed and left in place in two building foundations, and some process piping was filled with grout and left in place. This was all deeper than six feet below ground. 275,000 cubic meters of radioactive waste was also disposed. Approximately 600,000 property items were dispositioned by transfer, sale, donation or disposal as contaminated waste, all of which was huge logistical challenge. Materials were sent to a number of facilities around the country. 15,000 cubic meters of transuranic waste was shipped to the Waste Isolation Pilot Plant in New Mexico, consisting primarily of personal protective equipment.

Physical completion of cleanup meant that all buildings were removed with the exception of two vehicle inspection sheds. All Individual Hazardous Substance Sites (IHSS's) were dispositioned according to RFCA. Soil removal was completed where needed. Two landfills were closed with engineered covers and monitoring wells. Four groundwater treatment systems were built to remove contaminant loading to surface water, and there is continued evaluation of groundwater and surface water through the RFCA sampling network. Building 881, located 40 feet below grade, was found to be clean. At building 771, which was built into a mesa for bomb protection, workers fixed contamination in place. Hazards at the surface are the most difficult to control and present highest risk to human health and the environment. Drawings are available that show what was left and at what depths. DOE-LM has, and will continue to have, an ongoing presence at the site.

Regulatory completion involved the remedy selected in the CAD/ROD. This established two Operable Units (OUs) at the site. The Central Operable Unit (COU) consists of 1309 acres encompassing all of the areas requiring institutional controls and ongoing maintenance. The Peripheral Operable Unit (POU) was 4,000 acres of essentially uncontaminated former buffer area lands. EPA determined that the POU met unrestricted use/unlimited exposure conditions and delisted it from the National Priorities List (NPL). This means that there are no more requirements for monitoring, access controls, or maintenance. These 4,000 acres were transferred to the U.S. Fish and Wildlife Service (USFWS) and became the Rocky Flats National Wildlife Refuge. DOE has a responsibility for an additional 945 acres of POU land on the west side of the site. Because of mineral rights issues, this land was not suitable for the Refuge.

The remedy for the COU is intended to protect surface water quality based on Colorado Water Quality Control Commission standards for all surface water use classifications. It also serves to protect human health and the environment by controlling potential exposure pathways. Activities include monitoring, maintenance, and evaluation reporting. Institutional controls prohibit groundwater and surface water use, soil disturbance, damage to remedy components, and public access. DOE is also responsible for post-closure care for landfills, groundwater treatment systems, and performing CERCLA five year reviews.

The primary regulatory oversight of the CERCLA remedy is codified through the Rocky Flats Legacy Management Agreement (RFLMA). The Rocky Flats Site Operations Guide is the how-to operations guide for activities at the site. DOE-LM also maintains community and public interaction, such as the Stewardship Council, public meetings, contact records to document the consultative process, annual and quarterly reports, periodic non-RFLMA reporting and notification, and a public website.

Routine groundwater and surface water monitoring are performed in accordance with RFLMA. There are 97 groundwater wells onsite. At the Original Landfill (OLF), which was built onto a hillside, ongoing issues include hill stability, slumps, seeping, monitoring inclinometers, and maintaining wells. Other actions across the site include erosion controls and monitoring. Site management includes road maintenance and weed control. Ecological activities include revegetation and wetland mitigation, and monitoring and reporting on critical habitats, such as the Preble's Meadow Jumping Mouse. Scott noted that the site has breached seven dams so far. Murph Widdowfield asked how many dams were left and what the purpose was for breaching. Scott said the dams were no longer needed for runoff control and containment of potential accidental contamination. Three terminal dams are left, as well as remnants of the Present Landfill dam. He added that there are new compliance monitoring points on both creeks.

Deb Gardner asked where to find the map showing what left is below grade. Scott said it was in RFLMA and also on website (Figures 3 & 4). Vera Moritz (EPA) mentioned a meeting taking place that afternoon to discuss the Adaptive Management Plan (AMP). She said they have large maps posted at the DOE office if anyone wanted to see them. Shelley Cook asked about the 3-6 foot depth requirement for buried contamination and whether they need to maintain that depth. She also wondered whether soil that came in contact with fixed contamination could then migrate and re-surface. Scott said although they were required to clean to a three-foot depth, when doing the actual cleanup, they kept going until they got as much contaminated soil as possible. They actually found very little contamination as they went deeper into the soil. He said they do watch for erosion, subsidence, or any kind of earth movement. If something is found, they cover it back up. This is part of routine site inspection and maintenance; however they have not seen any significant problems to date. Tim Plass asked if there was any specific plan to historically record the site with photographs. Scott said they did do this and these photos could be found on the website. Tim also asked if there were any real surprises found during closure. Scott said the biggest surprise was when americium from Building 771 infrastructure lines migrated into North Walnut Creek and required a treatment system. He said another revelation was that the contamination found beneath the buildings was not nearly as bad as some expected and was quite insignificant. Joe Cirelli asked what types of mineral rights were found on the POU lands retained by DOE. Scott said it was primarily shallow aggregate, such as sand, gravel, and clay. David Allen requested that Scott post his presentation and notify the Board when it was up. Scott said he would.

<u>Adaptive Management Plan (AMP) monitoring update</u>

Rick DiSalvo, Assistant Project Manager and Environmental Compliance Lead, provided an update on Adaptive Management Plan monitoring. The AMP was created as part of the Surface Water Configuration Environmental Assessment (EA). The EA evaluated the impact of removing these water control structures. The site proposed removing the structures, such as dams, because there was significantly less water onsite to manage after closure than there was prior to closure. Previously a huge amount of water was brought in and used onsite. The EA evaluated the proposed action to breach the remaining retention pond dams (A-3 and PLF 2012, A-4. B-5, C-2). The EA resulted in a Finding of No Significant Impact (FONSI). The site plans to operate the dams in a flow-through configuration until they are breached.

The AMP is a monitoring and data evaluation program to assist in deciding to implement the proposed action for the terminal ponds in 2018-2020 timeframe or delay in order to gather additional data. All AMP activities are in addition to the mitigating actions included in EA, and was created to address the concerns of downstream communities. Mitigating actions in the EA include:

- RFLMA monitoring and reporting;
- protecting wildlife, birds and threatened and endangered species;
- erosion controls and revegetation plans;
- wetlands replacement and enhancement; and
- protective actions during construction (drain water to lower levels to increase potential habitat prior to breaching; dust control during construction; and complying with nationwide dredge and fill permit and construction stormwater permit).

The AMP was developed through a cooperative public process and involves regular public meetings with the community. These activities were incorporated as requirements of the EA.

Deb Gardner asked if the site monitors sediments. Rick said this was not in the AMP. He said that sediments in the ponds were characterized during cleanup and closure, and any needed cleanup was done at that time. Rick presented a map showing the monitoring points for RFLMA, non-RFLMA and AMP (Points of Compliance, Points of Evaluation, Areas of Concern, etc). The site has concluded that removal of the dams would not negatively affect water quality leaving the site; however the AMP process is delving into more detail about this question. The AMP is posted on the Rocky Flats website.

The AMP utilizes a dynamic, cooperative process to implement and revise if needed. It will be reviewed every two years. Routine AMP reporting includes data exchange and email notifications for sample collection and results. It also calls for a 14-day turnaround time for Point of Compliance (POC) samples. All results are posted to the GEMS system. There are quarterly summary reports, as well as annual status reports. The initial annual report was posted to the Rocky Flats website in February, 2012, and a meeting was scheduled later that day to discuss the report.

Per the AMP, monitoring results are evaluated in relation to the objective. These types of monitoring and their objectives include the following:

- Pre-discharge – water quality standards at POC's met
- Targeted groundwater (area of concern wells) – no indication plumes discharging to surface water
- Flow-through operations – water quality comparable to batch release results.
- Storm event – measurable variability; no increase in Pu, Am, TSS; uranium both increases and decreases (very soluble in water)

- Continuous flow paced sampling- significant variability in uranium, but well below standard at locations nearest site boundary; all other locations below EPA's maximum concentration limit for drinking water
- Grab sampling North and South Walnut Creeks
  - Uranium – noticeable spatial variation in average concentration upstream to downstream
  - Nitrate (N) – spatial variation upstream, natural biodegradation apparent downstream; SPPTS had small load impact on North Walnut Creek

David Allen asked about the status of reportable americium concentrations at GS10. Rick said that these results had triggered consultation with the regulators, and that they were still in process of evaluating the situation. The levels have remained a reportable condition. However, although americium decays into plutonium, the samples are not yet showing elevated plutonium. He said that the latest sample was below the standard, making 5-6 samples above the standard and 2-3 below since the initial exceedance.

Public comment

None

Updates/Big Picture Review

June 4, 2012

Potential Business Items

- Receive RFSC 2011 Audit

Potential Briefing Items

- Solar ponds performance (move to September or November)
- NRD update
- DOE quarterly update
- Continue overview of cleanup
- Actinide migration review

September 10, 2012 (second Monday)

Potential Business Items

- Initial review of 2013 budget
- Initial review of 2013 work plan

Potential Briefing Items

- DOE Quarterly update
- Regulatory overview
- Original landfill performance
- Update on CERCLA 5-year review

Issues to watch:

Americium and uranium levels upstream of pond B-3
Revegetation efforts (especially if drought-like conditions continue)
Adaptive Management Plan water quality testing results

Member Updates

Ann Lockhart announced that the Rocky Flats Cold War Museum Board voted to delay the Museum opening until 2013. She said there were still many things they needed to take care of, including fundraising. She added that the Stewardship Council was welcome to tour the building at any time.

The meeting was adjourned at 11:35 a.m.

Respectfully submitted by Erin Rogers.

Rocky Flats Stewardship Council
Check Detail
March 22 through May 21, 2012

Type	Num	Date	Name	Account	Paid Amount	Original Amount
Check		**3/27/2012**		**CASH-Wells Fargo-Operating**		**-3.50**
				Admin Services-Misc Services	-3.50	3.50
TOTAL					-3.50	3.50
Check	**1548**	**4/3/2012**	**Century Link**	**CASH-Wells Fargo-Operating**		**-26.52**
				Telecommunications	-26.52	26.52
TOTAL					-26.52	26.52
Bill Pmt...	**1549**	**4/3/2012**	**HUB SW**	**CASH-Wells Fargo-Operating**		**-2,856.19**
Bill	APP2...	3/21/2012		Insurance	-2,856.19	2,856.19
TOTAL					-2,856.19	2,856.19
Bill Pmt...	**1550**	**4/3/2012**	**Jennifer A. Bohn**	**CASH-Wells Fargo-Operating**		**-425.00**
Bill	12-25	3/31/2012		Accounting Fees	-425.00	425.00
TOTAL					-425.00	425.00
Bill Pmt...	**1551**	**4/3/2012**	**The Rogers Group, LLC**	**CASH-Wells Fargo-Operating**		**-525.00**
Bill	3/18/...	3/18/2012		Personnel - Contract	-525.00	525.00
TOTAL					-525.00	525.00
Bill Pmt...	**1552**	**4/12/2012**	**Blue Sky Bistro**	**CASH-Wells Fargo-Operating**		**-195.85**
Bill	943	4/2/2012		Misc Expense-Local Government	-195.85	195.85
TOTAL					-195.85	195.85
Bill Pmt...	**1553**	**4/12/2012**	**Crescent Strategies, LLC**	**CASH-Wells Fargo-Operating**		**-7,503.80**
Bill	3/31/...	3/31/2012		Personnel - Contract	-6,850.00	6,850.00
				Telecommunications	-143.85	143.85
				TRAVEL-Local	-36.21	36.21
				Postage	-215.99	215.99
				Printing	-257.75	257.75
TOTAL					-7,503.80	7,503.80
Bill Pmt...	**1554**	**4/12/2012**	**Seter & Vander Wall, P.C.**	**CASH-Wells Fargo-Operating**		**-1,241.70**
Bill	63016	3/31/2012		Attorney Fees	-1,241.70	1,241.70
TOTAL					-1,241.70	1,241.70
Bill Pmt...	**1555**	**5/3/2012**	**Crescent Strategies, LLC**	**CASH-Wells Fargo-Operating**		**-7,755.81**
Bill	4/30/...	4/30/2012		Personnel - Contract	-6,850.00	6,850.00
				Telecommunications	-140.85	140.85
				TRAVEL-Local	-90.47	90.47
				Postage	-15.99	15.99
				TRAVEL-Out of State	-658.50	658.50
TOTAL					-7,755.81	7,755.81
Bill Pmt...	**1556**	**5/3/2012**	**Jennifer A. Bohn**	**CASH-Wells Fargo-Operating**		**-663.00**
Bill	12-30	4/30/2012		Accounting Fees	-663.00	663.00

Rocky Flats Stewardship Council
Check Detail
March 22 through May 21, 2012

Type	Num	Date	Name	Account	Paid Amount	Original Amount
TOTAL					-663.00	663.00
Bill Pmt...	**1557**	**5/3/2012**	**The Rogers Group, LLC**	**CASH-Wells Fargo-Operating**		**-450.00**
Bill	5/2/1...	4/30/2012		Personnel - Contract	-450.00	450.00
TOTAL					-450.00	450.00
Check	**1558**	**5/3/2012**	**Century Link**	**CASH-Wells Fargo-Operating**		**-27.57**
				Telecommunications	-27.57	27.57
TOTAL					-27.57	27.57

ROCKY FLATS STEWARDSHIP COUNCIL

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MEMORANDUM

TO: Board
FROM: David Abelson
SUBJECT: 2011 Financial Audit
DATE: May 23, 2012

Attached for your review is Wagner and Barnes' draft 2011 financial audit of the Rocky Flats Stewardship Council. As he has done in past years, Eric Barnes will present and discuss the audit at the meeting, and will be prepared to answer any questions. He and his staff did not find any material deficiencies, and issued a clean audit.

Neither state law nor our grant with DOE requires the Stewardship Council to seek an audit. However, an independent audit is an important check that ensures that both the board and staff are managing the finances in accordance with applicable laws and regulations.

The Stewardship Council will need to formally accept the audit at the meeting. If you have any questions for Eric prior to the meeting, please email me your questions and I will forward them to him.

Action Item: Approve motion accepting Stewardship Council's 2011 audit.

APR/19/2012

Rocky Flats Stewardship Council

FINANCIAL STATEMENTS

With Independent Auditors' Report

December 31, 2011

Rocky Flats Stewardship Council

BASIC FINANCIAL STATEMENTS

December 31, 2011

Independent Auditors' Report

Board of Directors
Rocky Flats Stewardship Council
Boulder, Colorado

We have audited the accompanying financial statements of the governmental activities and the general fund of Rocky Flats Stewardship Council, as of December 31, 2011, which collectively comprise the Council's basic financial statements as listed in the table of contents. These financial statements are the responsibility of the Council's management. Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with auditing standards generally accepted in the United States of America. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatements. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

In our opinion, the financial statements referred to above present fairly, in all material respects, the respective financial position of the governmental activities and the general fund of Rocky Flats Stewardship Council, as of December 31, 2011, and the respective changes in financial position thereof, and the budgetary comparison for the general fund for the period ending December 31, 2011 in conformity with accounting principles generally accepted in the United States of America.

Management has omitted management's discussion and analysis that accounting principles generally accepted in the United States of America require to be presented to supplement the basic financial statements. Such missing information, although not a part of the basic financial statements, is required by the Governmental Accounting Standards Board, who considers it to be an essential part of financial reporting for placing the basic financial statements in an appropriate operational, economic, or historical context. Our opinion on the basic financial statements is not affected by this missing information.

Lakewood, Colorado
April XX, 2012

Rocky Flats Stewardship Council

STATEMENT OF NET ASSETS

December 31, 2011

	Governmental Activities
Assets	
Cash and cash equivalents	$ 146,823
Total assets	146,823
Liabilities	
Accounts payable	9,454
Accrued liabilities	550
Deferred grant revenue	5,510
Total liabilities	15,514
Net assets	
Restricted for grant expenditures	5,510
Unrestricted	125,799
Total net assets	$ 131,309

The accompanying Notes to Financial Statements are an integral part of these statements.

Rocky Flats Stewardship Council

STATEMENT OF ACTIVITIES

For the year ended December 31, 2011

Functions/Programs:	Expenses	Program Revenues: Net Charges for Services	Program Revenues: Operating Grants and Contributions	Program Revenues: Capital Grants and Contributions	Net (Expense) Revenue and Changes in Net Assets: Governmental Activities
Primary government	$ (122,873)	$ -	$ 129,893	$ -	$ 7,020
Total primary government	$ (122,873)	$ -	$ 129,893	$ -	7,020
		General revenues:			
		Interest Income			75
		Total general revenues			75
		Change in net assets			7,095
		Net assets - beginning			124,214
		Net assets - ending			$ 131,309

DRAFT

The accompanying Notes to Financial Statements are an integral part of these statements.

Rocky Flats Stewardship Council

BALANCE SHEET - GOVERNMENTAL FUNDS

December 31, 2011

	General Fund
Assets	
Cash and cash equivalents	$ 146,823
Total assets	146,823
Liabilities	
Accounts payable	9,454
Accrued liabilities	550
Deferred grant revenue	5,510
Total liabilities	15,514
Fund balance	
Restricted for:	
Grant expenditures	5,510
Unassigned:	
General government	125,799
Total fund balance	131,309
Total liabilities and fund balance	$ 146,823

Amounts reported for governmental activities in the Statement of Net Assets are the same as above.

The accompanying Notes to Financial Statements are an integral part of these statements.

Rocky Flats Stewardship Council

STATEMENT OF REVENUES, EXPENDITURES, AND CHANGES IN FUND BALANCE - GOVERNMENTAL FUNDS

For the year ended December 31, 2011

	Total General Fund and Governmental Funds
Revenues	
Grants	$ 121,893
Contributions from local governments	8,000
Interest Income	75
Total revenues	129,968
Expenditures	
General government	
Annual Audit	4,148
Accounting Fees	5,347
Attorney Fees	13,249
Administrative Service - miscellaneous	900
Insurance	3,459
Miscellaneous Expense- local government	979
Personnel- contract	84,950
Postage	1,032
Printing	1,098
Subscriptions/membership dues	950
Supplies	461
Telecommunications	1,988
Website	619
Travel - local	867
Travel - out of state	2,826
Total expenditures	122,873
Net change in fund balance	7,095
Fund balances - beginning	124,214
Fund balances - ending	$ 131,309

DRAFT

Amounts reported for governmental activities in the Statement of Net Assets are the same as above.

The accompanying Notes to Financial Statements are an integral part of these statements.

Rocky Flats Stewardship Council

STATEMENT OF REVENUES, EXPENDITURES, AND CHANGES IN FUND BALANCES - BUDGET AND ACTUAL - GENERAL FUND

For the year ending December 31, 2011

	Original and Final Budgeted Amounts	Actual	Variance with Final Budget - Favorable (Unfavorable)
Revenues			
U.S. Department of Energy - Office of Legacy Management	$ 125,000	$ 121,893	$ (3,107)
Contributions from local governments	8,000	8,000	-
Investment earnings	-	75	75
Total revenues	133,000	129,968	(3,032)
Expenditures			
General government			
Personnel	93,000	84,950	8,050
Travel	5,700	3,693	2,007
Equipment	500	-	500
Supplies	1,200	461	739
Contractual	40,100	24,623	15,477
Insurance	4,000	3,459	541
Postage	1,500	1,032	468
Printing	2,000	1,098	902
Subscriptions/membership dues	2,350	950	1,400
Telecommunications	3,400	1,988	1,412
Website	3,000	619	2,381
Total expenditures	156,750	122,873	33,877
Net change in fund balance	(23,750)	7,095	30,845
Fund balances - beginning	117,485	124,214	6,729
Fund balances - ending	$ 93,735	$ 131,309	$ 37,574

The accompanying Notes to Financial Statements are an integral part of these statements.

Rocky Flats Stewardship Council

NOTES TO FINANCIAL STATEMENTS

December 31, 2011

Note 1 – Summary of significant accounting policies

A. Reporting entity

The Rocky Flats Stewardship Council (Council) was organized on February 13, 2006 through an Intergovernmental Agreement (IGA) by and among the following governments: the City and County of Broomfield, the Counties of Jefferson and Boulder, the Cities of Arvada, Boulder, Golden, Northglenn and Westminster, and the Town of Superior. All jurisdictions are located adjacent to or near the U.S. Department of Energy's Rocky Flats weapons plant. The Cities of Golden and Northglenn are rotating parties, and annually alternate representation on the Council's Board of Directors. All other jurisdictions are permanent parties, with continuous representation on the Board of Directors. The Council was organized as the successor organization to the Rocky Flats Coalition of Local Governments (Coalition), also formed through an IGA, which concluded its existence shortly following the organization of the Council, having fulfilled its purpose in connection with the closure of the Rocky Flats Site.

The Council was formed for the purpose of overseeing all post-closure Rocky Flats activities. The legislative and administrative power of the Council is vested with a Board of Directors not to exceed twelve in number, one representing each of the seven Permanent Parties, one representing one of the Rotating Parties, and one representing up to four Members, each with one equal vote. Members are community stakeholder representatives, selected by the remaining Board of Directors upon application, and have a right to appoint a Director to the Board.

Under the terms of the IGA, the status of the Council is to be reviewed periodically by the local governments which are parties to the agreements to determine whether the Council will continue in existence. Also under the terms of the IGA, the Council is established as an "enterprise", as defined by Article X, Section 20 of the Colorado constitution, commonly referred to as the Taxpayer's Bill of Rights, or Tabor (Note 5).

The Council follows the Governmental Accounting Standards Board (GASB) accounting pronouncements which provide guidance for determining which governmental activities, organizations and functions should be included within the financial reporting entity. GASB pronouncements set forth the financial accountability of a governmental organization's elected governing body as the basic criterion for including a possible component governmental organization in a primary government's legal entity. Financial accountability includes, but is not limited to, appointment of a voting majority of the organization's governing body, ability to impose its will on the organization, a potential for the organization to provide specific financial benefits or burdens and fiscal dependency.

As of December 31, 2011, no component unit has been identified as reportable to the Council, nor is the Council a component unit of any other primary governmental entity.

B. Government-wide and fund financial statements

The government-wide financial statements include the statement of net assets and the statement of activities. These financial statements include all of the activities of the Council. Both statements distinguish between governmental activities, which normally are supported by taxes and intergovernmental revenues, and business-type activities, which rely to a significant extent on fees and charges for support.

The statement of net assets reports all financial and capital resources of the Council. The difference between the assets and liabilities of the Council is reported as net assets.

The statement of activities demonstrates the degree to which the direct expenses of a given function or segment is offset by program revenues. Direct expenses are those that are clearly identifiable with a specific function or segment. Program revenues include 1) charges to customers or applicants who purchase, use, or directly benefit from goods, services or privileges provided by a given function or segment, and 2) grants and contributions that are restricted to meeting the operational or capital requirements of a particular function or segment. Taxes and other items not properly included among program revenues are reported instead as general revenues.

C. Measurement focus, basis of accounting and financial statement presentation

The government-wide financial statements are reported using the *economic resources measurement focus* and the *accrual basis of accounting*. Revenues are recorded when earned and expenses are recorded when a liability is incurred, regardless of the timing of related cash flows.

Governmental fund financial statements are reported using the *current financial resources measurement focus* and the *modified accrual basis of accounting*. Revenues are recognized as soon as they are both measurable and available. Revenues are considered to be available when they are collectible within the current period or soon enough thereafter to pay liabilities of the current period. For this purpose, the government considers revenues to be available if they are collected within 60 days of the end of the current fiscal period. Expenditures generally are recorded when a liability is incurred, as under accrual accounting.

Eligible grant receipts and interest associated with the current fiscal period are all considered to be susceptible to accrual and so have been recognized as revenues of the current fiscal period. Other revenue items are considered to be measurable and available only when the Council receives cash.

The government reports the following major governmental fund:

> *The general fund* is the Council's primary operating fund.
> It accounts for all financial resources of the general government.

When both restricted and unrestricted resources are available for use, it is the Council's policy to use restricted resources first, then unrestricted resources as they are needed.

D. Use of estimates

The preparation of financial statements in conformity with accounting principles generally accepted in the United States of America requires Council management to make estimates and assumptions that affect the reported amounts of assets and liabilities and disclosure of contingent assets and liabilities at the date of the financial statements and the reported amounts of revenues and expenditures during the reporting period. Actual results could differ from those estimates.

E. Assets, liabilities, and net assets

1. Deposits and investments

The Council's cash and cash equivalents are considered to be cash on hand, demand deposits and short-term investments with maturities of three months or less.

Investments for the government are reported at fair value.

2. Capital assets

Capital assets, which include furniture and equipment, are reported in the government-wide financial statements. Capital assets are defined by the Council as assets with an initial, individual cost of more than $250. Such assets are recorded at historical cost if purchased or constructed. Donated capital assets are recorded at estimated fair market value at the date of donation.

The cost of normal maintenance and repairs that do not add to the value of the asset or materially extend the life of the asset are not capitalized. Improvements are capitalized and depreciated over the remaining useful lives of the related fixed assets, as applicable. Depreciation expense has been computed using the straight-line method for all assets, based on the estimated useful lives of the assets, estimated at 3 years.

3. Fund equity

Beginning with fiscal year 2011 the Council implemented GASB Statement No. 54, "Fund Balance Reporting and Governmental Fund Type Definitions." This statement provides more clearly defined fund balance categories to make the nature and extent of the constraints placed on a government's fund balances more transparent. In the fund financial statements the following classifications describe the relative strength of the spending constraints.

Restricted fund balance – The portion of fund balance constrained to being used for a specific purpose by external parties (such as grantors or bondholders), constitutional provisions or enabling legislation.

Unassigned fund balance – The residual portion of fund balance that does not meet any of the above or any other fund balance reporting criteria.

If more than one classification of fund balance is available for use when an expenditure is incurred, it is the Council's policy to use the most restrictive classification first.

At December 31, 2011, the Council had $5,510 restricted by grantors (for expenses connected with monitoring of post-closure Rocky Flats activities – see Note 1A. above).

The remaining fund balance is considered by the Council to be unassigned. At December 31, 2011, the Council had an unassigned fund balance in the general fund of $125,799.

F. Budgetary information

Annual budgets are adopted on a basis consistent with generally accepted accounting principles for all governmental funds. In accordance with the Colorado State Budget Law, the Council's Board of Directors follows these procedures in establishing the budgetary data reflected in the financial statements:

1. On or before October 15, the Board prepares a proposed operating budget for each fund, based on their respective basis of accounting, for the fiscal year commencing the following January 1. The operating budget includes proposed expenditures and the means of financing them.
2. After considering comments received, the Board approves the budget. The budget is formally adopted by resolution, published, and filed with the state.
3. Before December 31, the expenditures are appropriated for the ensuing year. The appropriation is at the total fund level and lapses at year-end.

Note 2 – <u>Cash and Investments</u>

Cash and investments as of December 31, 2011 are classified in the accompanying statements as follows:

Statement of net assets:	
Cash and cash equivalents	$146,823

<u>Deposits with Financial Institutions</u>

Colorado statutes require that the Council use eligible public depositories as defined by the Colorado Public Deposit Protection Act (the Act). Under the Act, amounts on deposit in excess of federal insurance levels must be collateralized. The eligible collateral is determined by the Act and allows the institution to create a single collateral pool for all public funds. The pool is to be maintained by another institution or held in trust for all the uninsured public deposits as a group. The market value of the collateral must be at least equal to 102% of the aggregate uninsured deposits.

The State Regulatory Commissions for banks and financial services are required by Statute to monitor the naming of eligible depositories and reporting of the uninsured deposits and assets maintained in the collateral pools.

At December 31, 2011, all of the Council's deposits were covered by insurance provided by the federal government. The Council was not subject to custodial credit risk at December 31, 2011.

The Council's cash deposits at December 31, 2011 are as follows:

	Carrying Balance	Bank Balance
Deposits with financial institutions	$146,823	$ 147,138
Total cash and cash equivalents	$146,823	$ 147,138

<u>Investments</u>

The Council has not adopted a formal investment policy, however, the Council follows state statutes regarding investments. Colorado revised statutes limit investment maturities to five years or less unless formally approved by the Board of Directors. Such actions are generally associated with a debt service reserve or sinking fund requirements.

Colorado statutes specify investment instruments meeting defined rating and risk criteria in which local governments may invest which include:

- Obligations of the United States and certain U.S. government agencies securities
- Certain international agency securities
- General obligation and revenue bonds of U.S. local government entities
- Bankers' acceptance of certain banks
- Commercial paper
- Local government investment pools
- Guaranteed investment contracts
- Written repurchase agreements collateralized by certain authorized securities
- Certain money market funds

As of December 31, 2011, the Council had no investments.

Note 3 – Capital Assets

An analysis of the changes in capital assets for the year ended December 31, 2011 follows:

	Balance 12/31/10	Additions	Deletions	Balance 12/31/11
Capital assets being depreciated:				
Furniture and equipment	$ 398	$ -	$ -	$ 398
Total capital assets	398	-	-	-
Accumulated depreciation	(398)	-	-	(398)
Capital assets, net	$ -	$ -	$ -	$ -

Note 4 – Net assets

The Council has net assets consisting of three components – invested in capital assets, restricted, and unrestricted.

Invested in capital assets consists of capital assets, net of depreciation. As of December 31, 2011, the Council had $0 invested in capital assets.

Restricted assets include net assets that are restricted for use either externally imposed by creditors, grantors, contributors, or laws and regulations of other governments or imposed by law through constitutional provisions or enabling legislation. As of December 31, 2011, the Council had $5,510 of restricted net assets.

As of December 31, 2011, the Council had unrestricted net assets of $125,799.

Note 5 - Risk management

The Council is exposed to various risks of loss related to torts, thefts of, damage to, or destruction of assets, errors or omissions, injuries to personnel, or natural disasters. The Council maintains commercial insurance for all risks of loss. Settled claims have not exceeded the commercial insurance coverage limits in any of the past three years.

Note 6 - Tax, spending and debt limitation

Article X, Section 20 of the Colorado Constitution, referred to as the Taxpayer's Bill of Rights (TABOR), contains tax, spending, revenue, and debt limitations which apply to the State of Colorado and all local governments.

Spending and revenue limits are determined based on the prior year's Fiscal Year Spending adjusted for allowable increases based upon inflation and local growth. Fiscal Year Spending is generally defined as expenditures plus reserve increases with certain exceptions. Revenue in excess of the Fiscal Year Spending limit must be refunded unless the voters approve retention of such revenue.

As an enterprise (Note 1), management believes that the Council is exempt from the provisions of TABOR. However, TABOR is complex and subject to interpretation. Ultimate implementation may depend upon litigation and legislative guidance.

*****

DOE Annual Report

- Cover memo
- Part of annual report – table of contents and executive summary

ROCKY FLATS STEWARDSHIP COUNCIL

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Jefferson County -- Boulder County -- City and County of Broomfield -- City of Arvada -- City of Boulder
City of Golden -- City of Northglenn -- City of Thornton -- City of Westminster -- Town of Superior
League of Women Voters -- Rocky Flats Cold War Museum -- Rocky Flats Homesteaders
Arthur Widdowfield

MEMORANDUM

TO: Stewardship Council Board
FROM: Rik Getty
SUBJECT: DOE Annual Report Briefing
DATE: May 23, 2012

We have scheduled seventy-five minutes for DOE to present its 2011 annual report update. The report, which is very detailed and lengthy (over 673 pages), can be found at: http://www.lm.doe.gov/Rocky_Flats/Documents.aspx The table of contents and executive summary are attached.

DOE will brief on the following topics in a format similar to past quarterly and annual report updates:

- surface water monitoring;
- groundwater monitoring;
- ecological monitoring; and,
- site operations (inspections, pond operations, security, general maintenance, etc.).

DOE will also provide a short update on the status of the 2012 CERCLA 5-year review.

Key issues from the report
The following are key items of note from the report: (quoting in part from the report)

1. Original Landfill (OLF)
   a. Monitoring of the inclinometers showed deflection, indicating localized movement. Minor localized surface cracking due to localized minor slumping was also observed. DOE believes continued monitoring and routine maintenance are currently adequate to address surface cracking.
   b. Surface-water monitoring at the OLF showed two analytes above the applicable standards for individual sample results. The concentrations did not recur, and RFLMA consultation was not required.
   c. Boron in all three downgradient OLF Resource Conservation and Recovery Act (RCRA) wells, and uranium in one of these wells, was statistically higher than

concentrations in upgradient groundwater wells. Boron concentrations are consistent with 2010 results. None are on an increasing trend.

2. Present Landfill (PLF)
    a. Water monitoring at the Present Landfill Treatment System (PLFTS) showed two analytes above the applicable standards for individual sample results. The concentrations did not recur, and RFLMA consultation was not required.
    b. Boron in groundwater samples from one of the downgradient PLF RCRA wells, and chromium and selenium in samples from another well, were both statistically higher than in upgradient groundwater wells. All are on an increasing trend. The boron concentrations are consistent with 2010 results.

3. Surface water
    a. All surface-water Points of Compliance showed acceptable water quality for the entire year.
    b. Modifications to surface-water and groundwater monitoring locations specified in RFLMA Attachment 2 were approved by CDPHE and EPA, and implemented in 2011.
    c. Surface-water flow volumes continue to show reductions from pre-closure volumes. (Reductions are a result of land configuration changes and removal of impervious surfaces such as parking lots.)

4. Plutonium and uranium exceedances
    a. Plutonium (Pu)—the 12-month rolling average exceeded the applicable standard at surface water monitoring point, SW027. SW027, which is a point of evaluation monitoring station, is located on the South Interceptor Ditch, upstream of Pond C-2 on Woman Creek. SW027 has flowed very little since 2010, and no new analytical data have been collected. As of April 30, 2011, the 12-month rolling average for Pu is no longer reportable at SW027.
    b. Uranium (U)—the 12-month rolling average exceeded the applicable standard at surface water monitoring point GS10. GS10, which is a point of evaluation monitoring station, is located on South Walnut Creek upstream of former Pond B-1. As of the end of 2011, the condition remains reportable.
    c. Americium (Am)—the 12-month rolling average exceeded the applicable standard at GS10. As of the end of 2011, the condition remains reportable.
    d. All other POE analyte concentrations remained below reporting levels throughout 2011.

5. Groundwater plume treatment systems
    a. Effluent testing at the Mound Site Plume Treatment System (MSPTS) and East Trenches Plume Treatment System continue to demonstrate the vast majority of contaminants have been removed. However, concentrations of some volatile organic compounds in the system effluent exceeded target concentrations.
    b. Phase II and Phase III upgrades to the Solar Ponds Plume Treatment System (SPPTS) were completed in May 2009. Concentrations of nitrate and uranium measured at the effluent discharge gallery along North Walnut Creek have sharply

decreased since closure in 2006, demonstrating the overall improvement resulting from the phased upgrades installed since 2008.

c. At the SPPTS, the uranium treatment system is not performing adequately even with the large decrease in uranium concentration observed at the discharge gallery; alternative approaches to uranium treatment were identified and are now being tested.
d. Increased sampling of SPPTS and North Walnut Creek locations continued to support various evaluations, including increasing uranium concentrations in the groundwater entering the treatment system compared to past concentration levels.
e. At the SPPTS, Phase III pilot-scale nitrate treatment studies were completed in 2011. According to the report, "Full-scale design based on the Phase III components is not practical; alternative approaches to nitrate treatment are being finalized."
f. Elevated nitrate concentrations in groundwater that led to the reportable condition at Area of Concern well B206989 (located east of the Landfill Pond dam) in 2007 did not continue into 2011. Concentrations of nitrate reported in 2011 were below the 10 milligrams per liter standard.

6. <u>Revegetation</u>
    a. Monitoring data continue to show that grassland species are taking hold at the site. Several locations met success criteria this year.

Please contact me if you have any questions.

LMS/RFS/S08568

Annual Report of Site Surveillance and Maintenance Activities at the Rocky Flats, Colorado, Site

Calendar Year 2011

April 2012

U.S. DEPARTMENT OF ENERGY | Legacy Management

Contents

Figures

Tables

The following information is available on CD or DVD at the end of this document

Available on CD:

Available on DVD:

Abbreviations

Ag	silver
Am	americium
AMP	Adaptive Management Plan
ANOVA	Analysis of Variance
AOC	Area of Concern
ASH	MSPTS Air Stripper Housing
B	boron
B	For sampling data, a laboratory and/or validation qualifier that indicates the constituent was also detected in the blank.
Be	beryllium
BMP	best management practice
CAD/ROD	Corrective Action Decision/Record of Decision
Cd	cadmium
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (also known as "Superfund")
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
CNHP	Colorado Natural Heritage Program
COU	Central Operable Unit
Cr	chromium
Cu	copper
CY	calendar year
D	For sampling data, a laboratory and/or validation qualifier that indicates analysis was performed at a dilution.
D&D	decontamination and decommissioning
DCA	dichloroethane
DCB	dichlorobenzene
DCE	dichloroethene
DER	duplicate error ratio
DOE	U.S. Department of Energy
DQA	data quality assessment
EPA	U.S. Environmental Protection Agency
ERP	*Emergency Response Plan for Rocky Flats Site Dams*
ESL	Environmental Sciences Laboratory
ETPTS	East Trenches Plume Treatment System
FC	Functional Channel
FR	*Federal Register*
ft/yr	feet per year

g	gram
GIS	geographic information system
gpm	gallons per minute
GWIS	Groundwater Intercept System
HRC	Hydrogen Release Compound
IA	Industrial Area
IC	institutional control
IHSS	Individual Hazardous Substance Site
IMP	Integrated Monitoring Plan
ITPH	Interceptor Trench Pump House
ITS	Interceptor Trench System
J	For sampling data, a laboratory and/or validation qualifier that indicates an estimated value.
K-H	Kaiser-Hill Company, LLC
L	liter
LANL	Los Alamos National Laboratory
LCS	laboratory control sample
LM	Office of Legacy Management
M&M	monitoring and maintenance
m^3	cubic meter
MDA	minimum detectable activity
M-K	Mann-Kendall
µg	microgram
µg/L	micrograms per liter
mg/L	milligrams per liter
MS	matrix spike
MSD	matrix spike duplicate
MSPTS	Mound Site Plume Treatment System
NA	not applicable
Ni	nickel
NOIPD	Notice of Intent for Partial Delete
NPL	National Priorities List
OBP	Oil Burn Pit
OLF	Original Landfill
OU	Operable Unit
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCE	tetrachloroethene
pCi	picocurie
pCi/L	picocuries per liter
pCi/µg	picocuries per microgram

PIP	Public Involvement Plan
PLF	Present Landfill
PLFTS	Present Landfill Treatment System
POC	Point of Compliance
POE	Point of Evaluation
POU	Peripheral Operable Unit
PQL	practical quantitation limit
Pu	plutonium
PU&D	Property Utilization and Disposal
QA	quality assurance
QC	quality control
R	For sampling data, a laboratory and/or validation qualifier that indicates a value rejected as unusable.
RCRA	Resource Conservation and Recovery Act
RER	relative error ratio
RFCA	*Rocky Flats Cleanup Agreement*
RFETS	Rocky Flats Environmental Technology Site
RFLMA	*Rocky Flats Legacy Management Agreement*
RFSOG	*Rocky Flats Site Operations Guide*
RMRS	Rocky Mountain Remediation Services
RPD	relative percent difference
Se	selenium
SED	Sitewide Ecological Database
SEEPro	Site Environmental Evaluation for Projects
SEP	Solar Evaporation Pond
SID	South Interceptor Ditch
S-K	Seasonal-Kendall
SPP	Solar Ponds Plume
SPPTS	Solar Ponds Plume Treatment System
STP	Sewage Treatment Plant
SVOC	semivolatile organic compound
TCA	trichloroethane
TCB	trichlorobenzene
TCE	trichloroethene
TSS	total suspended solids
U	uranium
U	For sampling data, a laboratory and/or validation qualifier that indicates an analyte not detected at the indicated concentration.
UHSU	upper hydrostratigraphic unit
USFWS	U.S. Fish and Wildlife Service

V&V	validation and verification
VC	vinyl chloride
VOC	volatile organic compound
WQP	water quality parameter
WWTP	Wastewater Treatment Plant
yr	year
Zn	zinc
ZVI	zero-valent iron

Executive Summary

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) is responsible for implementing the final response action selected in the *Final Corrective Action Decision/Record of Decision for Rocky Flats Plant (USDOE) Peripheral Operable Unit and Central Operable Unit* (CAD/ROD) issued September 29, 2006, for the Rocky Flats Site (Site).

Under the CAD/ROD, two Operable Units (OUs) were established within the boundaries of the Rocky Flats property: the Peripheral OU (POU) and the Central OU (COU). The COU consolidates all areas of the Site that require additional remedial or corrective actions while also considering practicalities of future land management. The POU includes the remaining, generally unimpacted portions of the Site and surrounds the COU. The response action in the Final CAD/ROD is no action for the POU and institutional and physical controls with continued monitoring for the COU. The CAD/ROD determined that conditions in the POU were suitable for unrestricted use. The U.S. Environmental Protection Agency (EPA) subsequently published a Notice of Partial Deletion from the National Priorities List for the POU on May 25, 2007.

DOE, EPA, and the Colorado Department of Public Health and Environment (CDPHE) have chosen to implement the monitoring and maintenance requirements of the CAD/ROD under, and as described in, the *Rocky Flats Legacy Management Agreement* (RFLMA), executed March 14, 2007. RFLMA Attachment 2 defines the COU remedy surveillance and maintenance requirements. The requirements include environmental monitoring; maintenance of the erosion controls, access controls (signs), landfill covers, and groundwater treatment systems; and operation of the groundwater treatment systems.

LM prepared the *Rocky Flats Site Operations Guide* to serve as the primary internal document to guide work performed to satisfy the requirements of RFLMA and implement best management practices at the Site.

This report addresses all surveillance and maintenance activities conducted at the Site during Calendar Year (CY) 2011 (January 1 through December 31, 2011). Highlights of the surveillance and maintenance activities are as follows:

- RFLMA references the use of contact records to document CDPHE approvals of field modifications to implement approved response actions. RFLMA Attachment 2 references the use of contact records to document the outcome of consultation related to addressing any reportable conditions. This report discusses RFLMA contact records issued in 2011 and the contact record status as of December 31, 2011.
- Monitoring of the Original Landfill (OLF) inclinometers installed in 2008 showed deflection, indicating localized movement, and minor localized surface cracking was also observed. The inclinometers were installed as part of the geotechnical investigation to address localized slumping and settling of the OLF cover observed in 2007. The annual report includes a review of the inclinometer data by a qualified geotechnical engineer. The data review concluded that the observed conditions are consistent with the geotechnical investigation findings. Continued monitoring and routine maintenance are presently considered adequate to address any observed surface cracking resulting from minor slumping due to observed localized movement.

- The biannual topographic survey of the OLF was completed in 2011 and reviewed by a qualified geotechnical engineer. Maintenance of the OLF diversion berms following the recommendations of the geotechnical engineer was performed in 2011 to maintain the required minimum berm heights.
- Modifications to surface-water and groundwater monitoring locations specified in RFLMA Attachment 2, "Legacy Management Requirements," were approved by CDPHE and EPA and implemented in 2011.
- Surface-water flow volumes continue to show expected reductions resulting from land configuration changes and removal of impervious surfaces.
- All surface-water Points of Compliance showed acceptable water quality for the entire year.
- Reportable 12-month rolling average plutonium (Pu) activities were observed starting on April 30, 2010, in surface water at RFLMA Point of Evaluation (POE) monitoring station SW027, which is located on the SID upstream of Pond C-2. SW027 has flowed very little since 2010, and no new analytical data have been collected. As of April 30, 2011, the 12-month rolling average for Pu is no longer reportable at SW027.
- Reportable 12-month rolling average uranium concentrations were observed starting on April 30, 2011, in surface water at RFLMA POE monitoring station GS10, which is located on South Walnut Creek upstream of former Pond B-1. Reportable 12-month rolling average americium (Am) activities were also observed starting on August 31, 2011. As of the end of CY 2011, both analytes were still reportable.
- All other POE analyte concentrations remained below reporting levels throughout CY 2011.
- The results of statistical evaluations of groundwater quality at the OLF and Present Landfill (PLF) were largely identical to the results of these evaluations performed in 2009.
- Water monitoring at the Present Landfill Treatment System (PLFTS) during CY 2011 showed two analytes detected above the applicable standards for individual sample results. The observed concentrations did not recur and RFLMA consultation was not required. Boron in groundwater samples from one of the downgradient PLF Resource Conservation and Recovery Act (RCRA) wells, and chromium and selenium in samples from another well, were both statistically higher in concentration than in upgradient groundwater and on increasing trends. The boron condition is consistent with 2010 results. Regulatory consultation was conducted in response to these conditions. Similar regulatory consultation was conducted in 2010.
- Surface-water monitoring for the OLF during CY 2011 showed two analytes detected above the applicable standards for individual sample results. The observed concentrations did not recur and RFLMA consultation was not required. Consistent with 2010, boron in all three downgradient OLF RCRA wells and uranium in one of these wells was determined to be present at statistically higher concentrations than in upgradient groundwater. None of these is on an increasing trend. Regulatory consultation was conducted in response to these conditions. Similar regulatory consultation was conducted in 2010.
- Analytical results for effluent from the Mound Site Plume Treatment System (MSPTS) and East Trenches Plume Treatment System continued to demonstrate the vast majority of contaminants is removed. However, concentrations of some volatile organic compounds in system effluent exceeded target concentrations. The treatment media at the MSPTS was replaced, the subsurface discharge gallery was repaired, and a test air stripper was installed

in the existing effluent manhole to polish water exiting the treatment cells. The air stripper, which operates for 12 hours per day and uses solar power, was optimized through the course of the year and will continue to be adjusted in 2012. It removes substantial residual contaminants from system effluent.

- Phase II and Phase III upgrades to the Solar Ponds Plume Treatment System (SPPTS) were completed and implemented in May 2009. Concentrations of nitrate and uranium measured at the effluent discharge gallery have sharply decreased since Site closure, demonstrating the overall improvement resulting from the phased upgrades installed since 2008. However, the Phase II uranium treatment component is not performing adequately; alternative approaches to uranium treatment were identified and are being tested in 2012. Phase III pilot-scale nitrate treatment studies were completed in 2011. Full-scale design based on the Phase III components is not practical; alternative approaches to nitrate treatment are being finalized. Increased sampling of SPPTS and North Walnut Creek locations continued to support various evaluations, including increasing uranium concentrations.
- Groundwater quality and flow at the Site were generally consistent with previous years. Statistical trending calculations indicated numerous significant concentration trends.
- Elevated nitrate concentrations in groundwater that led to the reportable condition at Area of Concern well B206989 (located east of the Landfill Pond dam) in 2007 did not continue into 2011. Concentrations of nitrate reported in 2011 were below the 10 milligrams per liter standard. A steadily decreasing trend in nitrate concentrations is evident, and it appears to have an inverse correlation to the water level in this well and a temporal correlation to changes in sampling methods.
- All RFLMA-required ecological data collection, analysis, and reporting were completed as scheduled.
- Revegetation monitoring data continue to document the establishment of the desirable grassland species at the Site. Several locations met success criteria this year.
- The annual data quality assessment showed that the Site continues to collect high-quality data sufficient for decision making.

Actinide Migration

- Cover memo
- Actinide Migration Evaluation (AME) summary report

ROCKY FLATS STEWARDSHIP COUNCIL

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MEMORANDUM

TO: Stewardship Council Board
FROM: Rik Getty
SUBJECT: Actinide Migration Evaluation in the Rocky Flats Environment
DATE: May 23, 2012

We have scheduled forty-five minutes for DOE to brief on the Actinide Migration Evaluation (AME) study at Rocky Flats. Understanding how actinides move through the Rocky Flats environment and taking appropriate actions to mitigate such movement were central to the cleanup, and remain the foundation of post-closure management. The AME study was pivotal to these efforts.

Background

Actinides are a class of elements starting with actinium, atomic number 89, and going through atomic number 103. As noted in the attachment, "Actinides are among the heaviest known elements and all are radioactive. Only thorium and uranium can be found naturally in abundance. Plutonium and americium are man-made. Actinides of concern at Rocky Flats…are uranium (atomic number 92), plutonium (atomic number 94) and americium (atomic number 95)." Plutonium, americium and uranium were either used in products manufactured at the site or were process by-products.

As site cleanup began in earnest in the mid 1990's, it was recognized that an independent scientific panel needed to be convened to examine the ways that actinides move in the Rocky Flats environment. The AME Program was initiated in 1996 to analyze how specific actinides move in the Rocky Flats environment, and thus help focus remediation efforts on minimizing such movement.

The AME panel included geologists, chemists, biologists, and other scientists from around the country. The culmination of the AME panel's work over six years was the AME Pathway Analysis Report, completed in April 2002. We have attached the summary report. It can also be found at:
http://www.lm.doe.gov/cercla/documents/rockyflats_docs/SW/SW-A-004544.PDF

For this study, the AME panel used actinide concentrations measured at Rocky Flats to estimate the average amount of uranium, plutonium, and americium that migrates offsite annually under then-current conditions. Four major transport pathways were considered and compared—air, surface water, groundwater and biota. Extreme events (e.g. storms, high winds, and fires) were also modeled to assess whether extreme conditions modify the relative importance of different migration pathways when compared with non-extreme conditions.

This study did not attempt to assess actinide-related health or ecological impacts. It did, however, provide recommendations based on the study results for long-term protection of the environment during and after site closure, with emphasis on surface water quality protection.

Actinide Solubility

Of importance when examining the transport of actinides is their relative solubility in water. Plutonium and americium are much less soluble than uranium. Thus, americium and plutonium are more likely to be transported by physical processes on the surface, such as erosion of contaminated particles by wind and water, than by chemical processes in the subsurface, such as dissolution in groundwater. Uranium, on the other hand, is more soluble than plutonium and americium and can be transported in significant amounts by both physical and chemical processes.

AME Pathway Analysis Results

As discussed below, data presented in the AME Pathway Analysis Report show that transport by air and surface water are the dominant transport pathways for all three actinides studied. Data also indicate groundwater is a significant pathway for uranium. The biological pathway is a minor transport mechanism for all actinides.

Air Transport Pathway

According to the AME Study results, transport of actinides through the air occurs largely by wind erosion of actinide-containing particulate matter from soil and dust-laden vegetation. The amount of plutonium and americium carried offsite via air transport is roughly 40 times greater than the amount carried offsite by surface water, while the amount of uranium carried offsite via air transport is roughly 10 times greater than the amount carried offsite by surface water.

Accordingly, during cleanup activities, DOE and CDPHE employed a robust air monitoring network. That effort showed that as a result of remediation activities, little contamination was leaving the site via the air transport pathway. Accordingly, a few years following completion of closure activities, DOE and CDPHE ceased air monitoring.

Surface Water Transport Pathway

The AME Study indicated that the type of ground cover contributes significantly to the amount of actinide contamination introduced into the watersheds. For instance, the study showed the central Industrial Area, which contained buildings, parking lots, etc, contributed the most plutonium to any body of water, although not in the area with the highest plutonium concentrations in surface soil. This fact suggests that the impervious asphalt cover in the Industrial Area facilitated runoff and thus erosion of contaminated soils into surface water. On the other hand, the 903 Pad area, which had the highest known levels of plutonium activity in soil, was in a well-vegetated basin and therefore generated less runoff and contributed less actinide contamination to surface water. Thus reduction of the impervious cover (asphalt, sidewalks, etc.) in the Industrial Area post-closure is likely contributing to significant reductions in actinide loads to surface water by decreasing the potential for soil erosion into the watershed.

Data also indicate that the ponds on North and South Walnut Creeks (A- and B-series ponds) settled particles, and generally removed 80 to 90 percent of the amount of plutonium and americium that flowed into the ponds. Sampling of the sediments in the ponds led to DOE remediating ponds B-1, B-2, and B-3. Large amounts of sediment containing low levels of actinides were removed and shipped off-site for disposal. The other ponds did not require sediment remediation based on characterization sampling of the sediments.

The report noted that uranium concentrations in surface water are relatively uniform across the site. As a result, the amount of uranium transported offsite in a given watershed, the panel concluded, is largely proportional to the amount of water in the watershed. This generalization, however, did not prove accurate. As the board is aware, currently GS10 on South Walnut has higher levels of U than other surface water monitoring locations. That balance could change over time since there is some complex geochemistry involved.

Groundwater Transport Pathway
AME Study results showed plutonium and americium are relatively immobile in the soil and groundwater because of their low solubility and tendency to be absorbed onto soil. The AME Study estimated the amount of plutonium and americium transported to surface water via groundwater is approximately one percent of the total amount transported in surface water.

AME data show uranium is the dominant actinide found in shallow groundwater at Rocky Flats because of its natural abundance. Nevertheless, as with plutonium and americium, the amount of uranium transported to surface water via groundwater is approximately one percent of the total amount transported in surface water.

Biological Transport Pathway
Studies performed at Rocky Flats by Dr. Ward Whicker and others indicate that plutonium has low bioavailability due to its insolubility. Consequently, uptake into plant and animal tissues is minor. There is little accumulation of plutonium in the tissues of insects, small mammals, snakes, or mule deer. The estimated amount of plutonium and americium transported offsite via biota is approximately 1/100,000 the amount transported offsite via surface water. For uranium, the ratio becomes 1/10,000,000.

Implication to Cleanup and Closure
The AME Study also includes recommendations for long-term protection of the environment during and after closure. Below is a summary of some of the recommendations for near-term remediation activities and post-closure site management. (As you read this material, remember that the report was issued in 2002, so we have 10 years of data since then.)

Near-Term Remediation Activities
Because particulate transport via air is a major transport pathway for plutonium and americium, the AME Study concluded that soil disturbance will likely increase the potential for soil erosion and thus plutonium and americium transport at Rocky Flats. This knowledge reinforced the importance of implementing soil erosion controls, such as protecting soil stockpiles and limiting excavation on windy days, to minimize airborne actinide transport during remedial activities.

Similarly, soil erosion into surface water is another major potential pathway for plutonium and americium movement. To address this issue, the AME Study recommended implementing erosion control measures during site remediation, including techniques such as minimizing vegetation disturbance and redirecting runoff away from excavations, in addition to maintaining the detention pond system during active site remediation.

Post Closure Site Management
The AME Study asserted that minimizing wind and water erosion should remain a high priority post-closure, particularly in areas with residual actinide activity. Planning for the long-term effectiveness of erosion control measures, such as limiting soil disturbance and maintaining stable slopes, should be of utmost importance. Since site closure in October 2005, DOE and its contractors have made erosion control one of their most important duties. Inspections are done routinely looking for areas where erosion control needs to be improved or added.

One of the latest examples is in the area of surface water monitoring location SW027 on the South Interceptor Ditch (SID), just upstream from pond C-2 in the Woman Creek drainage. SW027 collects water on an intermittent basis. When water is collected a portion originates from the 903 Pad area, where extensive soil remediation was performed during cleanup. However, there remain areas around the 903 Pad where residual soil contamination exists. It is believed that a recent plutonium exceedance in 2010-2011 at SW027 was likely from the 903 Pad area. After consultations with CDPHE and EPA, DOE installed a new series of erosion controls in this area to help mitigate future runoff.

Due to the long half-life of plutonium, about 24,000 years, it will be important for future generations to understand how actinides move through the Rocky Flats environment and what mitigating measures are required to minimize their movement.

Please contact me if you have any questions.

TABLE OF CONTENTS

ACTINIDE MIGRATION EVALUATION PATHWAY ANALYSIS SUMMARY REPORT

‘**Actinides** are those **14 elements** with atomic numbers 90 to 103 that follow the element actinium in the **Periodic Table of Elements.**’

ACTINIDE MIGRATION EVALUATION ADVISORY GROUP

The Actinide Migration Evaluation (AME) has an advisory group that provides scientific expertise in the fields of actinide chemistry, geochemistry, erosional transport, hydrogeology and microbiology. The AME is privileged to have the dedicated support of the following scientists:

- **Sumner J. Barr, Ph.D., (AME tenure: 2000 - present)**
  Consultant to Los Alamos National Laboratory (retired) -
  Air Transport of Radionuclides

- **Gregory R. Choppin, Ph.D., (AME tenure: 1998 - present)**
  Professor Emeritus, Dept. of Chemistry, Florida State University -
  Actinide Chemistry

- **David L. Clark, Ph.D., (AME tenure: 1996 - present)**
  Seaborg Institute Director and Fellow, Los Alamos National Laboratory -
  Actinide Chemistry

- **Arokiasamy J. (A.J.) Francis, Ph.D., (AME tenure: 2000 - present)**
  Brookhaven National Laboratory - Microbiological Processes and Actinide Mobility

- **Bruce D. Honeyman, Ph.D., (AME tenure: 1996 - 1999)**
  Colorado School of Mines - Radionuclide Geochemistry, Actinide Phase Speciation

- **David R. Janecky, Ph.D., (AME tenure: 1996 - present)**
  Environmental Science and Technology Program Office, Los Alamos National
  Laboratory - Actinide Geochemistry

- **Annie B. Kersting, Ph.D., (AME tenure: 2000 - present)**
  Analytical Nuclear Chemistry Division, Lawrence Livermore National Laboratory -
  Geochemistry and Colloidal Transport of Actinides

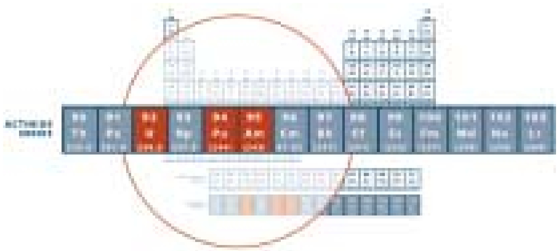
- **Leonard J. Lane, Ph.D., (AME tenure: 1999 - present)**
  Hydrology and Water Resources, Agricultural Research Service (retired) -
  Erosion and Sediment Transport, Actinide Fate and Transport

- **D. Kirk Nordstrom, Ph.D., (AME tenure: 1996 - 2000)**
  U.S. Geological Survey - Geochemistry, Actinide Fate and Transport

- **Peter H. Santschi, Ph.D., (AME tenure: 1996 - present)**
  Texas A&M University at Galveston - Radionuclide Geochemistry,
  Actinide Phase Speciation

INTRODUCTION AND RFETS HISTORY

THE ACTINIDE ELEMENTS



INTRODUCTION The Rocky Flats Environmental Technology Site (RFETS or Site), located near Denver, Colo., and owned by the United States Department of Energy (DOE), was formerly a manufacturing facility in the nation's Nuclear Weapons Complex. The Site is currently undergoing cleanup, closure and conversion to a National Wildlife Refuge. An important question was identified early in the closure planning – how do radioactive elements move in the environment?

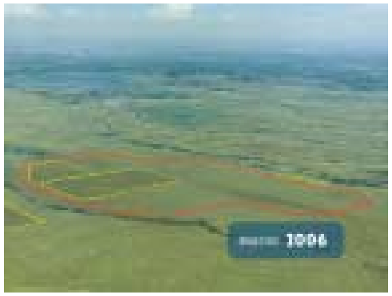
The Actinide Migration Evaluation (AME) Program was initiated in 1996 to address this question. Specifically, the AME focuses on issues of actinide behavior and mobility in surface water, groundwater, air, soil and biota at RFETS. For the purposes of this study, an actinide refers to the radioactive element uranium (U), plutonium (Pu) or americium (Am).

To address issues of actinide migration, the AME Program has brought together personnel with a broad range of relevant expertise in technical investigations, project management and external advisory roles. This effort, funded by DOE, involves identification of research investigations and approaches that can be used to solve short- and long-term issues related to actinide migration at the Site. Knowledge garnered through the AME Program is being used to characterize current RFETS environmental conditions and to recommend a path forward for long-term protection of surface water quality during closure and long-term stewardship of the Site.

WHAT ARE ACTINIDES?

Actinides are those 14 elements with atomic numbers 90 to 103 that follow the element actinium in the Periodic Table of Elements. Actinides are among the heaviest known elements and all are radioactive. Only thorium and uranium can be found naturally in abundance. Plutonium and americium are man-made. Actinides of concern at RFETS addressed in this report are uranium (atomic number 92), plutonium (atomic number 94) and americium (atomic number 95).

In the early 1950s, Rocky Flats was built as part of the nation's Nuclear Weapons Complex. In 1989, following decades of expansion, production operations were halted. Current cleanup efforts are scheduled for completion by 2006. The Site will then become a National Wildlife Refuge.



Effective cleanup of the Site requires a thorough understanding of how actinides move in the environment.

Throughout the AME Program, there has been extensive public discussion and participation in the scientific process and review of findings. Discussion of actinide migration technical issues with stakeholders, regulators, administrators and staff has been valuable as a means of focusing efforts on critical questions.

Data presented in this Report show that air and surface water are the major transport pathways for all actinides. This is particularly true for plutonium and americium, which are largely insoluble and are transported when wind and water erosion move the soil and sediment particles to which the plutonium and americium are bound. Groundwater is a significant pathway for uranium, which is more soluble than plutonium or americium. The biological pathway is a minor transport mechanism for all actinides.

This Summary Report is a condensed review of the study's major topics and findings. Detailed discussions, calculations and literature references to support subjects discussed in this document are included in the companion Technical Appendix.

PURPOSE The purpose of the AME Pathway Analysis Report is to provide a summary of the quantitative analyses that have been performed to examine the many processes that impact movement of actinides in the environment at RFETS. Evaluation of alternatives for remediating actinide contamination at RFETS must consider migration and mobility along all available environmental pathways. The ultimate objective of the pathway study is to compare and quantitatively rank the various pathways in terms of total actinide loads transported off site for a given time period. Major transport pathways addressed in this study include: air, surface water, groundwater and biota.

This study is limited to quantifying actinide movement and does not assess actinide-related human health impacts. However, references to pertinent risk-based health standards are made to provide perspective.

SITE HISTORY RFETS is located 16 miles northwest of downtown Denver. It was built as a production plant to manufacture triggers for nuclear weapons and purify plutonium recovered from retired weapons. These operations involved fabricating components out of plutonium, enriched and depleted uranium, beryllium and stainless steel. Nearly 40 years of weapons production left a legacy of radiological waste at the Site, including contaminated facilities, process waste lines and buried wastes. Plutonium dispersal from fires in production buildings and leakage of waste oil stored outdoors caused contamination of the immediate environment.

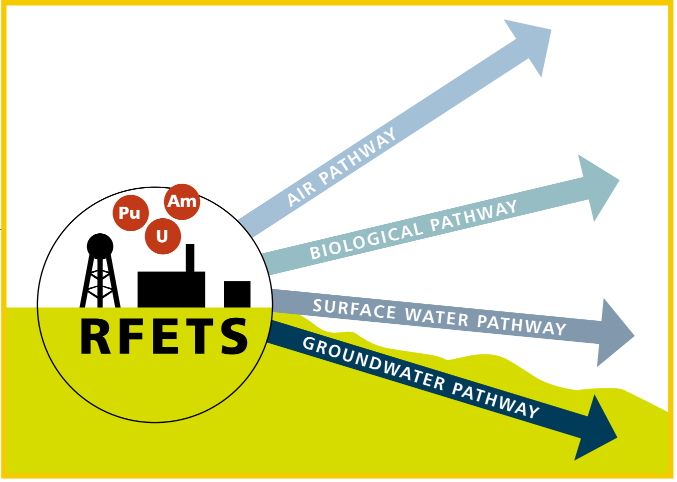
CLOSURE AND CLEANUP In 1992, the Site mission changed from production to one of closure and cleanup of the 385-acre Industrial Area and the surrounding 6,165-acre Buffer Zone. Today, RFETS is in the process of deactivating, decontaminating, decommissioning and demolishing all of the weapons production facilities and support buildings in the Industrial Area. The objective of the final closure phase is remediation of the environmental legacy of nuclear weapons production and transition to long-term stewardship as a National Wildlife Refuge.

CONCEPTUAL MODEL

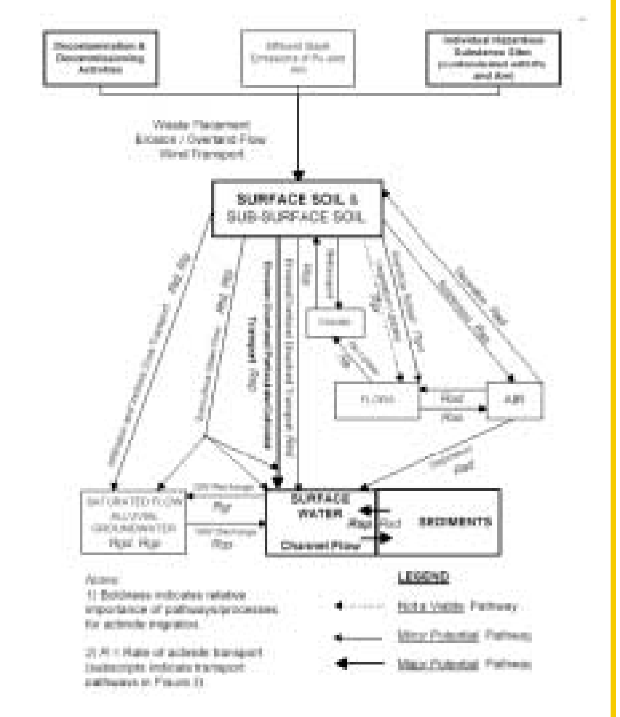
CONCEPTUAL MODEL In 1998, a document entitled "Conceptual Model for Actinide Migration Studies at the Rocky Flats Environmental Technology Site" was developed as an initial effort to provide a qualitative description of the relationships among potential actinide sources and transport pathways at RFETS (Kaiser-Hill, 1998).

The transport of actinide elements in the environment involves complex chemical and physical processes. These processes depend on the type and source of the actinide as well as the influence of the surrounding environmental media. To facilitate understanding of the potential routes for actinide transport in the RFETS environment, schematic models of actinide transport pathways were developed. One conceptual model was developed specifically for plutonium and americium, because they have similar geochemical and transport properties. A separate model was developed for uranium because of its different properties. These models formed the basis for quantitative analyses described in the Pathway Analysis Report. Development of the Pathway Analysis Report used both existing data from the literature and site-specific analyses. Field, laboratory and modeling studies were conducted to provide quantitative estimates of actinide migration.

CONCEPTUAL PATHWAY DIAGRAM



ORIGINAL CONCEPTUAL MODEL



INITIAL CONCEPTUAL MODEL DIAGRAM

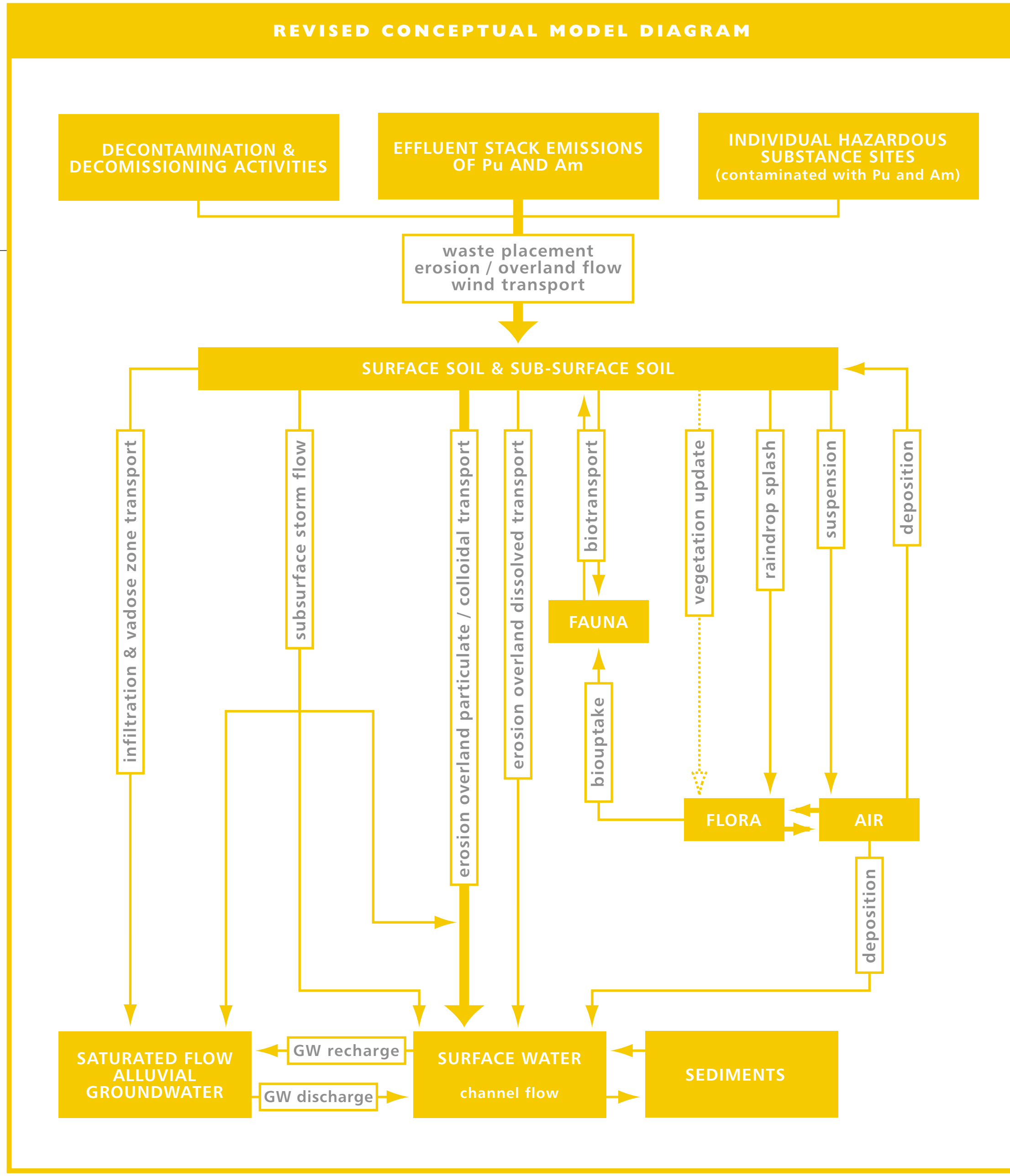
This chart was the first effort by the AME group to diagram how plutonium and americium move in the environment at RFETS. It was a familiar tool at public meetings and has evolved into the chart on the following page.

CONCEPTUAL MODEL LEGEND

- not a viable pathway
- minor potential pathway
- major potential pathway

ACTINIDE MIGRATION CONCEPTUAL MODEL

This flowchart, developed from the conceptual model, is a qualitative diagram of potential plutonium and americium movement pathways at RFETS. The Pathway Analysis Report quantifies potential pathways to determine their relative importance in RFETS actinide migration. Since the geochemical behavior of uranium is different from that of plutonium and americium, a separate conceptual model flowchart developed for uranium is in the Technical Appendix.



These drums leaked contaminated waste oil in the 1960s. The 903 Pad area is the Site's primary known source of plutonium and americium in the environment and is scheduled for cleanup in 2002.

LEAKING DRUMS RELEASED CONTAMINATION

A major release of plutonium to the environment occurred when plutonium-contaminated waste oil leaked from approximately 3,750 drums stored outside from 1958 to 1968. Although the drums were removed after leakage was detected, plutonium-contaminated soil was dispersed into the air during remediation activities and deposited east of the drum storage area. In 1969, the area was covered with gravel fill and an asphalt layer to prevent further wind dispersal. The remaining contamination in this area, known as the 903 Pad, continues to be one of the major sources of plutonium and americium contamination at the Site. Further remediation will remove the source material and reduce airborne transport of plutonium and americium.

ACTINIDES IN THE ENVIRONMENT Actinide elements occur in the environment at RFETS as both "background" material and as material released during operations at the Site. For plutonium and americium, background concentrations exist because of global fallout from historic atmospheric nuclear testing.

With uranium, background quantities occur naturally in the soil and underlying geologic material. A significant amount of naturally occurring uranium exists at RFETS as well as in the surrounding vicinity, as evidenced by the presence of the Schwartzwalder uranium ore mine within 16 kilometers (10 miles) of the Site. Differentiation between natural and man-made uranium contributions can be accomplished by examining characteristic differences in the mixtures of uranium isotopes. Such isotopic analyses have detected low levels of man-made uranium in shallow groundwater at locations somewhat removed from contaminant sources. However, in general, beyond the immediate vicinity of man-made uranium sources, the observed uranium concentrations are difficult to distinguish from natural background uranium.

SPATIAL DISTRIBUTION Plutonium and americium generally exhibit the same spatial distribution in surface soils, with wide variations in activities occurring throughout the Site. The highest concentrations are found at the 903 Pad and areas to the east of the Pad. Nearly all the plutonium and americium in RFETS soils is confined to the top 20 centimeters (8 inches) of soil and approximately 90 percent is located in the top 12 centimeters (5 inches) (Webb, et al., 1993; Litaor, et al., 1994).

BACKGROUND LEVELS OF ACTINIDES

Plutonium and Americium – Global Fallout from Nuclear Tests There were 541 acknowledged atmospheric nuclear tests conducted around the world, primarily from 1945 through 1963, prior to the Limited Test Ban Treaty. These tests resulted in the global dispersal of approximately 4,000 kilograms (360,000 curies) of plutonium and 95 kilograms of americium. Most of this fallout was distributed across the temperate regions of the Northern Hemisphere, resulting in background plutonium levels that generally range from approximately 0.003 to 0.03 picocuries per gram (pCi/gram) of surface soil. The background plutonium level found in Front Range soils is approximately 0.04 pCi/gram.

Uranium – Naturally Occurring in the Earth's Crust Uranium is found naturally in the earth's crust with an approximate average concentration of 1.6 pCi/gram. This amount varies depending on local geology, with natural uranium activity in Colorado soils ranging from approximately 0.5 to 3.0 pCi/g. Three isotopes compose natural uranium. The percent occurrences by mass are: uranium-238 (99.275 %), uranium-235 (0.719 %) and uranium-234 (0.0057 %). Each of these isotopes has different amounts of activity per unit mass, which explains why the activity in soil emitted from uranium-234 approximately equals the activity from uranium-238, even though there is much less uranium-234 by mass (see "Radioactivity per Unit Mass," Page 8).

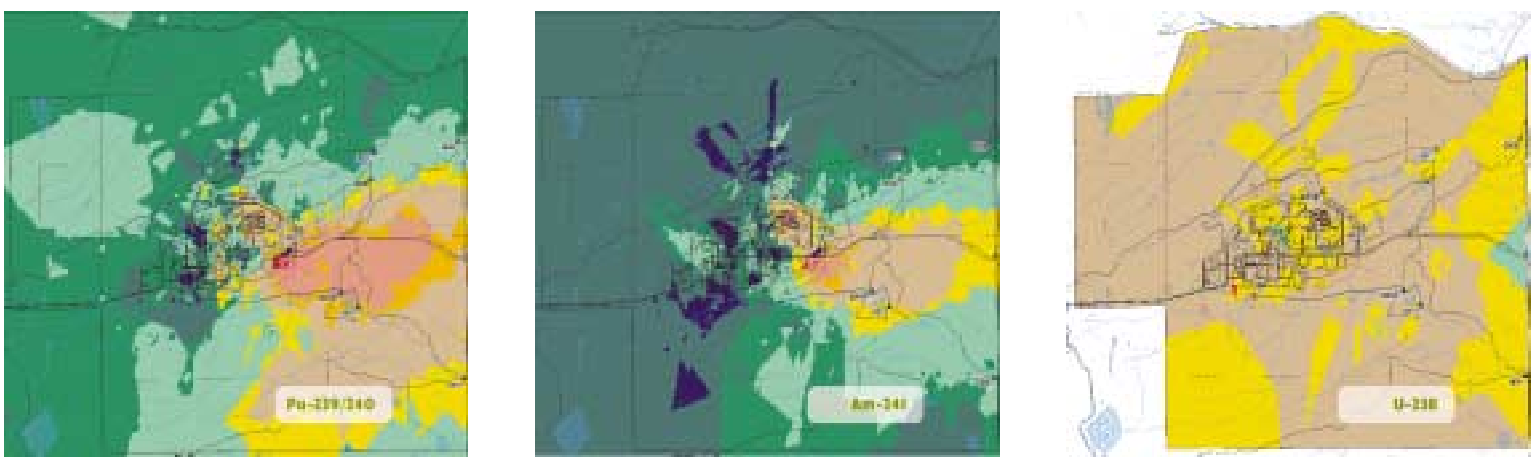
Uranium does not have the same spatial distribution observed for plutonium and americium in surface soils. Uranium is observed at varying levels of natural background activity across the Site, which complicates identifying uranium from man-made, versus natural, sources.

DATA GAPS The "Historical Release Report" identifies 215 total locations that are potentially contaminated by actinides. Acceptable data, as defined in the Technical Appendix, exist for surface or sub-surface soil contamination for plutonium, americium and uranium at 95 locations. Additional sampling is needed to more fully characterize actinide contamination at RFETS.

STATISTICAL METHODS USED WITH SOIL DATA

Although an extensive program exists to sample RFETS surface soils for actinides, it is not feasible to collect soil samples from every location at the Site. Therefore, to estimate actinide concentrations in soil at locations that have not been sampled, it is necessary to use data from adjacent locations that have been sampled. Various computerized estimation techniques have been developed for this purpose.

A geostatistical technique known as kriging was applied to the plutonium, americium and uranium surface soil sample data at RFETS to estimate concentrations of these actinides in the surface soil and generate the maps shown below.

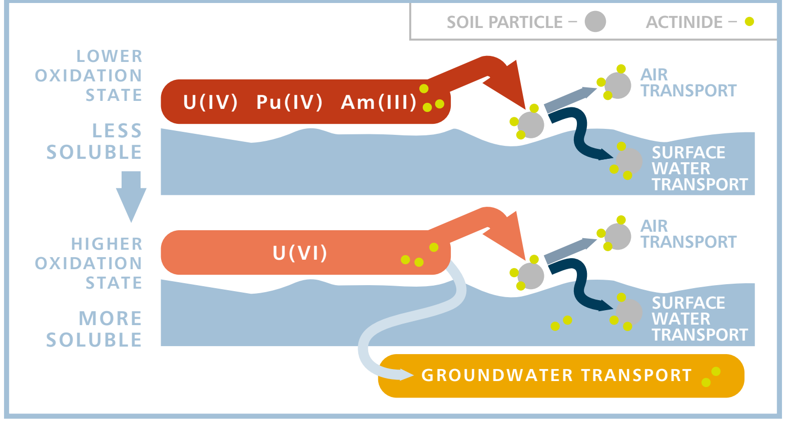


ACTINIDE SURFACE SOIL MAPS **Surface soil data for plutonium (left) and americium (center) display a similar pattern of wind-driven dispersal to the east of the primary source area – the 903 Pad. In contrast, uranium (right) exists at natural background levels across most of the Site except for small areas of higher activity located near contamination sources. In these maps of kriged data, red indicates highest contamination activity and green indicates areas with lowest activity. Larger versions of these maps are in the Technical Appendix.**

TRANSPORT Scientific literature and RFETS-specific studies indicate that the chemical and physical characteristics of plutonium, americium and uranium control how they are transported and where they eventually reside in the environment.

OXIDATION STATES The oxidation state of an actinide is determined by the number of electrons lost when the actinide combines with oxygen. The oxidation state is a function of the unique chemical characteristics of each actinide element as well as the geochemical conditions in the surrounding soil and water. In environmental conditions, plutonium and americium tend to exist in low oxidation states III (Am) and IV (Pu) that are relatively insoluble. In contrast, uranium is stable in both oxidation states IV and VI, with VI dominant in surface and near-surface oxidizing conditions. Because U (VI) forms compounds of greater solubility than Pu (IV) or Am (III), uranium exhibits a greater tendency to exist in chemical forms that are more soluble than plutonium or americium.

ACTINIDE CHEMISTRY
OXIDATION STATE AFFECTS ENVIRONMENTAL BEHAVIOR



COLLOIDS AND ACTINIDE TRANSPORT

Colloids are naturally occurring particles, defined as ranging in size from 0.1 to 0.001 micrometers. Colloids are found in nearly all surface water and groundwater and are formed as a result of the weathering of rocks, soils and decomposing plant materials. Due to their small size, colloids can remain suspended and are readily transported with groundwater. Suspended colloids are of interest as a transport mechanism for contaminants that strongly attach to mineral or organic surfaces, such as plutonium and americium (i.e., contaminants that do not readily dissolve in groundwater). The hydrology, water chemistry and geology of the surrounding environment influence the importance of colloids in facilitating transport of insoluble contaminants. Though colloid-facilitated transport of actinides has been observed at the Nevada Test Site, it is important to recognize that plutonium there was deposited during an underground nuclear test in fractured volcanic rock below the groundwater table. Geologic conditions at RFETS are significantly different than at the Nevada Test Site, but colloidal transport of actinides is a mechanism that still warrants consideration in the RFETS pathway analysis.

PLUTONIUM AND AMERICIUM GEOCHEMISTRY Because of the extremely low solubilities of plutonium and americium, these elements are predominantly associated with solids. They are either strongly sorbed, or attached, to soil and sediment particles or precipitated as oxides and hydroxides. The concentrations found in solution under the oxidizing environmental conditions common at RFETS are very low, around 1×10^{-15} moles/liter (also represented herein as 1E-15 moles/liter). Evidence indicates that reducing conditions which may exist in the treatment ponds or in landfill locations do not influence plutonium solubility at RFETS.

Studies performed to date and measurements at RFETS indicate that groundwater transport of plutonium and americium should be very low. Measured plutonium and americium concentrations in shallow groundwater below the Industrial Area range from the analytical detection limit (about 0.02 picocuries/liter [pCi/L]) to about 0.1 pCi/L. At present, it is not clear whether detections of plutonium and americium in shallow groundwater arise from surface contamination carried downward by well-drilling activities, from contamination during sampling and analysis, from sub-surface transport of actinide-bearing colloids or from a combination of these processes. These possibilities are currently being studied with a series of wells drilled and sampled under conditions that minimize the possibility of extraneous contamination.

Surface soil (0 to 15 centimeters [0 to 6 inches] below original grade), in contrast to the low levels observed in groundwater, has plutonium activities that range between 0 to 152,000 picocuries/gram [pCi/g]. Measurements of plutonium and americium movement show that the mobility of these actinides is largely controlled by erosion of surface soil by wind and water.

Since the data amassed indicate that plutonium and americium are present as insoluble forms and migration occurs via colloidal and particulate transport, contaminant transport modeling calculations must take these facts into account. Contaminant transport models that assume soluble forms and the existence of equilibrium conditions between soil and solution phases of plutonium and americium are of limited value for assessing the risk of exposure at RFETS. For plutonium and americium, models based on particulate transport processes are more appropriate and have been developed for use at the Site.

URANIUM GEOCHEMISTRY In contrast to plutonium and americium, uranium is most stable in the oxidation states IV and VI, with VI dominating in surface and near-surface oxidizing conditions. Because U (VI) forms compounds of much greater solubility than those formed by Pu (IV) or Am (III), uranium exhibits a greater tendency to exist in dissolved forms. Uranium is predominantly transported as dissolved chemical species, although transport can also occur in particulate form. Models used to estimate uranium transport must account for these processes and, accordingly, might suitably include a solubility and sorption-controlled mobility component.

RADIOACTIVITY PER UNIT MASS

Specific activity is used to quantify the amount of radioactivity emitted per unit of mass. The specific activity for each isotope of a given element is related to its radioactive half-life. The half-life is the time it takes for half of the atoms to decay. Specific activities for isotopes of interest are listed below. Note how the amount of activity per unit mass can vary by several orders of magnitude from one actinide isotope to another.

RADIONUCLIDE	HALF-LIFE (years)	SPECIFIC ACTIVITY (Ci/gram)
americium-241	4.32×10^{2}	3.53×10^{0}
plutonium-239	2.42×10^{4}	8.48×10^{-2}
plutonium-240	6.57×10^{3}	3.10×10^{-2}
uranium-234	2.47×10^{5}	6.25×10^{-3}
uranium-235	7.04×10^{8}	2.14×10^{-6}
uranium-236	2.34×10^{7}	8.85×10^{-6}
uranium-238	4.51×10^{9}	3.33×10^{-7}

An example of the importance of specific activity is demonstrated by examining the natural occurrence of uranium. Three uranium isotopes are found naturally in the environment. By mass, uranium-238 accounts for nearly all (99.275 %) of the naturally-occurring uranium, while uranium-235 (0.719 %) and uranium-234 (0.0057 %) account for the remaining mass. However, in terms of radioactivity, the amount of activity emitted from naturally-occurring uranium-234 and uranium-238 is roughly equal, despite the overwhelming abundance of uranium-238 atoms in a given sample.

MEASURING RADIOACTIVITY

What is a curie? The curie (Ci) is a unit of measure for radioactivity. The nuclei of the heaviest elements in the periodic table are unstable and emit radiation when their nuclei break up. An element that emits radiation is called radioactive and the emission process is often referred to as radioactive decay. The Ci was established as a unit of measure based on the radioactivity emitted by 1 gram of radium-226. The Ci is defined as 3.7×10^{10} nuclear decays per second. The activity emitted by a gram of an isotope of a radioactive element may vary greatly from the activity emitted by a gram of a different element or a different isotope and is related to its rate of radioactive decay (the half-life). Therefore, it is more meaningful to use a measure of radioactivity like the Ci, versus using mass or volume units, when discussing actinides and their radioactivity.

What is a picocurie? A picocurie (pCi) is one trillionth of a Ci (1×10^{-12} Ci). For studying actinides in the environment at RFETS, the Ci is often too large a unit of radioactivity in the same way that a fraction of a mile would be an awkward way to describe the thickness of a human hair. Therefore, activity in the environment at RFETS is frequently presented in units of pCi.

INTRODUCTION Transport of actinides through the air at RFETS occurs largely by wind erosion of actinide-containing particulate matter from soil and vegetation surfaces. RFETS-specific research suggests that dust-laden vegetation is the primary source for resuspended airborne plutonium under most conditions (Langer, 1991). Resuspension of actinides directly from soil surfaces is thought to be a lesser source except during high wind events or after soil has been disturbed and made more erosion-prone. Building stack and vent emissions are, to a much lesser extent, also sources of airborne actinides, though these sources will be eliminated as buildings are removed.

Data collected from air-monitoring stations like this one, near the 903 Pad, are used to quantify actinide movement by the wind. Air is a major transport pathway.

Overall, the general direction of airborne actinide transport at the Site follows the prevailing winds, from the north and west to the south and east. More importantly, Site data show that higher wind speeds occur almost exclusively from the northwest quadrant. This is significant because the amounts of soil resuspended are much higher during high-wind events than during periods with lower winds. Higher winds are also more effective at transporting particles further downwind from source areas before being redeposited.

Although the first few minutes of high winds may result in significant airborne particle transport, the emission rate decreases rapidly with time as the available inventory of erosion-prone particles is depleted. Sustained windy periods do not result in significantly greater emissions until the inventory is replenished by deposition or by other factors that increase soil erosion potential, such as freeze/thaw cycles, wet/dry cycles, rangeland fires, animal activities, rainsplash effects or other processes that disturb the soil. Following disturbances, erosion protection is restored by crusting of the soil, regrowth of vegetation and regeneration of a litter layer.

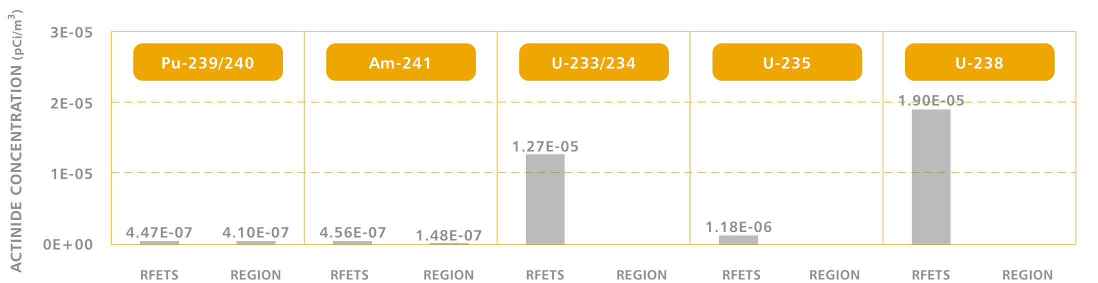
METHODOLOGY FOR QUANTIFYING ACTINIDE TRANSPORT Two different methods were used to quantify actinide transport via the air pathway. The first method is more closely linked to measured site data. It uses airborne average actinide concentration data from 1997 through 1999, collected at site perimeter monitoring stations, coupled with on-site wind data.

The second method involves a wind erosion emission estimation method and dispersion / deposition model developed for the Site. Off-site airborne transport was calculated for plutonium and americium as the difference between annual wind erosion emissions from the Site and deposition of actinides back onto the Site. Though this approach does not account for possible contributions from project or building emissions, wind erosion of actinides from soil and vegetation has been determined to represent the majority of air emissions from the Site during recent years.

Although the first method is a more "data-driven" estimation approach, it has uncertainty associated with wind speed data and airborne actinide data collected in different time steps, 15-minute and monthly intervals, respectively. The dispersion modeling approach, though not tied as closely to measured air actinide concentrations, provides the advantage that hypothetical off-normal events can also be investigated. Results from both methods, for normal conditions, provide a range of results for estimated annual quantities of airborne actinides transported off site.

CHART 1

AIRBORNE ACTINIDE CONCENTRATIONS –
MEDIAN MEASURED ACTIVITIES AT SITE PERIMETER COMPARED WITH REGIONAL BACKGROUND ACTIVITIES



NOTE: BACKGROUND AIRBORNE ACTIVITY FOR URANIUM NOT PRESENTED - VARIES WIDELY BY LOCATION

ACTINIDE CONCENTRATIONS IN AIR

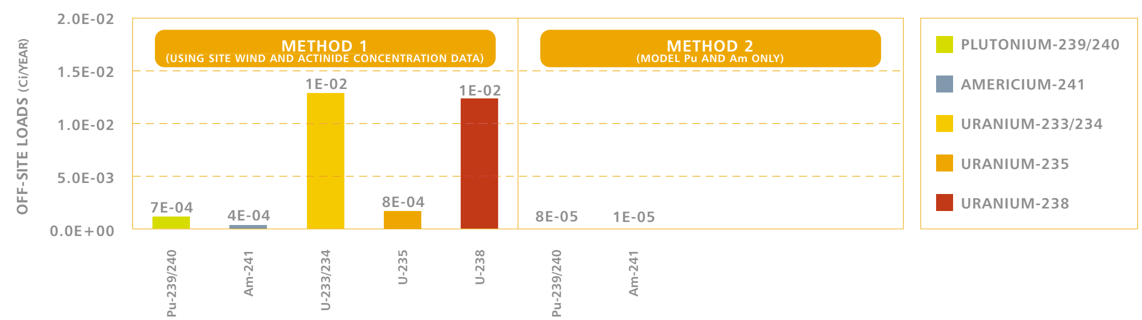
Chart 1 presents airborne actinide concentrations measured at the RFETS boundary. Units of measurement are pCi per cubic meter of air. Regional background activities are provided for plutonium and americium for comparison. Background concentrations of airborne plutonium and americium exist, as discussed earlier, because they were globally dispersed from historic weapons testing. Resuspension by the wind of the residual plutonium and americium causes a background level of these actinides in the air. Airborne uranium measured at the Site is similar to background because of its natural abundance in the soil. In Chart 1, the concentration presented for each actinide is the median of annual average concentrations measured at the RFETS perimeter monitoring locations from 1997 through 1999.

CHART 2

AIRBORNE ACTINIDES – TOTAL AVERAGE ANNUAL ACTIVITY TRANSPORTED OFF SITE –
RESULTS FOR TWO ESTIMATION METHODS

TOTAL ACTIVITY IN AIR

Estimated annual off-site airborne actinide loads are shown in Chart 2. Results are presented for two modeling methods described previously.



DISCUSSION: AIRBORNE PLUTONIUM AND AMERICIUM Model estimates for average annual off-site transport of plutonium range from 8×10^{-5} Ci to 7×10^{-4} Ci and for americium range from 1×10^{-5} Ci to 4×10^{-4} Ci. For both plutonium and americium, the estimation method based on measured Site wind and airborne actinide concentration data yielded higher predicted off-site transport than the model estimation method. The primary source of plutonium and americium in airborne loads at RFETS is from contaminated surface soil, or soil on vegetation surfaces, in the area near and east of the 903 Pad. Additional minor sources are building stack and vent emissions as well as background plutonium and americium in surface soil from global atmospheric nuclear fallout that gets resuspended by the wind.

Modeling results are consistent with the observed pattern of plutonium and americium surface soil contamination, originating in the 903 Pad area and migrating eastward as a result of prevailing winds from the west and northwest. Reconstruction of events associated with the 903 Pad contamination in the late 1960s suggests that much of the contamination was likely dispersed during a few high-wind events that followed closely after the contaminated soil had been disturbed by grading or weed control efforts (Meyer et al., 1996). Such activities can break up the surface crust, crush aggregated soil particles and remove vegetative cover, thereby renewing and increasing the reservoir of particles available for erosion. The resulting dispersion and deposition pattern indicates that substantial quantities of material can be moved through the air pathway by the sporadic events.

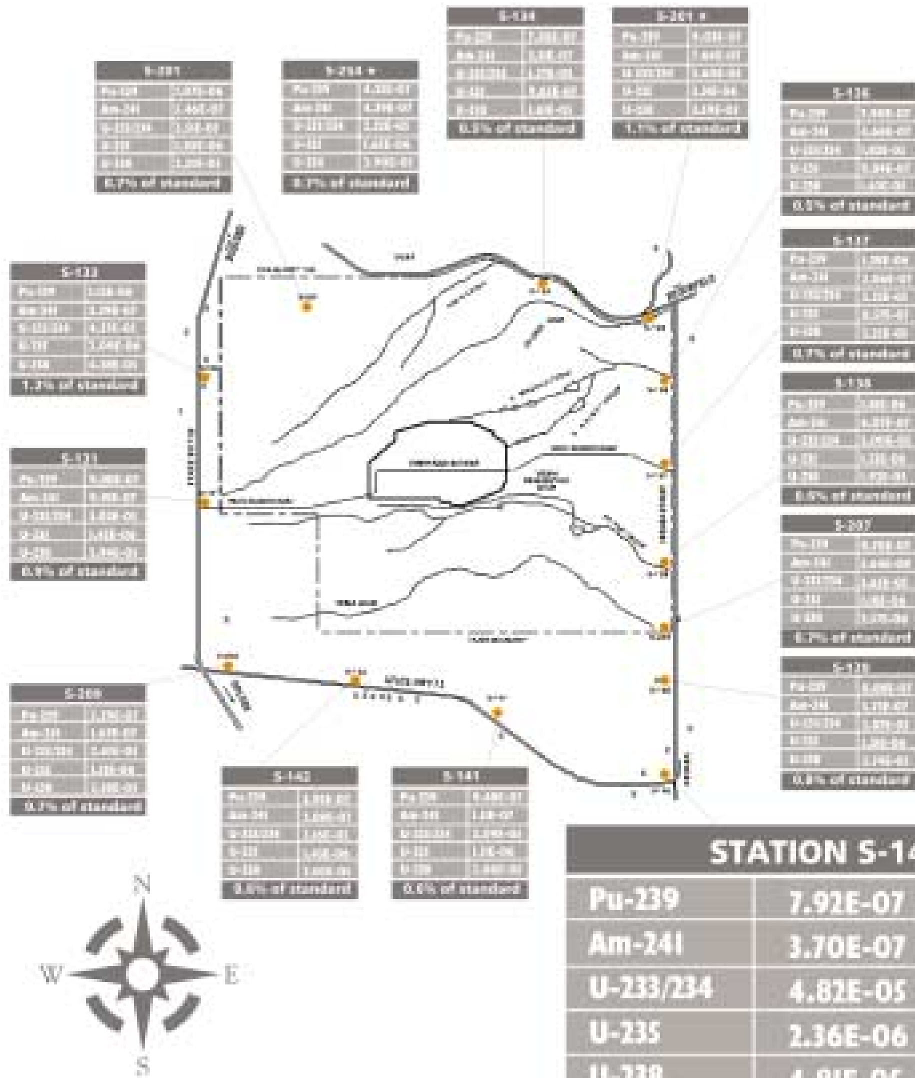
DISCUSSION: AIRBORNE URANIUM Naturally occurring uranium from the soil is the major component of airborne uranium leaving the Site. Based on the relative concentrations of uranium-233/234 and uranium-238, data from the sampling network confirm that almost all airborne uranium is naturally occurring. For comparison, the concentration of airborne uranium-233/234 activity measured at site boundary monitors ranges from 10 to 60 times more than the activity measured for airborne plutonium.

DISCUSSION: EXTREME EVENTS As a hypothetical extreme event, a model simulation was performed to study the effect on airborne actinide transport following a rangeland fire occurring on approximately 40 hectares (100 acres) in a plutonium-contaminated area near the 903 Pad. Modeling results indicate that average airborne plutonium concentrations would increase an estimated 5- to 13-fold in the vicinity of the burned area in the first year following a fire. Such an increase in concentrations would lead to greater off-site transport until the vegetation recovered and soil loss from wind erosion returned to pre-fire levels. The actual increase in actinide transport following a fire would depend on the size of the burned area, the intensity of the fire and the actinide concentrations in the area burned. Other extreme conditions, such as soil disturbance by heavy equipment, can increase airborne particulate emissions by nearly a factor of 20 (EPA, 1995).

AIRBORNE ACTINIDES

The air-monitoring location with the highest total average actinide concentration had a level equal to approximately 1.4 percent of the 10 millirem standard governing airborne radionuclide concentrations leaving DOE facilities. Results are based on data collected from 1997 through 1999.

AIRBORNE ACTINIDE CONCENTRATIONS



STATION S-140		
Pu-239	7.92E-07	pCi/m³
Am-241	3.70E-07	pCi/m³
U-233/234	4.82E-05	pCi/m³
U-235	2.36E-06	pCi/m³
U-238	4.81E-05	pCi/m³
1.4% of standard		

INTRODUCTION Actinides are transported in surface water by two main processes, depending on the actinide's solubility. First, insoluble actinides, such as plutonium, americium or uranium in lower oxidation states, sorb to soil or sediment particles that are eroded by water. The particles thereby transport the attached actinides. The second transport process involves actinides in solution, primarily uranium in the VI oxidation state, that move in surface water. Plutonium and americium are essentially insoluble and are not transported as dissolved species in significant quantities.

Surface water is monitored throughout the Site at automated stations. When the water flow rate of the water increases, this unit is programmed to increase the number of samples it collects.

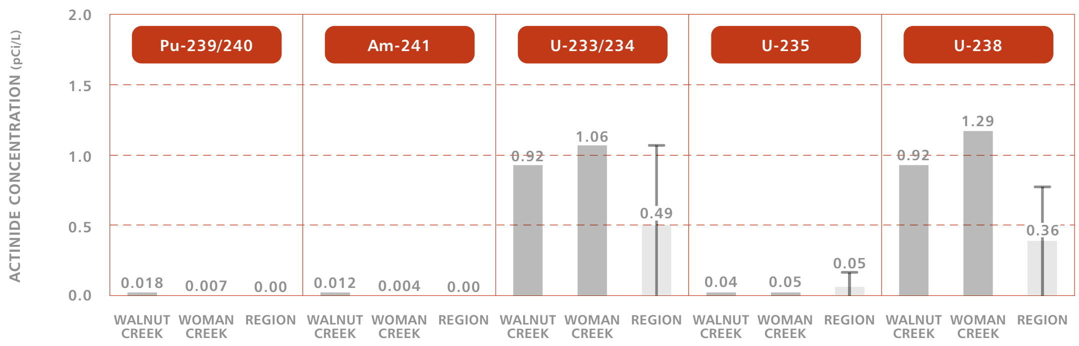
Surface water at RFETS flows generally from west to east, with three major drainages traversing the Site (see map at back of report, Page v). Walnut Creek drains the northern portion of the Site, including the majority of the Industrial Area, which runs off to the A- and B-series detention ponds. Woman Creek drains the southern portion of the Site, including southern Industrial Area runoff after it is diverted by the South Interceptor Ditch into Pond C-2. The third major drainage, Rock Creek, does not receive runoff from the Industrial Area or other contaminated areas. This pathway study focuses on the Walnut and Woman Creek drainage basins.

METHODOLOGY FOR QUANTIFYING ACTINIDE TRANSPORT The amount of actinide material, or load, transported in surface water past a specific location is a function of both the volume of water that flows past the location and the actinide concentration in the water. This surface water actinide load is calculated using data from automated monitoring stations that continuously measure water flow and periodically collect samples using a "flow-weighted" sampling protocol. This means sample volumes are collected in equal proportion to the volume of water passing the station. Multiple samples are collected and combined, resulting in an accumulated composite sample. The sample is representative of the actinide concentration for an entire volume of water passing the monitoring station. Annual surface water actinide loads were quantified in this study at eight site monitoring locations, using data from water years 1997 through 1999.

In addition to using measured data to quantify surface water actinide loads, models were developed to estimate impacts to surface water from pathways for which measured data is unavailable. Estimates of plutonium and uranium-238 inputs and outputs to surface water were made for: 1) deposition of airborne actinides to surface water, using a Gaussian plume model; 2) hillslope erosion and runoff of actinides to surface water, using the Watershed Erosion Prediction Project (WEPP) model coupled with actinide soil data; and 3) inflow and outflow of actinides to surface water from shallow alluvial sub-surface water, using water balance calculations coupled with monitoring-well data. These mass balance analyses were conducted on three study areas: the Walnut Creek detention ponds, Walnut Creek between the ponds and the site boundary and the South Interceptor Ditch drainage basin.

CHART 3

SURFACE WATER ACTINIDE CONCENTRATIONS – WALNUT AND WOMAN CREEKS COMPARED WITH REGIONAL BACKGROUND CONCENTRATIONS IN SURFACE WATER



NOTE: BOUNDARY URANIUM CONCENTRATIONS ESTIMATED USING VOLUME-WEIGHTED DATA FROM UPSTREAM STATIONS

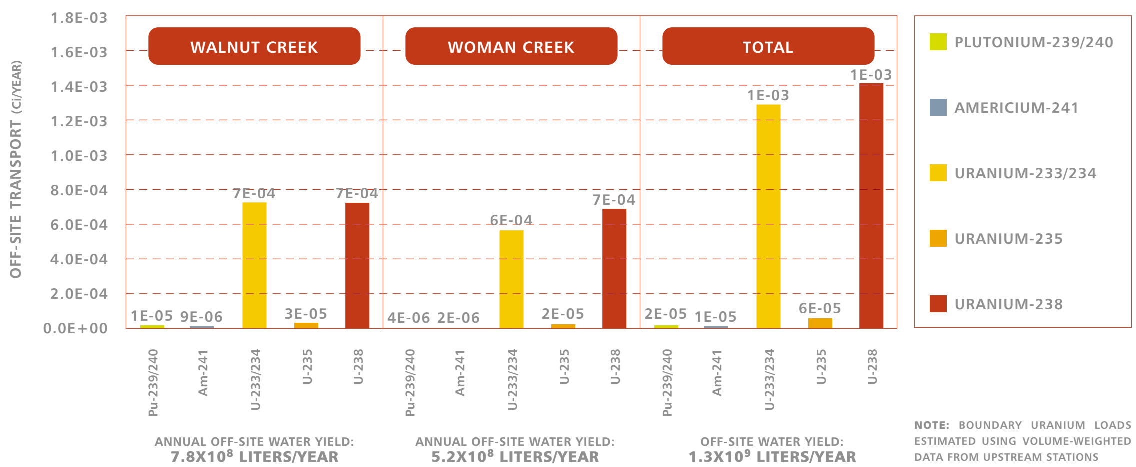
SURFACE WATER CONCENTRATIONS

Average surface water actinide concentrations in Walnut and Woman Creeks at the Site's eastern boundary are presented in Chart 3. Concentrations were calculated using a volume-weighted average based on samples and flow data collected from water years 1997 through 1999. Site measurements are compared with background concentrations of actinides measured in Front Range regional surface water that is not impacted by RFETS.

The actively managed detention ponds on South Walnut Creek (left) and North Walnut Creek (right) settle out 80 to 90 percent of the plutonium and americium loads carried into them from runoff.

CHART 4

SURFACE WATER ACTINIDE LOADS – ESTIMATED OFF-SITE TRANSPORT



NOTE: BOUNDARY URANIUM LOADS ESTIMATED USING VOLUME-WEIGHTED DATA FROM UPSTREAM STATIONS

SURFACE WATER LOADS

Off-site actinide loads in the Walnut and Woman Creek drainage basins, as well as the total load of both basins combined, are summarized in Chart 4. The measured average annual volume of surface water flowing off site is displayed for each basin at the bottom of the chart.

CHART 5

Pu MEASURED INPUTS

INPUT	DESCRIPTION	LOAD (pCi)
SW093	N. WALNUT IN	8.7E+06
GS10	S.WALNUT IN	2.9E+07
SW091	TRIBUTARY	1.7E+05
WWTP	TRIBUTARY	1.1E+06
SUBTOTAL		3.9E+07

Pu MODELED INPUTS

INPUT	DESCRIPTION	LOAD (pCi)
EROSION	DIFFUSE INPUT	8.2E+06
GROUNDWATER	DIFFUSE INPUT	1.2E+05
AIR DEPOSITION	DIFFUSE INPUT	6.5E+06
SUBTOTAL		1.5E+07

TOTAL INPUTS 5.4E+07

A- AND B- SERIES PONDS (study area)

Pu MEASURED OUTPUTS

INPUT	DESCRIPTION	LOAD (pCi)
GS11	N. WALNUT IN	2.5E+06
GS08	S.WALNUT IN	6.9E+06
SUBTOTAL		9.4E+06

TOTAL OUTPUTS 9.4E+06

GAIN (+) OR LOSS (-) OF Pu IN STUDY AREA

VARIABLES	DATA (pCi)	CHANGE FROM INPUT	REMARKS
MEASURED DATA ONLY (OUT - IN)	-2.9E+07	-76%	76% OF INFLOW PU ACCUMULATES
MEASURED + MODELED (OUT - IN)	-4.4E+07	-82%	82% OF INFLOW PU ACCUMULATES

MASS BALANCE ANALYSIS

An example of the detailed mass balance analyses performed on three surface water study areas is shown in Chart 5, which summarizes plutonium input and output loads to the Walnut Creek detention ponds. Results indicate a larger plutonium load flowing into the ponds than flowing out. This accumulation of plutonium in the ponds is attributed to particle settling which removes plutonium from the water column. Contributions of modeled input loads, such as deposition of airborne plutonium to surface water, are also quantified. A similar analysis for uranium-238 was done in the same study area. Those results are tabulated in the Technical Appendix. Other study areas analyzed in the same manner are the South Interceptor Ditch drainage basin and the section of Walnut Creek between the terminal ponds and the site boundary.

DISCUSSION: PLUTONIUM AND AMERICIUM IN SURFACE WATER The South Interceptor Ditch drainage basin, which includes hillslopes near the 903 Pad, has the highest levels of surface soil plutonium contamination at the Site. This basin is characterized by well-vegetated slopes and has only 14 percent impervious surface coverage. In contrast, the highly-developed central Industrial Area drainage basin is covered by approximately 47 percent impervious surfaces. Therefore, the South Interceptor Ditch basin has more water infiltration and less runoff per unit area than the central Industrial Area. Less runoff equates to less soil erosion and less actinide transport. As a result, despite having higher plutonium activities in the soil, the surface water plutonium load discharged per square meter of the South Interceptor Ditch basin (3.8 pCi/m^2/year) is roughly one-tenth of that measured in the central Industrial Area runoff.

Average concentrations of plutonium in surface water vary by a factor of nearly 40 at monitoring stations across the Site. Average plutonium concentrations measured in surface water range from 0.191 pCi/L, for central Industrial Area runoff monitored at station GS10, to 0.005 pCi/L for Woman Creek at station GS01 located near Indiana Street.

The actively managed detention ponds on North and South Walnut Creeks settle out particles and, as a result, remove roughly 80 percent to 90 percent of the plutonium and americium that flows into the ponds. The fraction of plutonium that doesn't settle is at least partially explained by site research which indicates approximately 10 percent of the plutonium and americium in runoff from the central Industrial Area, at station GS10, is attached to sub-micrometer-sized colloid particles (Santschi, 2000). The colloids are not likely to settle in the ponds. An additional important observation regarding plutonium transport involves the lower section of Walnut Creek, between the terminal detention ponds and the site boundary, where the average annual plutonium load measured at the downstream end is approximately 30 percent greater than the plutonium load measured at the upstream end. Site investigations suggest the plutonium source in this area is diffuse, low-level legacy contamination in watershed soils and channel sediments (RMRS, 1998).

DISCUSSION: URANIUM IN SURFACE WATER Concentrations of uranium, in contrast to plutonium and americium, are relatively uniform in surface water across the Site. As a result, uranium loads in each basin are largely a function of each basin's water yield. Quantifying the fractions of natural versus man-made uranium in surface water requires that samples be analyzed using a high-resolution analytical technique, such as inductively coupled plasma/mass spectrometry (ICP/MS). This type of analysis is planned to permit more accurate detection of man-made uranium in site surface water. Although surface water flowing from RFETS is not utilized for drinking water supplies, comparison with the drinking water standard for uranium provides perspective on water quality. Total uranium concentrations at RFETS Point of Evaluation and Point of Compliance monitoring stations from water years 1997 through 1999 averaged roughly one-tenth of the 30 microgram per liter Maximum Contaminant Level for drinking water.

DISCUSSION: AIR-TO-SURFACE WATER PATHWAY Model estimates were generated to characterize the air-to-surface water pathway for plutonium and uranium-238. These analytes also serve as analogs for the transport behavior of americium and other uranium isotopes. Model estimates indicate the air-to-surface water pathway provides a relatively minor load, less than 1 percent of the total input to surface water, for all actinides and for all areas of the Site, with one exception. For the Walnut Creek detention ponds, model results indicate approximately 12 percent of the total input load is from airborne deposition to surface water. The increased fraction from airborne deposition in this location is a function of the large surface area of the ponds and the close proximity of the 903 Pad, a large surface soil plutonium source.

DISCUSSION: SURFACE WATER INTERACTION WITH SUB-SURFACE WATER For plutonium, flow between surface water and shallow sub-surface alluvial water is a relatively minor transport pathway to and from surface water, comprising 1 percent or less of the total input or output load for any of the areas studied. In contrast, uranium transport in the shallow sub-surface is a relatively major pathway. Model estimates for uranium-238 in shallow sub-surface flow ranged from 7 percent of the output load in lower Walnut Creek to 83 percent of the input load in the South Interceptor Ditch basin.

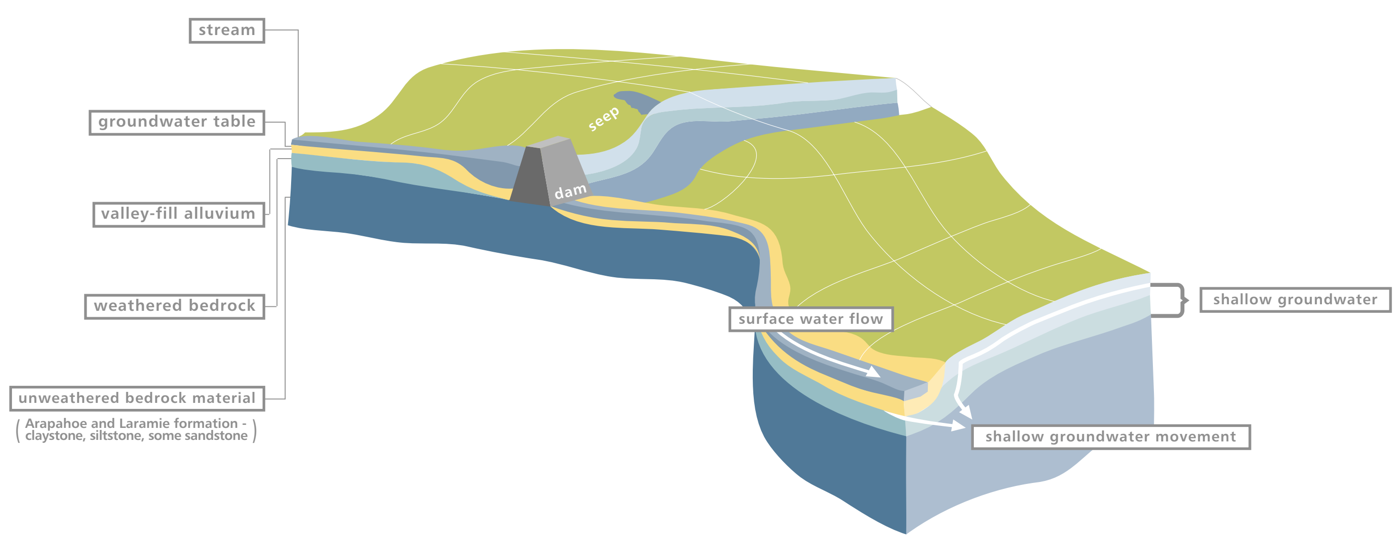
DISCUSSION: EXTREME EVENTS Model estimates of erosion indicate the plutonium load delivered from the South Interceptor Ditch basin is greater relative to other watersheds during extreme events. The plutonium load delivered from the 100-year, 6-hour storm event (97.1 mm) at the downstream end of the South Interceptor Ditch is approximately four times larger than the load delivered off site in Walnut Creek during the same storm. The explanation for the model-predicted impact of large storms is that the highest levels of plutonium contamination on Site are within the South Interceptor Ditch watershed. The hillslopes are well vegetated and have little runoff or erosion and plutonium transport, until an extreme storm event occurs. Remediation of soils within the South Interceptor Ditch watershed will reduce actinide loads transported in extreme events.

GROUNDWATER PATHWAY

INTRODUCTION Flowing beneath the ground surface, groundwater represents another pathway by which actinides can potentially be transported. This study focuses on "shallow" alluvial groundwater because geologic conditions at RFETS limit the depth of groundwater potentially impacted by Site contamination. Shallow groundwater refers to water flowing in the Site's alluvium and weathered bedrock geologic units and is found from just below the ground surface to depths of approximately 30 meters (100 feet), as shown in the figure below.

Shallow groundwater and surface water are inextricably linked. Water from stream channels infiltrates downward, recharging the shallow groundwater. Seeps discharge shallow groundwater to the surface. Therefore, it is not surprising that an actinide's solubility, which controls actinide transport in surface water, also dictates actinide transport in shallow groundwater. Insoluble actinides, such as plutonium, americium and uranium in the IV oxidation state, are relatively immobile in the soil and groundwater environment due to their low aqueous solubility and tendency to strongly sorb on soil media (Cleveland et al., 1976 and Honeyman and Santschi, 1997). However, work at RFETS, as well as studies in the literature, have shown that insoluble actinides can sorb to natural, sub-micrometer-sized colloid particles that can potentially facilitate actinide movement (Santschi, 2000). Another transport process similar to that observed in surface water involves more soluble actinides, such as uranium in the IV oxidation state, that move in solution with the shallow groundwater flow.

SHALLOW GROUNDWATER FLOW MODEL



Beneath areas with shallow groundwater flows in the alluvium and weathered bedrock geologic units, there is a thick, highly-impermeable, unweathered section of bedrock that inhibits downward groundwater flow. Because the shallow groundwater is inhibited from flowing vertically downward, it preferentially moves laterally along the unweathered bedrock surface and generally flows from west to east. The shallow groundwater flow is directed toward streams, where it either discharges as baseflow into the stream, evapotranspires to the atmosphere or continues as shallow groundwater flowing downstream within the more permeable valley-fill alluvium material just below the ground surface. Yet deeper, below the unweathered bedrock unit, is the regional Laramie-Fox Hills aquifer, approximately 200 to 300 meters (650 to 1,000 feet) below the Site. A U.S. Geological Survey study and a separate, peer-reviewed site investigation both indicate this aquifer will not be impacted by site activities because of the intervening unweathered bedrock layer, specifically the Laramie Formation, that has claystones with low hydraulic conductivities (Hurr, 1976; RMRS, 1996).

METHODOLOGY FOR QUANTIFYING ACTINIDE TRANSPORT Calculating actinide quantities transported off site each year in shallow groundwater requires quantifying: 1) the volume of shallow groundwater flowing off site; and 2) concentrations of different actinides in the shallow groundwater.

The volume of shallow groundwater flowing off site, or shallow groundwater flux, was calculated using the site-wide water balance model that uses the "MIKE SHE" computer code. This hydrologic model simulates all of the significant integrated hydrologic flow processes including overland flow, channel flow and sub-surface flow in the saturated and unsaturated zones. Lateral shallow groundwater flow off-site is computed for saturated flow within the unconsolidated alluvial and weathered bedrock material. For actinide transport analysis, off site shallow groundwater flux volumes were estimated for water year 2000 (from October 1999 through September 2000) for the Walnut Creek and Woman Creek groundwater basins. In addition to using model results for a normal precipitation year, shallow groundwater flux was estimated using precipitation data for January through May of 1995. Approximately 340 mm (13.5 in), or twice the average amount, of precipitation fell during this period. These model results provide insight into shallow groundwater flows during wet conditions.

Shallow groundwater actinide measurements, collected from alluvial wells near Walnut and Woman Creeks at the Site's eastern boundary, were used to determine the concentration of actinides in shallow groundwater flowing off site. The estimated annual shallow groundwater flux volumes for the Walnut and Woman Creek basins were multiplied by the average actinide concentrations within each basin to estimate the actinide loads transported off site in shallow groundwater.

DISCUSSION: PLUTONIUM AND AMERICIUM IN SHALLOW GROUNDWATER Determination of plutonium and americium concentrations in shallow groundwater at the Site is complicated by residual surface soil contamination potentially introduced down boreholes during drilling and well installation operations. Shallow groundwater samples collected using traditional bailing techniques may suspend these contaminated drilling-artifact soil materials, thereby producing shallow groundwater samples with artificially high plutonium or americium concentrations. As a result of potential well construction and sampling biases, new clean or "aseptic wells" were drilled and efforts to improve sampling protocols undertaken. This work is currently ongoing. Therefore, plutonium and americium concentrations in shallow groundwater wells used in this analysis may represent a "worst case" scenario. Mean plutonium activities in alluvial wells at the site boundary were 0.035 pCi/L (+/- 0.018 pCi/L) in the Walnut Creek shallow groundwater basin and 0.003 pCi/L (+/- 0.004 pCi/L) in the Woman Creek shallow groundwater basin.

DISCUSSION: URANIUM IN SHALLOW GROUNDWATER Uranium-233/234 and uranium-238 isotopes are the dominant actinides found in groundwater in terms of total activity because of their natural abundance, particularly in the RFETS region. Though the concentration of uranium in groundwater at RFETS is within the natural range, shallow groundwater flowing from the Site can have uranium from man-made sources. Special analytical techniques, such as ICP/MS, must be used to study isotopic ratios in the groundwater and determine whether any of the uranium has origins from man-made sources. For natural uranium, the ratio of uranium-235/uranium-238, by mass, is approximately 0.0072. A ratio less than 0.0072 indicates the presence of man-made uranium-238, or "depleted" uranium, whereas a ratio greater than 0.0072 indicates the presence of man-made uranium-235, or "enriched" uranium. Additionally, ICP/MS analysis can detect the presence of uranium-236, a reactor product that is not found in natural uranium.

Actinide concentrations in groundwater are determined by analyzing samples collected from wells. Most of the uranium found in groundwater at RFETS is from natural sources. Special analytical techniques are used to determine if any fraction comes from man-made uranium sources.

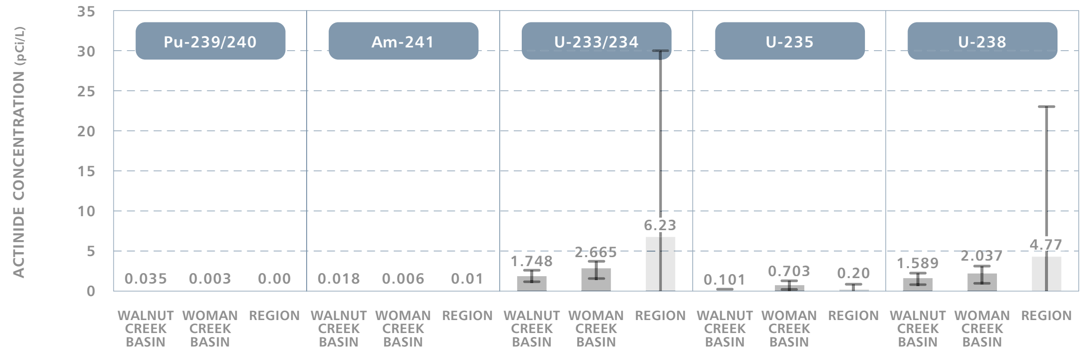
Samples collected at site wells from July 1999 to August 2000 were analyzed using ICP/MS. Most samples indicated uranium from natural sources. However, alluvial groundwater samples collected near the site boundary in both the Walnut and Woman Creek groundwater basins had uranium-235/uranium-238 mass ratios slightly less than the 0.0072 ratio found naturally. The small variation from the natural ratio, though potentially related to analytical uncertainty, indicates the shallow groundwater in these basins may have a small fraction of man-made "depleted uranium" as part of the total uranium concentration. In addition, the same Walnut Creek boundary location had detectable levels of uranium-236, an isotope that comes only from a man-made uranium source (RMRS, 2000).

GROUNDWATER CONCENTRATIONS

Chart 6 displays shallow groundwater actinide concentrations in the RFETS Walnut and Woman Creek groundwater basins. Site measurements are compared with background concentrations of actinides measured in Front Range regional upper hydrostratigraphic unit groundwater, or shallow groundwater, that is not impacted by RFETS.

CHART 6

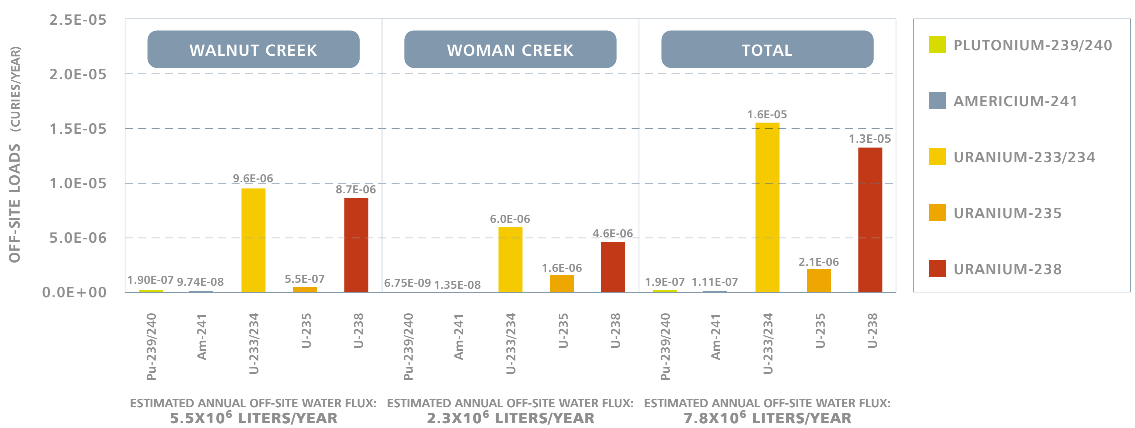
SHALLOW GROUNDWATER ACTINIDE CONCENTRATIONS – WALNUT AND WOMAN CREEK GROUNDWATER BASINS COMPARED WITH REGIONAL BACKGROUND ACTIVITY IN GROUNDWATER



NOTE: ERROR BARS REPRESENT MEAN 1 STANDARD DEVIATION ANALYTICAL ERROR OF ALL RESULTS

CHART 7

SHALLOW GROUNDWATER ACTINIDE LOADS – ESTIMATED ANNUAL OFF-SITE TRANSPORT BASED ON WATER YEAR 2000 PRECIPITATION



GROUNDWATER LOADS

Shallow groundwater actinide loads transported off site in the Walnut and Woman Creek groundwater basins are summarized in Chart 7. The model-estimated average annual volume of shallow groundwater yielded off site is displayed for each basin at the bottom of the chart.

GROUNDWATER FLUX – WET CONDITIONS

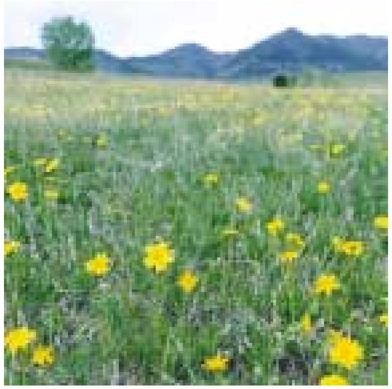
Model estimates of increased shallow groundwater flux during extreme precipitation conditions were calculated for May 1995, when 194 mm (7.65 in) of precipitation occurred, or roughly three times the May norm. The estimated flux of shallow groundwater flowing off site increased by approximately 100 percent in the Walnut Creek drainage and approximately 50 percent in the Woman Creek drainage. This provides some basis for estimating the impacts of extreme precipitation events on shallow groundwater flow and related actinide transport.

BIOLOGICAL PATHWAY

INTRODUCTION Movement of actinides via the biological pathway can occur by a variety of mechanisms that range from transport of soil and actinides by insects to actinide transport by deer that have ingested vegetation with actinide-bearing soil on plant surfaces. A large body of scientific literature addresses quantitative estimates of actinide intake and movement by different biological entities. Much of this research was specific to RFETS, including an extensive series of radioecology studies conducted from the 1960s through the 1990s by the Department of Radiology and Radiation Biology at Colorado State University (Whicker, 1979; Little, et. al., 1980; Webb, et al., 1993). These studies generally concentrated on areas contaminated with plutonium and other actinides in various compartments of the RFETS ecosystem and used field measurements and laboratory analyses of actinides in plant and animal tissues.

Mule deer have been the focus of research as the most likely mechanism for biological actinide transport at RFETS.

Site-specific research has been conducted on mule deer as a biological pathway for actinide movement for several reasons, including their mobility, amount of soil intake and their relative abundance, with a herd size of approximately 140 (Kaiser-Hill, 2000). Quantifying the off-site transport of actinides by mule deer provides a reference for comparing the effects of the overall macro-biological transport pathway. Other biological transport pathways and mechanisms, such as vegetation uptake of actinides and biogeochemical processes, are not quantified here but are addressed later in the Discussion section of this text (Page 22).



The Buffer Zone serves as attractive habitat for the Site's approximately 140 mule deer. Tracking data indicate approximately 5 percent of the herd leave the Site each year.

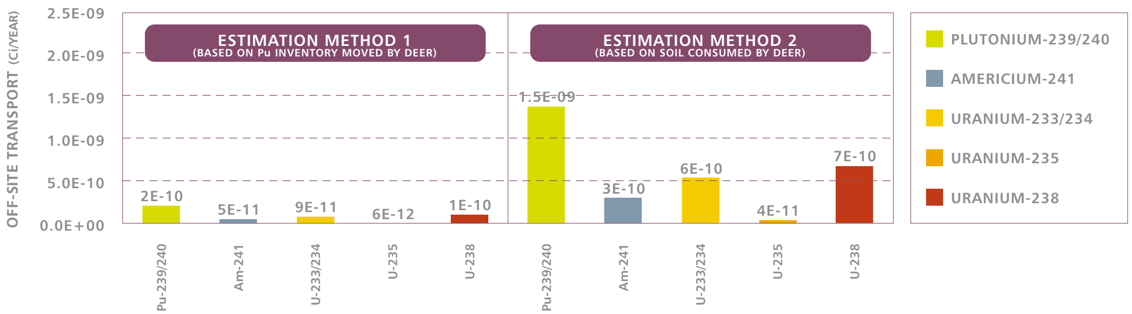
METHODOLOGIES FOR QUANTIFYING ACTINIDE TRANSPORT

Two different methods were used to quantify actinide transport off site via the biological pathway. The first method is based on a site-specific study that estimated less than 1 x 10^{-7} (one ten-millionth) of the plutonium inventory in soil is moved around the Site by mule deer each year and most of this is redeposited on DOE-controlled property (Whicker, 1979). This value, combined with data on the plutonium inventory in soil and average soil activity, provided a basis for calculating the amount of soil moved by mule deer. The second actinide transport estimation method is based on RFETS data quantifying the average amount of soil consumed by mule deer, over the year, to be approximately 16 grams per day (Arthur and Alldredge, 1979).

The estimated soil quantities moved or ingested by mule deer on site were used with additional data to quantify the amount of soil transported off site by mule deer. The other information included telemetry data that indicate approximately 5 percent of the deer herd leave the Site annually (Symonds and Alldredge, 1992). The time for a deer to completely cycle forage before its bowel is empty is approximately 48 hours (Alldredge and Reeder, 1972). This variable is important because most plutonium ingested by deer grazing in contaminated areas passes through the deer's gut, because of plutonium's low solubility and is redeposited to the ground in the form of fecal pellets (Whicker, 1979). Based on the amounts of soil transported off site by mule deer, the quantities of plutonium, americium, uranium-238, uranium-235 and uranium-233/234 transported off site were estimated using area-weighted average soil concentrations of these actinides.

CHART 8

BIOLOGICAL PATHWAY ACTINIDE LOADS – ESTIMATED OFF-SITE TRANSPORT BY MULE DEER



BIOLOGICAL PATHWAY LOADS

Estimates of actinide loads transported off site by mule deer, calculated using two different methods, are summarized in Chart 8.

DISCUSSION Estimates of plutonium activity transported off site by mule deer range from approximately 200 to 1,000 pCi per year. Areas most frequented at RFETS by mule deer are more heavily vegetated hillside grasslands, shrublands and woodlands (Kaiser-Hill, 2000). These areas provide greater erosion protection than sparsely vegetated areas and therefore limit indirect actinide movement caused by deer disturbing the soil. The limited erosion potential in heavily vegetated areas also reduces movement of deer pellets by erosion processes.

Site studies suggest there is limited redistribution of plutonium by biota in aquatic systems.

DISCUSSION: TERRESTRIAL FAUNA Plutonium is not a biologically essential element, nor does it serve as an analog for any other essential element (Higley and Whicker, 1999). There is little accumulation of plutonium in the tissues of arthropods, small mammals, snakes and mule deer. In general, biota investigations in the 903 Pad area showed that plutonium concentrations in biota were significantly lower than in soils. Arthropods and small mammals showed plutonium concentrations 100 times less than the concentrations in soil, with no significant differences in seven tissue types analyzed. The concentration hierarchy followed a downward trend from dead plant litter to fresh vegetation to animal compartments. Higher values for plant litter are expected since the litter is more closely associated with the surface soil and is prone to the accumulation of soil particulate matter. Generally, actinide sources in the environment have resulted in minor transfer of these elements into food webs, regardless of transport process.

DISCUSSION: OTHER HIGHLY MOBILE SPECIES Several other mobile species undoubtedly transport small quantities of actinides off site. Species such as waterfowl and other birds, coyotes and insects may transport actinides off site. However, data for these species are not available and would be difficult and in some cases logistically nearly impossible to obtain. Redistribution of contaminated soil by burrowing animals such as pocket gophers is a recognized phenomenon but is believed to only have a local effect on actinide redistribution (Whicker, 1979). Using the deer data and normalizing by the deer biomass, it is estimated that off-site transport by other selected terrestrial species is comparable to transport by deer, or possibly lower.

Studies conducted by CSU researchers show little accumulation of plutonium in animal tissues.

DISCUSSION: AQUATIC STUDIES Limited aquatic studies at RFETS indicate a very limited potential for biota to redistribute plutonium in aquatic systems. Paine (1980) found an increase in trophic-level concentration of plutonium does not occur. There appears to be a selective mechanism, which discriminates against plutonium at the phytoplankton to zooplankton level. The highest concentration in crawfish was found in the exoskeleton. Whole fish had detectable activity, but fish flesh showed none. These results indicate low bioavailability of the plutonium because of its low solubility and chemical partitioning to solid particles.

Plant tissues uptake very minor amounts of plutonium because of their insoluble nature.

DISCUSSION: TERRESTRIAL VEGETATION The uptake of plutonium into plant tissues is normally very minor because of its insoluble nature. The majority of plutonium measured in plant material is associated with surficial dust particles (Higley and Whicker, 1999).

DISCUSSION: SOIL MICROBES Microorganisms in soils, sediments and ponds may play a role in the regulation of actinide movement that occurs through surface soil erosion and colloidal transport processes. Potential interactions between indigenous microorganisms and actinides include bioreduction, bioprecipitation, biosorption and solubilization due to production of microbial metabolic products. Site-specific data on the microbial ecology of RFETS, however, do not exist, nor do studies detailing specific microbiological processes on actinide mobility in the surface soils, sub-surface material or surface water at the Site.

SUMMARY OF ACTINIDE LOADS Estimates of average annual actinide loads transported off site by each of the major pathways addressed in this report are summarized and compared in this section. In cases where more than one method was used to estimate off-site loads for a specific pathway, the method yielding the highest estimated off-site load was used for the comparison. Because quantities of actinides transported off site vary by several orders of magnitude depending on the actinide and transport pathway, a logarithmic scale is used to display the results (Chart 9). Therefore, each horizontal line represents an actinide load that is larger, by a factor of 10, than the line below. Actinide transport pathways are compared by order of magnitude due to the uncertainties associated with analytical measurements and model estimation results.

PATHWAY COMPARISON

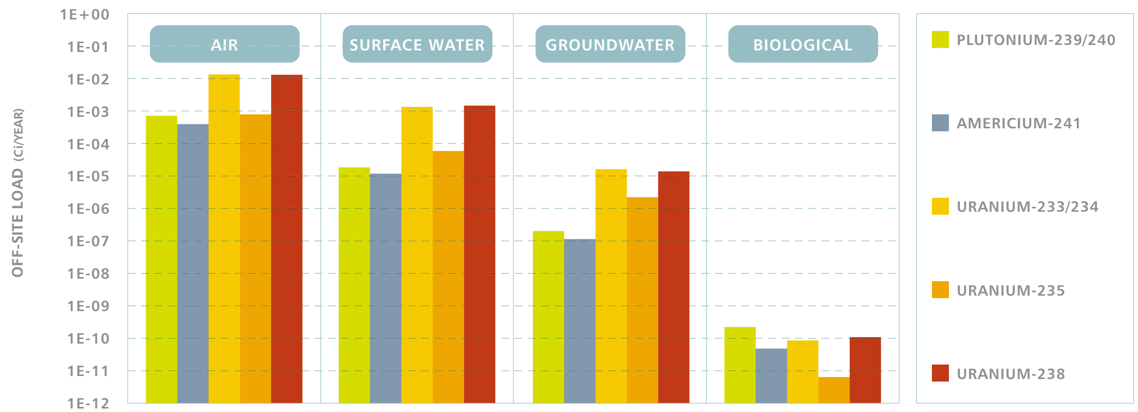
For all actinides, air and surface water are the dominant transport mechanisms. For plutonium, the estimated annual airborne load transported off site exceeds the surface water load by roughly a factor of 40. For americium, the trend of the results is the same, which is logical because both plutonium and americium are transported in a similar manner.

For shallow groundwater, estimated plutonium and americium loads are approximately two orders of magnitude less, or 1/100th, of the load conveyed in surface water. These shallow groundwater loads are, however, potentially biased high because of residual low-level surface soil contamination introduced down boreholes during drilling and well-installation operations. The ratio between surface water and groundwater in transporting loads of plutonium and americium off site is approximately the same as the ratio between volumes of surface water and shallow groundwater flowing off site.

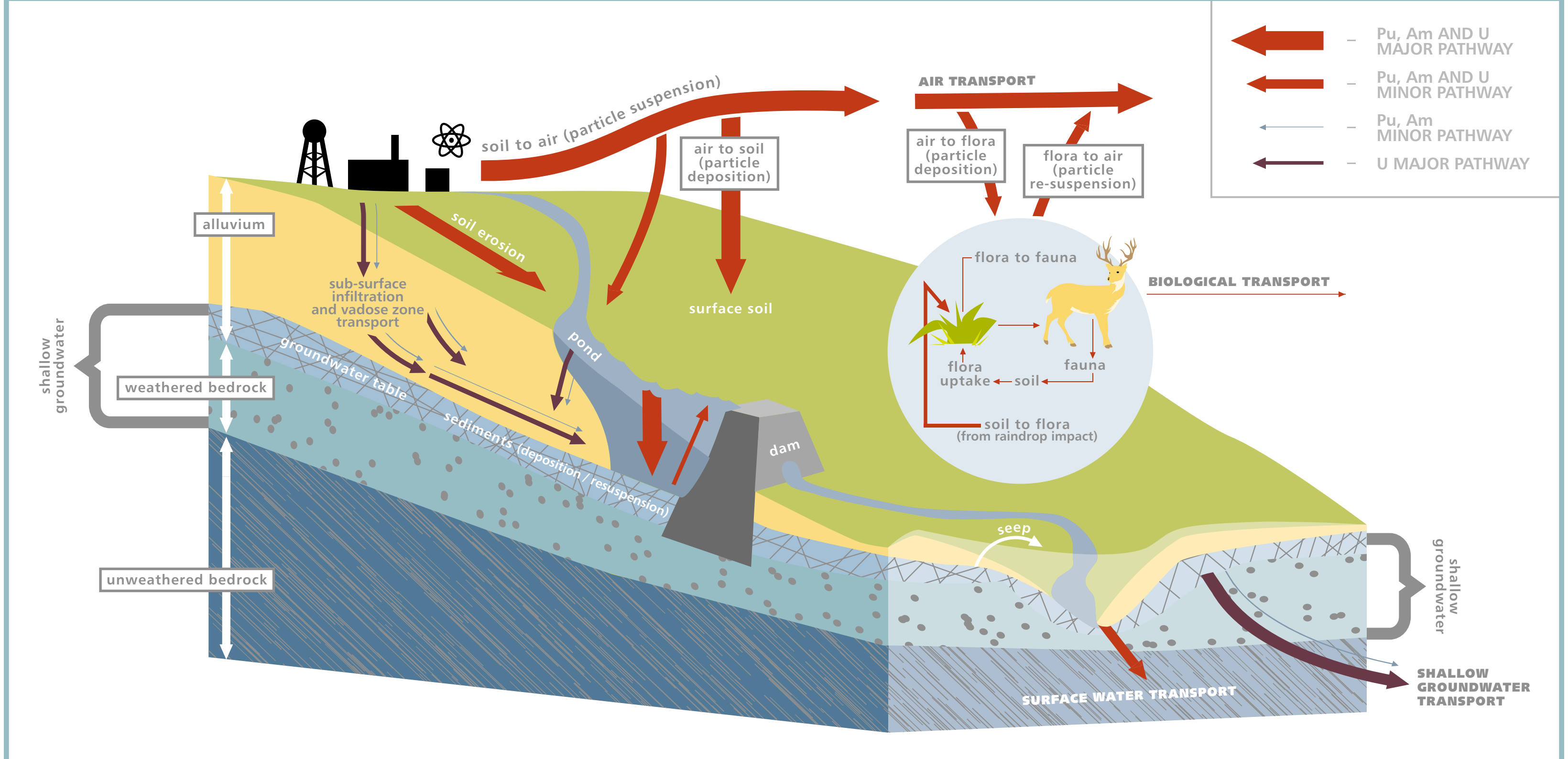
The biological pathway is also minor relative to the air and surface water pathways. It is estimated to transport approximately five orders of magnitude less, or 1/100,000, of the plutonium load compared with the surface-water pathway.

CHART 9

ALL PATHWAYS – ESTIMATED OFF-SITE ANNUAL ACTINIDE LOADS



UPDATED CONCEPTUAL DIAGRAM OF ACTINIDE MIGRATION



TRANSPORT PROCESSES - PLUTONIUM AND AMERICIUM COMPARED WITH URANIUM

Processes that transport plutonium and americium in the environment at RFETS are summarized in the diagram above. Larger arrows indicate more dominant pathways and smaller arrows indicate lesser pathways. The insoluble nature of plutonium and americium causes these actinides to be largely transported as particles attached to soil that is eroded by wind and water. Sub-surface transport of plutonium and americium is a relatively minor pathway, as is transport by biological mechanisms.

Uranium transport processes at RFETS are also shown above. Though not highly soluble, uranium is more soluble than plutonium and americium and is therefore more easily transported in the sub-surface. Hence, the arrows indicating a sub-surface pathway for uranium are larger than those for sub-surface plutonium or americium transport.

AIR TRANSPORT PATHWAY Transport of actinides through the air occurs largely by wind erosion of actinide-containing particulate matter from site soil and dust-laden vegetation. The general direction of airborne actinide transport follows the prevailing winds, from the northwest to the southeast. More importantly, higher winds, which transport much larger loads than lower winds, occur almost exclusively from the northwest quadrant.

For perspective on the quantity of airborne actinides measured at the Site, the air monitoring location with the highest total annual airborne actinide concentration from 1997 through 1999 was station S-140 in the southeast corner of the Site. This location had an airborne actinide level equal to approximately 1.4 percent of the 10 millirem regulatory standard governing airborne radionuclide concentrations at DOE facilities.

SURFACE WATER TRANSPORT PATHWAY The central Industrial Area, which drains to South Walnut Creek, yields the largest loads of plutonium and americium in surface water per square meter of drainage area. The Industrial Area has large impervious surfaces that generate large volumes of runoff during storms, which causes erosion and actinide loading in surface water. In contrast, the South Interceptor Ditch drainage has areas near the 903 Pad with the highest known levels of plutonium activity in soil, but the basin is largely well-vegetated and therefore generates less runoff that can cause erosion and transport actinides. The surface water plutonium load discharged per square meter of the South Interceptor Ditch basin (3.8 pCi/m^2/year) is roughly one-tenth of the load per square meter of watershed compared to the central Industrial Area.

However, for extreme conditions, the South Interceptor Ditch may yield proportionately higher actinide loads. Model results indicate a hypothetical 100-year, 6-hour storm event (97.1 mm) would cause significant erosion in the South Interceptor Ditch basin and result in plutonium loads to the channel that are two to three orders of magnitude higher than observed in the Walnut Creek basin. Remediation of soils within the South Interceptor Ditch watershed will reduce actinide loads transported during extreme events.

The detention ponds on North and South Walnut Creeks serve to settle out particles and generally remove 80 to 90 percent of the annual plutonium and americium load that flows into the ponds. This corresponds with site research that demonstrates approximately 10 percent of the plutonium and americium in surface water is sorbed to colloid particles that are not likely to settle in the ponds. Another important observation regarding plutonium transport involves the lower section of Walnut Creek. The average annual plutonium load measured in Walnut Creek near the site boundary is approximately 30 percent greater than the plutonium load measured upstream, below the detention ponds. Site investigations indicate the plutonium source in this area is diffuse legacy contamination in soils and sediments.

Uranium activities are relatively uniform in surface water across the Site. As a result, the uranium load delivered from different basins is largely a function of each basin's water yield. Though surface water across the Site has uranium concentrations below the Maximum Contaminant Level for drinking water, high resolution analytical techniques are planned to determine if uranium from man-made sources is impacting site surface water.

GROUNDWATER TRANSPORT PATHWAY At RFETS, potential groundwater actinide transport involves lateral, shallow groundwater flow in the alluvium and weathered bedrock geologic units. Shallow groundwater at the Site does not percolate down into the regional Laramie-Fox Hills aquifer. A thick, intervening layer of impermeable claystones in the Laramie Formation prevents vertical movement from the shallow groundwater down to the regional aquifer.

Shallow groundwater and surface water are linked. Plutonium and americium are relatively immobile in the soil and groundwater because of their low solubility and tendency to sorb onto soil. However, work at RFETS as well as studies in the literature have shown that insoluble actinides can sorb to natural, sub-micrometer-sized colloid particles that can facilitate actinide movement. In addition to colloidal transport, sub-surface actinide transport can occur when more soluble actinides, such as uranium in the (VI) oxidation state, move in solution.

Low levels of plutonium and americium have been detected in shallow groundwater wells at the eastern site boundary. However, determination of plutonium and americium levels in shallow groundwater is complicated by residual surface soil contamination potentially introduced down boreholes during drilling and well installation. New clean or "aseptic wells" were drilled and efforts to improve sampling protocols are currently ongoing. For this analysis, plutonium and americium activity measured in shallow wells may represent activities higher than what actually exists in the shallow groundwater.

Uranium-233/234 and uranium-238 isotopes are the dominant actinides found in shallow groundwater in terms of total activity because of their natural abundance. Uranium in RFETS shallow groundwater is generally within the range of uranium detected naturally. Data from high-resolution ICP/MS analyses indicate that uranium in most areas of the Site is from natural sources. However, shallow groundwater samples at the site boundary in the Walnut and Woman Creek groundwater basins have a uranium-235/uranium-238 ratio that is slightly less than found naturally. Though potentially related to analytical uncertainty, these results indicate alluvial groundwater in these basins potentially has a signature indicating a small fraction of the uranium is "depleted" uranium.

BIOLOGICAL TRANSPORT PATHWAY RFETS-specific studies and other scientific literature indicate that plutonium has low bioavailability, due to its insolubility. Consequently, uptake into plant and animal tissues is minor. There is little accumulation of plutonium in the tissues of arthropods, small mammals, snakes or mule deer.

Mule deer have been studied as a biological pathway for actinide movement because of their mobility, amount of soil intake and size of the herd. Based on the estimated plutonium inventory in soil and data on deer mobility, the plutonium activity transported off site by deer movement is estimated to be approximately 2×10^{-10} to 1×10^{-9} Ci annually.

CONCLUSIONS Quantified analyses of RFETS actinide pathways generally support the conceptual model which identified soil and sediment transport processes as the primary mechanisms for plutonium and americium transport. Measured and modeled data confirm that wind and water erosion are the dominant plutonium and americium transport pathways, though the magnitude of airborne transport is larger than previously suggested in the qualitative conceptual model study.

Modeled data also support the conceptual model in terms of shallow groundwater transport being a relatively minor pathway for plutonium and americium because of the low solubility and strong soil sorption characteristics of these actinides. Data also support the conceptual model regarding the importance of sub-surface uranium transport, due to its higher solubility. Analyses indicate most of the uranium in shallow groundwater is from natural sources. Uranium loads transported off site in shallow groundwater are small compared to surface water. However, discharges of shallow groundwater to the surface contribute a major fraction of the surface water uranium load in specific stream channels.

IMPLICATIONS FOR SITE CLOSURE

An objective of the Pathway Analysis Report is to provide recommendations for long-term protection of the environment, with emphasis on actinide surface water quality, during and after site closure, as specified in the Rocky Flats Cleanup Agreement. Based on the characterization of current actinide sources and quantitative analysis of actinide transport mechanisms, the following general implications apply to near-term site remediation, final site closure design and long-term site management and stewardship.

NEAR-TERM SITE REMEDIATION Field measurements and modeling analyses indicate air and surface water are the major transport pathways for plutonium and americium. Soil disturbance increases the potential for soil erosion and contaminant transport. For example, Environmental Protection Agency (EPA) emissions factors indicate heavy construction equipment activities can increase airborne particulate emissions by roughly a factor of 20. Plutonium and americium in surface soil east of the 903 Pad is evidence of widespread contamination believed to have been dispersed when disturbed soils were exposed to a few high wind events in the 1960s. Current understanding of transport processes combined with historic lessons reinforce the importance of implementing soil erosion controls, such as protecting soil stockpiles and limiting excavation on windy days, to minimize airborne actinide transport during remedial activities.

Similarly, soil erosion and transport by surface water is a major potential pathway for plutonium and americium movement. Appropriate erosion control measures should be implemented during site remediation, including techniques such as minimizing vegetation disturbance and redirecting runoff away from excavations. A surface water management and detention pond system, with the capacity to settle out plutonium and americium, should be maintained during active site remediation.

Minimizing soil erosion by wind and water is a key concept for controlling actinide movement during short-term remediation activities and for long-term Site management.

Groundwater is not a major pathway for plutonium and americium transport, but operation and maintenance of the existing groundwater treatment systems will protect surface water from potential sub-surface uranium transport. The biological pathway is a minor transport mechanism for actinides and does not require altered management during site remediation other than excluding wildlife from active remediation sites.

FINAL CLOSURE DESIGN When site remediation is complete, surficial actinide sources with the highest activities are likely to have been removed. These remedial actions will reduce the reservoir of available actinides and diminish the magnitude of airborne actinide transport from these areas.

Removal of large impervious surfaces from the Industrial Area will result in reduced surface water runoff with a corresponding reduction in soil erosion and actinide transport. The combination of reduced runoff and diminished actinide sources will reduce the actinide load transported by the surface water pathway. In addition to remediation of localized actinide sources, other diffuse, low-level actinide sources that contribute to surface water contaminant loads, as observed in lower Walnut Creek, should be managed as needed for long-term protection of surface water quality.

Minimizing wind and water erosion should remain as a central theme in the final site closure design, with attention given to the long-term functionality of erosion control features. In addition to general erosion protection measures, such as establishing a vegetation cover resistant to drought or other extreme ecological conditions, location-specific controls for surface water erosion should be considered for the final site configuration. Such measures include: (1) re-contoured or terraced slopes; (2) re-routed runoff; and (3) a surface water detention system with the capacity to entrap and settle particles that transport plutonium and americium.

Groundwater is a minor pathway for plutonium and americium, but can be an important transport pathway for uranium. Remediation of man-made uranium sources that impact surface water should provide long-term protection of surface water quality.

Biological mechanisms also have a minor direct influence on actinide movement, but they can indirectly influence actinide transport by causing soil disturbance that promotes erosion with resulting air and surface water actinide transport. Therefore, the final closure configuration design should minimize potential erosion effects caused by animals burrowing or otherwise disturbing the soil in parts of the Industrial Area with residual contamination.

LONG-TERM MANAGEMENT After final site closure, efforts to reduce soil erosion caused by wind and water should be continued by minimizing soil disturbance and maintaining stable slopes, particularly in areas with residual actinide activity. This approach includes using appropriate controls for managing biological resources and human impacts after the Site is converted into a National Wildlife Refuge. If post-closure monitoring identifies residual actinide activity that impacts surface water quality, the best available technology should be used to appropriately characterize and mitigate the actinide source.

FURTHER READING

The Technical Appendix of the Actinide Migration Evaluation Pathway Analysis Report provides more detailed analyses and further references for subjects addressed in this Summary Report. References cited in the Summary Report and additional information sources are listed below:

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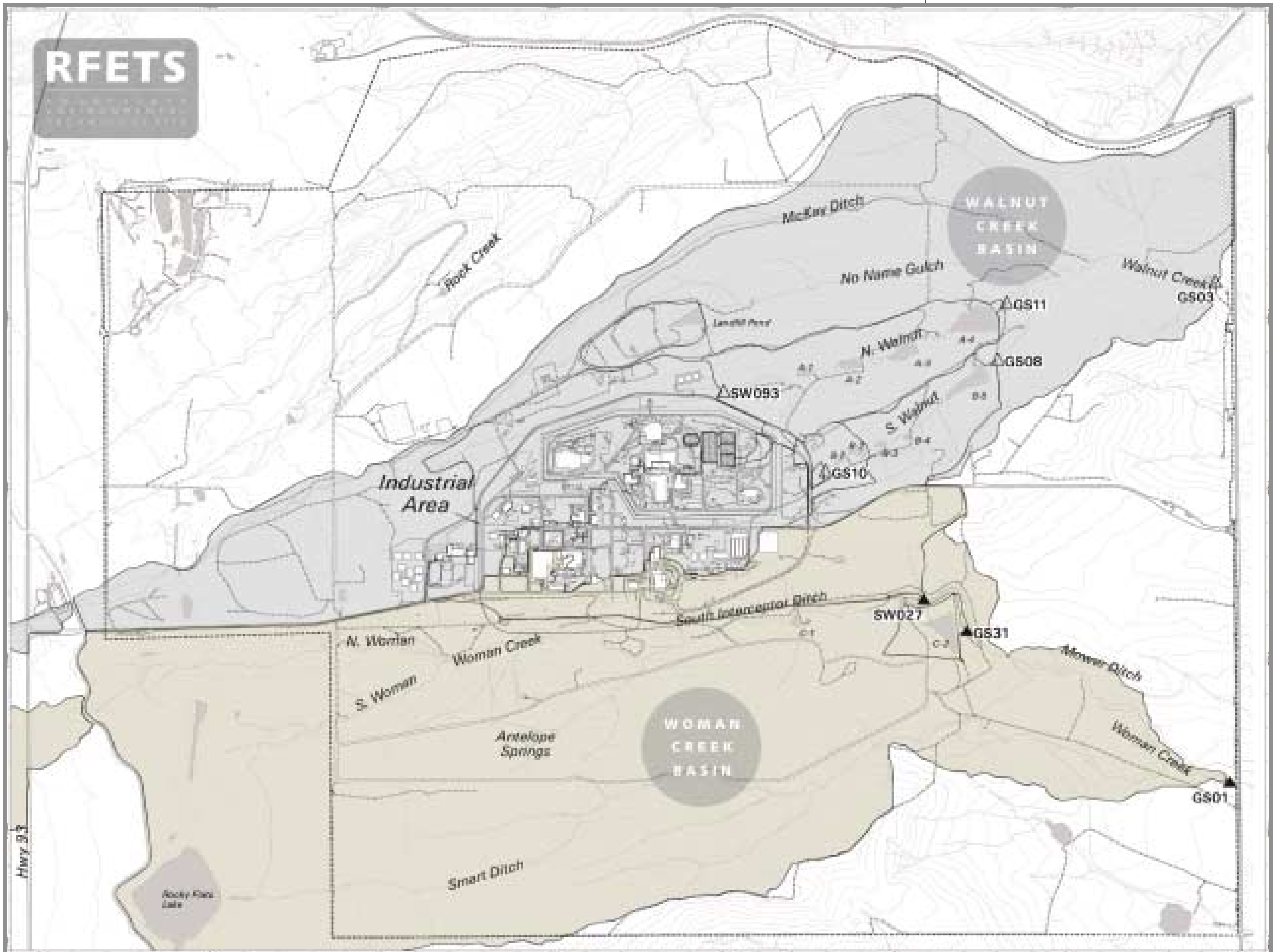
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WOMAN CREEK BASIN
McKay Ditch
Rock Creek
No Name Gulch
Walnut Creek
GS03
GS11
GS08
N. Walnut
S. Walnut
SW093
GS10
Industrial Area
South Interceptor Ditch
SW027
GS31
Mower Ditch
Woman Creek
GS01
N. Woman
S. Woman
Antelope Springs
Smart Ditch
Hwy 93