EPA-2043

Reid Rosnick/DC/USEPA/US		To	"Marion Loomis"
10/05/2010 06:37 AM		cc	
		bcc	
		Subject	Re: Conference Call re Subpart W

Ms Loomis,

My apologies for not responding sooner, I was out of the office on travel. Thanks for providing the draft ATSDR document entitled Public Health Assessment for LINCOLN PARK/COTTER URANIUM MILLCAÑON CITY, FREMONT COUNTY, COLORADO EPA FACILITY ID: COD042167585 SEPTEMBER 9, 2010.

The information found in the draft document is data collected from the 10 ambient air monitoring stations where particle-bound radionuclides are sampled (p. 47). These are the air sampling stations that are located near the facility boundaries, as well as stations near the golf course and in Lincoln Park (Fig. 23, p. 172). They are not specifically stations for the tailings impoundments, and as such, also register radon concentrations that may originate from other sources, namely the two inactive mills, ore stockpile areas, and other areas. In fact, I did not see any data collected by Method 115 in the draft report. The document is silent on the radon emissions specifically from the tailings impoundments, and the purpose of the draft Health Assessment was to evaluate available data and information on the release of hazardous substances from the *entire* Cotter mill (not just the tailings impoundments). Therefore, I am inclined not to list the document as a topic for discussion, other than to note it, and place it on the public Subpart W website in order to allow more opportunity for comment. The website URL is: http://www.epa.gov/radiation/neshaps/subpartw/rulemaking-activity.html Also, FYI, the conference call is today, October 5, 2010, at 11 AM, EDT, not tomorrow, as stated in your original e-mail.

I do agree with you that the draft report concludes that ambient air emissions of particle bound radionuclides have not resulted in exposures to the public that could cause adverse health outcomes. We are currently reviewing the Subpart W standard to determine if, after over 20 years of progress in the science of risk estimation, etc., the standard continues to be protective of human health and the environment. Thanks again for providing the ATSDR document.

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

"Marion Loomis"	Mr. Rosnick The Wyoming Mining As...	10/01/2010 11:49:11 AM

From: "Marion Loomis" <loomis@vcn.com>
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 10/01/2010 11:49 AM
Subject: Conference Call re Subpart W

Mr. Rosnick

The Wyoming Mining Association (WMA) is very concerned about claims that uranium mining

and processing may contribute to health impairment from the release of radon from uranium processing facilities. WMA would like to draw your attention to the attached report entitled Public Health Assessment for LINCOLN PARK/COTTER URANIUM MILLCAÑON CITY, FREMONT COUNTY, COLORADO EPA FACILITY ID: COD042167585 SEPTEMBER 9, 2010.   In summary the study *concludes that ambient air emissions of particle bound radionuclides have not resulted in exposures to the public at levels that could cause adverse health outcomes.*   The ATSDR looked at all of the air data collected from 1979 to present related to Cotter Corporation's Canon City Mill and concluded that outdoor concentration of radon contributed zero dust to the public, because it is a noble gas and does not stay in the lungs long enough to radioactively decay.
I understand that there will be a conference call on October 6 to discuss 40 CFR Part 61 Subpart W which deals with this issue. WMA requests that this study be on the agenda for discussion during that conference call.

Thank you.

Marion Loomis[attachment "Public Health Assessment for Cotter Corp.pdf" deleted by Reid Rosnick/DC/USEPA/US]

EPA-3366

Reid Rosnick/DC/USEPA/US	To	Angelique Diaz
10/06/2010 01:18 PM	cc	
	bcc	
	Subject	Re: Fw: WA 1-04 Task 5 Draft Report

I'm not sure about a deadline, but if you could look at it within the next week that would be great.

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

Angelique Diaz No problem. What is the deadline? An... 10/06/2010 01:16:55 PM

From: Angelique Diaz/R8/USEPA/US
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 10/06/2010 01:16 PM
Subject: Re: Fw: WA 1-04 Task 5 Draft Report

No problem. What is the deadline?

Angelique D. Diaz, Ph.D.
Environmental Engineer
Air Program, USEPA/Region 8
1595 Wynkoop Street (8P-AR)
Denver, CO 80202-1129
Office: 303.312.6344
Fax: 303.312.6064
diaz.angelique@epa.gov

Reid Rosnick Hi Angelique, I know how busy you are,... 10/06/2010 11:06:24 AM

From: Reid Rosnick/DC/USEPA/US
To: Angelique Diaz/R8/USEPA/US@EPA
Date: 10/06/2010 11:06 AM
Subject: Fw: WA 1-04 Task 5 Draft Report

Hi Angelique,

I know how busy you are, but if you would like to comment on this document, I'd appreciate it. Thanks

Reid

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov
----- Forwarded by Reid Rosnick/DC/USEPA/US on 10/06/2010 01:05 PM -----

From: Brian Littleton/DC/USEPA/US
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 10/05/2010 10:19 AM
Subject: Fw: WA 1-04 Task 5 Draft Report

****

Brian Littleton
EPA, Office of Air and Radiation/Radiation Protection Division
1200 Pennsylvania Avenue, NW - Mailcode 6608J
Washington D.C. 20460
(202) 343-9216

----- Forwarded by Brian Littleton/DC/USEPA/US on 10/05/2010 10:18 AM -----

From: "Steve Marschke" <stevemarschke@frontiernet.net>
To: Brian Littleton/DC/USEPA/US@EPA
Cc: "Deborah Schneider" <dschneider@scainc.com>, <LSkoski@aol.com>, "Judy Eley" <jeley@scainc.com>, "Abe Zeitoun" <azeitoun@scainc.com>
Date: 10/04/2010 10:13 AM
Subject: WA 1-04 Task 5 Draft Report

Good morning Brian,

Attached for EPA's review is the draft report for WA 1-04, Task 5 "Radon Emissions from Evaporation Ponds."

Steve

[attachment "WA 1-04 Task 5 - Draft.doc" deleted by Angelique Diaz/R8/USEPA/US]

EPA-2203

Reid Rosnick/DC/USEPA/US
10/07/2010 09:47 AM

To Angelique Diaz
cc
bcc
Subject Re: Fw: Piñon Ridge Construction Approval Application

I'll try to get it up today.

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

Angelique Diaz FYI - the Pinon Ridge application can b... 10/07/2010 09:17:53 AM

From: Angelique Diaz/R8/USEPA/US
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 10/07/2010 09:17 AM
Subject: Fw: Piñon Ridge Construction Approval Application

FYI - the Pinon Ridge application can be posted to the Subpart W website. Let me know what the timing will be on putting it up there so I know how to move forward with the FOIA request.

Thanks!
Angelique

Angelique D. Diaz, Ph.D.
Environmental Engineer
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1595 Wynkoop Street (8P-AR)
Denver, CO 80202-1129
Office: 303.312.6344
Fax: 303.312.6064
diaz.angelique@epa.gov
----- Forwarded by Angelique Diaz/R8/USEPA/US on 10/07/2010 07:16 AM -----

From: "Filas, Frank" <f.filas@EnergyFuels.com>
To: Angelique Diaz/R8/USEPA/US@EPA
Cc: Deborah Lebow-Aal/R8/USEPA/US@EPA, "Rogers, Zach" <ZRogers@EnergyFuels.com>, "Steven Brown" <sbrown@senes.ca>
Date: 10/06/2010 05:07 PM
Subject: RE: Piñon Ridge Construction Approval Application

Angelique: Our application does not contain any CBI. We have no objection to you posting the application and additional evaporation pond information on the Subpart W rulemaking website. Frank Filas

-----Original Message-----
From: Diaz.Angelique@epamail.epa.gov [mailto:Diaz.Angelique@epamail.epa.gov]
Sent: Wednesday, October 06, 2010 3:35 PM
To: Filas, Frank; Rogers, Zach

Cc: Lebow-Aal.Deborah@epamail.epa.gov
Subject: Piñon Ridge Construction Approval Application

I have recently received a FOIA request for the construction approval applications you submitted for the tailings impoundments and evaporation cells at the proposed Piñon Ridge uranium mill. Prior to providing a copy of your application I wanted to confirm with you that the application contains no Confidential Business Information (CBI). Please let me know no later than COB, Wednesday, October 13, 2010 if the applications contains CBI that should be withheld from the FOIA response.

I also wanted to inform you that EPA is considering placement of the application (minus any CBI) on the Subpart W rulemaking website.

Let me know if you have any questions.

Thank you,
Angelique

Angelique D. Diaz, Ph.D.
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Denver, CO 80202-1129
Office: 303.312.6344
Fax: 303.312.6064
diaz.angelique@epa.gov

Reid Rosnick/DC/USEPA/US
10/07/2010 01:18 PM

To Beth Miller
cc
bcc
Subject Re: Subpart W - Rulemaking page is updated.

Thank you.....

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

Beth Miller http://www.epa.gov/radiation/neshaps/s... 10/07/2010 01:18:21 PM

From: Beth Miller/DC/USEPA/US
To: Reid Rosnick/DC/USEPA/US@EPA
Cc: Glenna Shields/DC/USEPA/US@EPA
Date: 10/07/2010 01:18 PM
Subject: Subpart W - Rulemaking page is updated.

---

http://www.epa.gov/radiation/neshaps/subpartw/rulemaking-activity.html

Beth Miller
202-343-9223

EPA-945

Reid Rosnick/DC/USEPA/US
10/08/2010 02:12 PM

To "Michael Neumann"
cc
bcc
Subject Re: S Cohen work plan, Rev 1

Hi Mike,

Certainly. We welcome comments. To be completely honest, though, depending on the input I would have to reserve decisions on whether to incorporate comments because of additional costs for the contractor that I may not have the funding to cover.

Reid

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

"Michael Neumann" Reid, Thanks for posting the Risk... 10/08/2010 01:33:18 PM

From: "Michael Neumann" <mneumann@neutronenergyinc.com>
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 10/08/2010 01:33 PM
Subject: S Cohen work plan, Rev 1

Reid,
Thanks for posting the Risk Assessment work plan referred to on the Subpart W call earlier this week. Is there an opportunity for providing comment or input on the plan at this time?
Thanks.
Mike Neumann
Neutron Energy

EPA-946

"Michael Neumann" <mneumann@neutronenergyinc.com>
10/08/2010 03:07 PM

To	Reid Rosnick
cc	
bcc	
Subject	RE: S Cohen work plan, Rev 1

Thanks Reid. Understood and makes sense. I'll probably forward a few thoughts for consideration, regardless of disposition.
Mike

From: Rosnick.Reid@epamail.epa.gov [mailto:Rosnick.Reid@epamail.epa.gov]
Sent: Friday, October 08, 2010 12:12 PM
To: Michael Neumann
Subject: Re: S Cohen work plan, Rev 1

Hi Mike,

Certainly. We welcome comments. To be completely honest, though, depending on the input I would have to reserve decisions on whether to incorporate comments because of additional costs for the contractor that I may not have the funding to cover.

Reid

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

From:	"Michael Neumann" <mneumann@neutronenergyinc.com>
To:	Reid Rosnick/DC/USEPA/US@EPA
Date:	10/08/2010 01:33 PM
Subject:	S Cohen work plan, Rev 1

Reid,
Thanks for posting the Risk Assessment work plan referred to on the Subpart W call earlier this week. Is there an opportunity for providing comment or input on the plan at this time?
Thanks.
Mike Neumann
Neutron Energy

EPA-1561

Reid Rosnick/DC/USEPA/US	To	Beth Miller
10/12/2010 07:06 AM	cc	
	bcc	
	Subject	Fw: File Missing from Sub W website

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

----- Forwarded by Reid Rosnick/DC/USEPA/US on 10/12/2010 07:06 AM -----

From: Angelique Diaz/R8/USEPA/US
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 10/08/2010 05:45 PM
Subject: File Missing from Sub W website

Actually I looked again and it looks like the "Tailings Cell Design" and accompanying Appendices (A-K) are not on the website. These are located on the Tailings Facility CD.

-Angelique

Angelique D. Diaz, Ph.D.
Environmental Engineer
Air Program, USEPA/Region 8
1595 Wynkoop Street (8P-AR)
Denver, CO 80202-1129
Office: 303.312.6344
Fax: 303.312.6064
diaz.angelique@epa.gov

----- Forwarded by Angelique Diaz/R8/USEPA/US on 10/08/2010 03:41 PM -----

From: Angelique Diaz/R8/USEPA/US
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 10/08/2010 03:33 PM
Subject: Re: Fw: Piñon Ridge Construction Approval Application

It looks like everything is up there. Thank you for getting it done so quickly.

-Angelique

Angelique D. Diaz, Ph.D.
Environmental Engineer
Air Program, USEPA/Region 8
1595 Wynkoop Street (8P-AR)
Denver, CO 80202-1129
Office: 303.312.6344
Fax: 303.312.6064
diaz.angelique@epa.gov

Reid Rosnick	I'll try to get it up today. ---------------------...	10/07/2010 07:47:12 AM

From: Reid Rosnick/DC/USEPA/US
To: Angelique Diaz/R8/USEPA/US@EPA
Date: 10/07/2010 07:47 AM
Subject: Re: Fw: Piñon Ridge Construction Approval Application

---

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Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

Angelique Diaz	FYI - the Pinon Ridge application can b...	10/07/2010 09:17:53 AM

From: Angelique Diaz/R8/USEPA/US
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 10/07/2010 09:17 AM
Subject: Fw: Piñon Ridge Construction Approval Application

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Thanks!
Angelique

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----- Forwarded by Angelique Diaz/R8/USEPA/US on 10/07/2010 07:16 AM -----

From: "Filas, Frank" <f.filas@EnergyFuels.com>
To: Angelique Diaz/R8/USEPA/US@EPA
Cc: Deborah Lebow-Aal/R8/USEPA/US@EPA, "Rogers, Zach" <ZRogers@EnergyFuels.com>, "Steven Brown" <sbrown@senes.ca>
Date: 10/06/2010 05:07 PM
Subject: RE: Piñon Ridge Construction Approval Application

```
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-----Original Message-----
From: Diaz.Angelique@epamail.epa.gov [mailto:Diaz.Angelique@epamail.epa.gov]
Sent: Wednesday, October 06, 2010 3:35 PM
To: Filas, Frank; Rogers, Zach
Cc: Lebow-Aal.Deborah@epamail.epa.gov
Subject: Piñon Ridge Construction Approval Application
```

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I also wanted to inform you that EPA is considering placement of the application (minus any CBI) on the Subpart W rulemaking website.

Let me know if you have any questions.

Thank you,
Angelique

Angelique D. Diaz, Ph.D.
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Office: 303.312.6344
Fax: 303.312.6064
diaz.angelique@epa.gov

EPA-1315

Reid Rosnick/DC/USEPA/US
10/12/2010 09:06 AM

To Angelique Diaz
cc
bcc
Subject Re: File Missing from Sub W website

I think I have it covered now, please check and see if I got it all.

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

Angelique Diaz Actually I looked again and it looks like... 10/08/2010 05:45:23 PM

From: Angelique Diaz/R8/USEPA/US
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 10/08/2010 05:45 PM
Subject: File Missing from Sub W website

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----- Forwarded by Angelique Diaz/R8/USEPA/US on 10/08/2010 03:41 PM -----

From: Angelique Diaz/R8/USEPA/US
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 10/08/2010 03:33 PM
Subject: Re: Fw: Piñon Ridge Construction Approval Application

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-Angelique

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Reid Rosnick I'll try to get it up today. ---------------------... 10/07/2010 07:47:12 AM

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Subject: Re: Fw: Piñon Ridge Construction Approval Application

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Radiation Protection Division (6608J)
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1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
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Sent: Wednesday, October 06, 2010 3:35 PM
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Cc: Lebow-Aal.Deborah@epamail.epa.gov
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Office: 303.312.6344
Fax: 303.312.6064
diaz.angelique@epa.gov

Beth Miller/DC/USEPA/US	To	Tony Nesky
10/18/2010 08:59 AM	cc	Glenna Shields, Tony Nesky
	bcc	
	Subject	Re: Update to Subpart W Rulemaking Activity Page--2nd try--use this write up instead

Updated.

Beth Miller
202-343-9223

Tony Nesky Dear Beth, Somehow I didn't cut and p... 10/14/2010 03:06:43 PM

From:	Tony Nesky/DC/USEPA/US
To:	Tony Nesky/DC/USEPA/US@EPA
Cc:	Beth Miller/DC/USEPA/US@EPA, Glenna Shields/DC/USEPA/US@EPA
Date:	10/14/2010 03:06 PM
Subject:	Re: Update to Subpart W Rulemaking Activity Page--2nd try--use this write up instead

Dear Beth,

Somehow I didn't cut and paste right, and something was missing in the text for the Subpart W page. Please disregard my earlier message.

\Please add the following information to the Subpart W Rulemaking Activity Page--
http://www.epa.gov/radiation/neshaps/subpartw/rulemaking-activity.html

Please add it to above the section Public Participation by Email, and link it to the anchor "Public Meeting/Webinar Information" under the "On this page" bullet list.

Thanks. You know where to get me if you have questions.
Tony Nesky
Center for Radiation Information and Outreach
Tel: 202-343-9597
nesky.tony@epa.gov

Public Information Meeting, Corpus Christi Texas
November 4, 2010

EPA is holding public information meetings on November 4, 2010 to discuss its review of regulations on uranium and thorium milling and to solicit public input. The meetings are free and open to the public. All are welcome to participate. Two sessions will be offered for your convenience: one in the afternoon, and one in the evening. Advance registration is not required. Anyone who wants to speak may sign-up at the event. Public presentations will be time-limited to 5 minutes each.

<u>Location:</u>
Omni Corpus Christi Hotel – Marina
Riviera 1–2 Room
707 North Shoreline Blvd.
Corpus Christi, Texas 78401

<u>Meeting Times</u>:
Afternoon Session: 1:00-3:00 PM
Evening Session: 6:30-9:30 PM

Tony Nesky
Center for Radiation Information and Outreach
Tel: 202-343-9597
nesky.tony@epa.gov

Tony Nesky	Dear Beth, Please add the following inf...	10/14/2010 02:54:56 PM

Beth Miller/DC/USEPA/US	To	Reid Rosnick
10/21/2010 09:35 AM	cc	
	bcc	
	Subject	Fw: Update to Subpart W Rulemaking Activity Page--2nd try--use this write up instead

Beth Miller
202-343-9223
----- Forwarded by Beth Miller/DC/USEPA/US on 10/21/2010 09:34 AM -----

From:	Tony Nesky/DC/USEPA/US
To:	Tony Nesky/DC/USEPA/US@EPA
Cc:	Beth Miller/DC/USEPA/US@EPA, Glenna Shields/DC/USEPA/US@EPA
Date:	10/14/2010 03:06 PM
Subject:	Re: Update to Subpart W Rulemaking Activity Page--2nd try--use this write up instead

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Omni Corpus Christi Hotel – Marina
Riviera 1–2 Room
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Corpus Christi, Texas 78401

Meeting Times:
Afternoon Session: 1:00-3:00 PM
Evening Session: 6:30-9:30 PM

Tony Nesky
Center for Radiation Information and Outreach
Tel: 202-343-9597
nesky.tony@epa.gov

Tony Nesky	Dear Beth, Please add the following inf...	10/14/2010 02:54:56 PM

From: Tony Nesky/DC/USEPA/US
To: Beth Miller/DC/USEPA/US@EPA
Cc: Glenna Shields/DC/USEPA/US@EPA
Date: 10/14/2010 02:54 PM
Subject: Update to Subpart W Rulemaking Activity Page

EPA-3351

Brian Littleton/DC/USEPA/US		To	Reid Rosnick
11/02/2010 09:38 AM		cc	
		bcc	
		Subject	Re: Thursday's Teleconference

Reid,
That seems judicial, so I'll let the contractor know and we can move forward.
Brian

****
Brian Littleton
EPA, Office of Air and Radiation/Radiation Protection Division
1200 Pennsylvania Avenue, NW - Mailcode 6608J
Washington D.C. 20460
(202) 343-9216

Reid Rosnick   Hi Brian, I can make the conference cal...   11/02/2010 07:23:38 AM

From: Reid Rosnick/DC/USEPA/US
To: Brian Littleton/DC/USEPA/US@EPA
Date: 11/02/2010 07:23 AM
Subject: Re: Thursday's Teleconference

Hi Brian,

I can make the conference call at 11 AM tomorrow.

Regarding the risk assessments, I believe we should throw out the three sites in Steve's e-mail. They aren't going to give us much, and we really need the assessment to be completed. What do you think?

Reid

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

Brian Littleton   I should be able to let you know someth...   11/01/2010 02:52:01 PM

From: Brian Littleton/DC/USEPA/US
To: "Steve Marschke" <stevemarschke@frontiernet.net>
Cc: "Abe Zeitoun" <azeitoun@scainc.com>, "Deborah Schneider" <dschneider@scainc.com>, LSkoski@aol.com, Reid Rosnick/DC/USEPA/US@EPA, "Rose Gogliotti" <rgogliotti@scainc.com>
Date: 11/01/2010 02:52 PM
Subject: Re: Thursday's Teleconference

I should be able to let you know something tomorrow on the Task 4 risk analysis. Regarding the conference call, I am available on Wednesday at 11:00 am.

Brian

****

Brian Littleton
EPA, Office of Air and Radiation/Radiation Protection Division
1200 Pennsylvania Avenue, NW - Mailcode 6608J
Washington D.C. 20460
(202) 343-9216

"Steve Marschke" Hi Brian and Ried, We are supposed... 11/01/2010 02:08:43 PM

From: "Steve Marschke" <stevemarschke@frontiernet.net>
To: Reid Rosnick/DC/USEPA/US@EPA, Brian Littleton/DC/USEPA/US@EPA
Cc: "Rose Gogliotti" <rgogliotti@scainc.com>, <LSkoski@aol.com>, "Deborah Schneider" <dschneider@scainc.com>, "Abe Zeitoun" <azeitoun@scainc.com>
Date: 11/01/2010 02:08 PM
Subject: Thursday's Teleconference

Hi Brian and Ried,

We are supposed to have a WA 1-04 teleconference this Thursday, however, some personal matters have come up and I have to be out of the office from about 9:30 am to mid-afternoon. Would it be possible to re-schedule the teleconference for either this Wednesday or Friday or some other day/time?

BTW, Les and I have been revising the Task 5 report and we think we have more of what you were looking for. Among other enhancements, it now contains a sample evaporation pond radon release calculation for several sites, and compares those calculated radon releases to reported total site releases. The EP releases range from very small (<0.01%) to <10% of the total site radon release.

Also, we've been working on the Task 4 risk analysis. I have a couple of questions I'd like to discuss: 1) although licensed, the Churchrock and Crownpoint sites have not been developed, and currently the license is being appealed to the U.S. Supreme Court. Ried once said that we were to assume existing conditions when performing the risk analysis. Currently the existing condition is zero release. 2) the information I've found for the Vasquez site indicates that it has been mined out and production has ceased. Again, do you still want us to do a risk analysis using historical production data? Or, should we drop Vasquez from the list of site analyzed?

Steve

EPA-1070

"Sweeney,Katie"
<KSweeney@nma.org>

11/03/2010 02:42 PM

To Reid Rosnick
cc
bcc
Subject RE: NMA Meeting

Reid,

The 2011 Uranium Recovery Workshop will be held May 25-26 at the Grand Hyatt in Denver, Colo. Hope that works for your schedule!

Katie

From: Rosnick.Reid@epamail.epa.gov [mailto:Rosnick.Reid@epamail.epa.gov]
Sent: Wednesday, November 03, 2010 2:29 PM
To: Sweeney,Katie
Subject: NMA Meeting

Hi Katie,

Good to see you last week. Could you please give me the dates for the 2011 NRC/NMA meeting? I'm trying to figure out my travel for the coming year. Thanks.

Reid

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

EPA-1182

Tom Peake/DC/USEPA/US
11/08/2010 03:05 PM

To Setlow.Loren, Reid Rosnick
cc
bcc
Subject CAA standards for U mills vs 192?

I just want to confirm that 192 was for closed (as of 1978 for Title I) mills or those undergoing closure, and Subpart W was developed for operating facilities. Is this correct?

Tom Peake
Director
Center for Waste Management and Regulations
US EPA (6608J)
1200 Pennsylvania Ave, NW
Washington, DC 20460
phone: 202-343-9765

Physical Location and for deliveries:
Room 529
1310 L St, NW
Washington, DC 20005

EPA-1277

Reid Rosnick/DC/USEPA/US
11/08/2010 03:33 PM

To	Tom Peake
cc	Setlow.Loren
bcc	
Subject	Re: CAA standards for U mills vs 192?

Yes, with the exceptions that the design standards in 192.32(a) are used for the impoundment design in Subpart W, and after operating mills close down, the 192 standards are used for Title II facilities.

-----Tom Peake/DC/USEPA/US wrote: -----

To: Setlow.Loren@epamail.epa.gov, Reid Rosnick/DC/USEPA/US@EPA
From: Tom Peake/DC/USEPA/US
Date: 11/08/2010 03:05PM
Subject: CAA standards for U mills vs 192?

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1200 Pennsylvania Ave, NW
Washington, DC 20460
phone: 202-343-9765

Physical Location and for deliveries:
Room 529
1310 L St, NW
Washington, DC 20005

EPA-1278

Tom Peake/DC/USEPA/US
11/08/2010 03:36 PM

To Reid Rosnick
cc Setlow.Loren
bcc
Subject Re: CAA standards for U mills vs 192?

Thanks. I also noticed that 192.32 references Subpart W. I guess this was added in the 1995 update. Its not as cut and dry as one would think between the two regs.

Tom Peake
Director
Center for Waste Management and Regulations
US EPA (6608J)
1200 Pennsylvania Ave, NW
Washington, DC 20460
phone: 202-343-9765

Physical Location and for deliveries:
Room 529
1310 L St, NW
Washington, DC 20005

Reid Rosnick Yes, with the exceptions that the desig... 11/08/2010 03:33:21 PM

From: Reid Rosnick/DC/USEPA/US
To: Tom Peake/DC/USEPA/US@EPA
Cc: Setlow.Loren@epamail.epa.gov
Date: 11/08/2010 03:33 PM
Subject: Re: CAA standards for U mills vs 192?

Yes, with the exceptions that the design standards in 192.32(a) are used for the impoundment design in Subpart W, and after operating mills close down, the 192 standards are used for Title II facilities.

-----Tom Peake/DC/USEPA/US wrote: -----

To: Setlow.Loren@epamail.epa.gov, Reid Rosnick/DC/USEPA/US@EPA
From: Tom Peake/DC/USEPA/US
Date: 11/08/2010 03:05PM
Subject: CAA standards for U mills vs 192?

I just want to confirm that 192 was for closed (as of 1978 for Title I) mills or those undergoing closure, and Subpart W was developed for operating facilities. Is this correct?

Tom Peake
Director
Center for Waste Management and Regulations
US EPA (6608J)
1200 Pennsylvania Ave, NW
Washington, DC 20460
phone: 202-343-9765

Physical Location and for deliveries:

Room 529
1310 L St, NW
Washington, DC 20005

EPA-1850

Loren Setlow/DC/USEPA/US
11/29/2010 01:37 PM

To Reid Rosnick, Tom Peake
cc
bcc
Subject Virginia Uranium Web Pages

FYI,
Following is a link to the Piedmont Environmental Council's web pages on the uranium mining/mill proposal for the Coles Hill property in Virginia.
http://pecva.org/anx/index.cfm/1,266,2799,-1,html

Be sure to take a look at the home videos of flood waters from hurricane Fran after clicking on the section about uranium and water further down the page. Drowned sites closest too and downstream from the Coles Hill property I believe appear in video 1, and in video 2.

Another website concerning (anti) development in Virginia can be found here:
http://virginiaagainsturanium.blogspot.com/

Virginia Uranium's site is: http://www.virginiauranium.com/

--Loren

EPA-1045

"Oscar Paulson" <oscar.paulson@bresnan.net>

12/01/2010 11:09 PM

To Reid Rosnick

cc "Sweeney,Katie", "Oscar Paulson", "'Shelley \(RTEA\) Schutterle'"

bcc

Subject January 2011 Conference Call Date

Reid:

The following web page:

http://www.epa.gov/radiation/neshaps/subpartw/rulemaking-activity.html

states:

EPA will hold quarterly conference calls with interested stakeholders. The next conference call will occur on Tuesday January 5, 2011 at 11am EST, 10am CST, 9am MST and 8am PST. The call in number is 1-866-299-3188. You will be prompted for a conference code, which will be 2023439563. After entering the conference code press the # key and you will then be placed into the conference call.

I checked my calendar and January 5, 2011 falls on a Wednesday. What is the correct day and date for the conference call?

Oscar

Facility Supervisor
Kennecott Uranium Company
Sweetwater Uranium Project
P.O. Box 1500
42 Miles Northwest of Rawlins
Rawlins, Wyoming 82301-1500

Telephone: (307)-324-4924
Fax: (307)-324-4925
Cellular: (307)-320-8758

E-mail: oscar.paulson@riotinto.com

EPA-1057

Reid Rosnick/DC/USEPA/US

12/06/2010 09:05 AM

To "Oscar Paulson"

cc "Sweeney,Katie", "Oscar Paulson", "'Shelley \(RTEA\) Schutterle'"

bcc

Subject Re: January 2011 Conference Call Date

Hi Oscar,

The quarterly conference call will be held on Wednesday, January 5, 2011 at 11 AM EST. I will make sure that the April 2011 call falls on Thursday. Thanks

Reid

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

"Oscar Paulson" Reid: The following web page: 12/01/2010 11:09:08 PM

From: "Oscar Paulson" <oscar.paulson@bresnan.net>
To: Reid Rosnick/DC/USEPA/US@EPA
Cc: "Sweeney,Katie" <KSweeney@nma.org>, "Oscar Paulson" <oscar.paulson@riotinto.com>, "'Shelley \(RTEA\) Schutterle'" <Shelley.Schutterle@riotinto.com>
Date: 12/01/2010 11:09 PM
Subject: January 2011 Conference Call Date

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Oscar

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Sweetwater Uranium Project
P.O. Box 1500
42 Miles Northwest of Rawlins
Rawlins, Wyoming 82301-1500

Telephone: (307)-324-4924
Fax: (307)-324-4925
Cellular: (307)-320-8758

E-mail: oscar.paulson@riotinto.com

EPA-1030

"Chris Pugsley"
<cpugsley@athompsonlaw.com>
12/08/2010 09:32 AM

To Reid Rosnick
cc
bcc
Subject Nuclear Energy Institute

Good morning Reid:

I hope this note finds you well. I am writing to you to respectfully request that perhaps you or someone from EPA could attend the NEI Nuclear Fuel Supply Forum internal committee meetings (a group composed of all sectors of the fuel cycle) and give a short talk on EPA's efforts in reviewing and re-assessing its regulations for uranium recovery facilities at 40 CFR Part 61, Subpart W and 40 CFR Parts 190 and 192. I know that your talks have been extremely informative and I believe that your contribution to the meetings would be very much appreciated. The meetings are proposed for late January of 2011 and I was wondering if you would be willing to participate. If you believe that you will be able to participate, can you shoot me a quick e-mail and I will ask Suzanne Phelps from NEI to give you a call. Thank you very much for your time and consideration in this matter.

Christopher S. Pugsley, Esq.
Partner
Thompson & Pugsley, PLLC
1225 19th Street, NW
Suite 300
Washington, DC 20036
(202) 496-0780
(fax) (202) 496-0783
(cell) (202) 870-3387
cpugsley@athompsonlaw.com

EPA-1902

Reid Rosnick/DC/USEPA/US
12/08/2010 09:34 AM

To Loren Setlow, Tom Peake
cc
bcc
Subject Fw: Nuclear Energy Institute

Gentlemen,

Thoughts?

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov
----- Forwarded by Reid Rosnick/DC/USEPA/US on 12/08/2010 09:34 AM -----

From: "Chris Pugsley" <cpugsley@athompsonlaw.com>
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 12/08/2010 09:32 AM
Subject: Nuclear Energy Institute

Good morning Reid:

I hope this note finds you well. I am writing to you to respectfully request that perhaps you or someone from EPA could attend the NEI Nuclear Fuel Supply Forum internal committee meetings (a group composed of all sectors of the fuel cycle) and give a short talk on EPA's efforts in reviewing and re-assessing its regulations for uranium recovery facilities at 40 CFR Part 61, Subpart W and 40 CFR Parts 190 and 192. I know that your talks have been extremely informative and I believe that your contribution to the meetings would be very much appreciated. The meetings are proposed for late January of 2011 and I was wondering if you would be willing to participate. If you believe that you will be able to participate, can you shoot me a quick e-mail and I will ask Suzanne Phelps from NEI to give you a call. Thank you very much for your time and consideration in this matter.

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cpugsley@athompsonlaw.com

This message may contain information and/or attachments that are subject to attorney-client

EPA-2376

Reid Rosnick/DC/USEPA/US		To	Loren Setlow, Tom Peake
12/08/2010 09:36 AM		cc	
		bcc	
		Subject	Fw: Nuclear Energy Institute

Sorry,

I forgot to add this link:

http://www.nei.org/newsandevents/conferencesandmeetings/nfsf

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

----- Forwarded by Reid Rosnick/DC/USEPA/US on 12/08/2010 09:35 AM -----

From: "Chris Pugsley" <cpugsley@athompsonlaw.com>
To: Reid Rosnick/DC/USEPA/US@EPA
Date: 12/08/2010 09:32 AM
Subject: Nuclear Energy Institute

Good morning Reid:

I hope this note finds you well. I am writing to you to respectfully request that perhaps you or someone from EPA could attend the NEI Nuclear Fuel Supply Forum internal committee meetings (a group composed of all sectors of the fuel cycle) and give a short talk on EPA's efforts in reviewing and re-assessing its regulations for uranium recovery facilities at 40 CFR Part 61, Subpart W and 40 CFR Parts 190 and 192. I know that your talks have been extremely informative and I believe that your contribution to the meetings would be very much appreciated. The meetings are proposed for late January of 2011 and I was wondering if you would be willing to participate. If you believe that you will be able to participate, can you shoot me a quick e-mail and I will ask Suzanne Phelps from NEI to give you a call. Thank you very much for your time and consideration in this matter.

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(202) 496-0780
(fax) (202) 496-0783
(cell) (202) 870-3387
cpugsley@athompsonlaw.com

EPA-1419

Reid Rosnick/DC/USEPA/US	To	"Chris Pugsley"
12/09/2010 09:22 AM	cc	
	bcc	
	Subject	Re: Nuclear Energy Institute

Good Morning Chris,

Yes, I believe I'll be able to participate. Please have your NEI contact get in touch. Thanks, and if I don't speak with you, Happy Holidays

Reid

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

"Chris Pugsley" Good morning Reid: 12/08/2010 09:32:28 AM

From:	"Chris Pugsley" <cpugsley@athompsonlaw.com>
To:	Reid Rosnick/DC/USEPA/US@EPA
Date:	12/08/2010 09:32 AM
Subject:	Nuclear Energy Institute

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(cell) (202) 870-3387

cpugsley@athompsonlaw.com

EPA-5296

Susan Stahle/DC/USEPA/US

12/29/2010 12:35 PM

To	Elliott Zenick, Wendy Blake
cc	Patricia Embrey
bcc	
Subject	Cancelled: Rad NESHAP Subpart W Revision - must it be a MACT or GACT standard or could it be a risk-based standard?

EPA-1034

"Marion Loomis" <loomis@vcn.com>
10/01/2010 11:34 AM

To Reid Rosnick
cc
bcc
Subject Conference Call re Subpart W

1 attachment

Public Health Assessment for Cotter Corp.pdf

Mr. Rosnick

The Wyoming Mining Association (WMA) is very concerned about claims that uranium mining and processing may contribute to health impairment from the release of radon from uranium processing facilities. WMA would like to draw your attention to the attached report entitled Public Health Assessment for LINCOLN PARK/COTTER URANIUM MILLCAÑON CITY, FREMONT COUNTY, COLORADO EPA FACILITY ID: COD042167585 SEPTEMBER 9, 2010. In summary the study *concludes that ambient air emissions of particle bound radionuclides have not resulted in exposures to the public at levels that could cause adverse health outcomes.* The ATSDR looked at all of the air data collected from 1979 to present related to Cotter Corporation's Canon City Mill and concluded that outdoor concentration of radon contributed zero dust to the public, because it is a noble gas and does not stay in the lungs long enough to radioactively decay.
I understand that there will be a conference call on October 6 to discuss 40 CFR Part 61 Subpart W which deals with this issue. WMA requests that this study be on the agenda for discussion during that conference call.

Thank you.

Marion Loomis

Public Health Assessment for

LINCOLN PARK/COTTER URANIUM MILL
CAÑON CITY, FREMONT COUNTY, COLORADO
EPA FACILITY ID: COD042167585
SEPTEMBER 9, 2010

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

NOVEMBER 9, 2010

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Agency for Toxic Substances and Disease Registry....................................Thomas R. Frieden, M.D., M.P.H., Administrator
Christopher J. Portier, Ph.D., Director

Division of Health Assessment and Consultation………………………………………..William Cibulas, Jr., Ph.D., Director
Sharon Williams-Fleetwood, Ph.D., Deputy Director

Health Promotion and Community Involvement Branch………………………………Hilda Shepeard, Ph.D., M.B.A., Chief

Exposure Investigations and Consultation Branch……………………….……………………..Susan M. Moore, M.S., Chief

Federal Facilities Assessment Branch……………………………………………………....Sandra G. Isaacs, B.S., Chief

Superfund and Program Assessment Branch .... Richard E. Gillig, M.C.P., Chief

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
Attn: Records Center
1600 Clifton Road, N.E., MS F-09
Atlanta, Georgia 30333

You May Contact ATSDR Toll Free at
1-800-CDC-INFO or
Visit our Home Page at: http://www.atsdr.cdc.gov

PUBLIC HEALTH ASSESSMENT

LINCOLN PARK/COTTER URANIUM MILL

CAÑON CITY, FREMONT COUNTY, COLORADO

EPA FACILITY ID: COD042167585

Prepared by:

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Site and Radiological Assessment Branch

This information is distributed by the Agency for Toxic Substances and Disease Registry for public comment under applicable information quality guidelines. It does not represent and should not be construed to represent final agency conclusions or recommendations.

Foreword

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as the Superfund law. This law set up a fund to identify and clean up hazardous waste sites. The Environmental Protection Agency (EPA) and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment process allows ATSDR scientists and public health assessment cooperative agreement partners flexibility in document format when presenting findings about the public health impact of hazardous waste sites. The flexible format allows health assessors to convey to affected populations important public health messages in a clear and expeditious way.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high-risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to evaluate possible the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals, and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the public comments that related to the document are addressed in the final version of the report.

Conclusions: The report presents conclusions about the public health threat posed by a site. Ways to stop or reduce exposure will then be recommended in the public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA or other responsible parties. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also recommend health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Rolanda Morrison
ATSDR Records Center (MS F-09)
4770 Buford Hwy, NE
Building 106, Room 2108
Atlanta, GA 30341

Table of Contents

APPENDIX C - ATSDR'S EVALUATION PROCESS AND EXPOSURE DOSE CALCULATIONS

Acronyms and Abbeviations

CCAT	Colorado Citizens Against Toxic Waste
CDPHE	Colorado Department of Public Health and Environment
CREG	cancer risk evaluation guide
CV	comparison value
D	dissolved
EMEG	environmental media evaluation guide
EPA	US Environmental Protection Agency
LPWUS	Lincoln Park Water Use Survey
LTHA	lifetime health advisory for drinking water
MCL	maximum contaminant level
mg/L	milligrams per liter
μR/hr	microroentgen per hour
N	not defined in the CDPHE database
NA	not available
ND	not detected
NPL	National Priorities List
OU	operable units
pCi/g	picocuries per gram
pCi/L	picocuries per liter
ppm	parts per million
RAP	Remedial Action Plan
RBC	risk based concentration
RMEG	reference dose media evaluation guide
S	suspended
SCS	Soil Conservation Service
SSL	soil screening level
T	total
UMTRCA	1978 Uranium Mill Tailings Radiation Control Act
USGS	United States Geological Survey

I. SUMMARY

Introduction

ATSDR's top priority is to ensure that the community of Lincoln Park and surrounding communities have the best information possible to safeguard their health.

The purpose of this public health assessment (PHA) is to evaluate available data and information on the release of hazardous substances from the Cotter Uranium Mill to determine if people could be harmed by coming into contact with those substances. This PHA will also list actions, as needed, to be taken to protect the public's health.

Background

The Cotter Uranium Mill (Cotter) is located approximately two miles south of downtown Cañon City in Fremont County, Colorado. The community of Lincoln Park borders the site to the north and the housing developments of Dawson Ranch, Wolf Park, and Eagle Heights are located along Cotter's western boundary. The nearest residence is about 0.25 miles from the mill (Galant et al. 2007).

The 2,500-acre site includes two inactive mills, ore stockpile areas, a partially reclaimed tailings pond disposal area (i.e., the old ponds area), and a current tailings pond disposal area (i.e., the lined "main impoundment area"). A large portion of the site is used to store waste products in the impoundment area. The former mill area is fenced and is known as the "restricted area".

The Cotter Mill began operations in 1958, extracting uranium ore using an alkaline leach process. In 1979, the facility switched to an acid leach process for extracting uranium. Cotter suspended primary operations in 1987, and only limited and intermittent processing occurred until the facility resumed operations in 1999 with a modified alkaline-leaching capability until 2001. Cotter refabricated the mill circuits between 2002 and 2005 to operate using an acid process when it went into stand down in March 2006. Cotter is currently evaluating whether to re-engineer the mill for future operation.

Wastes containing metals and radionuclides were released from Cotter and entered the nearby environment. People could potentially be exposed to these wastes if they come into contact with them in drinking water, soil, sediment, biota (fruits and vegetables) or ambient air.

Conclusions

After evaluating the available data, ATSDR reached four important conclusions in this public health assessment:

Conclusion 1

ATSDR concludes that drinking water from contaminated private wells could harm people’s health. This is a public health hazard.

Basis for Conclusion

Private well sampling data collected from 1984 to 2007 revealed the presence of molybdenum at levels that could harm people’s health. A water use survey conducted in Lincoln Park in 1989 revealed that at least seven people used groundwater (from their private wells) for personal consumption. These and other residents whose private wells were affected by the highest molybdenum contamination may be at increased risk for health effects such as gout-like conditions. Individuals who do not take in enough dietary copper or who cannot process it correctly will be affected the most.

The lack of consistent monitoring over the years and the unknown usage of wells before the installation of the public water supply makes these past exposures difficult to accurately assess.

Most town residents are now connected to the public water supply and have thus eliminated their exposure to contaminated water. However, some residents are reported to have refused public water supply connections, and many may still have operational private wells. Additionally, no formal institutional controls exist to control groundwater use in Lincoln Park. Therefore, current and future uses of private wells for domestic purposes are still possible.

Conclusion 2

ATSDR concludes that accidentally eating or touching soil and sediment near the Cotter Mill property or in Lincoln Park will not harm people’s health. However, ATSDR cannot make conclusions about whether lead in soils near Cotter Mill could harm people’s health in the future.

Basis for Conclusion

Currently, the property near the Cotter Mill property is restricted access, vacant or used for industrial purposes; therefore, contact with soils near the property should be minimal. The soil sampling conducted at the site does not allow ATSDR to accurately assess potential exposures if the area is ever developed for residential, commercial or recreational uses. Therefore, a conclusion regarding future exposures cannot be made because not enough information is available about future development of this area.

ATSDR recommends that lead contamination in soil be re-evaluated if

Next Steps

the area is considered for development for residential or non-industrial uses.

Conclusion 3

ATSDR concludes that eating locally-grown fruits and vegetables irrigated with private well water will not harm most people's health. However, a person eating above-average amounts of fruits and vegetables (4 times the average consumer) might have a low increased risk for developing cancer over a lifetime. As a precaution, residents should limit their use of contaminated well water to irrigate their crops. In all cases, the crops should be thoroughly cleaned prior to eating.

Basis for Conclusion

Sampled locally-grown fruits and vegetables did not indicate the presence of contaminants at levels that would cause non-cancer health effects. The increased cancer risk is based on a person consuming more fruits and vegetables (95th percentile range) than a typical consumer. The cancer estimate is conservative because it assumes that a person would grow and eat fruits and vegetables that contain arsenic every day for 30 years. The amount of fruits and vegetables eaten will likely be much less than estimated, mainly because the growing season is not year-round.

The amount of a contaminant ingested would depend upon the type of crop eaten, the likelihood of the crop bioaccumulating any of the contaminants, how often the crop is eaten, if contaminated well water is used to irrigate the crop, and if the crop is thoroughly cleaned prior to eating them.

Conclusion 4

ATSDR concludes that ambient air emissions of particle bound radionuclides have not resulted in exposures to the public at levels that could cause adverse health outcomes.

Basis for Conclusion

With the exception of thorium-230 levels observed in 1981 and 1982, associated with excavation of contaminated tailings, every radionuclide monitored has been more than a factor of ten below annual dose based health limits to the public. The excavation releases appear to have only exposed on-site workers, but still below occupational limits at that time.

ATSDR is taking the following follow-up actions at this site:

Next Steps

ATSDR's Health Promotion and Community Involvement Branch (HPCIB) will conduct health-related educational activities in the community, as necessary.

ATSDR's HPCIB will coordinate community outreach and community involvement activities for the site.

ATSDR will continue to work with appropriate state and federal agencies and review additional relevant environmental data (including the water use survey) as it becomes available.

ATSDR will update the action plan for this site as needed. New environmental, toxicological, health outcome data, or implementing the above proposed actions may necessitate the need for additional or alternative actions at this site.

For More Information

If you have concerns about your health, you should contact you health care provider. You can also call ATSDR at 1-800-CDC-INFO for more information on the Lincoln Park/Cotter Uranium Mill site.

II. BACKGROUND

A. Site description and operational history

The Cotter Mill is located approximately two miles south of downtown Cañon City in Fremont County, Colorado (see Figure 1) [Galant et al. 2007]. The community of Lincoln Park borders the site to the north and the housing developments of Dawson Ranch, Wolf Park, and Eagle Heights are located along Cotter's western boundary. The nearest residence is about 0.25 miles from the mill [Galant et al. 2007].

The 2,500-acre site includes two inactive mills, ore stockpile areas, a partially reclaimed tailings pond disposal area (i.e., the old ponds area), and a current tailings pond disposal area (i.e., the lined "main impoundment area"). A large portion of the site is used to store waste products in the impoundment area. The former mill area is fenced and is known as the "restricted area" [Galant et al. 2007].

The Cotter Mill began operations in 1958, extracting uranium ore using an alkaline leach process. In 1979, the facility switched to an acid leach process for extracting uranium. Cotter suspended primary operations in 1987 [Weston 1998], and only limited and intermittent processing occurred until the facility resumed operations in 1999 with a modified alkaline-leaching capability until 2001 [EPA 2002]. Cotter refabricated the mill circuits between 2002 and 2005 to operate using an acid process when it went into stand down in March 2006 [Cotter 2007]. Cotter is currently evaluating whether to re-engineer the mill for future operation [CDPHE 2008].

Additional information about the history and licensing of the Cotter Mill can be found on the Colorado Department of Public Health and Environment's (CDPHE) and the US Environmental Protection Agency's (EPA) Web sites at http://www.cdphe.state.co.us/hm/cotter/sitedescript.htm and http://www.epa.gov/region8/superfund/co/lincolnpark/.

B. Remedial and regulatory history

Originally, mill tailings (i.e., solid ore processing waste), raffinate (liquid waste that remains after extraction), and other liquids from the alkaline leach process were stored in ten on-site unlined ponds. In 1978, lined impoundments were built on site to store process waste products. The main impoundment contained two cells to segregate acid-leach tailings and liquids in the primary impoundment cell from alkaline-leach tailings in the secondary impoundment cell (EPA 2002). By 1983, more than 2.5 million cubic yards of waste products from historic operations were transferred from the original unlined ponds to the secondary impoundment. All new process wastes are stored in the lined primary impoundment [Galant et al. 2007].

Because Cotter Mill operations released radionuclides and metals into the environment, soil around the mill and groundwater in the nearby Lincoln Park community became contaminated, primarily with molybdenum and uranium [CDPHE 2008]. In 1984, the Lincoln Park/Cotter Mill Site was added to the Superfund National Priorities List (NPL) [EPA 2008]. EPA divided the site into two operable

According to a signed Memorandum of Understanding, CDPHE is the lead regulatory agency overseeing cleanup at the Cotter Mill.

units (OUs)—OU1 consists of the on-site contamination and OU2 is the neighborhood of Lincoln Park (i.e., the off-site impacted area) [CDPHE 2008; EPA 2007]. Together, the Lincoln Park/Cotter Mill Superfund Site encompasses about 7.8 square miles (5,000 acres) [EPA 2004].

In 1988, the Cotter Corporation and CDPHE signed a Consent Decree and Remedial Action Plan (RAP) [Galant et al. 2007]. The purpose of the court-ordered action was to assess and mitigate human and environmental impacts from the Cotter Mill. As part of the settlement, Cotter agreed to clean up the site at the corporation's expense [EPA 2008]. The cleanup was estimated to take 16 years and cost $11 million [Galant et al. 2007]. EPA and the US Department of Energy have also contributed to cleanup costs [DOE 2003]. Remedial activities have focused on eliminating the sources of contamination at the Cotter Mill and eliminating exposures to Lincoln Park residents [CDPHE 2008]. Many of the activities outlined in the 1988 RAP have been completed, including the following:

- Connecting Lincoln Park residents to city water;
- Constructing a groundwater barrier at the Soil Conservation Service (SCS) Flood Control Dam to minimize migration of contaminated groundwater into Lincoln Park;
- Moving tailings and contaminated soils into a lined impoundment to eliminate them as a source of contamination; and
- Excavating contaminated stream sediments in Sand Creek.

The old ponds area was undergoing reclamation in late 2008 [Pat Smith, EPA Region 8, personal communication, August 2008]. Remaining activities include groundwater remediation and final site cleanup [CDPHE 2008; Galant et al. 2007]. Groundwater remediation activities have shown some positive results. However, the balance of the remedial activities listed in the Consent Decree have not been successful enough in mitigating the plume, and most have been discontinued (e.g., barrier wall, dam to ditch flushing, calcium-polysulfide fix/flush, and permeable reactive treatment wall). Table 1 below lists a timeline of process events, remedial activities, and government actions for the Lincoln Park/Cotter Mill Superfund Site.

Table 1. Lincoln Park/Cotter Mill Superfund Site Activity Timeline

Date	Type of Event[1]	Event[2]
July 1958	Process	Cotter Corporation began alkali leach process operations (licensing by the Atomic Energy Commission)
June 1965	Event	Flood that caused the unlined tailings ponds at the Cotter Mill to overflow into Lincoln Park
1971	Remediation	SCS Dam completed; dam pumps impounded surface water back to the main impoundment (groundwater barrier completed at a later date after 1988 RAP)
July 1972	Remediation	Pond 2 lined
June 1976	Remediation	Pond 10 lined
1978–1979	Remediation	A new lined impoundment consisting of two cells (primary and secondary) constructed adjacent to the old ponds area for management of wastes from the new mill (alkali process)
1979	Remediation	The old mill was demolished and new mill construction began
1979–present	Remediation	Impounded water at the SCS Dam pumped back to the main impoundment
1979–1998	Process	Operations switched from an alkali leach process to an acid leach mill; continuing operations intermittently
1980	Remediation	Old upstream method tailings ponds replaced by a full-height compacted earth embankment
1980	Remediation	Construction of Well 333 just north of Cotter; well removes contaminated water flowing from the old ponds area
June 1981	Remediation	Pond 3 lined
1981–1983	Remediation	Tailings from the unlined old ponds area (~2.5 million cubic yards) removed and placed in the new impoundment
December 9, 1983	Government Action	State of Colorado files a complaint against Cotter under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
September 21, 1984	Government Action	Cotter (OU1) and Lincoln Park (OU2) added to the NPL
1985–1986	Investigation	Remedial Investigation and Feasibility Study (GeoTrans 1986)
April 1986	Government Action	Memorandum of Agreement between EPA and the state of Colorado
April 8, 1988	Government Action	Consent decree signed, including a RAP that required cleanup activities
1988	Remediation	An additional 2 feet of soil was removed from the old ponds area and placed in the lined primary impoundment
1988	Remediation	Lined water distribution/surge pond constructed over Pond 7
1988	Remediation	Installation of a hydrologic clay barrier upgradient from the SCS Dam
1989	Remediation	The secondary impoundment cell was covered with liquid for dust control and to create evaporative capacity; additional contaminated soils were removed from the old ponds area and placed in the primary impoundment cell

Date	Type of Event[1]	Event[2]
1989–2000	Remediation	Installation of two hydraulic barriers (injection/withdrawal systems) to control groundwater flow from the old ponds area; discontinued in 2000 because the system was unproductive
1990–1996	Remediation	SCS Dam to DeWeese ditch flushing project
1990–1998	Remediation	Four pilot tests to evaluate the effectiveness of active flushing of vadose zone and aquifer for contaminant removal in OU1
October 29, 1991	Report	Health Risk Assessment of the Cotter Uranium Mill Site: Phase I (HRAP 1991)
January 7, 1993	Report	RAP final report, Willow Lakes (Cotter)
1993–1999	Remediation	Sand Creek Soil Cleanup Action identified and removed approximately 9,000 cubic yards of tailings, soil, and sediment from Sand Creek (Cotter 2000)
1995	Licensing	Cotter filed a license amendment with the state for alkaline leach processing of uranium ore (approved 2/97)
November 19, 1996	Report	Supplemental Human Health Risk Assessment: Phase II Final Report (Weston 1996)
1996–1998	Remediation	Flush/fixation process using Calcium Polysulfide in surface infiltration cells
February 1997	Government Action	Radioactive materials license amendment became effective
1998	Process	Mill reconverted to an alkaline leach process
September 29, 1998	Report	Ecological Risk Assessment, Lincoln Park Superfund Site (Stoller Corporation and Schafer & Associates)
1998	Report	Supplemental Human Health Risk Assessment, Phase III Final Report (Weston 1998)
1999	Remediation	Old ponds area surface soils (~100,000 cubic yards) were removed and placed in the lined primary impoundment
May 1999	Process	Cotter resumed operations (which had been intermittent since 1979) with modified alkaline-leaching capability
September 30, 1999	Investigation	Final Focused Feasibility Study, Lincoln Park
June 2000	Remediation	Installation of a permeable reactive treatment wall across Sand Creek channel, north of SCS Dam in DeWeese Dye Ditch flush (to fulfill EPA requirement to address contaminated groundwater that was bypassing the SCS Dam barrier)
2000–2005	Process	Cotter proposes modifications to the circuit to process zircon ore. Process was not successful and discontinued by 2005.
January 2002	Government Action	EPA issued a Record of Decision for Lincoln Park requiring “No Further Action” for surface soils within Lincoln Park (EPA 2002)
April 2002	Government Action	The governor of Colorado passed an emergency bill requiring an Environmental Assessment be conducted before shipping out-of-state radioactive waste to Cotter
July 9, 2002	Government Action	CDPHE denied Cotter’s license amendment request, preventing receipt of shipments for direct disposal

Date	Type of Event[1]	Event[2]
September 13, 2002	Government Action	State of Colorado allowed Cotter to receive limited amounts of waste material as a test of its handling/storage capability
2002/2003	Investigation	Sampling for plutonium, uranium, lead and molybdenum in the Canon City vicinity (CDPHE 2003)
January 3, 2003	Government Action	EPA issued a notice of unacceptability under the Off-Site Rule regarding the five Proposed Units and impoundments previously found acceptable
2003	Remediation	Permeable reactive treatment wall not functioning as designed
September 9, 2004	Investigation	Cotter submits Feasibility Study for Old Ponds Area with six alternatives
December 15, 2004	Government Action	State health officials approved a 5-year extension of Cotter's uranium-processing license but denied requests to become a disposal facility for off-site radioactive materials
February 1, 2005	Government Action	Cotter filed a request for a hearing regarding the conditions of the license renewal
October 2005	Investigation	Survey of lead in indoor dust, soils, and blood in Lincoln Park to investigate potential impacts of historic smelters (ATSDR 2006a, 2006b, 2006c, 2006d)
April 2006	Government Action	A judge recommended in CDPHE's favor and Cotter filed an exception on the direct disposal issue only
2006	Remediation	To replace the permeable reactive treatment wall, water building up behind barrier is pumped back to the impoundments
January 2007	Government Action	CDPHE signed a Final Agency Decision, affirming the judge's Decision on the license. Cotter filed an appeal to be able to dispose of out-of-state soils in its primary impoundment.
2008	Process	Cotter decides not to take the case to the Court of Appeals, effectively ending the licensing issues from the 2004 renewal.

[1] Describes the general nature of events/actions relating to the Lincoln Park/Cotter Mill Superfund Site.

[2] Includes events/actions most pertinent to ATSDR's evaluation of exposures and potential health effects. Not all site-related events and reports are included.

C. Demographics

ATSDR examines demographic data to identify sensitive populations, such as young children, the elderly, and women of childbearing age, and to determine whether these sensitive populations are exposed to any potential health risks. Demographics also provide details on population mobility and residential history in a particular area. This information helps ATSDR evaluate how long residents might have been exposed to contaminants. According to the 2000 census, 1,170 people live within one mile of the Cotter Mill property—90 of whom are age 6 or younger, 190 are women of childbearing age (15–44 years), and 243 are age 65 or older. Figure 2 in Appendix B shows the demographics within one mile of the mill.

Cañon City is the largest population center in Fremont County with 15,760 residents (see Table 2 below). The Cañon City Metro area includes Cañon City, North Cañon, Lincoln Park, Brookside, Prospect Heights, Four Mile Ranch, Shadow Hills, Dawson Ranch, and the Colorado State Correctional Facilities. Florence is the second largest community in the area with a population of 3,816. The unincorporated portions of Fremont County represent 55% of the population and include Lincoln Park, Prospect Heights, and Shadow Hills [Cotter 2007].

Table 2. Population of communities near the Cotter Mill

Community	2000 Census Population	2006 Population Estimate
Brookside	219	218
Cañon City	15,431	15,760
Coal Creek	303	380
Florence	3,653	3,816
Lincoln Park	3,904	Not available
Rockvale	426	432
Williamsburg	714	700
Fremont County	46,145	47,727

Source: Cotter 2007; Galant et al. 2007

The unincorporated community of Lincoln Park is located in the greater Cañon City area, south of the Arkansas River and north of the Cotter Mill (see Figure 1). The community consists of single and multi-family homes, trailer parks, and rural single family homes. Many of the residents are retired and own their homes. The Lincoln Park area is currently experiencing growth [Galant et al. 2007].

The largest employers in Fremont County are the Colorado Department of Corrections and the Federal Bureau of Prisons. Tourism is the second largest employer in the Cañon City area [Cotter 2007; Galant et al. 2007]. Additional industry and manufacturing employers in Fremont County include Portec, Inc.; Holcim, Inc.; Thermal Ceramics; and Cañon Industrial Ceramics [Cotter 2007]. The health care and school systems also employ a substantial number of people in the county [CCAT, personal communication, August 2008].

D. Land use and natural resources

The Cotter Mill is located within an industrial zone. All abutting lands are zoned for agriculture-forestry. The semi-rural community of Lincoln Park is comprised predominantly of residential developments, agricultural plots and orchards, and small grazing parcels. The Shadow Hills Golf Course is located to the north of the Cotter Mill complex. The land to the south and east of the site is largely undeveloped. Recently, several high end homes have been built near the golf course and in the Wolf Park and Dawson Ranch areas. The distance from Cotter Mill's restricted area to the nearest home is about 0.25 mile [Galant et al. 2007].

Fremont County contains a large amount of public land managed by the US Department of the Interior Bureau of Land Management and the US Department of Agriculture Forest Service. Some of these areas are leased for livestock grazing, aggregate mining, and firewood removal. Visiting the many scenic attractions in Colorado's High Country (e.g., the Royal Gorge Bridge) and rafting in the Arkansas River are popular recreational activities [Cotter 2007].

1. Hydrogeology

In the vicinity of the Cotter Mill, contaminated groundwater primarily migrates along the near surface alluvium and fractured, weathered bedrock immediately underlying the alluvium (<100 feet deep) [USGS 1999a]. Groundwater migration is generally in northerly directions from the mill area, along the Sand Creek drainage area, through a gap in Raton Ridge, and into Lincoln Park. However, groundwater contamination has also been found in the vicinity of the Shadow Hills Golf Course, which is west of the Sand Creek drainage [EPA 2007]. The hydrogeology of the Lincoln Park/Cotter Mill Superfund Site can be conceptually divided into two areas: the upgradient area near the mill and the downgradient area to the north-northeast in Lincoln Park [USGS 1999a].

- In the upgradient area near the mill, the rate of groundwater flow is limited by small hydraulic conductivities [USGS 1999a]. However, cracks in the bedrock, fractures, and weathering enhance water transmission and allow groundwater to travel at considerable rates. Monitoring wells in the upgradient area, specifically in the Poison Canyon Formation, yield small amounts of water.

- The downgradient area in Lincoln Park is characterized by an "alluvial aquifer" comprised of alluvium and terrace alluvium, to a depth of 0–60 feet, and the underlying weathered and/or fractured bedrock below the alluvium. In this area, groundwater can be transmitted at substantial rates. The mix of gravel, sand, silt, and clay in this aquifer yields 10 to 400 gallons per minute to wells in Lincoln Park. The aquifer discharges to Sand Creek, as well as to multiple springs and seeps as far downgradient as the Arkansas River, approximately 2.5 miles downgradient from the Cotter site.

2. Geology

The Cotter Mill is located in a topographic depression resulting from an underlying structure called the Chandler syncline. The core of the syncline is the Poison Canyon formation, which is the uppermost bedrock unit beneath the site. Soils near the mill are shallow and well drained.

The top layer consists of brown loam. The subsoil is a pale brown loam, grading into a yellowish brown sandy loam. Areas north of the mill are covered with Quaternary alluvium consisting of gravel, cobble, boulders, and sand [EPA 2002].

3. Hydrology

The Cotter Mill lies within the Sand Creek watershed [HRAP 1991]. The main hydrologic feature of the Lincoln Park/Cotter Mill Superfund Site is Sand Creek, a primarily ephemeral creek [EPA 2007]. The creek originates at Dawson Mountain (south of the Cotter Mill), travels north through the Cotter Mill, intersects the DeWeese Dye Ditch, and runs north-northeast through Lincoln Park. It becomes perennial for the last 0.25–0.5 mile before its confluence with the Arkansas River. The DeWeese Dye Ditch is one irrigation ditch that flows between the Cotter Mill and Lincoln Park.

An ephemeral creek has flowing water only during, and for a short duration after, precipitation. A perennial creek has flowing water year-round.

Alluvial material (sediment deposited by flowing water) associated with Sand Creek is the predominant migration pathway for mill-derived contaminants in groundwater. Sand Creek carved a channel into the Vermejo formation at the Raton outcrop in the vicinity of the SCS Dam, which filled with permeable sediments, creating a preferential pathway for alluvial groundwater into Lincoln Park. The alluvial aquifer in Lincoln Park receives recharge from the DeWeese Dye Ditch, Crooked Ditch, Pump Ditch, ditch laterals, and ponds filled by the DeWeese Dye Ditch [EPA 2007].

4. Prevailing Wind Patterns

Cotter’s monitoring network includes an on-site meteorological station that continuously measures a standard set of meteorological parameters (e.g., wind speed, wind direction, temperature, and relative humidity). The wind rose in Figure 3 in Appendix B depicts the statistical distribution of measured wind speeds and wind directions. During 2008, wind patterns at the station were principally westerly (i.e., winds out of the southwest to northwest) and accounted for 55% of the total winds [Cotter 2008b]. Easterly winds (i.e., winds out of the southeast to northeast) accounted for a smaller, but still significant, portion (26%) of the observed wind directions. Southerly and northerly winds were much less common. A nearly identical profile was observed in 2007. Other average parameters measured in 2008 follow: air temperature of 53.4 °F; relative humidity of 41%; and rainfall of 5.18 inches.

The prevailing westerly and easterly wind patterns are reasonably consistent with trends in the observed concentrations. Ambient air concentrations of selected site-related pollutants were highest at the perimeter monitoring stations directly east and west of the primary operations. There is a hilly ridge that straddles the western border of the site, blocking much east/west wind flow. However, it should be noted that prevailing wind patterns measured at Cotter Mill may not be representative of surface winds throughout the area, especially considering the proximity of nearby terrain features.

E. Past ATSDR involvement

ATSDR has been involved with the Lincoln Park site in the past. In October 1983, ATSDR completed a Public Health Assessment for the site. After reviewing available groundwater data, ATSDR concluded that the potential long term health effects from consumption of the contaminated water were:

- cancer and kidney damage, from uranium;
- gout-like symptoms, from molybdenum; and
- possibly a group of physiological and psychological symptoms, from selenium.

None of the potential health effects were definitive.

Numerous questions and concerns have been voiced by residents of Lincoln Park regarding the historical sites of numerous milling and smelting facilities in the Cañon City area. Among the various concerns were specific concerns about residual lead contamination from these milling and smelting operations. In response to these concerns, and after a specific request by the EPA, ATSDR evaluated the health risks associated with lead contamination in the area. ATSDR focused on two primary issues: 1) the blood lead level of children living in the area and 2) lead contaminated dust in homes in the Lincoln Park area.

In September and October 2005, ATSDR conducted an Exposure Investigation (EI) to answer the questions presented by the community and EPA. Previously, ATSDR concluded that lead levels in house dust and lead exposures to children represented an indeterminate health hazard because of a lack of available data. ATSDR conducted the EI to gather data on blood lead levels in the children, and soil and indoor dust level from homes.

The activities of the EI included:

- Collecting 44 indoor dust samples from 21 homes in Lincoln Park
- Collecting 80 composite soil samples from 22 properties (sampling conducted by EPA)
- Obtaining 45 blood samples from 21 households (42 blood samples were analyzed)

After evaluating the data obtained during the EI, ATSDR concluded that blood lead levels in adults and children, lead levels in dust in homes, and lead levels in soil did not represent a public health harard. ATSDR recommended no further actions related to lead in dust in homes, but did recommend routine monitoring of children’s blood lead levels in the Lincoln Park area.

In September 2005, ATSDR conducted a blood lead testing program as a service to the community of Lincoln Park. A total of 115 children from a local school were tested for blood lead. None of the children tested had elevated blood lead levels. Therefore, ATSDR concluded that the children tested did not have unusual exposures to lead at the time of testing. ATSDR recommended that local and state agencies continue routine monitoring of lead levels in area children.

Full reports discussed above may be obtained by contacting any of the contacts listed at the end of this report, by visiting our website at www.atsdr.cdc.gov or by calling our toll-free hotline at 800-232-4636.

III. EVALUATION OF EXPOSURE PATHWAYS

A. What is meant by exposure?

An exposure pathway has five elements: (1) a source of contamination, (2) an environmental media, (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population. The *source* is the place where the chemical or radioactive material was released. The *environmental media* (such as groundwater, soil, surface water, or air) transport the contaminants. The *point of exposure* is the place where people come into contact with the contaminated media. The *route of exposure* (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. The people actually exposed are the *receptor population*.

ATSDR's public health assessments are driven by exposure to, or contact with, environmental contaminants. Contaminants released into the environment have the potential to cause harmful health effects. Nevertheless, *a release does not always result in exposure*. People can only be exposed to a contaminant if they come in contact with that contaminant—if they breathe, eat, drink, or come into skin contact with a substance containing the contaminant. If no one comes in contact with a contaminant, then no exposure occurs, and thus no health effects could occur. Often the general public does not have access to the source area of contamination or areas where contaminants are moving through the environment. This lack of access to these areas becomes important in determining whether people could come in contact with the contaminants.

The route of a contaminant's movement is the *pathway*. ATSDR identifies and evaluates exposure pathways by considering how people might come in contact with a contaminant. An exposure pathway could involve air, surface water, groundwater, soil, dust, or even plants and animals. Exposure can occur by breathing, eating, drinking, or by skin contact with a substance containing the chemical contaminant. ATSDR identifies an exposure pathway as completed or potential, or eliminates the pathway from further evaluation.

- *Completed exposure pathways* exist for a past, current, or future exposure if contaminant sources can be linked to a receptor population. All five elements of the exposure pathway must be present. In other words, people have or are likely to come in contact with site-related contamination at a particular exposure point via an identified exposure route. As stated above, a release of a chemical or radioactive material into the environment does not always result in human exposure. For an exposure to occur, a completed exposure pathway must exist.

- *Potential exposure pathways* indicate that exposure to a contaminant could have occurred in the past, could be occurring currently, or could occur in the future. It exists when one or more of the elements are missing but available information indicates possible human exposure. A potential exposure pathway is one which ATSDR cannot rule out, even though not all of the five elements are identifiable.

- An *eliminated exposure pathway* exists when one or more of the elements are missing. Exposure pathways can be ruled out if the site characteristics make past, current, and future human exposures extremely unlikely. If people do not have access to contaminated areas, the pathway is eliminated from further evaluation. Also, an exposure pathway is eliminated if site monitoring reveals that media in accessible areas are not contaminated.

Contact with contamination at the Cotter Mill is an eliminated exposure pathway.

Because the mill site itself is fenced and access is restricted, exposure to on-site contamination by the public at the Cotter Mill is limited. Further, remediation efforts have removed some of the on-site soil contamination, including moving millions of cubic yards of tailings and contaminated soils from unlined ponds to lined impoundments (EPA 2002). In some areas, contaminated soil was removed down to bedrock. In addition, various process changes reduced the release of contaminated materials (EPA 2002). Any potential exposure by the occasional trespasser to remaining impacted soils at the Cotter Mill would be too infrequent to present a health hazard.

B. How does ATSDR determine which exposure situations to evaluate?

ATSDR scientists evaluate site conditions to determine if people could have been, are, or could be exposed (i.e., exposed in a past scenario, a current scenario, or a future scenario) to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated media (soil, sediment, water, air, or biota) has occurred, is occurring, or will occur through ingestion, dermal (skin) contact, or inhalation.

If exposure was, is, or could be possible, ATSDR scientists consider whether contamination is present at levels that might affect public health. ATSDR scientists select contaminants for further evaluation by comparing them to health-based comparison values. These are developed by ATSDR from available scientific literature related to exposure and health effects. Comparison values are derived for each of the different media and reflect an estimated contaminant concentration that is *not likely* to cause adverse health effects for a given chemical, assuming a standard daily contact rate (e.g., an amount of water or soil consumed or an amount of air breathed) and body weight.

Comparison values are not thresholds for adverse health effects. ATSDR comparison values establish contaminant concentrations many times lower than levels at which no effects were observed in experimental animals or human epidemiologic studies. If contaminant concentrations are above comparison values, ATSDR further analyzes exposure variables (for example, duration and frequency of exposure), the toxicology of the contaminant, other epidemiology studies, and the weight of evidence for health effects.

Some of the comparison values used by ATSDR scientists include ATSDR's environmental media evaluation guides (EMEGs), reference dose media evaluation guides (RMEGs), and cancer risk evaluation guides (CREGs) and EPA's maximum contaminant levels (MCLs). EMEGs, RMEGs, and CREGs are non-enforceable, health-based comparison values developed by ATSDR for screening environmental contamination for further evaluation. MCLs are enforceable drinking water regulations developed to protect public health. Effective May 2008, Colorado established state groundwater standards for uranium and molybdenum.

You can find out more about the ATSDR evaluation process by calling ATSDR's toll-free telephone number, 1-800-CDC-INFO (1-800-232-4636) or reading ATSDR's Public Health Assessment Guidance Manual at http://www.atsdr.cdc.gov/HAC/PHAManual/.

C. If someone is exposed, will they get sick?

Exposure does not always result in harmful health effects. The type and severity of health effects a person can experience because of contact with a contaminant depend on the exposure concentration (how much), the frequency (how often) and/or duration of exposure (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants). Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how the individual absorbs, distributes, metabolizes, and excretes the contaminant. Together, these factors and characteristics determine the health effects that may occur.

In almost any situation, there is considerable uncertainty about the true level of exposure to environmental contamination. To account for this uncertainty and to be protective of public health, ATSDR scientists typically use worst-case exposure level estimates as the basis for determining whether adverse health effects are possible. These estimated exposure levels usually are much higher than the levels that people are really exposed to. If the exposure levels indicate that adverse health effects are possible, ATSDR performs more detailed reviews of exposure and consults the toxicologic and epidemiologic literature for scientific information about the health effects from exposure to hazardous substances.

D. What exposure situations were evaluated for residents living near the Cotter Mill?

ATSDR obtained information to support the exposure pathway analysis for the Lincoln Park/Cotter Mill Superfund Site from multiple site investigation reports; state, local, and facility documentation; and communication with local and state officials. The analysis also draws from available environmental and exposure data for groundwater, soil, surface water and sediment, and biota. Throughout this process, ATSDR examined concerns expressed by the community to ensure exposures of special concern are adequately addressed. ATSDR identified the following exposure pathways for further evaluation:

1. Exposure to site-related contaminants in groundwater in Lincoln Park.

2. Contact with site-related contaminants in soil adjacent to the Cotter Mill and in Lincoln Park.

3. Contact with site-related contaminants in surface water downstream from the Cotter Mill.

4. Exposure from eating produce locally grown in Lincoln Park.

5. Exposure from site-related soil contaminants in windborne dust.

6. Exposure from air emission sources (stacks and uncontrolled fugitive dust)

This exposure pathway analysis focuses on past, current, and future exposures for residents living near the Cotter Mill, with a focus on the community of Lincoln Park. Some attention is also paid to exposures at the Shadow Hills Golf Course and along the county road. Table 3 below provides a summary of exposure pathways evaluated in this public health assessment.

1. *Exposure to groundwater in Lincoln Park*

In the past, a number of residences used wells[1] on their property (GeoTrans 1986; IMS 1989). Based on a 1989 water use survey in Lincoln Park, 60 out of 104 wells, springs, and cisterns were used to obtain water for domestic purposes, including consumption and irrigation (IMS 1989). See Table 14 in Appendix A for the reported groundwater uses in the Lincoln Park area. Seven survey respondents indicated that they used groundwater for domestic consumption, accounting for 5 to 100% of their total water consumption. Based on the survey, five residents had private wells that were affected by contaminated groundwater; these residents were connected to the municipal water supply between 1989 and 1993 [EPA 2002]. The 1988 RAP requires Cotter to connect eligible affected users with legal water rights for a well to the town water supply [CDPHE 2005]. Cotter checks the State of Colorado's Engineer's Office database for new water permits and reports their findings in their annual ALARA reports [Pat Smith, EPA Region 8, personal communication, August 2008].

The use of private groundwater wells in the past was a completed exposure pathway. Most residences are now connected to the public water supply. The current and future use of these wells is a potential exposure pathway because the extent to which these wells are used is not well documented.

While the majority of town residents are now connected to the public water supply [Galant et al. 2007], several residences also have operational private wells. A 2005 summary of the RAP status reports that some residents have refused public water supply connections [CDPHE 2005]. Additionally, no formal institutional controls exist to control groundwater use in Lincoln Park [EPA 2007]. The United States Geological Survey (USGS) reports that existing private wells are used primarily for stock watering and irrigation [USGS 1999a]. However, a newspaper article reports that at least one residence, located on Grand Avenue in Lincoln Park, used private well water for consumption as recently as 2002 [Plasket 2002]. Based on a 2007 review of Colorado State well permits for residences in the plume configuration, at least one well is permitted for irrigation and domestic use, but no details of actual use are documented [EA 2007]. On properties that continue to use private wells, new purchasers are offered connection to the town's municipal water system [Galant et al. 2007]. In late 2008, EPA conducted another water use survey to verify whether groundwater is being utilized by residences in Lincoln Park. Well water samples were also collected and analyzed. Once available, ATSDR will review the information and will revise the public health assessment, if needed.

2. *Contact with soil adjacent to the Cotter Mill and in Lincoln Park*

People (especially children) might accidentally ingest soil or exposed sediment, and dust generated from these materials, during normal activities. Everyone ingests some soil or dust every day. Small children (especially those of preschool age) tend to swallow more soil or dust than any other age group because children of this age tend to have more contact with soil through play activities and have a tendency for more hand-to-mouth activity. Children in elementary school, teenagers, and adults swallow much smaller amounts of soil or dust. The amount of grass

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[1] The term "well" is used to represent all groundwater sources, and includes both wells and springs.

cover in an area, the amount of time spent outdoors, and weather conditions also influence how much contact people have with soil.

a) Contact with soil near the Cotter Mill

Soils adjacent to the Cotter Mill have been contaminated by wind-blown particulates [CDPHE 2005]. Elevated levels are primarily detected in soils directly east and west of the facility [Weston 1998]. This distribution of contaminated soils is consistent with wind patterns in the area, which blow mainly from west to east with occasional flows from east to west. The primarily vacant areas directly east and west of the facility are referred to as a "buffer zone" between the Cotter Mill and residential developments [EPA 2002]. Therefore, limited opportunities for exposure to impacted site-adjacent soils exist—people are not expected to be in this area on a daily basis and for an extended period of time. One exception may be at the Shadow Hills Golf Course, located immediately north of the Cotter mill complex. Exposure to potentially impacted soil at this public golf course is unlikely due to grass cover.

Contact with contaminated soil near the Cotter Mill (i.e., in the buffer zone) is a past, current, and future potential exposure pathway.

For nearly 50 years, Cotter has intermittently hauled materials by truck, possibly losing some materials along the county road leading to the facility and along the access road entering the mill site [MFG 2005]. The public could be exposed to potentially impacted soils along the county road. However, there is limited potential for exposure to contaminants along the access road, since access to the Cotter Mill is restricted and Cotter remediated soil adjacent to the access road in 2007 and 2008.

b) Contact with soil and sediment in the community of Lincoln Park

The community of Lincoln Park is located approximately 1.5 miles north-northeast of the restricted area of the Cotter Mill. Contaminated materials from the Cotter Mill may have contributed to soil contamination in Lincoln Park in two ways:

1. Dust from soil or tailings associated with site operations could be transported by wind to Lincoln Park. However, wind patterns in the area suggest that wind-blown contamination is not likely a considerable source of soil contamination in Lincoln Park (Weston 1998). Additionally, on-site remediation at the Cotter Mill substantially reduced the sources of soil contamination.

2. Potentially impacted groundwater used for irrigation could lead to the accumulation of chemicals in town soils [Weston 1998].

Further, in the past, contaminated surface water runoff from the Cotter Mill entered Sand Creek, where it was transported downstream toward Lincoln Park [EPA 2002]. However, Sand Creek is not believed to be used for recreational activities—the creek is ephemeral and on private land until it goes under the river walk and enters the Arkansas River [Phil Stoffey, CDPHE, personal communication, June 2007].

Contact with contaminated sediment in Sand Creek was a past potential exposure pathway. Due to the remediation of Sand Creek, current and future contact is an eliminated exposure pathway.

Contact with contaminated soil in Lincoln Park was a past completed exposure pathway. Cotter has performed all required off-site soil cleanup activities, as outlined in the RAP [EPA 2002]. CDPHE reports that the Cotter Mill poses no risk to the residents of Lincoln Park by exposure to soil [Weston 1998], and EPA and CDPHE have advised “No Further Action” in regards to Lincoln Park soils [EPA 2002]. EPA’s Record of Decision states that surface-soil cleanup activities have eliminated or reduced risks to “acceptable” levels [EPA 2002, 2007]. Therefore, current and future contact with soil and sediment is an eliminated exposure pathway.

3. Contact with surface water downstream from the Cotter Mill

In the past, people could have come in contact with contamination in surface water during recreational activities. The Arkansas River is used primarily for fishing and boating or rafting, as well as some swimming [Phil Stoffey, CDPHE, personal communication, June 2007]. Sand Creek is on private land until it goes under the river walk and enters the Arkansas River, and is generally not used for recreational activities [Phil Stoffey, CDPHE, personal communication, June 2007]. Many Lincoln Park residents use water from the DeWeese Dye Ditch to irrigate their orchards and gardens [Galant et al. 2007].

Contact with contaminated surface water near the Cotter Mill was a past potential exposure pathway. Due to the construction of the SCS Dam and the remediation of Sand Creek, current and future contact is an eliminated exposure pathway.

4. Exposure from eating locally grown produce

Many Lincoln Park residents have orchards and gardens. Water from the DeWeese Dye Ditch is primarily used to irrigate the orchards and gardens, however, some residents use water from their groundwater wells [Galant 2007; IMS 1989]. If fruits and vegetables are grown in contaminated soil and/or irrigated with contaminated water, the people who eat this produce could be exposed to contamination.

5. Exposure from breathing windborne dust

Many Lincoln Park residents are concerned about the arid environment and the risks of breathing in contaminated dust from the site. The profile of air emission sources at Cotter Mill has changed considerably over the years. These sources include both releases through stacks and uncontrolled (or fugitive) dust emissions. Stack emissions occurred during times of active processing at Cotter Mill; however, the magnitude of these stack emissions has varied, depending on production rates and effectiveness of air pollution controls. The sources of fugitive dust emissions have also changed. In the past, the site had many uncontrolled sources of wind-blown dust, which would cause particulate matter (along with any chemical and radiological constituents) to be emitted into the air. Examples of these sources include ore handling operations, stockpiles, and the previous unlined holding ponds. Many of these sources of wind-blown dust have since been controlled or eliminated, causing facility-wide fugitive dust emissions to decrease considerably over the years, though some fugitive dust emissions (e.g., from unpaved roads) continue to occur.

Table 3. Exposure pathways for residents living near the Cotter Mill

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Groundwater							
Completed Exposure Pathway							
Private groundwater wells	Tailings and other wastes from the Cotter Mill (heavy metals and radionuclides)	Migration of groundwater into the Lincoln Park area	Residential tap water drawn from private wells	Residents, including children, who are not connected to the public water supply and rely on private wells	Ingestion, Dermal contact	Past	Past consumption of groundwater from private wells has been documented and was, therefore, a completed exposure pathway.
Potential Exposure Pathway							
Private groundwater wells	Tailings and other wastes from the Cotter Mill (heavy metals and radionuclides)	Migration of groundwater into the Lincoln Park area	Residential tap water drawn from private wells	Residents, including children, who are not connected to the public water supply and rely on private wells	Ingestion, Dermal contact	Current Future	The extent to which private wells are currently used in Lincoln Park is uncertain. Although most residents are supplied with town water, documents indicate that residents have been drinking private well water as recently as 2002, and are permitted to use wells for unspecified domestic purposes. However, it is believed that water from wells is used primarily for irrigation and other non-drinking purposes. Therefore, current and future use of water from private wells is a potential exposure pathway.

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Soil and Sediment							
Completed Exposure Pathway							
Surface soil and dust in Lincoln Park	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust; soil irrigated by contaminated groundwater	Residences and public areas	Residents, including children	Dermal contact, Incidental ingestion, Inhalation	Past	Prior to remediation, contaminants were detected in soil from residential lawns and gardens. Therefore, contact with contaminated soil in Lincoln Park was a past completed exposure pathway.
Potential Exposure Pathways							
Surface soil near the Cotter Mill	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust	The Shadow Hills Golf Course west of the Cotter Mill; along the county road leading to the Cotter Mill	Golfers at the public golf course; people on the county road	Dermal contact, Incidental ingestion, Inhalation	Past Current Future	Soils adjacent to the Cotter Mill have been contaminated by wind-blown particulates. Therefore, contact with soil near the Cotter Mill, especially at the public golf course and along the county road, is a past, current, and future potential exposure pathway.
Sediment in Sand Creek	Tailings, dusts, and other wastes from the Cotter Mill	Tailings carried in surface water runoff	Along Sand Creek	Recreational users; children playing along Sand Creek	Dermal contact, Incidental ingestion	Past	There were limited opportunities for exposure since Sand Creek was not used for recreational purposes. Therefore, exposure to sediments prior to the Sand Creek Cleanup project was a past potential exposure pathway.
Eliminated Exposure Pathways							
Surface soil at the Cotter Mill	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust; surface water runoff	Unauthorized access is not allowed	None	None	Past Current Future	Because the mill site itself is fenced and access is restricted, contact with on-site contamination is an eliminated exposure pathway. Further, remediation efforts have removed some impacted soils.

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Surface soil and dust in Lincoln Park	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust; soil irrigated with contaminated groundwater	Cleanup activities have eliminated or reduced risks to acceptable levels	None	None	Current Future	Due to the sampling and remediation in Lincoln Park, current and future contact with soil and dust is an eliminated exposure pathway.
Sediment in Sand Creek	Tailings, dusts, and other wastes from the Cotter Mill	Tailings carried in surface water runoff	Contaminated sediment was removed from Sand Creek	None	None	Current Future	Sediment in Sand Creek is no longer a hazard since the completion of the Sand Creek Cleanup project. Therefore, current and future contact with sediment in Sand Creek is an eliminated exposure pathway.
Surface Water							
Potential Exposure Pathway							
Surface water near the Cotter Mill	Tailings and other waste from the Cotter Mill	Surface water runoff; transport from Sand Creek to the Arkansas River	Along Sand Creek between the Cotter Mill and the Arkansas River; the DeWeese Dye Ditch; the Arkansas River	Recreational users (mostly in the Arkansas River, limited recreational use in Sand Creek); people irrigating with water from the DeWeese Dye Ditch	Incidental ingestion, Dermal contact	Past	In the past, surface water in Sand Creek was found to contain elevated levels of metals and radionuclides. Therefore, past contact with contaminated surface water near the Cotter Mill was a potential exposure pathway.
Eliminated Exposure Pathway							
Surface water near the Cotter Mill	Tailings and other waste from the Cotter Mill	Surface-water runoff; transport from Sand Creek to the Arkansas River	Contamination was removed from Sand Creek	None	None	Current Future	Due to the construction of the SCS Dam and the remediation of Sand Creek, current and future contact with contaminated surface water is an eliminated exposure pathway.

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Locally Grown Produce							
Potential Exposure Pathway							
Produce grown in Lincoln Park	Tailings, dusts, and other wastes from the Cotter Mill	Produce grown in contaminated soil or irrigated with contaminated water	Orchards and gardens in Lincoln Park	People who eat locally grown produce	Ingestion	Past Current Future	Because many Lincoln Park residents have orchards and gardens, eating locally grown produce is a past, current, and future potential exposure pathway.
Air Emissions							
Completed Exposure Pathway							
Ambient air near the Cotter Mill facility	Ground-level fugitive emissions (e.g., wind-blown dust) and elevated point sources (e.g., stacks)	Windblown dust; stack emissions into the air and transport to off-site locations	Off-site or down-wind locations	People who live in the vicinity of Cotter Mill or downwind of the stacks	Inhalation	Past Future Present	Cotter's air monitoring network monitors air concentrations at off-site locations. With the facility currently in "stand down" status, facility emissions are now predominantly fugitive; air quality impacts should be characterized by perimeter monitoring stations.

IV. EVALUATION OF ENVIRONMENTAL CONTAMINATION

A. Groundwater

Prior to 1980, Cotter disposed of waste in unlined ponds, which allowed contaminated liquids to leach into the groundwater [EPA 2002]. Groundwater was shown to be contaminated as far away as the Arkansas River, which is approximately 2.5 miles downgradient from the mill [EPA 2002]. Results from the 1984–1985 Remedial Investigation found that despite attempts at remediation, the new, lined impoundments were leaking and the old ponds area was a continuing source of groundwater contamination [GeoTrans 1986]. This study also found that a gap in the ridge at the SCS Dam, built in 1971 across Sand Creek on the Cotter property, was allowing shallow groundwater to move downgradient towards Lincoln Park, resulting in concentrations of molybdenum and uranium that were 2,000 times above background levels at that time.

Groundwater concentrations of molybdenum and uranium have decreased in recent years, but concentrations have not yet returned to background levels in some wells [Weston 1998]. Figures 4 and 5 show the extent of the molybdenum and uranium concentrations, respectively, above water quality standards (0.035 milligrams per liter [mg/L] for molybdenum and 0.03 mg/L for uranium). The highest levels in Lincoln Park were detected nearest to the Cotter property in the vicinity of the DeWeese Dye Ditch [Weston 1998]. Additionally, despite remediation efforts, the physical and chemical groundwater data suggest minor leakage from the primary impoundment at the Cotter site [CDPHE 2007a; EPA 2002; USGS 1999b].

1. Remedial actions for controlling groundwater contamination

Since the early- to mid-1980s, remedial actions aimed at controlling groundwater contamination and the spread of the resulting plume have taken place. Remediation has targeted the area along the primary surface groundwater migration pathway, which runs parallel to Sand Creek [USGS 1999a]. Remediation has included the following:

- In the early 1980s, contaminated materials were moved into lined impoundments [EPA 2002].

- In 1988, a hydrologic clay barrier was installed on the Cotter property to help contain the contaminated groundwater plume associated with the Cotter Mill.

- In 1989, a network of injection and withdrawal wells were constructed downgradient of the lined impoundment to reverse the hydraulic gradient and prevent the northward migration of contaminated groundwater. This system was discontinued in 2000, because the system had little or no discernable effect on groundwater conditions [CDPHE 2005].

- Dam to ditch flushing began in 1990. However, this effort was discontinued in 1996 due to citizens’ concerns about contaminant concentrations rising in groundwater wells as the plume was being flushed [CDPHE 2005].

- In 2000, a permeable reactive treatment wall was constructed across Sand Creek channel in the DeWeese Dye Ditch flush, downstream of the SCS Dam [EPA 2002]. Although the permeable reactive treatment wall has not performed as anticipated, it is acting as a barrier to additional groundwater flowing into Lincoln Park [Phil Egidi, CDPHE, personal communication, July 2008].

These efforts have reduced groundwater contamination downgradient of the Cotter Mill [CDPHE 2008; EPA 2002; USGS 1999a], although the rate at which groundwater quality is being restored is slower than anticipated [EPA 2007]. Cotter and CDPHE continue to explore options for cleaning the groundwater. Until a solution is reached, contaminated groundwater is captured at the SCS Dam and pumped back to the on-site lined impoundments [CDPHE 2008].

2. Nature and extent of groundwater contamination in Lincoln Park

CDPHE maintains a database containing environmental sampling data from various sources dating back to 1961. The most recent data entered into the database are from September 2007. To evaluate exposures to residents of Lincoln Park, ATSDR identified data within the CDPHE database for the wells reported to be in use during the 1989 water use survey (see Table 14 in Appendix A). After discussions with a CDPHE representative, the following assumptions were made while summarizing the data within the database.

- For chemicals, samples that were designated “Y” in the detect flag column and contained a zero in the result value column, but no value in the reporting detection limit column were excluded from the summary statistics. For radionuclides, however, these samples were included in the summary statistics since zero is considered a valid result.

- Samples that were designated “N” in the detect flag column and had the same value in the result value column as the reporting detection limit column were included in the summary statistics as ½ the reporting detection limit.

- Negative result values for manganese and iron were assumed to be not detected and were included in the summary statistics as ½ the reporting detection limit.

- Negative values[2] for radionuclides were included in the summary statistics.

a) Wells used for personal consumption

The 1989 *Lincoln Park Water Use Survey* identified seven wells used for personal consumption (IMS 1989). Data for six of the wells are available in the CDPHE database (see Table 14). The seventh well had a broken pump at the time of the survey [IMS 1989]; no data for this well appear to be in the database. The data for wells reportedly used for personal consumption in 1989 are summarized in Table 15. Samples were collected intermittently from 1984 to 2007. The locations of these wells are shown in Figure 6. With the exception of molybdenum and uranium, the data are limited (e.g., only two wells were sampled for the majority of the chemicals and none were sampled for radionuclides).

When this document was written, data from EPA’s 2008 water use survey were not yet available. ATSDR will update well use information when the data are available.

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[2] Negative values for radionuclides occur when samples are not much different from background, since standard protocol is to subtract background radioactivity from the sample count.

However, all six wells were repeatedly tested for molybdenum and uranium, which were the only chemicals detected above comparison values (see Table 15). Of the personal consumption wells, Well 189 contains the highest molybdenum and uranium concentrations. Well 189 is the only well with levels of uranium consistently detected above the comparison value (see Figure 6).

It is difficult to evaluate the molybdenum and uranium data over time, because of the limited sampling data for these wells and the inconsistency of sampling the same wells over time. The molybdenum and uranium concentrations in the personal consumption wells over time are graphically shown in Figure 7 and Figure 8 in Appendix B, respectively. Well 168 (house well on Grand Avenue)[3] and Well 189 (house well on Hickory)[4] were sampled the most frequently. No clear pattern of decreasing concentrations from 1984 to 2007 exists.

The USGS identified Well 10 (So. 12th St.) and Well 114 (Pine) as representative of background for the Lincoln Park area [Weston 1998]. The data available in the CDPHE database for these two wells are summarized in Table 16.[5] The average concentration of molybdenum in the wells used for personal consumption (0.082 mg/L; see Table 15) is higher than the average concentration found in the background wells (0.023 mg/L; see Table 16). The average uranium concentration in the wells used for personal consumption (0.028 mg/L; see Table 15) is only slightly higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

(1) Grand Avenue Well

In a 2002 newspaper article, a resident on Grand Avenue reported drinking water from their well [Plasket 2002]. Limited data (1 to 20 samples) are available in the CDPHE database for this location (see Figure 6). Samples were collected and analyzed for most chemicals in 1984, and then from either 2004 or 2005 to 2007. Samples from this well were also tested for molybdenum and uranium from 1988 to1991. The water from this well was tested for several chemicals, but not for radionuclides. None of the samples detected chemicals above comparison values (see Table 17).

b) Wells used to irrigate fruit and vegetable gardens

When this document was written, data from EPA’s 2008 water use survey were not yet available. ATSDR will update well use information when the data are available.

The 1989 *Lincoln Park Water Use Survey* identified 22 wells used to irrigate fruit and 21 wells used to irrigate vegetable gardens [IMS 1989].[6] Data for 28 of these wells are available in the CDPHE database (see Table 14). Samples were sporadically collected from these wells and analyzed for various chemicals between 1962 and 2007. Samples were collected and analyzed for radionuclides from

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[3] There are five non-detected molybdenum values for Well 168. Four of them are most likely due to the detection limit being too high for the level of molybdenum in that well. The detection limits were 0.01 mg/L for three of the samples and 0.05 mg/L for one of the samples. The concentrations in that well hover around 0.01 mg/L.

[4] One of the non-detected molybdenum concentrations in Well 189 is unexplainable. The detection limit (0.01 mg/L) is low enough to have detected the level of molybdenum typically found in the well. The detection limit (0.5 mg/L) for the other non-detected concentration is too high for the level of molybdenum typically found in the well.

[5] Groundwater samples from the background wells were not tested for radionuclides.

[6] Some wells were used for both purposes.

1995 to 2000. The data for wells reportedly used to irrigate fruit and vegetable gardens in 1989 are summarized in Table 18 (chemicals) and Table 19 (radionuclides). The locations of these wells are shown in Figure 9. The data for these wells are much more robust than the data available for the wells used for personal consumption, in part due to the increased number of wells. Molybdenum and uranium were sampled in all 28 wells used for irrigation. Five wells were tested for radionuclides.

The maximum concentrations in the wells used to irrigate fruit and vegetable gardens exceeded the comparison values for molybdenum, selenium, sulfate, total dissolved solids, and uranium. The average concentrations exceeded comparison values only for molybdenum, total dissolved solids, and uranium. Looking at data from 2000 to 2007, only the average molybdenum concentration (0.1 mg/L) continued to exceed the comparison value.

The average concentration of molybdenum in the wells used to irrigate fruit and vegetable gardens (0.99 mg/L; see Table 18) is higher than the average concentration found in the wells that USGS identified as background for Lincoln Park (0.023 mg/L; see Table 16). Similarly, the average uranium concentration in the wells used to irrigate fruit and vegetable gardens (0.13 mg/L; see Table 13) is higher than the average concentration in the background wells (0.021 mg/L; see Table 16). The average concentration for total dissolved solids in the wells used to irrigate fruit and vegetable gardens (550 mg/L; see Table 18) is also higher than the average concentration found in the background wells (429 mg/L; see Table 16).

c) Wells used to water livestock

When this document was written, data from EPA's 2008 water use survey were not yet available. ATSDR will update well use information when the data are available

The 1989 *Lincoln Park Water Use Survey* identified 22 wells used to water livestock [IMS 1989]. Data for 19 of these wells are available in the CDPHE database (see Table 14). Samples were sporadically collected from these wells and analyzed for various chemicals between 1962 and 2007. Samples were collected and analyzed for radionuclides from 1995 and 1996. The data for wells reportedly used to water livestock in 1989 are summarized in Table 20 (chemicals) and Table 21 (radionuclides). The locations of these wells are shown in Figure 10. Only one to four wells were sampled for the majority of the chemicals, however, molybdenum and uranium were sampled in all 19 wells used to water livestock. Two wells were tested for radionuclides.

The maximum concentrations exceeded the comparison values for molybdenum, sulfate, total dissolved solids, and uranium. The average concentrations only exceeded comparison values for molybdenum and uranium. Looking at data from 2000 to 2007, only the average molybdenum concentration (0.08 mg/L) continued to exceed the comparison value.

The average concentration of molybdenum in the wells used to water livestock (0.212 mg/L; see Table 20) is an order of magnitude higher than the average concentration found in the wells that USGS identified as background for Lincoln Park (0.023 mg/L; see Table 16). The average uranium concentration in the wells used to water livestock (0.034 mg/L; see Table 20) is higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

d) *Wells used to water lawns*

When this document was written, data from EPA's 2008 water use survey were not yet available. ATSDR will update well use information when the data are available.

The 1989 *Lincoln Park Water Use Survey* identified 42 wells used to water lawns [IMS 1989]. Data for all 42 wells are available in the CDPHE database (see Table 14). Samples were sporadically collected from these wells and analyzed for various chemicals between 1962 and 2007. Samples were collected and analyzed for radionuclides from 1995 to 2000. The data for wells reportedly used to water lawns in 1989 are summarized in Table 22 (chemicals) and Table 23 (radionuclides). The locations of these wells are shown in Figure 11. Several wells were sampled for each chemical, and molybdenum and uranium were tested in all 42 wells used to water lawns. Seven wells were sampled for radionuclides.

The maximum concentrations exceeded the comparison values for chloride, molybdenum, selenium, sulfate, total dissolved solids, and uranium. The average concentrations exceeded comparison values for molybdenum, sulfate, total dissolved solids, and uranium. Looking at data from 2000 to 2007, only the average molybdenum concentration (0.1 mg/L) continued to exceed the comparison value from 2000 to 2007, while the average uranium concentration (0.03 mg/L) was at the comparison value.

The average concentration of molybdenum in wells used to water lawns (2.2 mg/L; see Table 22) is two orders of magnitude higher than the average concentration found in the wells that USGS identified as background for Lincoln Park (0.023 mg/L; see Table 16). The average sulfate concentration in wells used to water lawns (351 mg/L; see Table 22) is almost six times higher than the average concentration in the background wells (61 mg/L; see Table 16). The average concentration for total dissolved solids in wells used to water lawns (746 mg/L; see Table 22) is higher than the average concentration found in the background wells (429 mg/L; see Table 16). The average dissolved uranium concentration in wells used to water lawns (0.233 mg/L; see Table 22) is an order of magnitude higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

(1) Well 138

Well 138 (field well on Cedar Street; see Figure 11) was identified during the *1998 Supplemental Human Health Risk Assessment* as the maximally impacted off-site well [Weston 1998]. In 1989, Well 138 was used only to water the lawn [IMS 1989]. Adequate data for this well are available in the CDPHE database. Samples were collected from Well 138 and analyzed for various chemicals between 1968 and 2000. Samples were collected and analyzed for radionuclides from 1995 to 2000. The data for Well 138 are summarized in Table 24 (chemicals) and Table 25 (radionuclides).

The maximum concentrations exceeded the comparison values for chloride, molybdenum, selenium, sulfate, total dissolved solids, and uranium. The average concentrations also exceeded comparison values for molybdenum, sulfate, total dissolved solids, and uranium. A clear decrease in concentrations occurred over time for molybdenum (see Figure 12), selenium (see Figure 13), and uranium (see Figure 14).

Well 138 has higher levels of contamination than the wells that USGS identified as background for Lincoln Park. The average concentration of molybdenum in Well 138 (8.0 mg/L; see Table 244) is hundreds of times higher than the average concentration found in the background wells (0.023 mg/L; see Table 16). The average sulfate concentration in Well 138 (1,059 mg/L; see Table 24) is considerably higher than the average concentration in the background wells (61 mg/L; see Table 16). The average concentration for total dissolved solids in Well 138 (1,530 mg/L; see Table 24) is three times higher than the average concentration found in the background wells (429 mg/L; see Table 16). The average dissolved uranium concentration in Well 138 (0.73 mg/L; see Table 24) is more than an order of magnitude higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

e) Groundwater trends over time

To evaluate the levels of molybdenum, selenium, and uranium in groundwater over time, ATSDR combined and graphed all the groundwater data for the wells used for personal consumption, irrigating fruit and vegetables, watering livestock, and watering lawns (Figures 15 through 17 in Appendix B). Figure 15 shows a pattern of decreasing concentrations of molybdenum in groundwater over time. The concentrations of selenium seem to hold steady, but do decrease slightly over time (see Figure 16). The concentrations of uranium also clearly decrease over time (see Figure 17).

B. Soil and sediment

1. Background levels

Cotter was required by the 1988 RAP to establish background levels of certain elements in soils and sediments. Twenty soil samples were collected from five sub-basins considered free from mill-related contamination to represent natural background typical of the area near the mill [HRAP 1991]. Table 4 below presents the results of that study, which were further supported by additional sampling [CDPHE 2005].

Table 4. Background soil and sediment levels

	Soil		Sediment	
	Average	Upper Confidence Limit	Average	Upper Confidence Limit
Molybdenum	2.4 ppm	4.6 ppm	2.3 ppm	4.7 ppm
Uranium	2.1 ppm	2.9 ppm	2.0 ppm	3.4 ppm
Radium-226	1.3 pCi/g	1.9 pCi/g	1.1 pCi/g	1.7 pCi/g
Thorium-230	1.8 pCi/g	3.2 pCi/g	1.5 pCi/g	3.1 pCi/g
Gamma Exposure Rates	9.4 µR/hr	--	--	--

Source: CDPHE 2005; HRAP 1991
pCi/g – picocuries per gram
ppm – parts per million
µR/hr – microroentgen per hour

2. *Off-site soil contamination and remediation*

As part of the 1988 RAP, Cotter was required to survey soils outside the restricted area (the fenced active mill site) and to remediate contaminated soils with levels of radium and molybdenum that are above the established background [CDPHE 2005].

As part of the *1998 Supplemental Human Health Risk Assessment* [Weston 1998], Weston (a contractor for Cotter) collected surface soil samples (0-2 inches) from eight zones around the mill property (see Figure 18 in Appendix B). Each zone was divided into 8 to 12 grids. Four samples were collected near the center of each grid and were composited (i.e., combined and homogenized) to form a single representative sample [Weston 1998]. The results of this sampling are shown in Table 26 (chemicals) and Table 27 (radionuclides). The maximum concentrations exceeded the comparison values for arsenic[7] in all eight zones, for cadmium in all zones except one (D), for lead in three zones (F, G, and H), and for radium-226 in four zones (A, B, C, and E). The average concentrations also exceeded comparison values for arsenic[7] in all eight zones, for cadmium in one zone (F), for lead in one zone (H), and for radium-226 in two zones (A and B). The average radium-226 and thorium-230 concentrations were higher than the established average background levels in all eight zones (see 4 for background).

Cotter has occasionally hauled ore and other materials by truck to the site for processing at their facility. To assess the potential that material has been lost alongside the county road leading to the mill and the access road entering the mill site, MFG (a contractor to Cotter) scanned the county road (assuming CR 143) from the road leading to the Shadow Hills Golf Course to the Cotter Mill access road for gamma radiation (see Figure 19). They also collected soil samples to establish a correlation between the gamma exposure rate and the concentration of gamma emitters in the soil. A total of 16 locations were sampled—five along the county road, five along the mill's access road, and six from background locations. The locations were not chosen to estimate an average concentration, but rather to provide data for a range of gamma exposure rates. Each sample was a composite of 10 aliquots within a 100 x 100 meter area [MFG 2005]. The results of this sampling are shown in Table 28. The maximum and average radium-226 and natural uranium concentrations exceeded the comparison values for samples taken along the mill's access road. The maximum and average radium-226 concentrations also exceeded the comparison value for samples taken along the county road. Average concentrations of all radionuclides sampled were higher along the county road and the mill's access road than from those areas designated as background (see Table 28).

There is limited potential for exposure to contaminants along the access road since access to the Cotter Mill is restricted and soils along the access road were remediated in 2007 and 2008.

To address public concerns about the impact of the Cotter Mill on the health of Cañon City residents, CDPHE collected 21 soil samples in January 2003 [CDPHE 2003]. Each sample was a composite of 30–40 scrape samples[8] from each location. Seven samples from Lincoln Park were

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[7] The *1998 Supplemental Human Health Risk Assessment* found no discernible spatial pattern for arsenic around the Cotter Mill, indicating that arsenic levels have not been measurably altered by airborne releases from the mill (Weston 1998).

[8] Surface soil samples were collected using a method developed specifically to look for airborne contamination that settled to the ground (CDPHE 2003).

collected, including one sample of suspected flood sediment (Pine Street near Elm Avenue), two samples of dust (one from a barn loft and one from a residential attic), and four samples of surface soil (one from the McKinley Elementary School playground). Seven samples were collected from areas east of the mill, including the Brookside Head Start School. Six samples were collected from areas west of the mill, including a private residence. One sample was collected from the extreme northern part of Cañon City to represent the regional background (corner of Orchard Avenue and High Street). The sampling event was intentionally biased toward finding the highest amounts of contamination possible [CDPHE 2003]. Sample locations are shown in Figure 20. The data from this sampling event are summarized in Table 29 (chemicals) and Table 30 (radionuclides). The maximum concentrations for lead and radium-226 exceeded the comparison values. The average concentration for lead also exceeded the comparison value. The average concentration for radium-226 did not exceed the comparison value.

Since 1994, Cotter has been annually collecting surface soil samples (0–6 inches) at 10 environmental air monitoring stations that are located along the facility's boundary and in residential areas (see Figure 21). From 1979 to 1993, soils were collected every 9 months. The data from this effort are summarized in Table 31. The maximum concentration for radium-226 exceeded the comparison value; however, the average concentration of samples over the timeframe did not.

a) The nearest resident

The nearest resident is located 0.25 mile from the restricted area [Galant et al. 2007]. One of the air monitoring stations annually monitored by Cotter was established as "the nearest resident" (AS-212). This location is between the Cotter Mill and an actual residence [Cotter 2007]. The limited data for this location are shown in Table 32 (chemicals) and Table 33 (radionuclides). The maximum concentration for radium-226 exceeded the comparison value; however, the average concentration did not.

b) Lincoln Park

EPA determined that sediment and soil in Lincoln Park are no longer an issue since the completion of the Sand Creek Cleanup project in 1998 [EPA 2002, 2007].

As part of the 1988 RAP, Cotter was required to conduct a gamma scintillometer survey in Lincoln Park to evaluate whether soils had been contaminated by windblown and waterborne contaminants from the facility. In December 1988, 127 scintillometer readings were taken near intersections in Lincoln Park. The average external gamma radiation for Lincoln Park was 9.8 microroentgen per hour (µR/hr), which is considered to show "no elevated gamma in Lincoln Park" [CDPHE 2005; HRAP 1991].

As part of the *1996 Supplemental Human Health Risk Assessment* [Weston 1996], Weston compiled data from several past soil studies, including the following:

- Samples collected at the air monitoring location in Lincoln Park in 1987 and 1988

- Samples collected from yards of 10 participants in the Lincoln Park water use survey in 1989
- Samples collected from residential gardens in Lincoln Park in 1990
- Samples collected from lawns and gardens in Lincoln Park in 1996

The data from these studies are collectively summarized in Table 34 (chemicals) and Table 35 (radionuclides). Only the maximum and average concentrations for arsenic exceeded the comparison value.

The soil samples collected from yards of the participants in the 1989 *Lincoln Park water use survey* were also analyzed for molybdenum and uranium. The average molybdenum concentration was 2.0 ppm and the average uranium concentration was 2.8 ppm [HRAP 1991]. The samples collected as part of the 1990 residential garden soil survey were also analyzed for molybdenum. The average concentration was 0.13 ppm [HRAP 1991]. These concentrations are well below the comparison values for molybdenum (300 ppm) and uranium (100 ppm).[9]

As part of the *1998 Supplemental Human Health Risk Assessment* [Weston 1998], 73 surface soil samples were collected from lawns (0–2 inches) and gardens (0–6 inches) in Lincoln Park. For sampling purposes, Lincoln Park was divided into seven areas and 6–16 samples were taken from each area [Weston 1998]. The results of this sampling are shown in Table 26 (chemicals) and Table 27 (radionuclides). Only the maximum and average arsenic concentrations exceeded the comparison value.

The effect of irrigation with contaminated well water on the levels in the soil was also examined during the *1998 Supplemental Human Health Risk Assessment* [Weston 1998]. The soil samples from Lincoln Park were divided into two categories—those irrigated with well water that had been impacted by mill releases and those not believed to have been irrigated with contaminated well water. These data are shown in Table 36 (chemicals) and Table 37 (radionuclides). The concentrations of arsenic, molybdenum, and uranium were statistically higher in soil samples irrigated with impacted well water [Weston 1998].

(1) Lead in Lincoln Park

Residents of Lincoln Park expressed concerns about lead contamination in soil and dust due to historical and current mining and milling operations in the area. Six potential sources of lead are located near the community of Lincoln Park—the Cotter Mill, the Empire Zinc Smelter (also known as New Jersey Zinc and the College of the Cañons), the US Smelter Facility, the Cañon City Copper Smelter, the Ohio Zinc Company, and the Royal Gorge Smelter [EPA 2004]. The Lincoln Park neighborhood is located generally east-southeast of these facilities and the general wind direction is west to east.

To address the residents' concerns, EPA requested that ATSDR assess the health risk associated with lead contamination in Lincoln Park. After a site visit and discussions with the community,

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[9] The data for molybdenum and uranium are not summarized in Table because the raw data for these two chemicals are not presented in the *1996 Supplemental Human Health Risk Assessment* (Weston 1996).

ATSDR focused assessments on two primary issues—1) blood lead levels in children living in Lincoln Park and 2) lead contaminated dust in homes in Lincoln Park.

ATSDR reviewed the available data on blood lead levels in children and concluded that the rate of elevated blood lead levels for Fremont County is below the state average. However, it was not possible to evaluate whether area children, including "high risk" children, were being adequately screened for blood lead levels [ATSDR 2006a]. To further assess blood lead levels, ATSDR tested the blood level of 115 "at risk" school children in 2005. None of the children had elevated blood lead levels [ATSDR 2006b].

ATSDR reviewed the available data on lead levels in household dust and found the data to be sparse and/or lacking. ATSDR conducted a screening level evaluation of the available dust samples and concluded that the data were not sufficient to determine the magnitude or extent of the potential hazard associated with levels of lead in household dust [ATSDR 2006c]. To further assess the health impacts in Lincoln Park, ATSDR, in collaboration with the Colorado Citizens Against Toxic Waste (CCAT) and EPA, collected and analyzed 44 indoor dust samples, 80 surface soil samples (0–2 inches or 0–6 inches) from 22 properties, and 45 blood samples. The results of this exposure investigation did not indicate the presence of unusual levels of lead in residential indoor dust samples, the soil at those homes, or in the blood of occupants of those homes [ATSDR 2006d].

EPA's report documenting the residential soils sampling project can be accessed at the following site: http://www.epa.gov/region8/superfund/co/lincolnpark/.

c) Sand Creek

Sand Creek is primarily an ephemeral creek that passes through the Cotter Mill and runs north-northeast through Lincoln Park. It becomes perennial for the last 0.25–0.5 mile before its confluence with the Arkansas River. Prior to the construction of the SCS Dam north of the Cotter Mill in 1971, surface water and sediment from the facility flowed down the Sand Creek drainage into Lincoln Park [CDPHE 2005; GeoTrans 1986]. Mill tailings in the Old Tailings Pond Area are the source of the mill-derived contaminants (primarily radium-226 and thorium-230) in Sand Creek [Cotter 2000].

During the *1986 Remedial Investigation* [GeoTrans 1986], sediment samples were collected from the following locations in Sand Creek to evaluate present (i.e., 1985) and historical loadings from the Cotter Mill.

- SD01 – mouth near the Arkansas River
- SD02 – near spring where flow begins (reflects migration of contaminants in the groundwater)
- SD04 – below the SCS Dam in
    (1) an abandoned stock watering pond (formed by diversion of runoff water into a depression adjacent to Sand Creek)
    (2) in drainage (reflects historical picture of uncontrolled emissions)
    (3) in drainage above #2 (reflects historical picture of uncontrolled emissions)

- SD05 – above the SCS Dam adjacent to the west property edge

The results of this sampling are presented in Table 38 and Table 39. Only the concentrations for arsenic and radium-226 exceeded ATSDR's comparison values.

As part of the 1988 RAP, Cotter was required to evaluate the mill's potential impacts to Sand Creek and remove sediments that exceeded the radium-226 cleanup goal of 4.0 picocuries per gram (pCi/g), which allows unrestricted use of the creek [Cotter 2000]. A total of 721 samples were systematically collected along the 1.25 mile stretch from just north of the Cotter Mill to where Sand Creek becomes perennial (see Figure 22). Surveying and cleanup began in the spring of 1993 and continued until remediation was completed in December 1998. Approximately 9,000 cubic yards of soil were removed from Sand Creek and disposed of on Cotter property [Cotter 2000]. The excavated areas were backfilled with clean soil [CDPHE 2005]. Thirty confirmatory samples established that the average site-wide radium-226 concentration was 1.5 pCi/g (below the cleanup goal of 4.0 pCi/g) and the average site-wide thorium-230 concentration was 3.9 pCi/g after remediation [Cotter 2000]. In addition to the sampling and remediation for radium-226, seven of the confirmation samples were analyzed for 10 chemicals in 1998 [Cotter 2000]. These results are presented in Table 40. Only the maximum and average concentrations for arsenic exceeded ATSDR's comparison value.

At the time of mill closure, Cotter was required by the 1988 RAP to survey molybdenum and radium-226 in sediments in the perennial stream segments of Sand Creek and Willow (Plum) Creek to determine whether these areas have been impacted by the mill. If necessary, sediments above background will be removed and properly disposed of (CDPHE 2005).

d) The Fremont Ditch

The Fremont Ditch system is downstream of Sand Creek. It diverts water from near the confluence of Sand Creek and the Arkansas River downgradient toward Florence. The ditch receives substantial amounts of water from Sand Creek during low flows in the Arkansas River. During these periods, any contaminants moving down Sand Creek would likely be transported to Fremont Ditch [GeoTrans 1986].

As part of the 1988 RAP, Cotter was also required to conduct a gamma survey of the dry beds of the Fremont Ditch. Cotter sampled sediment in Fremont Ditch from its head gate near Sand Creek to about a quarter mile downstream. The average radium-226 level was 1.86 pCi/g, which was below the cleanup standard of 4 pCi/g. The state agreed with Cotter that the Fremont Ditch did not require remediation because the concentrations of gross alpha (3.8 pCi/g), uranium (6.6 ppm), and molybdenum (2.2 ppm) were also low [CDPHE 2005].

C. Surface water

1. Nature and extent of contamination

The Cotter Mill is a non-discharge facility, meaning that Cotter does not release wastewater to the surface water system. All remediation water is pumped to on-site impoundments for evaporation or recycling. However, prior to construction of the SCS Dam in 1971, storm events carried contaminated surface water and sediments from the facility down the Sand Creek drainage [CDPHE 2005]. One event in particular, a flood in June 1965, caused the unlined tailings ponds at the Cotter Mill to overflow into Lincoln Park. Sediment in the Lincoln Park portion of Sand Creek was contaminated with tailings that were carried in surface water runoff from the mill [EPA 2007].

CDPHE maintains a database containing surface water monitoring data dating back to 1962. The most recent data entered into the database are from September 2007. To evaluate exposures to people living near the Cotter Mill, ATSDR extracted surface water data collected from Sand Creek, the DeWeese Dye Ditch, and the Arkansas River. After discussions with a CDPHE representative, the following assumptions were made while summarizing data within the database.

The SCS Dam was built to prevent surface water and sediment from flowing into Lincoln Park during storm-generated floods. Since the construction of the dam, Lincoln Park no longer receives runoff from the Cotter Mill. Additionally, since 1979, impounded water collected at the dam has been pumped back to the lined impoundment on site [EPA 2002; GeoTrans 1986; HRAP 1991].

- Samples that were designated “N” in the detect flag column and had the same value in the result value column as the reporting detection limit column were included in the summary statistics as ½ the reporting detection limit.

- Negative result values for manganese and iron were assumed to be not detected and were included in the summary statistics as ½ the reporting detection limit.

- Negative values[10] for radionuclides were included in the summary statistics.

a) Sand Creek

From 1993 to 1998, Cotter conducted the Sand Creek Cleanup project to identify and remove mill tailings that had moved into the creek bed as the result of surface water runoff from the Cotter Mill prior to the construction of the SCS Dam. Sediments above the radium-226 cleanup goal of 4.0 pCi/g were removed, which allows unrestricted use of the creek [Cotter 2000; EPA 2002].

Two locations in Sand Creek—one at Ash Street (008) and one at the confluence with the Arkansas River (506)—are sampled as part of the surface water monitoring program (Cotter 2007). The CDPHE database contains surface water monitoring data from these two locations, which are summarized in Table 41 (chemicals) and Table 42 (radionuclides). The maximum concentrations for manganese, molybdenum, sulfate, and total dissolved solids exceeded the comparison values. However, for all four of these chemicals, only the maximum concentrations exceeded comparison values—the second highest detected concentrations were below comparison values. None of the average concentrations exceeded comparison values.

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[10] Negative values for radionuclides occur when samples are not much different from background, since standard protocol is to subtract background radioactivity from the sample count.

As part of the *1991 Health Risk Assessment of the Cotter Uranium Mill Site* [HRAP 1991], the Health Risk Assessment Panel (HRAP) reviewed over 18,000 samples collected from 1976–1989, from 55 different surface water locations. More than 95% of the surface water data were collected from 10 main locations. The location in Sand Creek at Ash Street (008, formerly known as 555) was one of these locations. The average molybdenum (0.009 mg/L) and uranium (0.016 mg/L) concentrations from this location were well below the comparison values (molybdenum: 0.035 mg/L; uranium: 0.03 mg/L).[11]

b) DeWeese Dye Ditch

The DeWeese Dye Ditch is an irrigation ditch that flows between the Cotter Mill and Lincoln Park. The ditch diverts water from Grape Creek to irrigate about 1,200 acres during the summer growing period [GeoTrans 1986]. The ditch crosses Sand Creek downstream from the SCS Dam, but does not join it. Seepage from the ditch recharges groundwater within the Sand Creek drainage. This process dilutes and flushes the contaminated groundwater under Lincoln Park [EPA 2002].

The CDPHE database contains surface water monitoring data from two locations in the DeWeese Dye Ditch—one upstream of the confluence with Forked Gulch (520) and one at Cedar Avenue (526). The location at Cedar Avenue is sampled as part of the surface water monitoring program [Cotter 2007]. The data for both locations are summarized in Table 43 (chemicals) and Table 44 (radionuclides). The maximum concentrations exceeded the comparison values for iron, manganese, total dissolved solids, and dissolved uranium. However, for iron and manganese, only the maximum concentrations exceeded comparison values—the second highest detected concentrations were below comparison values. Only three of the total dissolved solids samples and three of the dissolved uranium samples were detected above comparison values. None of the average concentrations exceeded comparison values.

Molybdenum and uranium data from 1984 to 1989, from the same two locations in the DeWeese Dye Ditch (520 and 526), are summarized in the *1991 Health Risk Assessment of the Cotter Uranium Mill Site* (HRAP 1991). The average molybdenum and uranium concentrations were well below the comparison values (see Table 5 below).

Table 5. Average molybdenum and uranium concentrations in the DeWeese Dye Ditch

Chemical	Average concentration at Location 520 (mg/L)	Average concentration at Location 526 (mg/L)	Comparison Value (mg/L)
Molybdenum	0.003	0.003	0.035
Uranium	0.002	0.0019	0.03

Source: HRAP 1991

Molybdenum data that were several orders of magnitude greater than any other observed sample (i.e., outliers) were not used to calculate the average concentrations (HRAP 1991).

It was not possible to determine whether these data are included in the CDPHE database.

c) Arkansas River

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[11] It was not possible to determine whether these data are included in the CDPHE database.

From April 1989 to June 1990, Cotter and their consultant, Western Environmental Analysts, conducted bi-weekly sampling in the Arkansas River at the following five locations:

The Arkansas River sampling plan was approved by the CDPHE Water Quality Control Division [CDPHE 2005].

1. Parkdale (background)
2. Grape Creek
3. 1st Street (upstream of where Sand Creek enters the Arkansas River)
4. Mackenzie Avenue Bridge (downstream from where Sand Creek enters the Arkansas River)
5. Where Highway 67 to Florence crosses the river

Water, sediment, autotrophs (algae), primary consumers/detrivores (tadpoles, macroinvertebrates), and carnivores (fish) were collected and tested for molybdenum, uranium, radium-226, and thorium-230. Extremely low concentrations were detected, which indicated no statistical evidence of an increase in contamination downstream on the Arkansas River [CDPHE 2005].

In addition, four synoptic sampling events (i.e., sampling of water in-flows) were conducted between Canyon Mouth and Highway 67. The purpose of the synoptic sampling was to determine whether tributary flows reflect unusual sources of uranium or molybdenum. The sampling showed that other sources such as Fourmile Creek, as well as Sand Creek and Plum Creek, contribute to increases in the Arkansas River [CDPHE 2005].

Two locations in the Arkansas River—one upstream of Sand Creek at 1st Street (907) and one downstream of Sand Creek at Mackenzie Avenue (904)—are sampled as part of the surface water monitoring program [Cotter 2007]. The CDPHE database contains surface water monitoring data from these two locations, which are summarized in Table 45 (chemicals) and Table 46 (radionuclides). At both locations, the maximum concentrations exceeded the comparison value for sulfate. The maximum concentration for total dissolved solids exceeded the comparison value for the upstream location, but not the downstream location. In all three instances, these maximum concentrations appear to be outliers and are the only concentrations that exceeded comparison values—the second highest detected concentrations were below comparison values. The maximum concentration for molybdenum also exceeded the Colorado state groundwater standard for the upstream location, but not the downstream location. None of the average concentrations exceeded comparison values.

Data from 1984 to 1989, from two locations in the Arkansas River—one upstream of Sand Creek near Grape Creek (502) and one downstream of Sand Creek near Fourmile Bridge (504)—are summarized in the *1991 Health Risk Assessment of the Cotter Uranium Mill Site* [HRAP 1991]. The average molybdenum and uranium concentrations were well below the comparison values (see Table 6 below).

Table 6. Average molybdenum and uranium concentrations in the Arkansas River

Chemical	Average concentration upstream of Sand Creek near Grape Creek (502) (mg/L)	Average concentration downstream of Sand Creek near Fourmile Bridge (504) (mg/L)	Comparison Value (mg/L)
Molybdenum	0.00391	0.0056	0.035
Uranium	0.00532	0.00574	0.03

Source: HRAP 1991

Molybdenum data that were several orders of magnitude greater than any other observed sample (i.e., outliers) were not used to calculate the average concentrations (HRAP 1991).

d) Willow Lakes

The Willow Lakes are comprised of several small ponds near the Arkansas River in the Willow Creek watershed, which lies directly to the east of the Sand Creek watershed. The Willow Lakes receive water from shallow groundwater and surface runoff [HRAP 1991].

Cotter was required by the 1988 RAP to evaluate whether the Willow Lakes had been contaminated by the mill. Water, sediment, autotrophs (algae), primary consumers/detrivores (tadpoles, macroinvertebrates), and carnivores (fish) from the Willow Lakes and three comparison lakes were collected and tested for molybdenum, uranium, and radium. The information showed that the Willow Lakes had not been contaminated by the Cotter Mill [CDPHE 2005].

D. Locally grown produce

1. Nature and extent of contamination

As part of the *1996 Supplemental Human Health Risk Assessment* (Weston 1996), Weston compiled available food data from several past studies. Samples included chicken meat, fruit (apples, cherries, grapes), and vegetables (asparagus, carrots, lettuce, tomatoes, turnips). The local samples were compared to food collected from supermarkets. The data are presented in Table 47 and Table 48 in Appendix A. The limited sample data suggest that the chemicals and radionuclides found in the foods are probably natural in origin, however, it was not possible to exclude the possibility that some food types may be influenced by mill-related contaminants [Weston 1996].

To further evaluate exposures to residents who eat locally grown fruits and vegetables, a sampling program was initiated in Lincoln Park during the *1998 Supplemental Human Health Risk Assessment* [Weston 1998]. People were asked to donate locally grown produce samples for analysis. The fruits and vegetables sampled are presented in the table below. The samples were tested for heavy metals and radionuclides. The analytical results of the sampling program are summarized in Table 49 and Table 50 in Appendix A.

Fruits Sampled

- Apples
- Cantaloupe
- Grapes
- Honey dew melon
- Plums
- Watermelon

Vegetables Sampled

- Acorn squash
- Beets
- Carrots
- Celery
- Corn
- Cucumbers
- Green Beans
- Green Onions
- Kohlrabi
- Patty pan squash
- Peppers
- Pumpkin
- Rhubarb
- Squash
- Tomatoes
- Turnip Greens
- Turnips
- Winter squash

The samples were divided into two categories—(1) produce that was grown in soil known to have been irrigated with contaminated well water (fruits n = 16; vegetables n = 43) and (2) produce that was grown in soil not believed to have been irrigated with contaminated well water (fruits n = 1; vegetables n = 6). A statistical comparison of the data for the two categories of vegetables indicated that irrigation with contaminated well water did not cause a significant increase in contaminant levels (Weston 1998). The following trends were also noted:

- The concentrations of most metals were higher in root vegetables than other types of vegetables and fruit.
- Concentrations were much lower in peeled turnips than in whole turnips, suggesting that most of the contamination was on or in the surface layer.
- There was high variability both within and between the different types of produce.
- Concentration values were below the limit of detection for many of the samples.

E. Ambient Air

ATSDR reviewed ambient air monitoring data and air sampling data collected from the following two sources:

- Cotter Mill has operated an ambient air monitoring program to characterize air quality impacts of radioactive particulates and radon for more than 20 years. ATSDR accessed summaries of the monitoring data from Cotter Mill's annual Environmental and Occupational Performance Reports, which are posted to the CDPHE's web site; and
- The state of Colorado operated three particulate monitoring stations in Fremont County, one each in Lincoln Park, Cañon City, and Florence. The station in Cañon City continues to operate today. ATSDR downloaded measured concentrations of particulate matter, and some chemical constituents of particulate matter, from EPA's Air Quality System (AQS) database—a publicly accessible online clearinghouse of ambient air monitoring data. Some of the measurements collected by these monitors date back 40 years.

Historically, Cotter Mill had two general types of air emission sources: ground-level fugitive emissions (e.g., wind-blown dust) that would be expected to have greatest air quality impacts nearest the source; and elevated point sources (e.g., stacks) that have the potential for having peak ground-level impacts at downwind locations. With the facility currently in "stand down" status, facility emissions are now predominantly fugitive and their air quality impacts should be adequately characterized by the perimeter monitoring stations.

1. *Nature and extent of air contamination*

ATSDR compiled and evaluated ambient air monitoring data to assess potential air quality impacts from Cotter Mill's past and ongoing operations. As will be discussed later, ambient air concentrations of some substances changed considerably from one year to the next—in some cases, annual average concentrations vary by more than a factor of 250 over the period of record. These substantial changes in measured air contamination levels can sometimes be traced back to site-specific activities.

To provide background information and context for the air quality trends documented later in this report, the following list identifies key milestones over the history of Cotter Mill's operations. The timeline is not intended to be a comprehensive listing of site-specific events, but rather focuses on events and activities expected to be *associated with notable changes in the facility's air emissions*.

- 1958: Cotter Corporation begins its uranium milling operations at the Cotter Mill site
- 1979: Continuous operations cease, but intermittent operations continue
- 1981-1983: Cotter excavates 2,500,000 cubic yards of contaminated tailings from unlined holding ponds and places the material in a newly constructed, lined surface impoundment
- 1987: Cotter suspends its primary milling operations and only limited and intermittent ore processing occurs for the next 12 years
- 1993-1999: Cotter excavates 9,000 cubic yards of contaminated tailings, soil, and sediment from 1.25 miles of Sand Creek near the facility
- 1999: Cotter excavates 100,000 cubic yards of contaminated soil in "near surface soils" from the on-site Old Pond Area and places this material into the lined, surface impoundment
- 1999: Milling operations using a different production process begin
- 2005: Cotter ceases its routine operations and enters "stand down" status; site remediation activities continue; stack emissions from most sources continue into 2006, after which the main operational stack is for the laboratory baghouse
- 2009: Cotter submits letter to CDPHE announcing its intent to refurbish the mill, rather than decommission it

The following sections summarize the data and air quality trends for particulate matter, selected particle-bound radionuclides, radon gas and gamma radiation.

a) Ambient Air Monitoring for Radioactive Substances

The Cotter Mill monitoring network is operated by Cotter Mill in accordance with guidelines and requirements set forth by the U.S. Nuclear Regulatory Commission (USNRC 1980) and the Radioactive Materials License established between Cotter Mill and the state of Colorado [CDPHE 2009]. The purpose of the network is to characterize the extent to which Cotter Mill's operations affect off-site air quality.

Cotter Mill's ambient air monitoring network has been operating from 1979 to the present, but the number of monitoring stations included in the network has changed over time. In 1979, four stations were fully operational; this increased to seven by 1981 and to ten by 1999. These ten monitoring stations continue to operate today. Each station is equipped with the same monitoring equipment: an environmental air sampler used to collect particulates for analysis of particle-bound radionuclides; a radon track etch measurement device; and an environmental thermoluminescent dosimeter (TLD) for measuring gamma exposure. The height of the sampling inlet probes was not specified in the reports that ATSDR reviewed to prepare this health assessment. Table 51 in Appendix A identifies the monitoring stations and their periods of operation. Figure 23 in Appendix B shows the approximate locations of the monitoring stations. For purposes of this evaluation, ATSDR has classified the ten monitoring stations as being either "perimeter" or "off-site." The five "perimeter" monitoring stations are located along or just within Cotter Mill's property line; and the five "off-site" monitoring stations are located off-site, anywhere from 0.5 mile to 4 miles from the Cotter Mill property line.

(1) Particulate Matter

At each of the 10 monitoring stations described above, Cotter Mill operates a high-volume total suspended particulate (TSP) sampling device. For each sampling period, the devices are loaded with glass fiber filters that collect airborne particulates as ambient air passes through the sampling apparatus. The TSP sampling devices collect 1-week integrated samples; when the sampling period ends, field personnel remove filters, record observations on chain-of-custody forms, and store filters for subsequent laboratory analysis.

Cotter prepares annual summary reports for its environmental monitoring network, and those reports document monthly average TSP concentrations measured at each station. ATSDR had access to the summary reports for 2006, 2007, and 2008. TSP data from earlier years can be accessed through data reports that CDPHE has on compact disk. Over the last three years, annual average TSP concentrations were consistently higher in the more populated areas (Lincoln Park and Cañon City) than at the perimeter monitoring stations. In 2008, for instance, the annual average TSP levels at Lincoln Park and Cañon City were 29.9 $\mu g/m^3$ and 26.5 $\mu g/m^3$, respectively; in contrast, annual average concentrations at the five perimeter monitoring stations ranged from 15.5 $\mu g/m^3$ to 21.4 $\mu g/m^3$.

Although quantitative quality control information was not available when summarizing Cotter's TSP data, these measurements can be compared to CDPHE's PM_{10} monitoring results in Cañon City during the same time frame. From 2006 to 2008, the annual average TSP levels measured by Cotter Mill in Cañon City were 26.6 $\mu g/m^3$, 26.3 $\mu g/m^3$, and 26.5 $\mu g/m^3$, respectively; the annual average PM_{10} levels measured by CDPHE in Cañon City during these same years were

16.5 µg/m^3, 16.4 µg/m^3, and 15.0 µg/m^3. The difference between the TSP and PM_{10} annual average concentrations in Cañon City are within the expected range and direction (i.e., TSP levels exceeding PM_{10} levels), which gives some assurance in the quality of the underlying data sets.

(2) Particle-Bound Radionuclides

Weekly particulate filters collected at the 10 stations mentioned in the previous section are not only weighed for mass loading but are also analyzed at Cotter Mill's analytical laboratory for concentrations of five radionuclides, identified below. All laboratory analyses are conducted according to methodologies approved by CDPHE.

Field sampling and laboratory analyses for particle-bound radionuclides are conducted according to specifications outlined in Cotter Mill's Quality Assurance Program Plan (QAPP). This document is revised periodically and submitted to CDPHE for review. The QAPP outlines many quality control and quality assurance procedures implemented to ensure that the network's measurements are of a known and high quality. Examples of specific procedures followed include: routine collection and analysis of blank samples to ensure sampling media and laboratory equipment are not contaminated; quarterly calibration of flow rates for the "high volume" samplers; audit of sampler flow rates using special equipment; collection of duplicate samples that are analyzed in replicate to quantify measurement precision; and participation in a "laboratory exchange program" through which a subset of environmental samples (mostly water samples, by all appearances) are split and sent to Cotter Mill's laboratory and two commercial laboratories for analyses. While these and other quality control procedures give some assurance that samples are collected and analyzed with fine attention to data quality, the reports available to ATSDR during this review generally did not present the actual data quality metrics (e.g., the relative percent difference in duplicate samples or for inter-laboratory audits, contamination levels found in blanks) for the particle-bound radionuclides.

The key findings from the monitoring program for the five radionuclides measured are below. For each substance, a section compares the measured concentrations to regulatory limits or health-based comparison values, comments on temporal and spatial variations, and then presents a brief summary.

- **Natural uranium (^{nat}U).** Table 52 in Appendix A presents the history of annual average ^{nat}U concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.
    - *Screening.* Cotter Mill compares measured concentrations of ^{nat}U to an "effluent concentration" (9.0 x 10^{-14} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 52 exceed this derived concentration guide. The highest annual average concentration over the period of record (2.5 x 10^{-14} µCi/ml at a perimeter monitoring station in 1982) is 3.6 times below this screening value. The highest annual average in 2008 (4.4 x 10^{-16} µCi/ml at a

perimeter monitoring station) was approximately 200 times below the screening value, and larger margins are observed for the off-site monitoring stations.

- *Spatial and temporal variations.* Generally, the highest annual average concentrations of ^{nat}U were observed at perimeter monitoring stations, with lower levels observed at the off-site stations. During most years, the annual average values did not vary considerably (by more than an order of magnitude) across all of the stations. As an exception, the 1982 annual average ^{nat}U concentration observed at the west boundary monitoring station was roughly 50 times greater than the annual averages observed at the other monitoring stations during the same year; this "spike" at one station during one year was most likely caused by air emissions associated with an on-site tailings excavation project. As another exception, in several years between 1998 and 2006, annual average ^{nat}U concentrations at the mill entrance road monitoring station were more than an order of magnitude higher than those recorded at all other stations, which most likely reflects contributions from clean-up of the site entry road and delivery of ores (which mostly ended in 2006). As noted above, the highest annual average concentration of ^{nat}U was observed in 1982, and more recent (2004-2008) annual average levels are considerably lower.

- *Summary.* Every annual average concentration of ^{nat}U recorded to date has been lower than Cotter Mill's health-based regulatory limit. In the last five years, the annual average concentrations at every station have been at least 20 times below this limit. It seems unlikely that air emissions from the mill would lead to an off-site "hot spot" of ^{nat}U concentrations that could be considerably higher than the levels measured by the monitoring network.

- **Thorium-230 (^{230}Th).** Table 53 in Appendix A presents the history of annual average ^{230}Th concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{230}Th to an "effluent concentration" (2.0×10^{-14} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. The annual average concentration at the west boundary monitoring station exceeded this value in 1981 and 1982, as did the annual average concentration in 1981 at the east boundary monitoring station. The highest annual average concentration recorded by this network (9.0×10^{-14} µCi/ml at the west boundary in 1982) was 4.5 times higher than the derived concentration guide. Concentrations decreased over the years, and the highest annual average in 2008 (7.2×10^{-16} µCi/ml at a perimeter monitoring station) was a factor of 28 times lower than the screening value, and larger margins are observed for the off-site monitoring stations.

  - *Spatial and temporal variations.* Without exception, the highest annual average concentrations of ^{230}Th were observed at perimeter monitoring stations, with considerably lower levels observed at the off-site stations—a spatial trend suggesting that Cotter Mill's emissions very likely account for a considerable portion of the measured levels. As with natural uranium, the ^{230}Th concentrations exhibited a notable "spike" in 1981-1982, when 2.5 million cubic yards of on-site tailings were excavated from the unlined ponds. As an illustration of this effect, the highest annual average concentration in 1981 (3.0×10^{-14} µCi/ml at a perimeter monitoring station) was nearly 370 times higher than the annual average concentration measured in Cañon City. Moreover, the highest concentrations were observed at the monitoring station closest to, and downwind from, the excavation activity. Average concentrations of ^{230}Th decreased markedly after the 1981-1982 peak: the most recent (2004-2008) annual average concentrations at perimeter stations are all at least 20 times lower than the highest levels from 1981-1982.

  - *Summary.* In 1981 and 1982, annual average concentrations of ^{230}Th at two perimeter monitoring stations exceeded Cotter Mill's health-based regulatory limit; however, for every other calendar year, every station's annual average concentration was lower than this limit. In the last five years, the annual average concentrations at every station were between six and 30 times below this limit. For the off-site monitoring stations, however, all annual average concentrations during this 5-year time frame were at least a factor of 40 below Cotter Mill's health-based regulatory limit.

- **Thorium-232 (^{232}Th).** Table 54 in Appendix A presents the history of annual average ^{232}Th concentrations measured in Cotter Mill's monitoring network. Laboratory analyses for this radionuclide first began in 2001. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{232}Th to an "effluent concentration" (4.0×10^{-15} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 54 exceed this derived concentration guide. In 2008, the highest annual average concentration (3.1×10^{-17} µCi/ml in Lincoln Park) was a factor of 128 lower than the screening value.

  - *Spatial and temporal variations.* Unlike ^{nat}U and ^{230}Th, for which measured concentrations were consistently (if not always) highest at perimeter monitoring stations, the highest annual average concentrations of ^{232}Th have always been observed at off-site monitoring stations, most commonly at the Lincoln Park monitoring station. Moreover, of all the radionuclides measured, annual average concentrations of ^{232}Th exhibited the least variability from station to station. For any given year between 2001 and 2008, annual average concentrations at the ten monitoring stations fell within a factor of three of each other. The annual average concentrations did not exhibit considerable variability from one year to the next.

  - *Summary.* Over the last five years, annual average concentrations of ^{232}Th at every monitoring station were more than 60 times lower than Cotter Mill's health-based regulatory limit. The spatial variations in ^{232}Th concentrations have been limited, suggesting that air emissions from Cotter Mill may be relatively insignificant for this radionuclide.

- **Radium-226 (^{226}Ra).** Table 55 in Appendix A presents the history of annual average ^{226}Ra concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{226}Ra to an "effluent concentration" (9.0×10^{-13} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 55 exceed this derived concentration guide. In 2008, the highest annual average concentration (7.9×10^{-16} µCi/ml at a perimeter monitoring station) was three orders of magnitude lower than the screening value.

  - *Spatial and temporal variations.* In almost every year between 1979 and 2008, the highest annual average concentrations of ^{226}Ra were measured at perimeter monitoring stations, and primarily at the west boundary and mill entrance road locations. For most years, the highest annual average value at the facility's perimeter was usually between one and two orders of magnitude greater than the lowest annual average concentration at off-site locations—a pattern that points to facility emissions as a likely source for contributing to at least part of the measured concentrations. At the four perimeter stations with the longest period of record, the highest annual average concentrations occurred prior to 1985, and the current (2008) levels at these stations are between 10 and 100 times lower than those peaks.

  - *Summary.* The spatial variations in ^{226}Ra concentrations suggest that Cotter Mill's emissions contribute to the measured levels. However, over the last five years, annual average concentrations of ^{226}Ra at every monitoring station were more than 390 times lower than Cotter Mill's health-based regulatory limit.

- **Lead-210 (^{210}Pb).** Table 56 in Appendix A presents the history of annual average ^{210}Pb concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{210}Pb to an "effluent concentration" (6.0×10^{-13} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 56 exceed this derived concentration guide. In 2008, the highest annual average concentration (1.9×10^{-14} µCi/ml at a perimeter monitoring station) was more than a factor of 30 lower than the screening value.

- *Spatial and temporal variations.* The main distinguishing feature of the ^{210}Pb monitoring data (when compared to data for the other radionuclides) is the low variability, both spatially and temporally. Since 1983, annual average concentrations across the ten monitoring stations tended to fall within a factor of two; and year-to-year variability was of a comparable magnitude. This lack of variability points to a "background effect" (i.e., the measured concentrations likely are not the result of Cotter Mill's emissions, but reflect typical atmospheric levels for this part of the country). In 1981-1982, annual average concentrations at a perimeter monitoring station were slightly higher than what was routinely measured at all other locations and years; and these slightly elevated levels likely reflected air quality impacts from the excavation of the unlined holding ponds.

- *Summary.* Of all the radionuclides considered, ^{210}Pb showed the least variability in annual average concentrations, suggesting that the monitoring data characterize background levels and not a site-specific contribution. From 1983 to the present, annual average concentrations during every year and at every station were generally at least 20 times below Cotter Mill's health-based regulatory limit.

With one exception, the five radioactive substances measured by Cotter Mill's network were below their corresponding health-based regulatory limits at all 10 monitoring stations and for the entire 30 years of record. As the exception, annual average ^{230}Th concentrations exceeded health-based regulatory limits during a tailing pond excavation project, but this was limited to a short time frame (1981-1982) and the immediate proximity of the facility (two fenceline monitoring locations). The spike in measured concentrations during this time frame was far less pronounced (if not completely imperceptible) at monitoring stations in Lincoln Park or Cañon City. Another spatial variation linked to site activities is the relatively elevated readings (e.g., for ^{nat}U) observed at the "mill entrance road" monitoring station between roughly 1997 and 2006.

Over the last five years, annual average concentrations of every radionuclide were at least 20 times lower than health-based screening limits at the five off-site monitoring stations. This large margin provides some assurance that the monitoring network has adequate coverage in terms of monitors—it is quite possible that annual average ambient air concentrations of radionuclides at some un-monitored off-site locations exceed what has been measured to date, but it is far less likely that the network is failing to capture a "hot spot" with concentrations more than 20 times higher than the levels that are currently measured.

b) *Radon Gas*

Cotter measures radon gas concentrations at the same ten monitoring stations where particle-bound radionuclides are sampled. The annual environmental monitoring reports provide very limited information on the sampling methodology, other than noting that the detectors are apparently exposed to ambient air for a calendar quarter and then retrieved for laboratory analysis. Recent data summary reports suggest that a new sampling and analytical method was implemented in the second quarter of 2002. This new method outputs combined ^{220}Rn (from natural thorium) and ^{222}Rn (from natural uranium). However, the report does not describe what the previous sampling and analytical method measured.

According to Cotter's radon sampling procedures (Cotter 2004b), the sampling devices are "Landauer Type DRNF Radon Detectors." The reports provided to ATSDR suggest that various quality control measures have been implemented for this sampling (e.g., collection and analysis of duplicate samples to characterize precision), but they do not document quantitative data quality metrics. The method detection limit for the combined ^{220}Rn/^{222}Rn measurement is 70 pCi/m^3 (Cotter 2004b). This appears to offer adequate measurement sensitivity, because most quarterly average concentrations measured since this method was implemented are at least an order of magnitude greater than the detection limit.

Table 57 presents the annual average ^{220}Rn/^{222}Rn concentrations that Cotter has measured from 2002 to the present. Data are not presented for earlier years (1979 to 2001), as they may not be directly comparable due to the use of different measurement technologies. Cotter has recently concluded that its radon monitoring data "demonstrate slightly elevated readings at boundary locations [when compared to] readings in residential areas at background levels" (Cotter 2008b). This statement seems to be supported, in a general sense, by the monitoring results, though the difference between the perimeter and the off-site concentrations is much lower in certain years, particularly in 2008.

The approach used for screening the ^{220}Rn/^{222}Rn concentrations differs from that used for other radionuclides. Cotter screens the ^{220}Rn/^{222}Rn using an approach approved by CDPHE. In this approach, Cotter derives an "effective effluent limit" based on a baseline regulatory limit, an equilibration factor for the measurements, and average background concentrations that are calculated semi-annually. The details of this derivation are documented in a letter that CDPHE sent to Cotter in June, 2004. The net effect of this calculation approach is that the "effective effluent limit" (i.e., the concentration used for screening purposes) can vary across the monitoring stations and years. To illustrate this point, between 2006 and 2008, the "effective effluent limit" of ^{220}Rn/^{222}Rn concentrations ranged from 1,290 to 1,981 pCi/m^3, depending on the magnitude of the background concentrations at the time. During this time frame, measured concentrations at perimeter monitoring stations reached as high as 85% of the "effective effluent limit."

c) *Gamma Radiation*

Cotter measures gamma radiation levels at the same ten monitoring stations where particle-bound radionuclides are sampled. Measurements are made using thermoluminescent dosimeters (TLDs) that are exposed for 3-month periods before being sent off-site for analysis. Every calendar quarter, an additional duplicate TLD is deployed to at least one monitoring station to assess measurement precision, and a control TLD is placed in a lead-shielded box at another location to serve as a "blank" sample. However, the site reports provided to ATSDR did not contain any quantitative metrics of data quality (e.g., relative percent difference in co-located samples).

Table 58 presents annual average gamma radiation exposure rates between 1979 and 2008, by monitoring station; these annual averages were calculated from the quarterly TLD measurements from each calendar year. For every year on record, the highest annual average exposure rate was observed at one of the perimeter monitoring stations. Since Cotter installed the monitoring station at the mill's entrance road in 1994, this station has recorded the highest annual average exposure rates every year through the present. The relatively high readings at this location are believed to result primarily from past spillage or incoming materials entering the facility (Cotter 2008b). Under oversight from CDPHE, Cotter removed contamination alongside the entrance road in 2006 and 2007, with exposure rates decreasing thereafter.

Cotter's monitoring reports do not include health-based screening evaluations for these measurements, but they do acknowledge that the exposure rates near the facility perimeter (and particularly along the entrance road) exceed background levels. Specifically, the reports assume that the Cañon City station's measurements reflect "background" contributions from all external sources. The report indicates that the reported background level at this station (10.2 µR/hr) is equivalent to a dose of 89 mrem/year.

d) *Ambient Air Monitoring for non-Radioactive Substances*

To prepare this summary, ATSDR accessed all ambient air monitoring data that the state of Colorado collected in Fremont County and reported to EPA's Air Quality System (AQS), an online clearinghouse of monitoring data that states collect to assess compliance with federal air quality standards. The AQS database included monitoring results for three locations in Fremont County: one in Cañon City, one in Lincoln Park, and one in Florence. This section summarizes only those data collected in Cañon City and in Lincoln Park given their closer proximity to Cotter Mill. However, the monitoring summarized in this section was not conducted to characterize air quality impacts associated with Cotter Mill's emissions; the measured concentrations at these locations likely reflect contributions from many different local emission sources (e.g., mobile sources, wind-blown dust, wood-burning stoves). The AQS database does not specify quality control parameters for the monitoring results; however, state agencies that submit data to AQS are supposed to thoroughly validate measured concentrations before entering them into the database.

(1) Particulate Matter (TSP, PM_{10}, and $PM_{2.5}$)

The state-operated Cañon City and Lincoln Park monitoring stations measured three different size fractions of particulate matter between 1969 and the present. Following standard practice, all three size fractions were measured in 24-hour average integrated samples that were typically collected once every 6 days, though more frequent monitoring occurred during some years. Measurements were collected using either standard technologies (e.g., high-volume samplers for TSP and PM_{10}) or EPA-approved Federal Reference Method devices. A brief summary of the measurements follows:

- **TSP measurements.** From 1969 through 1987, high-volume sampling devices were used to measure TSP. Table 59 in Appendix A presents the maximum and annual average TSP concentrations measured by the two monitoring stations over the period of record. Annual average TSP in Cañon City did not change considerably from 1969-1987. In Lincoln Park, only two calendar years have complete data sets; the annual average concentration in 1982 was below the range of annual averages observed at Cañon City.

The fact that TSP levels were lower in Lincoln Park than in Cañon City suggests that Cotter Mill's emissions are not the primary contribution to TSP levels in the area.

- **PM_{10} measurements.** The state of Colorado began monitoring PM_{10} in Cañon City in 1987 and continues this monitoring today. The monitoring station was originally located at the courthouse in Cañon City, but the state moved the monitoring equipment in 1987 to a less obstructed site at city hall. Annual average PM_{10} concentrations throughout the period of record range from 15 to 23 µg/m^3, well below EPA's former National Ambient Air Quality Standard for annual average levels (50 µg/m^3). Between 1987 and 2009, only one measured 24-hour average concentration exceeded EPA's current health-based standard; that occurred in 1988 and likely reflected contributions from many different local sources and should not be attributed solely to Cotter Mill's emissions.

- **$PM_{2.5}$ measurements.** In 1991 and 1992, the state conducted $PM_{2.5}$ monitoring at its Cañon City station. All measured 24-hour average concentrations and both annual average concentrations were lower than the health-based standards that EPA would develop later in the 1990s. This monitoring occurred before EPA designated Federal Reference Methods for $PM_{2.5}$ measurement devices.

(2) Constituents of Particulate Matter

Between 1978 and 1987, the state of Colorado analyzed some of the TSP filters collected in Cañon City and Lincoln Park for chemical constituents. This included analyses for metals (iron, lead, manganese, and zinc) and ions (nitrate and sulfate). Table 60 summarizes these measurements by presenting the highest 24-hour average concentration and the highest annual average concentration for the period of record.

V. PUBLIC HEALTH EVALUATION

A. Introduction

This section of the public health assessment evaluates the health effects that could possibly result from exposures to site-related contaminants at or near the Cotter Mill site. For a public health hazard to exist, people must contact contamination at levels high enough and for long enough time to affect their health. The environmental data and conditions at the site revealed five completed exposure pathways:

1. Exposure to site-related contaminants in groundwater in Lincoln Park.
2. Contact with site-related contaminants in soil adjacent to the Cotter Mill and in Lincoln Park.
3. Contact with site-related contaminants in surface water downstream from the Cotter Mill.
4. Exposure from eating produce locally grown in Lincoln Park
5. Exposure to ambient air near the Cotter Mill facility

B. How Health Effects are Evaluated

The potential health effects associated with completed exposure pathways (listed above) will be evaluated in this section. For chemicals found to exceed comparison values, ATSDR calculated exposure doses and estimated non-cancer and cancer risks, where applicable. The calculations estimate the amount of the chemical to which a person may have been exposed. Calculated exposure doses are then compared to the available health guidelines to determine whether the potential exists for adverse non-cancer health effects. In the event that calculated exposure doses exceed established health guidelines (e.g., ATSDR's Minimal Risk Levels or EPA's Reference Doses), an in-depth toxicological evaluation is necessary to determine the likelihood of harmful health effects. ATSDR also may compare the estimated amount of exposure directly to human and animal studies, which are reported in ATSDR's chemical-specific toxicological profiles. Not only do the toxicological profiles provide health information, they also provide information about environmental transport, human exposure, and regulatory status.

A detailed explanation of ATSDR's evaluation process for determining cancer and non-cancer health effects is contained in Appendix C of this document. The equations to calculate exposure doses, the exposure scenarios, and the exposure assumptions used to estimate exposures at this site are also in Appendix C.

ATSDR's **Minimal Risk Level (MRL),** which is derived from human and animal studies, is an estimate of daily exposure to a contaminant below which non-cancer health effects are unlikely to occur.

EPA's **Reference Dose** An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used. Generally used in EPA's noncancer health assessments.

C. Groundwater Pathway: Private wells used for personal consumption

As discussed above, the data from the 1989 *Lincoln Park Water Use Survey* survey indicated approximately 7 wells are used for personal consumption; sampling data for 6 of the 7 wells were available to ATSDR for evaluation. Samples were collected intermittently from 1984 to 2007.

Although most residents in Lincoln Park currently use municipal water for drinking purposes, the survey reveals that residents at 7 locations still use their private wells for drinking purposes. It is not verified whether residents who reported using their well water for personal consumption also use their well water for other household purposes, such as bathing and showering. Some residents report that they and others used their private wells for personal consumption and other household uses in the past (before the installation of the municipal water line). Therefore, it is reasonable to assume that many more people obtained their drinking water from private wells in the past, and that some people are continuing to use their private wells for drinking, and possibly, household purposes.

Very little quantitative information is known about what levels of contamination residents may have been exposed to in the past. However, ATSDR attempted to address this issue by assuming that the average resident would have been exposed to the average chemical concentration (i.e., temporal average per well) detected in the 6 private wells for which we have sampling data. There is some uncertainty in using this estimate because some people may have been exposed to more, and some to less, than the estimated amount. To capture the resident who may have been more highly exposed (or a worst case scenario), ATSDR used the average chemical concentration from the single private well that consistently contained the highest chemical concentrations (Well 189). ATSDR assumed that adults and children drank the water from this well for 350 days per year for 30 years (adults) and 6 years (children), respectively.

Molybdenum was the only chemical in private wells that had an average detected level (0.082 mg/L) that exceeded its comparison value (0.05 mg/L). The average level of molybdenum in Well 189 (0.16 mg/L) also exceeded the comparison value for molybdenum in drinking water. Therefore, molybdenum was retained as a chemical of concern and evaluated for possible adverse health effects. The maximum detected level of uranium (0.067 mg/L), but not the average detected level (0.028 mg/L), also exceeded the comparison value of 0.03 mg/L for uranium. Additionally, the average detected level of uranium in Well 189 (0.048 mg/L) exceeded the comparison value for uranium. Therefore, ATSDR evaluated uranium more closely for potential adverse health effects. Table 7 below summarizes the estimated child and adult doses for molybdenum and uranium that guide the health discussion below. (See Table C1 in Appendix C for a detailed discussion of how these values were derived.)

Table 7. Estimated Child and Adult Doses for Molybdenum and Uranium in Drinking Water

Chemical	Exposure Group	Adult Estimated Dose (mg/kg/day)	Child Estimated Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Molybdenum	Well 189 (high exposures)	0.004	**0.010**	0.005 Chronic Oral RfD
	All wells (average exposures)	0.002	0.005	
Uranium	Well 189 (high exposures)	0.001	**0.003**	0.002 Intermediate Oral MRL
	All Wells (average exposures)	0.0008	0.002	

1. Molybdenum

Molybdenum is a naturally occurring element found in various ores. Molybdenum is also considered an essential dietary nutrient in humans and animals. Foods such as legumes, leafy vegetables, nuts and cereals tend to be higher in molybdenum than meats, fruits, and root and stem vegetables [WHO 2003]. The Food and Nutrition Board (FNB) of the Institute of Medicine has determined the Tolerable Upper Intake Level[12] (UL) for molybdenum in children and adults [FNB 2001] as follows:

- children 1 to 3 years of age - 0.3 mg/kg/day;
- children 4 to 8 years of age - 0.6 mg/kg/day;
- children 9 to 13 years of age - 1.1 mg/kg/day;
- adolescents 14 to 18 years of age - 1.7 mg/kg/day; and
- adults - 2.0 mg/kg/day.

a) Health Evaluation of Molybdenum

Drinking water from a private well contaminated with molybdenum would result in an estimated dose of 0.002 mg/kg/day for an average adult and 0.005 mg/kg/day for an average child. The adult dose is lower than the oral RfD of 0.005 mg/kg/day for molybdenum. The estimated child dose is equal to the oral RfD (0.005 mg/kg/day) for molybdenum. Therefore, adverse health

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[12] UL = maximum level of daily nutrient intake that is likely to pose no risk of adverse health effects in all individuals. The UL represents the total intake from food, water, and supplements.

effects are not expected for the average adult or child who drank from a private well contaminated with molybdenum.

Adults who may have had high exposures, such as those similar to Well 189, have an estimated dose of 0.004 mg/kg/day, and children who may have had high exposures have an estimated dose of 0.010 mg/kg/day. The adult high dose is less than the oral RfD for molybdenum. However, the estimated child high exposure dose is 2 times greater than the oral RfD of 0.005 mg/kg/day for molybdenum. Because the estimated exposure dose for children exceeds the long-term health guidelines for molybdenum, the possibility of health consequences from this exposure was evaluated further.

To further evaluate the possibility of adverse health effects, ATSDR divides the lowest observed adverse effect level (LOAEL) and/or the no observed adverse effect level (NOAEL) by the site-specific exposure doses. Interpretation of the resulting value is subjective and depends on a host of toxicological factors. Further evaluation consists of a careful comparison of site-specific exposure doses and circumstances with the epidemiologic and experimental data on the chemical. The purpose of the comparison is to evaluate how close the estimated exposure doses are to doses that cause health effects in humans or animals.

The oral RfD for molybdenum is based on a human epidemiological study that found a LOAEL of 0.14 mg/kg/day for increased serum uric acid levels and prevalence of gout-like condition in Armenian villagers [Koval'skiy 1961]. A higher incidence (18-31%) of a gout-like disease was associated with high intake of molybdenum (10-15 mg/day) from soil and plants. The gout-like condition was characterized by pain, swelling, inflammation and deformities of the joints, and, in all cases, an increase in the uric acid content of the blood. In a number of cases, illnesses of the GI tract, liver, and kidneys accompanied the condition [EPA IRIS]. In deriving the oral RfD, an uncertainty factor of 3 was used for protection of sensitive human populations and a factor of 10 was used for the use of a LOAEL instead of a NOAEL for a long-term study in a human population. The estimated child high dose (0.010 mg/kg/day) for molybdenum at the Cotter Mill/Lincoln Park site is 14 times lower than the LOAEL from this study. There was no NOAEL determination for molybdenum from this study.

Molybdenum is known to interfere with copper metabolism in ruminant animals (grazing animals that "chew their cud," such as sheep or cows); the resulting copper deficiency is reported to cause the animal's hair/wool to turn white [FNB 2001]. This is a problem with ruminant animals in particular because high dietary molybdenum reacts with moderate to high dietary sulfur in the rumen (the first stomach) to form thiomolybdates. These compounds greatly reduce copper absorption, and certain thiomolybdate species can be absorbed and interfere systemically with copper metabolism [Spear 2003]. This interaction between thiomolybdates and copper is not expected to occur to a significant degree in humans [Turnlund 2002]. Although the exact effect of molybdenum intake on copper status in humans remains to be clearly established, individuals who do not take in enough dietary copper or cannot process it correctly could be at increased risk of molybdenum toxicity [FNB 2001].

In conclusion, children who drink water containing high concentrations of molybdenum could be at increased risk of adverse health effects such as gout-like symptoms. However, molybdenum is not stored at high levels in the body, so it is unlikely that children will suffer long-term health effects once the exposure is stopped [FNB 2001]. In healthy people, excess molybdenum is not associated with adverse health outcomes. However, individuals who do not take in enough dietary copper or cannot process it correctly could be at increased risk for adverse health effects. The actual risk of adverse health effects occurring depends on the concentration of molybdenum in the water and how much water is drunk. Therefore, private wells known to be contaminated with molybdenum should not be used for drinking purposes.

b) Additional Comments about Molybdenum in Drinking Water

- ATSDR did not evaluate potential exposures to molybdenum that could occur if well water is used for other household purposes such as showering or bathing. If it is confirmed that residents are using their wells for other potable purposes, then exposure levels would increase, as well as the likelihood of adverse health effects. However, exposure to airborne and/or dermal molybdenum is not likely to be a major exposure pathway because of the physicochemical properties of molybdenum.

- The estimated dose for children and adults at this site did not exceed the Tolerable Upper Intake Level (UL) for molybdenum established by the Institute of Medicine. However, ATSDR's evaluation did not consider molybdenum intake from other sources, including food and supplements, which would increase total intake.

- Molybdenum is often found naturally in the geology of this region. The wells identified and sampled as background for the Lincoln Park area contained an average molybdenum concentration of 0.023 mg/L. This concentration is lower than the average of 0.082 mg/L found in private wells used for personal consumption. The maximum concentration of molybdenum in a background well (0.3 mg/L) was about the same as that in a private well (0.28 mg/L) used for personal consumption.

- Overall molybdenum levels in groundwater decreased over time. Molybdenum levels measured from 1968 to 2000 show a clear pattern of decrease in molybdenum concentrations. Therefore, exposures to molybdenum in groundwater were likely higher in the past, and may continue to decrease in the future.

People who currently own private wells are not prevented from using their private wells for any purpose. New residents who move to the area may install new wells in the contaminated zone and use their well for any purpose. Therefore, this exposure pathway will continue to exist as a potential exposure pathway in the future.

2. Uranium

Throughout the world uranium is a natural and common radioactive element. Uranium is a silver-white, extremely dense, and weakly radioactive metal. It is typically extracted from ores containing less than 1% natural uranium. Natural uranium is a mixture of three isotopes: 238U (99.2739%), 235U (0.7204%), and 234U (0.0057%). It usually occurs as an inorganic compound with oxygen, chlorine, or other elements [NHANES 2005]. Rocks, soil, surface and ground water, air, plants, and animals all contain varying amounts of uranium. Colorado ranks third, behind Wyoming and New Mexico, tied with Arizona and Utah, as the state with the most uranium reserves in the United States [EIA 2001].

a) Health Evaluation of Uranium

Natural uranium is radioactive but poses little radioactive danger—it releases only small amounts of radiation that cannot travel far from its source. Moreover, unlike other types of radiation, alpha radiation released by natural uranium cannot pass through solid objects, such as paper or human skin. You have to eat, drink, or breathe natural uranium in order to be exposed to the alpha radiation; however, no adverse effects from natural uranium's radiation properties have been observed in humans. The National Academy of Sciences determined that bone sarcoma is the most likely cancer from oral exposure to uranium; its report noted, however, that this cancer has not been observed in exposed humans and concluded that exposure to natural uranium may have no measurable effect [BEIR IV].

Scientists have seen chemical effects in people who have ingested large amounts of uranium. Kidney disease has been reported in both humans and animals that were exposed to large amounts of uranium; however, the available data on soluble (more bioavailable) and insoluble uranium compounds are sufficient to conclude that uranium has a low order of metallotoxicity in humans [Eisenbud and Quigley 1955].

When uranium is ingested most of it leaves the body through the feces and a small portion (approximately 2% for an adult) will be absorbed into the blood stream through the gastrointestinal (GI) tract. Most of the uranium in the blood is excreted from the body through urine excretion within a few days; however, a small amount will be retained in the kidneys, bone, and soft tissue for as long as several years. The percentage of the uranium retained in the kidneys over time is different for acute and chronic ingestion of uranium (as long as the individual continues to drink the water). When an individual discontinues drinking the uranium contaminated water, the percentage of retention in the kidney decreases similar to an acute exposure. In the case of chronic ingestion of drinking water containing uranium, the kidney retention (or kidney burden) increases rapidly in the first two weeks. After approximately 100 days, the amount present in the kidney is approximately 5% of the daily intake for an infant and approximately 3% for all other ages. After 25 years of chronic ingestion, the uranium kidney burden reaches equilibrium for all age groups at approximately 6.6% of the daily intake [Chen et al 2004].

Nephrotoxicity (kidney toxicity) occurs when the body is exposed to a drug or toxin such as uranium that causes temporary or permanent damage to the kidneys. When kidney damage occurs, blood electrolytes (such as potassium and magnesium) and chemical wastes in the blood (such as creatinine) become elevated indicating either a temporary condition or the development of kidney failure. Creatinine is a chemical waste molecule that is generated from muscle metabolism. The kidneys maintain the blood creatinine in the normal range. Creatinine is a fairly reliable indicator of kidney function. As the kidneys are impaired, the creatinine level in the blood will rise because of the poor clearance by the kidney. If detected early, permanent kidney problems may be avoided.

Several mechanisms for uranium-induced kidney toxicity have been proposed. In one of these, uranium accumulates in specialized (epithelial) cells that enclose the renal tubule, where it reacts chemically with ion groups on the inner surface of the tubule. This interferes with ion and chemical transport across the tubular cells, causing cell damage or cell death. Cell division and regeneration occur in response to cell damage and death, resulting in enlargement and decreased kidney function. Heavy metal ions, such as uranyl ions, may also delay or block the cell division process, thereby magnifying the effects of cell damage [Leggett 1989, 1994; ATSDR 1999].

Animal and human studies conducted in 1940s and 1950s provide evidence that humans can tolerate certain levels of uranium, suffering only minor effects on the kidney [Leggett 1989]. Most of these studies involved inhalation exposures to uranium; however, the kidney is the target organ for inhaled as well as ingested uranium. On the basis of this tolerance, the International Council on Radiologic Protection (ICRP) adopted a maximal permissible concentration of 3 μg of uranium per gram of kidney tissue for occupational exposure in 1959 [Spoor and Hursh 1973]. This level has often been interpreted as a threshold for chemical toxicity.

More recent papers have been published on effects of uranium at levels below 3 μg/g, and those papers have discussed possible mechanisms of uranium toxicity [Diamond 1989; Leggett 1989, 1994; Zhao and Zhao 1990; Morris and Meinhold 1995]. It is thought that the kidney may develop an acquired tolerance to uranium after repeated doses; however, this tolerance involves detectable histological (structural) and biochemical changes in the kidney that may result in chronic damage. Cells of the inner surface of the tubule that are regenerated in response to uranium damage are flattened, with fewer energy-producing organelles (mitochondria). Transport of ions and chemicals across the tubule is also altered in the tubule cells [Leggett 1989, 1994; McDonald-Taylor et al. 1997]. These effects may account for the decreased rate of filtration through the kidney and loss of concentrating capacity by the kidney following uranium exposure. Biochemical changes include diminished activity of important enzymes (such as alkaline phosphatase), which can persist for several months after exposure has ended. Therefore, acquired tolerance to uranium may not prevent chronic damage, because the kidney that has developed tolerance is not normal [Leggett 1989]. Acting on the basis of this recent information for uranium, researchers have suggested that exposure limits be reduced to protect against these chronic effects on the kidney.

Renal damage appears to be definite at concentrations of uranium per gram of kidney tissue above 3 μg/g for a number of different animal species, but mild kidney injury can occur at uranium concentrations as low as 0.1 to 0.4 μg/g in dogs, rabbits, guinea pigs, and rats after they inhale uranium hexafluoride or uranium tetrachloride over several months [Maynard and Hodge 1949; Hodge 1953; Stokinger et al. 1953; Diamond 1989]. Zhao and Zhao proposed a limit of uranium to the kidney of 0.26 μg/g based on renal effects in a man who was exposed to high concentrations of uranyl tetrafluoride dust for 5 minutes in a closed room [Zhao and Zhao 1990]. The man showed signs of kidney toxicity, including increased protein content in the urine (proteinuria) and nonprotein nitrogen. These signs persisted for 4.6 years, gradually returning to normal values. The kidney content 1 day after the accident was estimated to be 2.6 μg/g.

A study conducted in Finland and published in 2002 observed 325 people that had used their drilled wells for drinking water over a period of 13 years on average (range 1 – 34 years) [Kurttio et. al 2002]. The median uranium concentration in the water was 28 ppb (range 0.001 –

1,920 ppb). The study showed an association between increased uranium exposure through drinking water and tubular function, but not between uranium exposure and indicators of glomerular injury. The primary target is the proximal convoluted tubule of the kidney which is where most of the sodium, water, glucose, and other filtered substances are reabsorbed and returned to the blood. The authors of the study indicated that tubular dysfunction may merely represent a manifestation of subclinical toxicity, and it is unclear if it carries a risk of development into kidney failure or overt illness. This study concluded that "The public health implications of these findings remain uncertain, but suggest that the safe concentration of uranium in drinking water may be close to the guideline values proposed by the WHO and the U.S.EPA." However, this study found that altered tubular function was statistically significant at water uranium concentrations exceeding 300 µg/L [Kurttio et. al 2002], or 0.3 mg/L, which is an order of magnitude higher than EPA's guideline (0.035 mg/l) and the highest average concentration at the Lincoln Park site (0.048 mg/L). At 300 µg/L and assuming ingestion of two liters of water per day, the kidney burden after 25 years of chronic ingestion would be 39.6 µg of uranium with a uranium concentration per gram of kidney tissue of 0.13 µg/g.

A review of studies of uranium effects on the kidney [Morris and Meinhold 1995] suggests a probability distribution of threshold values for kidney toxicity ranging from 0.1 to 1 µg/g, with a peak at about 0.7 µg/g. The researchers proposed that the severity of effects increases with increasing dose to the kidney with probably no effects below 0.1 to 0.2 µg/g, possible effects on the kidney at 0.5 µg/g, more probable effects at 1 µg/g, and more severe effects at 3 µg/g and above [Morris and Meinhold 1995; Killough et al. 1998b].

If an adult in Lincoln Park drank 2 liters (L) of uranium-contaminated water per day (at the highest average exposure concentration of 0.048 mg/L, or 48 µg/L) for 25 years or longer, then the maximum daily ingestion would be 96 µg of uranium, resulting in a uranium kidney burden of 6.3 µg (96 µg × 0.066). The weight of both kidneys in adults is about 300 g [Madsden et al 2007]. Thus, the uranium concentration per gram of kidney tissue for an adult would be 0.02 µg/g. If a child drank 1 L of uranium-contaminated water per day (at the highest average exposure concentration of 0.048 mg/L, or 48 µg/L) for 100 days to 25 years, then the maximum daily ingestion would be 48 µg of uranium, resulting in a uranium kidney burden of 1.4 µg (48 µg x 0.03). The weight of both kidneys in a child is about 100 g; therefore, the uranium concentration per gram of kidney tissue to be 0.01 µg/g. The calculated kidney uranium concentration for adults and children is below the level found to cause harm in published studies.

ATSDR's health-based guidelines for ingested (and inhaled) uranium are lower than the lower limit threshold for kidney toxicity proposed by Morris and Meinhold (1995). ATSDR's guidelines are derived by use of levels of toxicity observed in animal studies, and those guidelines incorporate safety factors to account for uncertainty in extrapolating from animals to humans and to protect the most sensitive human individuals [ATSDR 1999].

Note that urinalysis has limitations as a test for kidney toxicity. First, the presence of substances in urine may indicate that kidney damage has occurred, but it cannot be used to determine whether the damage was caused by uranium. Second, most uranium leaves the body within a few days of exposure, so that urine tests can be used only to determine whether exposure has occurred in the past week or two. Finally, the tests may be used to detect mild effects on the kidney, but such effects are generally transient in nature and may not result in permanent damage. More severe effects involve greater damage to the kidney that is likely to be clinically manifest and longer lasting. The kidney has incredible reserve capacity and can recover even after showing pronounced clinical symptoms of damage; however, biochemical and functional changes can persist in a kidney that appears to have recovered structurally [Leggett 1989, 1994; CDC 1998].

The maximum average uranium concentration detected in a private well was 0.048 mg/L, or 48 µg/L. The residence where this concentration was detected is not connected to the municipal water supply and is noted to use a private well for personal consumption. Drinking water from this private well containing uranium would result in an estimated dose of 0.001 mg/kg/day for an adult and 0.003 mg/kg/day for a child. The adult dose is lower than the intermediate oral MRL. The estimated child dose slightly exceeds the MRL of 0.002 mg/kg/day for an intermediate-duration oral exposure. The MRL level for intermediate-duration oral exposure is also protective for chronic-duration oral exposure because the renal toxicity of uranium exposure is more dependent on the dose than on the duration of the exposure. The MRL is based on a LOAEL of 0.05 mg U/kg/day for renal effects in rabbits. The estimated child dose is an order of magnitude lower than the LOAEL; therefore, adverse health effects are not likely.

Although older evaluations suggested carcinogenicity of uranium among smokers, the U.S. EPA has withdrawn its classification for carcinogenicity for uranium; the International Agency for Research on Cancer (IARC) and the National Toxicology Program (NTP) have no ratings [NHANES 2005].

D. Soil Pathway: Surface Soil near Cotter Mill and Lincoln Park

As discussed above, surface soil samples were collected from areas around the Cotter Mill property, from property access roads and in the Lincoln Park area. Surface soil sampling data were available from eight designated zoned areas around Cotter Mill and in Lincoln Park. People who live or recreate in these areas could accidentally ingest some contaminated soil or get it on their skin. ATSDR evaluated these potential exposure scenarios to determine if concentrations of chemicals and radionuclides in soil are high enough to cause adverse health effects.

ATSDR assumed that the average adult would accidentally ingest 100 milligrams of soil per day and would also contact the contaminated soil with their skin (dermal). Small children were not assumed to access the soil around Cotter Mill because these areas are primarily industrial or vacant. The vacant area has been designated as a “buffer zone” between the Cotter Mill property and the residential areas. Therefore, it is unlikely that small children would access the area. A residential exposure scenario was used to evaluate potential exposures in Lincoln Park. For Lincoln Park, we assumed that a small child would ingest 200 mg of soil per day, and an adult would ingest 100 mg/day, for 350 days per year.

Concentrations of arsenic, cadmium and lead exceeded their comparison values in soil taken from the area surrounding Cotter Mill. The concentration of radium-226 was the only radionuclide to exceed its comparison value in soil near Cotter Mill. Arsenic was the only chemical to exceed its comparison value in soil in Lincoln Park. The highest zonal average concentration of arsenic, cadmium, lead and radium-226 was used to estimate exposure doses. If the highest zonal average concentration of a chemical would not result in adverse health effects, it follows that lower concentrations of the chemical would not as well.

1. *Soil Near Cotter Mill*

a) Arsenic

Arsenic is a naturally occurring element that is widely distributed throughout the earth's crust and may be found in air, water, and soil [ATSDR 2000]. Arsenic in soil exists as inorganic and organic arsenic. Generally, organic arsenic is less toxic than inorganic arsenic, with some forms of organic arsenic being virtually non-toxic. Inorganic arsenic occurs naturally in soil, and children may be exposed to arsenic by eating soil or by direct skin contact with soil containing arsenic [ATSDR 2007].

The estimated dose of arsenic for adolescents and adults at this site is 0.00002 mg/kg/day. This dose is lower than the Minimal Risk Level (MRL) of 0.0003 mg/kg/day for arsenic; therefore, non-cancer health effects are not likely from being exposed to arsenic in surface soil near Cotter Mill (Zones A through H). The chronic oral MRL of 0.0003 mg/kg/day for inorganic arsenic was derived by dividing the identified chronic No Observable Adverse Effect Levels (NOAEL) of 0.0008 mg/kg/day (obtained from human epidemiologic studies) by an uncertainty factor of three to account for the lack of data on reproductive toxicity and to account for some uncertainty as to whether the NOAEL accounts for all sensitive individuals [ATSDR 2007]. The Lowest Observed Adverse Effect Level (LOAEL) associated with these epidemiologic studies was 0.014 mg/kg/day, where exposure to arsenic above this level resulted in hyperpigmentation of the skin, keratosis (patches of hardened skin), and possible vascular complications [ATSDR 2007].

The U.S. Environmental Protection Agency (EPA), the International Agency for Research on Cancer (IARC), and the National Toxicology Program (NTP) classify arsenic as a human carcinogen. The EPA has developed an oral cancer slope factor to estimate the excess lifetime risk for developing cancer. Using EPA's cancer slope factor for arsenic, and based on a 30 year exposure scenario, ATSDR calculated a lifetime estimated cancer risk level of 1×10^{-5} for exposure to arsenic in soil near Cotter Mill. Qualitatively, we interpret this as a very low increased lifetime risk of developing cancer.

b) Cadmium

The estimated dose for adolescents and adults for cadmium is 0.00002 mg/kg/day, which is lower than the MRL of 0.0001 mg/kg/day for cadmium; therefore, non-cancer adverse health effects are not likely. The U.S. Department of Health and Human Services (DHHS), IARC, and EPA have determined that cadmium is carcinogenic to humans. Although cadmium can be carcinogenic when inhaled, human or animal studies have not provided sufficient evidence to show that cadmium is a carcinogen by oral routes of exposure (ATSDR 1999b). Therefore, a cancer evaluation for cadmium was not done as part of this assessment.

c) Lead

The highest average concentration of lead detected in any of the zones (Zone H) is 445 ppm, which is only slightly higher than the soil screening value of 400 ppm for lead. A value of 400 ppm is commonly used to evaluate lead in soil in residential properties. The property near the Cotter Mill site is currently restricted, vacant or used for industrial purposes; therefore contact with these soils should be minimal. Adverse health effects are not expected to occur from these limited exposures to soils near the site. Exposures to lead, however, should be re-evaluated should the area ever be considered for residential or other non-industrial use.

Maximum lead concentrations in zones F, G and H are 800 ppm, 450 ppm, and 1,400 ppm, respectively. To protect children from exposure to lead, it is important to know the average lead level in a yard or other frequent play area. The *1998 Supplemental Human Health Risk Assessment* provides the only characterization of surface soils adjacent to the Cotter Mill property (See Figure 17, Zones A through H). The soil sample results in this report were generated by collecting four samples from the center of a grid and compositing the samples to form a single representative sample. The size of each sampled grids, however, appears to be larger than 100 x 100 feet, which is the size that triggers additional sampling for lead (EPA 1995). Although the sampling in the *1998 Supplemental Human Health Risk Assessment* measured contamination in soils at several properties near Cotter Mill, it does not allow ATSDR to evaluate contamination in individual exposure units (yards, playgrounds, etc), as would be required to accurately assess exposures in a residential setting, commercial or recreational setting. The sample design is sufficient for making general public health decisions about exposure to lead in soil based on current use patterns. However, any future public health decision regarding the soil near the Cotter Mill property must be made with the limitations of the current sampling design in mind.

The Centers for Disease Control and Prevention (CDC) has established a level of concern for case management of 10 micrograms lead per deciliter of blood (µg/dL). This means that when blood lead levels in children exceed 10 µg/dL, CDC recommends that steps be taken to lower their blood lead levels. However, some agencies and public health officials have mistakenly used this level in blood as a safe level of exposure or as a no effect level. Recent scientific research has shown that blood lead levels below 10 µg/dL cause serious harmful effects in young children, including neurological, behavioral, immunological, and development effects. Specifically, lead causes or is associated with decreases in intelligent quotient (IQ), attention deficit hyperactivity disorder (ADHD), deficits in reaction time, visual-motor integration, fine motor skills, withdrawn behavior, lack of concentration, sociability, deceased height, and delays in puberty, such as breast and pubic hair development, and delays in menarche [CDC].

d) Radium-226

The average concentrations of radium-226 detected in Zones A and B are higher than allowed by the Uranium Mill Tailing Act (UMTRA). That standard does not apply in this case, since the Cotter Mill is still considered active.

The highest average soil concentration of 9.2 pCi/g in surface soil would result in a dose from radium’s decay gammas of 58 mrem per year above background, assuming that residents spend 12 hours per day 365 days per year sitting or lying on the highest measured radium concentration of 9.2 pCi/g on the haul road. Since Zones A and B are buffer areas (actually haul roads), the time spent in these areas would be much lower (less than 2 hours per day) and the resulting dose would be roughly 10 mrem per year above background, to a maximally exposed individual.

2. *Soil in Lincoln Park*

a) Arsenic

The estimated arsenic dose for an adult in Lincoln Park is 0.00003 mg/kg/day, which is an order of magnitude lower than the MRL of 0.0003 mg/kg/day for arsenic. The estimated arsenic dose for a child in Lincoln Park is 0.0003 mg/kg/day, which is equal to the MRL of 0.0003 mg/kg/day for arsenic. Children are estimated to have higher arsenic doses than adults because they tend to engage in activities that increase their soil ingestion exposure, and because they weigh less than adults. Neither children nor adults should experience adverse health effects from exposure to arsenic in soil in Lincoln Park.

Arsenic is a naturally occurring element in soil. Arsenic has also historically been used in a variety of industrial applications, including bronze plating, electronics manufacturing, preserving animal hides, purifying industrial gases, and mining, milling and smelting activities. Studies of background levels of arsenic in soils have revealed that background concentrations range from 1 ppm to 40 ppm, with average values around 5 ppm [ATSDR 2007]. The average arsenic concentration detected in Lincoln Park was 31 ppm, a concentration within the observed background range but higher than the average background concentration. The maximum concentration of arsenic detected in Lincoln Park was 50 ppm.

Although the maximum arsenic concentration is higher than the observed background concentration, this fact alone does not definitely point to an anthropogenic source for the arsenic found in soil in Lincoln Park. Uncertainty exists regarding whether the arsenic levels detected are a natural occurrence or from past milling operations in the area.

Several factors contribute to whether people have contact with contaminated soil, including:

- grass cover, which is likely to reduce contact with contaminated soil when grass cover is thick but increase contact with soil when grass cover is sparse or bare ground is present,
- weather conditions, which is likely to reduce contact with outside soil during cold months because people tend to stay indoors more often,
- the amount of time someone spends outside playing or gardening, and
- people's personal habits when outside, for instance, children whose play activities involve playing in the dirt are likely to have greater exposure than other children

Using EPA's cancer slope factor for arsenic, and based on a 30 year exposure scenario, ATSDR calculated a lifetime estimated cancer risk level of 5×10^{-5} for exposure to arsenic in Lincoln Park. Qualitatively, we interpret this as no apparent increased lifetime risk of developing cancer.

E. Surface Water: Sand Creek, DeWeese Dye Ditch, and the Arkansas River

People who swim or wade in the surface waters of Sand Creek, the DeWeese Dye Ditch, or the Arkansas River will get surface water on their skin and they might also accidentally ingest some of the surface water. To estimate exposures to adults and children who may have come into contact with contaminated surface water, ATSDR assumed that adults and children will swallow 50 mL of water per hour while swimming or wading, for 104 days per year for 30 and 6 years, respectively. Molybdenum exceeded its comparison value in Sand Creek and the Arkansas River. Manganese exceeded its comparison value in Sand Creek and the DeWeese Dye Ditch. ATSDR conservatively selected the maximum concentration for each chemical to estimate exposures.

1. Manganese

The estimated exposure dose for manganese is 0.0007 mg/kg/day for adults and 0.0006 mg/kg/day for children. Both adult and child doses are considerably lower than the reference dose of 0.05 mg/kg/day for manganese. Therefore, no adverse health effects are expected to occur as a result of exposure to manganese in surface waters.

2. Molybdenum

The estimated exposure dose for molybdenum is 0.00002 mg/kg/day for adults and 0.00006 mg/kg/day for children. Both adult and child doses are below the chronic oral reference dose (RfD) of 0.005 mg/kg/day for molybdenum. Therefore, no adverse health effects are expected to occur as a result of exposure to molybdenum in surface waters.

F. Homegrown Fruits and Vegetables

Ingestion of contaminated foods is a potential exposure pathway for this site. Residents may have been exposed to contaminants when they ate homegrown fruits and vegetables after using contaminated groundwater (either surface water or private well water) to irrigate their crops, or after growing their crops in contaminated soil. The soil may become contaminated from contaminated water or from tailings, dusts and other wastes deposited in the soil in the past.

Eating fruits, vegetables, herbs, or other produce grown in gardens with contaminated soil can cause exposure. This type of exposure occurs because some plants slowly absorb small amounts of the chemicals found in soil into their plant tissue or because contaminated soil can adhere to the exterior surface of produce, particularly low-growing leafy produce or produce where the underground portion is eaten. Some of these absorbed chemicals are essential nutrients and are actually good for humans to eat, but other chemicals can present health hazards if they are found at high enough levels and are consumed on a regular basis.

Generally, there is not a strong relationship between levels of heavy metals in soils and plants [Vousta 1996]. The uptake of heavy metal concentration depends on speciation of metal, soil characteristics, the type of plant species and other characteristics [Laizu 2007]. Table 8 below developed by Sauerbeck (1988) provides a qualitative guide for assessing heavy metal uptake into a number of plants.

Table 8. Plant Uptake of Heavy Metals

High	Moderate	Low	Very Low
Lettuce	Onion	Corn	Beans
Spinach	Mustard	Cauliflower	Peas
Carrot	Potato	Asparagus	Melons
Endive	Radish	Celery	Tomatoes
Crest		Berries	Fruit
Beet			
Beet leaves			
Source: USEPA (1991), Human Health Evaluation Manual, Supplemental Guidance: “Standard Default Exposure Factors.”			

To address the concern regarding contaminated crops, residents contributed locally grown produce for sampling analysis. ATSDR used the sampling results to estimate an exposure dose for each contaminant using typical consumption rates for the average and above-average (95th percentile) consumer in the Western United States. Child and infant consumption rates were also used to assess exposures to these vulnerable populations. Table 9 below provides the consumption rates used by ATSDR for homegrown fruits and vegetables.

Table 9. Homegrown Fruit and Vegetable Consumption Rates for the Western United States

Food	Consumer Type†	Intake Rate (g/kg/day)	Standard Error
Homegrown fruits	Average consumer	2.62	0.3
	Above-average consumer	10.9	
	Child	4.1	NA
	Infant (1 to 2 years)	8.7	
Homegrown vegetables	Average consumer	1.81	0.1
	Above-average consumer	6.21	
	Child	2.5	NA
	Infant (1 to 2 years)	5.2	

Sources: EPA Exposure Factors Handbook, Volume II, 1997; Child-Specific Exposure Factors Handbook, 2008
g/kg/day: grams per kilogram per day
NA = not applicable
†An average consumer is represented here as a person who eats fruits and vegetables in the typical range (mean intake). An above average consumer is a person who eats more fruits and vegetables than is typical, represented here by the 95th percentile intake.

All of the estimated fruit and vegetable doses were below health guideline values except for those for arsenic (See Table C4 in Appendix C). The estimated doses for fruits for the above-average consumer (95th percentile intake rate) and for infants exceed the chronic health guideline for arsenic. The above-average consumer and infant doses for fruit are 0.0006 mg/kg/day and 0.0004 mg/kg/day, respectively. Also, the estimated doses for vegetables for the above-average consumer (95th percentile intake rate) and for infants exceed the chronic health guideline for arsenic. The vegetable doses are 0.0005 mg/kg/day for an above-average consumer and 0.0004 mg/kg/day for an infant. These doses exceed the chronic oral MRL of 0.0003 mg/kg/day for arsenic.

Next, ATSDR assumed that a person will eat both fruits and vegetables daily. To do this, we added the calculated doses for fruits and vegetables to derive a single dose. The estimated fruit and vegetable doses for the above-average consumer, child and infant exceed the health guideline of 0.0003 mg/kg/day for arsenic. The above-average consumer dose is 0.001 mg/kg/day; the child dose is 0.0004 mg/kg/day; and the infant dose is 0.0008 mg/day/day.

The chronic oral MRL of 0.0003 mg/kg/day for inorganic arsenic was derived by dividing the chronic No Observable Adverse Effect Level (NOAEL) of 0.0008 mg/kg/day (obtained from human epidemiologic studies) by an uncertainty factor of 3 to account for the lack of data on reproductive toxicity and to account for some uncertainty as to whether the NOAEL accounts for all sensitive individuals [ATSDR 2007]. The Lowest Observed Adverse Effect Level (LOAEL) associated with these epidemiologic studies was 0.014 mg/kg/day, where exposure to arsenic above this level resulted in hyperpigmentation of the skin, keratosis (patches of hardened skin), and possible vascular complications [ATSDR 2007]. The child and infant doses are below or equal to the NOAEL, and the above-average consumer dose is 14 times lower than the dose that caused adverse health effects in epidemiologic studies. Therefore, adverse health effects are not expected in infants, children or the above-average consumer.

Using EPA's cancer slope factor for arsenic and the above consumer exposure dose, and based on a 30 year exposure scenario, ATSDR calculated a lifetime estimated cancer risk level of 6×10^{-4} for exposure to arsenic in fruits and vegetables. Qualitatively, we interpret this as a low to moderate increased risk of developing cancer over a lifetime.

ATSDR conservatively assumed that every consumer ate homegrown fruits and vegetables every day for 30 years. In reality, it is likely that most people only eat homegrown fruits and vegetables during a defined season, usually a 3 to 4 month period during the summer/fall growing season. Therefore, the true risk to consumers is likely overestimated.

ATSDR also noted that the highest arsenic level detected in lawns and gardens in Lincoln Park was 50 ppm. This level is near what is typically observed as background arsenic levels (1 ppm to 40 ppm) in soil. This suggests that the contaminated well water used to irrigate crops is not contributing significantly to arsenic soil levels, or other soil additives may have been added that dilute soil contamination [ODEQ 2003]. The highest arsenic level detected in soil at the site was 86 ppm. There were no sampling data for arsenic in drinking or irrigation water. ATSDR is unsure if the arsenic found in soil at this site is a natural occurrence or from an anthropogenic (man-made) source.

Plants vary in the amount of arsenic they absorb from the soil and where they store arsenic. Some plants move arsenic from the roots to the leaves, while others absorb and store it in the roots only [Peryea 1999]. The best method of reducing exposure to external arsenic from homegrown vegetables is to soak and wash residual soil from produce before bringing it into the home and washing the produce again thoroughly indoors before eating [ATSDR 2007]. It is always a good health practice to wash all fruits and vegetables thoroughly before eating, whether they are bought or homegrown.

Molybdenum was the only other contaminant to approach a health guideline when calculating a single dose for fruits and vegetables. The above-average consumer and infant doses are 0.005mg/kg/day, which is equal to the chronic health guideline of 0.005mg/kg/day for molybdenum.

G. Air Pathway

ATSDR looked at all the air data collected from 1979 to present. Concentrations of radionuclides in air from direct release or re-suspension of radioactive contaminants in soil were less than a tenth of ATSDR's health based comparison value (100 millirem per year) at all off-site sampling locations (CC-1/2, LP-2, AS-210, AS-212, OV-3). ATSDR evaluated doses to all age groups and found that adults would have received the highest doses, because of their higher breathing rate. Infants only received one quarter the dose of an adult.

Table 10 below breaks down the dose estimates by age group and by the highest annual concentration measured for each radionuclide and by the highest location. The two highest doses were both in 1982, during the excavation of the unlined settling ponds and were measured at the on-site sampling location AS-204, that was directly adjacent to the dewatered ponds. Neither of those doses would have been to the public. The combined dose to a worker near AS-204 would have been less than a third of the sum in the table since the worker was there less than 8 hours per day for 5 days a week, or 70 mrem of inhalation dose for the year 1982, while the numbers in Table 10 reflect 24/7 exposure through the year. Doses listed in Table 10 did not result in any elevated exposures to the public.

Table 10. Annual Effective Doses by Highest Concentration, Location and Age Group

Radionuclide	Highest Year	Highest Location	Concentration (µCi/ml)	Dose to Infant (mrem/yr)	Annual Dose to Adult	Notes
Natural Uranium (µCi/ml)	1979	AS-204	2.48E-14	2.72	5.97	
Thorium-230 (µCi/ml)	1982	AS-204	8.95E-14	71.57	272.68	
Thorium-232 (µCi/ml)	2001	CC#2	8.33E-17	0.07	0.27	
Radium-226 (µCi/ml)	1985	AS-202	9.63E-15	1.25	2.75	
Lead-210 (µCi/ml)	1982	AS-204	9.95E-14	7.01	16.77	Dose from Radon Progeny
Radon-220/222 (pCi/l)	2004	AS-202	1.50E+00	NA	NA	No dose from Radon

Most of the calculated inhalation dose was from the isotope Thorium-230 (Th-230). Table 11 below lists just the dose from Th-230 for the highest annual average concentration at each sampling station. Again it can be seen that the on-site concentrations are consistently orders of magnitude higher than at off-site locations in Cañon City, Lincoln Park and west of the site boundary.

Outdoor concentrations of radon contributed zero dose to the public, because it is a noble gas and does not stay in the lungs long enough to radioactively decay. On the other hand, the dose from radon decay products (e.g., lead-210) attached to respirable dust held constant year over year and accounted for an annual inhalation dose of four to seven millirem annually. Radon decay product concentration off-site did not appear to be related to releases from the site. Radon and its decay products appear to be from natural background and do not represent any health threat at the reported concentrations.

Table 11. Annual Doses from Thorium-230 by Location and Year

Year	Highest Location	Concentration (µCi/ml)	Annual Dose to Infant (mrem/yr)	Annual Dose to Adult(mrem/yr)
1982	AS-204	8.95E-14	71.57	272.68
1982	AS-202	2.12E-14	16.95	64.59
1983	AS-203	9.79E-15	7.83	29.83
1982	AS-206	1.26E-14	10.08	38.39
2000	AS-209	4.16E-15	3.33	12.67
2005	AS-210	4.85E-16	0.39	1.48
2000	AS-212	6.69E-16	0.53	2.04
1982	LP-1/2	7.49E-16	0.60	2.28
1982	CC-1/2	9.18E-16	0.73	2.80
1982	OV-3	3.15E-15	2.52	9.60

VI. COMMUNITY HEALTH CONCERNS

Responding to community health concerns is an essential part of ATSDR's overall mission and commitment to public health. The community associated with a site is both an important resource for and a key audience in the public health assessment process. Community members can often provide information that will contribute to the quality of the health assessment. Therefore, during site visits and telephone conversations with community members, ATSDR obtained information from the community regarding their specific health concerns related to the site.

In some cases, ATSDR was unable to address a community health concern because 1) adequate scientific information on the particular health effect is not available or is limited or 2) the available scientific data are insufficient to assess whether the specific health effect is related to exposure to a particular chemical. Where feasible, ATSDR addressed the health concerns identified by the community. Below is a summary of the community concerns and ATSDR's response to those concerns.

1. How did the 1965 flood event affect my health?

In June 1965, prior to the construction of the SCS Dam in 1971, a flood caused the unlined tailings ponds at the Cotter Mill to overflow into Lincoln Park. According to the residents, the waters flowed north through the gap in the ridge, down Pine Street, and ultimately down 12th Street (Sharyn Cunningham, CCAT, personal communication, February 2008). There is concern that this flood event contaminated groundwater wells and that dust from soil or tailings may have been resuspended by wind and distributed in Lincoln Park. Community members are very concerned that current illnesses may be a result of this tailings pond flood event.

There is documentation that ponds at the Cotter Mill historically overflowed, which led to the construction of the SCS Dam. Aerial photography from October 1970 indicates that one of the evaporation ponds overflowed into an alluvial channel tributary to Sand Creek (Wilder et al. 1983). A chronology compiled by CDPHE states that in October 1970 and January 1971, an evaporation pond overflowed with high levels of total dissolved solids, sodium, molybdenum, sulfate, and high radiation (CDPHE 1975).However, since the construction of the SCS Dam, there are no recorded surface water discharges past the dam (GeoTrans 1986).

ATSDR tried to locate data to evaluate the potential health effects resulting from this flood event. No data from 1965 or 1966 exist in the CDPHE database. The *1986 Remedial Investigation* (GeoTrans 1986) states that off-site groundwater contamination in the Lincoln Park areas was first identified in 1968; therefore, any data prior to 1968 are unlikely to exist. The only data ATSDR found related to this flood event were from a sediment sample collected in January 2003 (CDPHE 2003). To address community concerns, CDPHE collected a sample of suspected flood sediment from Pine Street near Elm Avenue. This area was identified by a property owner who was present during the flood. The sample was collected from two locations. About 250 grams of soil were collected from each location to a depth of approximately 18 inches. No obvious soil horizons were identified, and no significant differences in gamma radiation were noted between shallow and deep soils. The results are presented in Table 12 below. All concentrations from this one sample are below comparison values.

The results of the sediment sample from the flood did not exceed any comparison values. If this sample was representative of the material moved by the floodwaters, it would not cause any adverse health effects.

Table 12. Concentrations found in a suspected flood sediment sample, January 2003

Chemical	**Concentration (ppm)**	**Comparison Value (ppm)**
Lead	87	400
Molybdenum	Not detected	300
Uranium	1.6	100
Radionuclide	**Concentration (pCi/g)**	**Comparison Value (pCi/g)**
Cesium-137	0.12	Not available
Lead-210	2.2	Not available
Plutonium-239, 240	Not detected	Not available
Potassium-40	22.5	Not available
Radium-226	2.2	15
Radium-228	1.3	15

Source: CDPHE 2003

2. Were an adequate number of soil samples collected during the *1998 Supplemental Human Health Risk Assessment*?

The community expressed concern that not enough samples were collected during the *1998 Supplemental Human Health Risk Assessment*. Weston, a contractor for Cotter, collected surface soil samples (0-2 inches) from eight zones around the mill property (see Figure). Each zone was divided into 8 to 12 grids. Four samples were collected near the center of each grid and were composited (i.e., combined and homogenized) to form a single representative sample (Weston 1998). The dates the samples were collected were not specified in the report; however, it is assumed to be in the 1994–1996 timeframe. In 1995, EPA released guidance for obtaining representative soil samples at Superfund sites (EPA 1995). The systematic grid sampling approach used by Weston conforms with EPA's guidance for delineating the extent of contamination. The number of samples taken from each grid for compositing, however, is not entirely consistent with EPA's guidance. For grids larger than 100 x 100 feet, which it appears that the grids established by Weston are, EPA recommends collecting nine aliquots from each grid. Compositing four aliquots from each grid is recommended for grids smaller than 100 x 100 feet (EPA 1995). Because the timeframe of the sampling is unclear, it is not known whether EPA's 1995 guidance was available during Weston's sampling effort.

3. Are there high levels of thorium near the Black Bridge?

The community expressed concern that high thorium levels were detected in surface water near the Black Bridge. This bridge is located where a railroad spur crosses the Arkansas River between the 4th Street and 9th Street bridges. The closest sampling location in the Arkansas River is upstream at 1st Street (907). Thorium-230 was sampled at this location as part of the surface water monitoring program between 1995 and 2007. These data are summarized below in Table 13. The highest thorium-230 concentration detected was 2.5 picocuries per liter (pCi/L) (suspended sample) in August 2007. This concentration is below levels known to cause adverse health effects. It should also be noted that the Black Bridge is located upstream of the confluence with Sand Creek.

Table 13. Thorium-230 data upstream of the Black Bridge

Chemical	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)
Thorium-230 (D)	121/127	-0.1	0.1	1
Thorium-230 (S)	115/120	0	0.2	2.5
Thorium-230 (T)	7/7	0.1	0.3	0.7

Source: CDPHE 2007b
Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
Thorium-230 "D" and "S" samples were collected between 1995 and 2007. Thorium-230 "T" samples were only collected in 1995.

D – dissolved
pCi/L – picocuries per liter
S – suspended
T – total

4. I grew up near the Cotter plant. Does this increase my risk of getting cancer?

Soil sampling data from the nearest residence to the Cotter plant did not indicate the presence of chemicals at levels above established guidelines. Soil sampling data from the Lincoln Park community did not reveal the presence of contaminants at levels associated with adverse health effects, including cancer. Air data do not indicate the presence of chemicals at levels associated with adverse health effects, including cancer. If you drank water from a contaminated private well, you might be at increased risk for gout-like conditions, such as pain, swelling, inflammation and deformities of the joints. However, once exposure is stopped, the risk of adverse health effects goes down.

5. I used water from my private well or surface water to irrigate my crops and garden vegetables. Am I going to get sick?

According to our evaluation, people who ate fruits or vegetables irrigated with contaminated well water are not at increased risk for non-cancer health effects. However, people who eat more than the average amount of fruits and vegetables (95th percentile consumers) might be at increased risk for developing cancer over a lifetime. This conclusion is based on a person eating approximately 4 times more fruits and vegetables than the average person every day for 30 years.

People who grew fruits and vegetables at their home and used their well water to irrigate their crops submitted crop samples for analysis. The analysis revealed that vegetables irrigated with well water did not cause a significant increase in contaminant levels (Weston 1998). As a precaution, however, we recommend washing all homegrown fruits and vegetables before eating them.

6. **I have lived in Lincoln Park since the 1960s. I know of many neighbors and family members who are sick. Is uranium from the mill making us sick?**

Uranium primarily acts as a heavy metal toxin. Renal toxicity is the hallmark effect of uranium exposure, specifically to the proximal tubules of the kidney. We looked at CDC's Compressed Mortality Database "WONDER" looking specifically at specific modes of kidney failure that could be associated with uranium toxicity. Fremont County in Colorado had an age adjusted rate for renal failure as the cause of death of 7.1 per 100,000, for the years 1999-2006. The state average during that same period was 12.1 per 100,000[13]. From the available health outcome data, it does not appear that residents in the area have elevated rates of kidney disease, which could be associated with uranium exposure.

7. **My husband worked at the plant. Was I possibly exposed when he brought his dirty work clothes home?**

Workers in industrial settings have the potential to expose their household members to work-related chemicals if residues attach to the worker's clothing, skin, shoes, or in their vehicles and is inadvertently brought into the home. Whether and to what magnitude these take-home exposures actually occur depends on a number of factors, including the nature of the job held by the worker, the occupational practices of the industrial facility (e.g., providing workers with disposable gowns and gloves), and the precautions/practices of the worker and other family members. ATSDR did not evaluate potential exposures to workers' families because the data needed to quantitatively or qualitatively make a determination on potential health effects were not available.

8. **I used contaminated water from my private well water for many years as a potable source of water for my family. Are we now at risk for adverse health effects?**

The levels of molybdenum were high enough in some wells to cause adverse health effects in individuals who were exposed for many years. Once exposure is stopped, the risk of adverse health effects goes down. Residents, particularly individuals who do not take in enough dietary copper or cannot process copper correctly, might be at increased risk for gout-like conditions. The levels of other contaminants are too low to cause adverse health effects.

9. **CCAT conducted a health survey and submitted it to ATSDR. Why didn't ATSDR use the results of this survey to determine if people are experiencing adverse health effects in the community?**

The community organization CCAT conducted a health survey in 2004–2005. The survey included responses from 239 individuals in the Lincoln Park area. Volunteers went door-to-door in Lincoln Park and the surrounding areas to administer the health surveys. Each person filled out a survey and submitted it to a volunteer. A tabulation of self-reported illnesses reported by respondents included occurrences of cancer; lung, health, skin, central nervous system, kidney, and thyroid problems; reproductive issues, including chromosomal and congenital defects;

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[13] Centers for Disease Control and Prevention, National Center for Health Statistics. Compressed Mortality File 1999-2006. CDC WONDER On-line Database, compiled from Compressed Mortality File 1999-2006 Series 20 No. 2L, 2009. Accessed at http://wonder.cdc.gov/cmf-icd10.html on Sep 30, 2009 10:42:05 AM

autoimmune disease, psychological disorders, and gout. Although ATSDR could not use the survey to make conclusions about disease associations, we did use the survey results to focus our attention and pursue a more in-depth scientific analysis of the health conditions identified by the community.

While the CCAT health survey was a good effort by the community to examine the frequency of their various health concerns, there are many issues that make it of limited use in determining the prevalence of adverse health effects present in the entire community and their potential associations with exposure to environmental contaminants. Some of these issues include the use of a relatively small convenience sample, the lack of medical verification of self-reported health outcomes, and the need for individual-level exposure data. Convenient samples are typically not representative of the entire population, so results cannot be extrapolated to the community. People who participate in nonrandomized surveys such as this may provide biased information because of perceived relationships between environmental contamination or other risk factors and their health. Many of the self-reported health outcomes measured in the survey are present in most populations and are related to several different potential causes beyond environmental exposures, such as lifestyle or genetics. Therefore, without any assessment of exposure, it is not possible to link the occurrence of disease to environmental concerns.

10. **CDPHE previously ordered Cotter to have all environmental samples analyzed by an external laboratory until Cotter could demonstrate that its laboratory had addressed various deficiencies. Why was this done and how did it affect the data used by ATSDR?**

Cotter’s license requires the company to collect and report a wide range of environmental measurements. Cotter’s own analytical laboratory conducted most of the measurements between the late 1970s and the present. The main exception is that an external analytical laboratory measured contamination levels in most of the samples collected in 2005 and 2006.

For many years, Cotter has participated in so-called “round robin” inter-laboratory performance evaluations. As part of these evaluations, selected environmental samples are split every calendar quarter and simultaneously sent to Cotter’s laboratory and to three external analytical laboratories for analysis. The measurement results are then compared to assess the performance of Cotter’s laboratory. CDPHE’s website presents data from these inter-laboratory comparisons from 2007 to the present. Earlier comparisons are not readily available, mostly because Cotter’s laboratory was not analyzing samples throughout much of 2005 and 2006 and data from earlier years have since been archived from CDPHE’s website.

In September 2008, Cotter submitted a letter to CDPHE documenting five quarters of inter-laboratory comparisons for groundwater samples [Cotter 2008]. These comparisons presented “round robin” data for more than two dozen substances or indicators, including uranium, molybdenum, selenium, nitrate, and selected radionuclides. In some cases, Cotter’s laboratory tended to measure higher concentrations than the other participating laboratories; but in other cases, the opposite was observed. With one exception, the differences between the measurements made by the various laboratories fell within the range typically observed or expected.

The exception is for molybdenum, for which Cotter's laboratory did not meet pre-established comparability limits for the "round robin" sampling. Specifically, in two out of the five quarters of samples that were collected, Cotter's laboratory did not meet the acceptable limits.[14] In contrast, the three external laboratories' molybdenum measurements met the pre-established comparability limits for all five quarters considered in this report. The table below presents the specific concentration measurements for the two quarters of interest, and these measurements show that (in these two instances) the molybdenum levels measured by Cotter were less than 50 percent of the average concentrations calculated from the three external laboratories' measurements.

After CDPHE requested that Cotter investigate the issue further, Cotter prepared a written response to the issue [Cotter 2009]. The response suggests that the poor performance on these samples resulted from the analytical method used. Cotter uses atomic adsorption to measure molybdenum levels in groundwater samples, and the external laboratories used a different method (inductively coupled plasma with mass spectrometry). When molybdenum concentrations are below roughly 0.5 mg/L, Cotter measures molybdenum by atomic adsorption *graphite furnace* analysis; but at higher concentrations, analysis is by atomic adsorption *flame* analysis. The two quarters with the poor comparisons both had concentration levels below 0.5 mg/L, leading Cotter to infer that the underreporting was associated with the graphite furnace analyses. In January 2009, Cotter proposed several measures that were believed to cause the graphite furnace analyses to perform better, and CDPHE approved of the proposed remedy.

Overall, the "round robin" studies have demonstrated that Cotter's analytical laboratory met pre-specified performance criteria for almost every one of the substances considered. Only for molybdenum was a performance issue noted, and it appears that Cotter's laboratory previously used a method that would understate molybdenum concentrations, but typically only when those concentrations were less than approximately 0.5 mg/L. This issue was observed for samples collected between January 2007 and March 2008, but it likely also affected earlier samples that Cotter's laboratory analyzed; and this negative bias should be considered in any uses of these data. Measurements collected since this timeframe likely do not exhibit the same negative bias, given the changes that Cotter proposed to its analytical methods.

Inter-Laboratory Comparison Results for Molybdenum: First Quarter 2007 & First Quarter 2008

Parameter	Analytical Laboratory			
	Cotter	Laboratory #1	Laboratory #2	Laboratory #3
Inter-Laboratory Comparison for First Quarter 2007				
Measurement 1 (mg/L)	0.012	0.0263	0.027	0.024
Measurement 2 (mg/L)	0.012	0.025	0.027	0.0232
Average (mg/L)	0.012	0.0257	0.027	0.0236
Avg across three comparison laboratories (mg/L)		0.025		
Inter-Laboratory Comparison for First Quarter 2008				
Measurement 1 (mg/L)	0.01	0.0281	0.029	0.0267
Measurement 2 (mg/L)	0.011	0.0274	0.029	0.0274
Average (mg/L)	0.011	0.0278	0.029	0.0271
Avg across three comparison laboratories (mg/L)		0.028		

Note: Every laboratory was supposed to analyze each sample twice, thus providing data allowing for intra-laboratory and inter-laboratory comparisons.

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[14] CDPHE actually voiced concern about three quarters of Cotter's molybdenum data, even though only two of these three quarters did not meet the pre-established comparability limits.

VII. CONCLUSIONS

ATSDR reached four important conclusions in this public health assessment:

1. ATSDR concludes that drinking water for many years from contaminated private wells could harm people's health. This is a public health hazard.

   Private well sampling data collected from 1984 to 2007 revealed the presence of molybdenum at levels that could harm people's health. A water use survey conducted in Lincoln Park in 1989 revealed that at least seven people used groundwater (from their private wells) for personal consumption. These and other residents whose private wells were affected by the highest molybdenum contamination may be at increased risk for health effects such as gout-like conditions, particularly individuals who do not take in enough dietary copper or cannot process copper correctly.

   The lack of consistent monitoring over the years and the unknown usage of wells before the installation of the public water supply make these past exposures difficult to accurately assess.

   Most town residents are now connected to the public water supply and have eliminated their exposure to the contaminated well water. However, some residents are reported to have refused public water supply connections, and many may still have operational private wells. Additionally, no formal institutional controls exist to control groundwater use in Lincoln Park. Therefore, current and future uses of private wells for domestic purposes are still possible.

2. ATSDR concludes that accidentally eating or touching soil and sediment near the Cotter Mill property or in Lincoln Park will not harm people's health. However, ATSDR cannot make conclusions about soils near Cotter Mill if the properties closest to the facility are developed for residential or other non-industrial uses in the future.

3. ATSDR concludes that eating locally-grown fruits and vegetables irrigated with private well water will not harm most people's health. However, a person eating above-average amounts of fruits and vegetables (4 times the average consumer) might have a low increased risk for developing cancer over a lifetime. As a precaution, residents should limit their use of contaminated well water to irrigate their crops. In all cases, the crops should be thoroughly cleaned prior to eating.

4. ATSDR concludes that ambient air emissions of particle bound radionuclides have not resulted in completed exposures to the public at levels that could cause adverse health outcomes. With the exception of thorium-230 levels observed in 1981 and 1982, associated with excavation of contaminated tailings, every radionuclide monitored has been more than a factor of ten below annual dose based health limits to the public. The excavation releases appear to have only exposed on-site workers, but still below occupational limits at that time.

VIII. RECOMMENDATIONS

Based upon ATSDR's review of the environmental data and the concerns expressed by community members, the following recommendations are appropriate and protective of the health of residents in and around the Lincoln Park area.

- Residents should be informed about the health risks associated with contaminated private wells and advised to connect to the public water supply if possible. Local officials should advise new residents who move to the area of the groundwater contamination and that they should have their water supply tested before using groundwater for household purposes.

- Residents should discontinue of use of any impacted private wells for household purposes, including watering livestock and crops.

- CDPHE should continue to monitor the groundwater contaminant plume to assess whether additional wells may be impacted in the future.

- CDPHE should conduct a water use survey in the affected area to determine how groundwater is being utilized by residents in Lincoln Park.

- CDPHE should evaluate the need for further analysis of lead in soil should the areas adjacent to the Cotter Mill property change current use patterns.

- ATSDR in the short-term, and CDPHE in the long-term, should advise residents who have fruit and vegetable gardens to wash the crops thoroughly before eating them. This measure is just a precaution to remove soil adhering to the surface of the crop.

IX. PUBLIC HEALTH ACTION PLAN

The public health action plan for the site contains a description of actions that have been taken or will be taken by ATSDR or other government agencies at the site. The purpose of the public health action plan is to ensure that this document both identifies public health hazards and provides a plan of action designed to mitigate and prevent harmful human health effects resulting from exposure to the hazardous substances at this site.

Public health actions COMPLETED:

- ATSDR conducted site visits to gather community health concerns, to communicate to identified stakeholders, and to gather relevant site-related data;
- ATSDR's Exposure Investigations and Site Assessment Branch (EISB) performed two Exposure Investigations to 1) evaluate blood lead levels in children living in the Lincoln Park area and 2) evaluate lead in dust in homes in the Lincoln Park area. (These documents are available on our website at www.atsdr.cdc.gov.)

Public health actions PLANNED:

- ATSDR's Health Promotion and Community Involvement Branch (HPCIB) will conduct health-related educational activities in the community, as necessary.
- ATSDR's HPCIB will coordinate community outreach and community involvement activities for the site.
- ATSDR will continue to work with appropriate state and federal agencies and review, if requested, additional relevant environmental data (including the water use survey) as it becomes available.
- ATSDR will re-evaluate and revise the public health action plan if needed. New environmental, toxicological, health outcome data, or implementing the above proposed actions may necessitate the need for additional or alternative actions at this site.

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Appendix A - Tables

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Table 14. Well Use in Lincoln Park, 1989

Well Number	Description	Reported Well Use				
		Personal Consumption	Irrigating Fruit	Irrigating Vegetable Gardens	Watering Livestock	Watering Lawns
117	Logan (LPWUS)		✓			✓
119	Birch (LPWUS)			✓		✓
122	Elm (LPWUS)					✓
123	Cedar (LPWUS)					✓
124	Elm (LPWUS)			✓		✓
129	Elm (LPWUS)		✓	✓		✓
130	Poplar (LPWUS)		✓			✓
138	Field well, Cedar (LPWUS)					✓
139	House well, Cedar (LPWUS)					✓
140	C. R. Ransom house well, Cedar (LPWUS)		✓	✓		✓
144	Cedar (LPWUS)		✓	✓	✓	✓
165	Spring, Elm (LPWUS)	✓		✓		✓
166	Willow (LPWUS)				✓	✓
168	Grand (house well) (LPWUS)	✓			✓	✓
173	Beulah (LPWUS)		✓			✓
174	Chestnut (LPWUS)		✓		✓	✓
189	Hickory (LPWUS)	✓				
198	Grand (LPWUS)	✓	✓	✓	✓	✓
206	Grand (field well) (LPWUS)				✓	
212	Cedar (LPWUS)		✓	✓		✓
219	Locust (LPWUS)	✓				
221	Elm (LPWUS)					✓
222	Elm (LPWUS)					✓

Well Number	Description	Reported Well Use				
		Personal Consumption	Irrigating Fruit	Irrigating Vegetable Gardens	Watering Livestock	Watering Lawns
223	Elm (LPWUS)				✓	
224	Elm (LPWUS)		✓			✓
226	Chestnut (LPWUS)					✓
229	Grand (LPWUS)				✓	✓
230	Birch (LPWUS)		✓			✓
231	Birch (LPWUS)		✓	✓		
235	Elm (LPWUS)				✓	
237	Elm (LPWUS)				✓	
239	Grand (LPWUS)		✓	✓	✓	✓
241	Grand (LPWUS)				✓	
243	Chestnut (LPWUS)					✓
245	Elm (LPWUS)				✓	
246	Elm (LPWUS)		✓			✓
252	Poplar (cistern* in barn) (LPWUS)					✓
255	Riley Dr. (LPWUS)	✓	✓			✓
261	Elm (LPWUS)		✓	✓		✓
262	Cedar (LPWUS)		✓	✓		✓
263	Willow (LPWUS)					✓
264	Chestnut (LPWUS)		✓	✓		✓
266	Willow (LPWUS)		✓	✓		✓
267	Willow (spring) (LPWUS)		✓	✓	✓	✓
269	Birch			✓		✓
273	Willow (cistern #1) (LPWUS)			✓		✓
274	Grand (LPWUS)		✓	✓		✓
278	Cedar (LPWUS)					✓

Well Number	Description	Reported Well Use				
		Personal Consumption	Irrigating Fruit	Irrigating Vegetable Gardens	Watering Livestock	Watering Lawns
280	Grand (LPWUS)				✓	
284	Spring - Grand St. (LPWUS)				✓	
285	Grand (LPWUS)				✓	
286	Willow (cistern #2) (LPWUS)				✓	
287	Willow (LPWUS)			✓		✓
288	Poplar (cistern* on porch)					✓
293	Cedar (LPWUS)		✓	✓	✓	✓
	Totals	6	22	20	19	42

Source: IMS 1989

*Modified from the original spelling: “cystern”
Street numbers have been excluded for privacy reasons.

LPWUS – Lincoln Park Water Use Survey

Table 15. Groundwater sampling data (chemicals) from wells used for personal consumption

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Chloride	N/T*	11/11	4.5	8.8	14	Spring, Elm [165]	13-Mar-84	250 (Secondary MCL)	165, 168	1984, 2005–2007
Iron	D	2/12	0.04	0.06	0.1	Grand (house well) [168]	19-Aug-05	26 (RBC)	165, 168	1984, 2004–2007
Manganese	D	2/12	0.002	0.008	0.01	Grand (house well) [168]	13-Dec-04	0.5 (RMEG, child)	165, 168	1984, 2004–2007
Molybdenum	D	52/59	0.007	**0.082**	**0.28**	Hickory [189]	19-Jan-89	0.035 (SS); 0.05 (RMEG, child)	165, 168, 189, 198, 219, 255	1984, 1988–1991, 1995, 2000–2007
Nitrate	T	8/8	0.5	2.9	7.7	Grand (house well) [168]	19-Mar-07	10 (MCL)	168	2005–2007
Selenium	D	0/2	ND	ND	ND	--	--	0.05 (c-EMEG, child)	165, 168	1984
Sulfate	N/T*	11/11	15	62	214	Grand (house well) [168]	19-Aug-05	250 (Secondary MCL)	165, 168	1984, 2005–2007
Total Dissolved Solids	N/T*	11/11	240	330	410	Spring, Elm [165]	13-Mar-84	500 (Secondary MCL)	165, 168	1984, 2005–2007
Uranium	D	56/57	0.001	0.028	**0.067**	Hickory [189]	15-Dec-06	0.03 (MCL)	165, 168, 189, 198, 219, 255	1984, 1988–1991, 1995, 2001–2007

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The source of water used for personal consumption at 1935 Elm [165] was a spring.

* For chloride, sulfate, and total dissolved solids, 1984 data were designated “N” and 2005–2007 data were designated “T”.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
SS – Colorado state groundwater standard
T – total

Table 16. Groundwater sampling data (chemicals) from background wells

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	0/25	ND	ND	ND	--	10 (c-EMEG, child)	1981, 1988–1994
Ammonia	N	3/45	0.02	0.4	4.2	26-Jan-90	30 (LTHA)	1988–1994
Ammonium	T	0/3	ND	ND	ND	--	NA	1995
Chloride	N/T*	168/168	3	12	110.3	07-Jan-80	250 (Secondary MCL)	1975, 1976, 1978–2007
Iron	D	24/79	0.02	0.03	0.3	16-May-89	26 (RBC)	1981–2007
Manganese	D	13/79	0.005	0.007	0.05	16-Mar-99	0.5 (RMEG, child)	1981–2007
Molybdenum	D	116/193	0.005	0.023	**0.3**	09-Nov-82, 09-Jun-76	0.035 (SS); 0.05 (RMEG, child)	1975, 1976, 1979–2007
Nitrate	N/T*	70/79	0.4	2.5	**50.4****	10-Feb-89	10 (MCL)	1988–2007
Selenium	D	10/103	0.001	0.003	0.015	15-Apr-80	0.05 (c-EMEG, child)	1975, 1977–1988, 1996–2000
Sulfate	N/T*	171/171	10	61	**434**[§]	18-Aug-80	250 (Secondary MCL)	1975–2007
Total Dissolved Solids	N/T*	171/171	286	429	**1,580**[†]	18-Aug-80	500 (Secondary MCL)	1980–2007
Uranium	D	155/193	0.004	0.021	**0.29**	07-Aug-79	0.03 (MCL)	1975–1977, 1979–2007

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The USGS identified Well 10 (1220 So. 12th St.) and Well 114 (1408 Pine) as representative of background for the Lincoln Park area (Weston 1998).

* For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated "N" and post-1995 data were designated "T".
** Only two of 79 samples were above the CV.

[§] Only one of 171 samples was above the CV.
[†] The maximum concentration appears to be an outlier. The next highest concentration is 590 mg/L.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
SS – Colorado state groundwater standard
T – total

Table 17. Groundwater sampling data (chemicals) from the Grand Avenue Well

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Chloride	N/T*	10/10	4.5	8.250	11	20-Jun-84, 20-Jun-05	250 (Secondary MCL)	1984, 2005–2007
Iron	D	2/11	0.04	0.06	0.1	19-Aug-05	26 (RBC)	1984, 2004–2007
Manganese	D	2/11	0.002	0.009	0.01	13-Dec-04	0.5 (RMEG, child)	1984, 2004–2007
Molybdenum	D	15/20	0.008	0.01	0.015	21-Jun-04	0.035 (SS); 0.05 (RMEG, child)	1984, 1988–1991, 2004–2007
Nitrate	T	8/8	0.5	2.9	7.7	19-Mar-07	10 (MCL)	2005–2007
Selenium	D	0/1	ND	ND	ND	--	0.05 (c-EMEG, child)	1984
Sulfate	N/T*	10/10	15	58	214	19-Aug-05	250 (Secondary MCL)	1984, 2005–2007
Total Dissolved Solids	N/T*	10/10	240	322	402	19-Mar-07	500 (Secondary MCL)	1984, 2005–2007
Uranium	D	20/20	0.001	0.013	0.0218	28-Mar-05	0.03 (MCL)	1984, 1988–1991, 2004–2007

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
* For chloride, sulfate, and total dissolved solids, 1984 data were designated “N” and 2005–2007 data were designated “T”.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database

ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
SS – Colorado state groundwater standard
T – total

Table 18. Groundwater sampling data (chemicals) from wells used to irrigate fruit and vegetable gardens

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Aluminum	D	3/120	0.01	0.186*	0.02	Elm [124] & Elm [129]	15-Mar-95	10 (c-EMEG, child)	117, 119, 124, 129, 130, 140, 144	1981, 1988–1995
Ammonia	N	10/53	0.01	0.3	0.6	house well, Cedar [140]	23-Aug-88	30 (LTHA)	119, 124, 129, 130, 140, 144	1988–1995
Ammonium	T	0/3	ND	ND	ND	--	--	NA	119, 140, 144	1995
Cadmium	D	0/3	ND	ND	ND	--	--	0.002 (c-EMEG, child)	119, 140, 144	1995
Chloride	N/T**	784/793	2.5	19.6	232	house well, Cedar [140]	05-Apr-79	250 (Secondary MCL)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1975, 1976, 1978–2007
Copper	D	0/3	ND	ND	ND	--	--	0.1 (i-EMEG, child)	119, 140, 144	1995
Iron	D	114/398	0.011	0.029	0.31	Elm [129]	21-Apr-03	26 (RBC)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1981–2007
Manganese	D	69/397	0.0007	0.008	0.13	house well, Cedar [140]	09-Sep-94	0.5 (RMEG, child)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1981–2007
Molybdenum	D	1,052/1,077	0.004	0.99	42	house well, Cedar [140]	12-May-73	0.035 (SS); 0.05 (RMEG, child)	All 28 wells (see Table 14)	1968–2007
Nickel	D	0/3	ND	ND	ND	--	--	0.2 (RMEG, child)	119, 140, 144	1995

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Nitrate	N/T**	159/185	0.1	1.7	9.8	Cedar [144]	14-May-70	10 (MCL)	119, 124, 129, 130, 140, 144, 174, 224	1970, 1988–2007
Selenium	D	115/626	0.001	0.003	**0.082†**	house well, Cedar [140]	21-Apr-78	0.05 (c-EMEG, child)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224, 264	1974–1988, 1995–2000
Sulfate	N/T**	798/800	8	214	**25,460‡**	house well, Cedar [140]	07-May-79	250 (Secondary MCL)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1975–2007
Total Dissolved Solids	N/T**	767/767	31	**550**	**3,438**	house well, Cedar [140]	20-Apr-81	500 (Secondary MCL)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1980–2007
Uranium	D	1,048/1,088	0.0003	**0.13**	**2.54**	house well, Cedar [140]	05-Jan-79	0.03 (MCL)	All 28 wells (see Table 14)	1962–1964, 1967, 1968, 1971, 1974–2007
	S	1/20	0.081	0.005§	**0.081**	house well, Cedar [140]	27-May-97		140, 174, 224	1995–2000
Vanadium	D	0/3	ND	ND	ND	--	--	0.03 (i-EMEG, child)	119, 140, 144	1995
Zinc	D	2/3	0.005	0.01	0.022	Birch [119]	25-Aug-95	3 (c-EMEG, child)	119, 140, 144	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The source of water used to water fruits and vegetable gardens at 1935 Elm [165] was a spring.

* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated "N" and post-1995 data were designated "T".
[†] Only two of 626 samples were above the CV.
[‡] The maximum concentration appears to be an outlier. The next highest concentration is 1,948 mg/L from the same well [140] in 1981.
[§] The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 19. Groundwater sampling data (radionuclides) from wells used to irrigate fruit and vegetable gardens

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Location of Maximum	Date of Maximum	CV (pCi/L)	Wells Sampled	Years Sampled
Lead-210	D	29/29	-0.2	0.22	1.5	Birch [119]	21-Jun-95	NA	119, 140, 144, 174, 224	1995–2000
	S	20/20	-0.1	0.15	0.6	house well, Cedar [140]	22-Feb-96, 05-May-99		140, 174, 224	1995–2000
Polonium-210	D	29/29	-0.1	0.13	0.6	Cedar [144]	08-Mar-95, 21-Jun-95,	NA	119, 140, 144, 174, 224	1995–2000
	S	20/20	0	0.12	0.6	house well, Cedar [140]	22-Feb-96, 05-Dec-96		140, 174, 224	1995–2000
Radium-226	D	29/29	0	0.12	0.5	house well, Cedar [140]	12-May-95	5 (MCL radium-226/228)	119, 140, 144, 174, 224	1995–2000
	S	19/19*	0	0	0	--	--		140, 174, 224	1995–2000
Thorium-230	D	28/28	-0.1	0.08	0.3	Birch [119] house well, Cedar [140]	25-Aug-95 21-Feb-95	NA	119, 140, 144, 174, 224	1995–2000
	S	17/17	0	0.08	0.3	house well, Cedar [140]	05-May-99		140, 174, 224	1995–2000

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
*The detect flag is "Y" for all 19 samples, however, the result value is zero for all 19 samples.

CV – comparison value
D – dissolved
MCL – maximum contaminant level

NA – not available
pCi/L – picocuries per liter
S – suspended

Table 20. Groundwater sampling data (chemicals) from wells used to water livestock

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Aluminum	D	0/19	ND	ND	ND	--	--	10 (c-EMEG, child)	144	1981, 1988–1995
Ammonia	N	0/10	ND	ND	ND	--	--	30 (LTHA)	144	1988–1995
Ammonium	T	0/1	ND	ND	ND	--	--	NA	144	1995
Cadmium	D	0/1	ND	ND	ND	--	--	0.002 (c-EMEG, child)	144	1995
Chloride	N/T*	160/160	2.5	14	185	Cedar [144]	24-Aug-83	250 (Secondary MCL)	144, 166, 168, 174	1970, 1975, 1976, 1979–1989, 1991–2007
Copper	D	0/1	ND	ND	ND	--	--	0.1 (i-EMEG, child)	144	1995
Iron	D	27/97	0.03	0.04	0.19	Cedar [144]	18-Oct-01	26 (RBC)	144, 166, 168, 174	1970, 1981–2007
Manganese	D	14/96	0.0007	0.007	0.02	Cedar [144]	13-Jul-81, 13-Sep-83, 17-May-01, 06-Jun-02, 23-Oct-03	0.5 (RMEG, child)	144, 166, 168, 174	1981–2007
Molybdenum	D	271/286	0.006	0.212	1	Cedar [144]	12-May-71	0.035 (SS); 0.05 (RMEG, child)	All 19 wells (see Table 14)	1968–1971, 1975–1977, 1979–2007
Nickel	D	0/1	ND	ND	ND	--	--	0.2 (RMEG, child)	144	1995

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Nitrate	N/T*	55/58	0.1	1.8	9.8	Cedar [144]	14-May-70	10 (MCL)	144, 168, 174	1970, 1988–2007
Selenium	D	10/119	0.001	0.003	0.011	Cedar [144]	19-Mar-80	0.05 (c-EMEG, child)	144, 166, 168, 174	1975–1977, 1979–1988, 1995–2000
Sulfate	N/T*	162/162	10	95	**1,650****	Cedar [144]	18-Aug-80	250 (Secondary MCL)	144, 166, 168, 174	1970, 1975–1977, 1979–1989, 1991–2007
Total Dissolved Solids	N/T*	162/162	195	465	**860**	Cedar [144]	18-Aug-80	500 (Secondary MCL)	144, 166, 168, 174	1970, 1980–2007
Uranium	D	283/302	0.001	**0.034**	**0.46**	Cedar [144]	28-Jun-68	0.03 (MCL)	All 19 wells (see Table 14)	1962–1964, 1967, 1968, 1971, 1975–1977, 1979–2007
	S	0/1	ND	ND	ND	--	--		174	1996
Vanadium	D	0/1	ND	ND	ND	--	--	0.03 (i-EMEG, child)	144	1995
Zinc	D	0/1	ND	ND	ND	--	--	3 (c-EMEG, child)	144	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
** The maximum concentration appears to be an outlier. The next highest concentration is 340 mg/L from the same well [144] in 1984.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 21. Groundwater sampling data (radionuclides) from wells used to water livestock

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Location of Maximum	Date of Maximum	CV (pCi/L)	Wells Sampled	Years Sampled
Lead-210	D	4/4	-0.1	0.1	0.3	Cedar [144]	08-Mar-95	NA	144, 174	1995, 1996
	S	1/1	0.2	0.2	0.2	Chestnut [174]	19-Sep-96		174	1996
Polonium-210	D	4/4	-0.1	0.3	0.6	Cedar [144]	08-Mar-95, 21-Jun-95	NA	144, 174	1995, 1996
	S	1/1*	0	0	0	Chestnut [174]	19-Sep-96		174	1996
Radium-226	D	4/4	0.1	0.1	0.1	--**	--**	5 (MCL radium-226/228)	144, 174	1995, 1996
	S	1/1*	0	0	0	Chestnut [174]	19-Sep-96		174	1996
Thorium-230	D	4/4	0	0.05	0.1	Cedar [144] Chestnut [174]	20-Sep-95 19-Sep-96	NA	144, 174	1995, 1996
	S	1/1*	0	0	0	Chestnut [174]	19-Sep-96		174	1996

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
* The detect flag is "Y" for the one sample, however, the result value is zero.
** All four result values were 0.1 pCi/L.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended

Table 22. Groundwater sampling data (chemicals) from wells used to water lawns

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Aluminum	D	11/239	0.01	0.19*	0.13	Field well, Cedar [138]	18-Dec-90	10 (c-EMEG, child)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144	1981, 1988–1995
Ammonia	N	21/112	0.01	0.3	0.9	Field well, Cedar [138]	23-Aug-88	30 (LTHA)	119, 122, 123, 124, 129, 130, 138, 139, 140, 144	1988–1995
Ammonium	T	0/5	ND	ND	ND	--	--	NA	119, 138, 139, 140, 144	1995
Cadmium	D	0/5	ND	ND	ND	--	--	0.002 (c-EMEG, child)	119, 138, 139, 140, 144	1995
Chloride	N/T**	1,362/1,372	2.5	30	450	Field well, Cedar [138]	12-Aug-80	250 (Secondary MCL)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1975, 1976, 1978–2007
Copper	D	0/5	ND	ND	ND	--	--	0.1 (i-EMEG, child)	119, 138, 139, 140, 144	1995
Iron	D	205/683	0.005	0.031	0.31	Field well, Cedar [138] Elm [129]	09-Mar-95 21-Apr-03	26 (RBC)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1981–2007

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Manganese	D	134/683	0.0005	0.008	0.13	house well, Cedar [140]	09-Sep-94	0.5 (RMEG, child)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1979, 1981–2007
Molybdenum	D	1,755/1,790	0.004	2.2	56.7	Field well, Cedar [138]	11-Aug-72	0.035 (SS); 0.05 (RMEG, child)	All 42 wells (see Table 14)	1968–2007
Nickel	D	0/5	ND	ND	ND	--	--	0.2 (RMEG, child)	119, 138, 139, 140, 144	1995
Nitrate	N/T**	277/314	0.1	1.8	9.8	Cedar [144]	14-May-70	10 (MCL)	119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 168, 174, 224	1970, 1988–2007
Selenium	D	320/1,105	0.001	0.005	0.134	Field well, Cedar [138]	13-Jul-81	0.05 (c-EMEG, child)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224, 264	1974–1976, 1978–1988, 1995–2000
Sulfate	N/T**	1,382/1,384	8	351	25,460†	house well, Cedar [140]	07-May-79	250 (Secondary MCL)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1975–2007

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Total Dissolved Solids	N/T**	1,311/1,311	31	**746**	**4,373**	Field well, Cedar [138]	06-Mar-81	500 (Secondary MCL)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1980–2007
Uranium	D	1,733/1,789	0.0003	**0.233**	**5.161**	Field well, Cedar [138]	01-Aug-68	0.03 (MCL)	All 42 wells (see Table 14)	1962–1964, 1967, 1968, 1971, 1974–2007
	S	4/38	0.0067	0.010	**0.26**	Field well, Cedar [138]	27-May-97		138, 140, 174, 224	1995–2000
Vanadium	D	0/5	ND	ND	ND	--	--	0.03 (i-EMEG, child)	119, 138, 139, 140, 144	1995
Zinc	D	3/5	0.005	0.007	0.022	Birch [119]	25-Aug-95	3 (c-EMEG, child)	119, 138, 139, 140, 144	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated "N" and post-1995 data were designated "T".
† The maximum concentration and the second highest concentration (23,200 mg/L from Well 138 in 1978) appear to be outliers. The third highest concentration is 3,360 mg/L from Well 138 in 1979.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 23. Groundwater sampling data (radionuclides) from wells used to water lawns

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Location of Maximum	Date of Maximum	CV (pCi/L)	Wells Sampled	Years Sampled
Lead-210	D	53/53	-0.2	0.2	1.5	Birch [119]	21-Jun-95	NA	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	38/38	-0.1	0.1	0.6	house well, Cedar [140]	22-Feb-96, 05-May-99		138, 140, 174, 224	1995–2000
	T	1/1*	0	0	0	Field well, Cedar [138]	06-Sep-96		138	1996
Polonium-210	D	53/53	-0.1	0.2	0.9	Field well, Cedar [138]	04-May-99	NA	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	38/38	0	0.1	0.6	house well, Cedar [140]	22-Feb-96, 05-Dec-96		138, 140, 174, 224	1995–2000
	T	1/1	0.5	0.5	0.5	Field well, Cedar [138]	06-Sep-96		138	1996
Radium-226	D	51/51	0	0.1	0.5	house well, Cedar [140]	12-May-95	5 (MCL radium-226/228)	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	37/37**	0	0.003	0.1	Field well, Cedar [138]	30-Oct-95		138, 140, 174, 224	1995–2000
	T	2/2	0	0.05	0.1	Field well, Cedar [138]	06-Sep-96		138	1995–1996
Thorium-230	D	51/51	-0.1	0.08	0.4	Field well, Cedar [138]	06-Aug-98	NA	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	34/34	0	0.06	0.3	house well, Cedar [140]	05-May-99		138, 140, 174, 224	1995–2000
	T	1/1	0.1	0.1	0.1	Field well, Cedar [138]	06-Sep-96		138	1996

Source: CDPHE 2007b
Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
* The detect flag is "Y" for the one sample, however, the result value is zero.
** For all but one sample, the result value is zero.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended
T – total

Table 24. Groundwater sampling data (chemicals) from Well 138

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	8/57	0.05	0.23*	0.13	18-Dec-90	10 (c-EMEG, child)	1981, 1988–1995
Ammonia	N	10/42	0.02	0.29	0.9	23-Aug-88	30 (LTHA)	1988–1995
Ammonium	T	0/1	ND	ND	ND	--	NA	1995
Cadmium	D	0/1	ND	ND	ND	--	0.002 (c-EMEG, child)	1995
Chloride	N/T**	199/199	5.5	70	450	12-Aug-80	250 (Secondary MCL)	1975, 1976, 1978–2000
Copper	D	0/1	ND	ND	ND	--	0.1 (i-EMEG, child)	1995
Iron	D	21/106	0.01	0.025	0.31	09-Mar-95	26 (RBC)	1981–2000
Manganese	D	21/107	0.01	0.008§	0.06	11-Jun-91	0.5 (RMEG, child)	1979, 1981–2000
Molybdenum	D	253/253	1.1	8.0	56.7	11-Aug-72	0.035 (SS); 0.05 (RMEG, child)	1968–1973, 1975, 1976, 1978–2000
Nickel	D	0/1	ND	ND	ND	--	0.2 (RMEG, child)	1995
Nitrate	N/T**	59/62	0.7	2.3	4.1	11-Jun-91	10 (MCL)	1988–2000
Selenium	D	102/151	0.001	0.011	0.134†	13-Jul-81	0.05 (c-EMEG, child)	1974–1976, 1978–1988, 1995–2000
Sulfate	N/T**	200/200	71	1,059	23,200‡	01-Nov-78	250 (Secondary MCL)	1975, 1976, 1978–2000
Total Dissolved Solids	N/T**	202/202	290	1,530	4,373	06-Mar-81	500 (Secondary MCL)	1980–2000

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Uranium	D	253/253	0.0005	**0.73**	**5.161**	01-Aug-68	0.03 (MCL)	1968, 1974–1976, 1978–2000
	S	3/18	0.007	0.016	**0.26**	27-May-97		1995–2000
Vanadium	D	0/1	ND	ND	ND	--	0.03 (i-EMEG, child)	1995
Zinc	D	0/1	ND	ND	ND	--	3 (c-EMEG, child)	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated "N" and post-1995 data were designated "T".
§ The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
† Only three of 151 samples were above the CV.
‡ The maximum concentration appears to be an outlier. The next highest concentration is 3,360 mg/L in 1979.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 25. Groundwater sampling data (radionuclides) from Well 138

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Date of Maximum	CV (pCi/L)	Years Sampled
Lead-210	D	21/21	-0.2	0.22	1.1	03-Aug-95	NA	1995–2000
	S	18/18	0	0.08	0.2	27-May-97, 06-Feb-98, 29-Jul-99, 19-Oct-99		1995–2000
	T	1/1*	0	0	0	06-Sep-96		1996
Polonium-210	D	21/21	0	0.28	0.9	04-May-99	NA	1995–2000
	S	18/18	0	0.11	0.4	28-Aug-00		1995–2000
	T	1/1	0.5	0.5	0.5	06-Sep-96		1996
Radium-226	D	19/19	0	0.13	0.4	21-Mar-96	5 (MCL radium-226/228)	1995–2000
	S	18/18	0	0.006	0.1	30-Oct-95		1995–2000
	T	2/2	0	0.05	0.1	06-Sep-96		1995, 1996
Thorium-230	D	20/20	0	0.07	0.4	06-Aug-98	NA	1995–2000
	S	17/17	0	0.04	0.2	04-May-99, 29-Jul-99		1995–2000
	T	1/1	0.1	0.1	0.1	06-Sep-96		1996

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
*The detect flag is “Y” even though the result value is zero.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended
T – total

Table 26. Surface soil sampling data (chemicals) from eight zones around the Cotter Mill and from Lincoln Park

Chemical		Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G	Zone H	Lincoln Park	CV (ppm)
Arsenic	Range (ppm)	**33–69**	**19–39**	**14–42**	**10–40**	**16–38**	**17–60**	**17–33**	**19–86**	**13–50**	0.5 (CREG), 20 (c-EMEG, child)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (ppm)	**45**	**30**	**25**	**26**	**28**	**35**	**26**	**42**	**31**	
Beryllium	Range (ppm)	0.5–1.6	0.5–0.9	0.6–1	0.5–1.2	0.6–1.7	0.5–0.7	0.6–0.7	0.5–0.9	0.5–1.7	100 (c-EMEG, child)
	Frequency of Detection	9/10	11/12	9/12	10/10	6/8	8/8	4/4	7/8	72/73	
	Average (ppm)	0.8	0.7	0.7	0.6	0.7	0.6	0.7	0.6	0.7	
Cadmium	Range (ppm)	**1.2–15**	**2.1–13**	**2.2–16**	2.5–6.8	**5.3–18**	**8.9–110**	**1.6–20**	**4.4–51**	0.5–5	10 (c-EMEG, child)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	68/73	
	Average (ppm)	6.9	6.4	6.4	4.1	9.8	**36.5**	7.9	**21.1**	1.4	
Lead	Range (ppm)	43–270	45–240	46–260	47–130	100–280	**68–800**	**37–450**	**61–1,400**	17–270	400 (SSL)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (ppm)	132	104	113	74	173	380	201	**445**	120	
Manganese	Range (ppm)	180–480	320–630	200–500	110–750	150–420	140–400	200–370	210–770	290–640	3,000 (RMEG , child)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (ppm)	336	422	356	391	298	268	290	439	424	
Selenium	Range (ppm)	5–7	39	7–16	5	ND	ND	ND	7	5–44	300 (c-EMEG, child)
	Frequency of Detection	5/10	1/12	2/12	1/10	0/8	0/8	0/4	1/8	7/73	
	Average (ppm)	4.2*	5.5*	4*	2.8*	ND	ND	ND	3.1*	3.5*	

Source: Weston 1998

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.

Each sample is a composite of four subsamples collected from the corners of a 10x10 square established near the center of the grid.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.
See Figure for a map of the sampling zones.

* The calculated averages are lower than the minimum detected concentrations due to including ½ the detection limit in the calculation.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
ND – not detected
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Table 27. Surface soil sampling data (radionuclides) from eight zones around the Cotter Mill and from Lincoln Park

Radionuclide		Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G	Zone H	Lincoln Park	CV (pCi/g)
Lead-210	Range (pCi/g)	1.6–9.7	3.0–14.4	2.5–6.0	2.3–4.5	2.6–6.1	2.7–4.9	1.2–4.4	1.5–4.7	0.7–4.2	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	58/58	
	Average (pCi/g)	6.3	8.2	4.1	3.4	4.4	3.9	2.9	2.6	2.1	
Radium-226	Range (pCi/g)	2.4–10.7	3.6–16.5	1.3–5.7	1.4–2.3	2.5–5.6	1.9–3.0	1.4–1.9	1.2–2.2	1.1–2.2	5 (UMTRCA, surface)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	58/58	
	Average (pCi/g)	6.6	9.2	2.6	1.8	3.9	2.5	1.7	1.5	1.5	
Thorium-230	Range (pCi/g)	3.6–35.3	5.8–40.1	1.6–21.7	1.8–4.4	4.3–12.1	3.6–8.3	1.7–2.8	1.6–11.9	1.0–4.2	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	58/58	
	Average (pCi/g)	17.7	20.9	5.9	2.5	7.7	5.2	2.4	3.3	1.7	
Uranium, natural	Range (pCi/g)	0.871–4.288	1.541–5.427	0.737–5.628	0.737–1.64	1.005–2.412	0.6432–1.943	0.5561–1.005	0.536–1.206	0.6566–3.417	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (pCi/g)	2.45	3.29	1.98	1.17	1.52	1.21	0.83	0.73	1.215	
Uranium-234	Range (pCi/g)	0.436–2.14	0.771–2.71	0.369–2.81	0.369–0.82	0.503–1.21	0.322–0.972	0.278–0.503	0.268–0.603	0.328–1.709	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (pCi/g)	1.23	1.65	0.991	0.584	0.758	0.606	0.413	0.366	0.607	

Radionuclide		**Zone A**	**Zone B**	**Zone C**	**Zone D**	**Zone E**	**Zone F**	**Zone G**	**Zone H**	**Lincoln Park**	**CV (pCi/g)**
Uranium-238	Range (pCi/g)	0.436–2.14	0.771–2.71	0.369–2.81	0.369–0.82	0.503–1.21	0.322–0.972	0.278–0.503	0.268–0.603	0.328–1.709	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (pCi/g)	1.23	1.65	0.991	0.584	0.758	0.606	0.413	0.366	0.607	

Source: Weston 1998

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that radionuclide.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.
Each sample is a composite of four subsamples collected from the corners of a 10x10 square established near the center of the grid.
See Figure for a map of the sampling zones.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 28. Surface soil sampling data (radionuclides) from the county road and the Cotter Uranium Mill access road

Radionuclide		Samples from background areas	Samples along the county road	Samples along the access road*	CV
Radium-226	Range (pCi/g)	0.8–2.1	3.8–14	2.7–**351**	5 pCi/g (UMTRCA, surface)
	Frequency of Detection	5/5	5/5	6/6	
	Average (pCi/g)	1.42	7.7	**65**	
Thorium-230	Range (pCi/g)	0.2–2.4	9.7–25	10–395	NA
	Frequency of Detection	3/5	5/5	6/6	
	Average (pCi/g)	1.53	20	87	
Uranium, natural	Range (ppm)	1.18–3.05	5.28–29.2	4.31–922	100 ppm (i-EMEG, child for highly soluble salts)
	Frequency of Detection	5/5	5/5	6/6	
	Average (ppm)	1.87	13.6	**161**	
Uranium-238**	Range (pCi/g)	0.39–1.01	1.74–9.64	1.42–304	NA
	Frequency of Detection	5/5	5/5	6/6	
	Average (pCi/g)	0.62	4.5	53	
Gamma Exposure Rates	Range (µR/hr)	NA	13.8–55.3	18.6–893	NA
	Frequency of Detection	NA	NA	NA	
	Average (µR/hr)	15.7	25.8	73.7	

Source: MFG 2005

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value.
Each sample consists of 10 aliquots taken from 0–6 inches within a 100 m^2 area.
See Figure for a map of the sampling locations.

*There is limited potential for exposure to contaminants along the access road since access to the Cotter Mill is restricted and soils along the access road were remediated in 2007 and 2008.
**Uranium-238 concentrations were calculated by multiplying the natural uranium concentrations by 0.33.

CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
µR/hr – microroentgen per hour
NA – not available
pCi/g – picocuries per gram
ppm – parts per million
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 29. Soil data (chemicals) from samples taken by CDPHE, January 2003

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Location of Maximum	CV (ppm)
Lead	20/20	23	410	3,651*	Private barn in Lincoln Park (dust sample)	400 (SSL)
Molybdenum	0/20	ND**	ND**	ND**	--	300 (RMEG , child)
Uranium	20/20	1.2	6.0	31	Mill Entrance Road	100 (i-EMEG, child for highly soluble salts)

Source: CDPHE 2003, 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
See Figure for a map of the sampling locations.
The sampling event was intentionally biased toward finding the highest amounts of contamination possible (CDPHE 2003).

*The second highest lead concentration is 908 ppm from a location northwest of the Cotter Mill.
**The molybdenum detection limit was 25 ppm.
§ Concentrations from the background location on the corner of Orchard Avenue and High Street were not included in the table.

CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ND – not detected
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA's soil screening level for residential areas

Concentrations from the Background Location§

Lead	36 ppm
Molybdenum	ND
Uranium	1.3 ppm

Table 30. Soil data (radionuclides) from samples taken by CDPHE, January 2003

Radionuclide	Frequency of Detection	Minimum (pCi/g)	Average (pCi/g)	Maximum (pCi/g)	Location of Maximum	CV (pCi/g)
Cesium-137	20/20	0	0.64	1.33	Private residence in Lincoln Park (dust sample)	NA
Lead-210	20/20	1.9	9.7	22.8	East of the Cotter Mill	NA
Plutonium-239, 240	9/20	0.03	0.03*	0.06	East of the Cotter Mill & a private residence in Lincoln Park (dust sample)	NA
Potassium-40	20/20	17.6	22.6	31.9	East of the Cotter Mill	NA
Radium-226	20/20	1.4	7.8	21.2	East of the Cotter Mill	15 (UMTRCA, subsurface)
Radium-228	20/20	0.6	1.0	1.3	Private barn in Lincoln Park (dust sample), private residence in Lincoln Park (dust sample), Pine St near Elm Ave in Lincoln Park (sediment sample), Northwest of the Cotter Mill	15 (UMTRCA, subsurface)

Source: CDPHE 2003, 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that radionuclide.
Averages were calculated using ½ the reporting detection limit for non-detects.
See Figure for a map of the sampling locations.
The sampling event was intentionally biased toward finding the highest amounts of contamination possible (CDPHE 2003).

* The calculated average is the same as the minimum detected concentration due to including ½ the detection limit in the calculation.
** Concentrations from the background location on the corner of Orchard Avenue and High Street were not included in the table.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Concentrations from the Background Location**

Cesium-137	0.2 pCi/g
Lead-210	3.2 pCi/g
Plutonium-239, 240	ND
Potassium-40	19.5 pCi/g
Radium-226	1.9 pCi/g
Radium-228	1.0 pCi/g

Table 31. Surface soil sampling data from 10 air monitoring locations

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Location of Maximum	Date of Maximum	Years Sampled	CV (ppm)
Molybdenum	106/134	0.6	15.1	251.3	AS-204 (West Boundary)	2002	1992–2006*	300 (RMEG, child)
Radionuclide	**Frequency of Detection**	**Minimum (pCi/g)**	**Average (pCi/g)**	**Maximum (pCi/g)**	**Location of Maximum**	**Date of Maximum**	**Years Sampled**	**CV (pCi/g)**
Radium-224**	10/10	-5.7	-2.9	0.3	Lincoln Park	2006	2006	5 (UMTRCA, surface)
Radium-226	246/251	<0.5	3.9	**53.5**	AS-209 (Mill Entrance Road)	2002	1979–2006[†]	5 (UMTRCA, surface)
Thorium-230	107/107	0.4	22.2	354	AS-209 (Mill Entrance Road)	2002	1996–2006	NA
Thorium-232	60/60	0.5	1.4	7.9	AS-209 (Mill Entrance Road)	2002	2001–2006	NA
Uranium	258/262	<0.001	4.6	73.6	AS-209 (Mill Entrance Road)	2002	1979–2006	NA

Source: Cotter 2007; GeoTrans 1986

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value.
Uranium and radium-226 were also tested in soil from two additional off-site locations (Oro Verde #1 and Oro Verde #2) in 1983 and 1984.
See Figure for a map of the air monitoring locations.

*Data from 2006 are unavailable.
**Data are blank corrected.
[†] Results from 2005 were not reported based on quality assurance analysis (Cotter 2007).

CV – comparison value
NA – not available
pCi/g – picocuries per gram
ppm – parts per million
RMEG – reference dose media evaluation guide
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 32. Soil sampling data (chemicals) from location AS-212 (the Nearest Resident)

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Date of Maximum	Years Sampled	CV (ppm)
Lead	1/1	199	199	199	15-Jan-03	2003	400 (SSL)
Molybdenum	7/8	1.6	11.3	42.4	2005	1999–2005	300 (RMEG , child)
Uranium	1/1	4.9	4.9	4.9	15-Jan-03	2003	100 (i-EMEG, child for highly soluble salts)

Source: CDPHE 2007b, Cotter 2007

Averages were calculated using ½ the reporting detection limit for non-detects.
See Figure for the location of AS-212, the nearest resident.

CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Table 33. Soil sampling data (radionuclides) from location AS-212 (the Nearest Resident)

Radionuclide	Frequency of Detection	Minimum (pCi/g)	Average (pCi/g)	Maximum (pCi/g)	Date of Maximum	Years Sampled	CV (pCi/g)
Cesium-137	1/1	0.61	0.61	0.61	15-Jan-03	2003	NA
Lead-210	1/1	8	8	8	15-Jan-03	2003	NA
Plutonium-239, 240	1/1	0.03	0.03	0.03	15-Jan-03	2003	NA
Potassium-40	1/1	17.7	17.7	17.7	15-Jan-03	2003	NA
Radium-224*	1/1	-3.6	-3.6	-3.6	2006	2006	5 (UMTRCA, surface)
Radium-226	8/8	1.4	3.3	7.5	2004	1999–2004, 2006	5 (UMTRCA, surface)
Radium-228	1/1	0.9	0.9	0.9	15-Jan-03	2003	5 (UMTRCA, surface)
Thorium-230	8/8	3.3	10.1	20	2004	1999–2006	NA
Thorium-232	6/6	0.7	1.0	1.1	2001, 2002	2001–2006	NA
Uranium	8/8	2.0	5.2	13	2004	1999–2006	NA

Source: CDPHE 2007b, Cotter 2007

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that radionuclide.
See Figure for the location of AS-212, the nearest resident.

*Data are blank corrected.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 34. Surface soil sampling data (chemicals) from lawns and gardens in Lincoln Park

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Location of Maximum	Years Sampled	CV (ppm)
Arsenic	15/15	31	**44**	**50**	garden soil	1996	0.5 (CREG), 20 (c-EMEG, child)
Beryllium	14/15	0.5	0.7	1.1	lawn soil	1996	100 (c-EMEG, child)
Cadmium	14/15	0.5	1.2	1.9	lawn soil	1996	10 (c-EMEG, child)
Manganese	15/15	290	428	640	lawn soil	1996	3,000 (RMEG , child)
Selenium	1/32	18	1.7*	18	garden soil	1990, 1996	300 (c-EMEG, child)

Source: Weston 1996 (some or all of these data may also be included in Table)

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.

* The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
ppm – parts per million
RMEG – reference dose media evaluation guide

Table 35. Surface soil sampling data (radionuclides) from yards, gardens, and air monitoring locations in Lincoln Park

Radionuclide	Frequency of Detection	Minimum (pCi/g)	Average (pCi/g)	Maximum (pCi/g)	Source of Maximum	Years Sampled	CV (pCi/g)
Lead-210	17/17	0.4	1.6	2.5	0–2” garden sample	1990	NA
Polonium-210	17/17	1.1	1.7	2.6	0–2” garden sample	1990	NA
Radium-226	19/19	0.8	1.5	2.0	0–2” garden sample	1987, 1988, 1990	5 (UMTRCA, surface)
Thorium-228	17/17	1.0	1.4	1.8	0–2” garden sample	1990	NA
Thorium-230	17/17	1.0	1.5	2.3	0–2” garden sample	1990	NA
Uranium-234	29/29	0.355	1.23	1.95	Soil from the yard of a participant in the LPWUS	1987–1990	NA
Uranium-235	0/17	ND*	ND*	ND*	--	1990	NA
Uranium-238	29/29	0.355	1.21	1.95	Soil from the yard of a participant in the LPWUS	1987–1990	NA

Source: Weston 1996

*The uranium-235 detection limit was 0.2 pCi/g.

CV – comparison value
LPWUS – Lincoln Park Water Use Survey
NA – not available
ND – not detected
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 36. Surface soil data (chemicals) from lawns and gardens in Lincoln Park

Chemical		Samples from locations irrigated with contaminated well water	Samples from locations not irrigated with contaminated well water	CV (ppm)
Arsenic	Range (ppm)	14–50	13–38	0.5 (CREG), 20 (c-EMEG, child)
	Frequency of Detection	26/26	47/47	
	Average (ppm)	36*	28*	
Beryllium	Range (ppm)	0.5–1.1	0.6–1.7	100 (c-EMEG, child)
	Frequency of Detection	25/26	47/47	
	Average (ppm)	0.7	0.8	
Cadmium	Range (ppm)	0.6–1.9	0.5–5	10 (c-EMEG, child)
	Frequency of Detection	23/26	45/47	
	Average (ppm)	1.2	1.5**	
Lead	Range (ppm)	17–270[†]		400 (SSL)
	Frequency of Detection	73/73[†]		
	Average (ppm)	122	121	
Manganese	Range (ppm)	290–640	320–580	3,000 (RMEG , child)
	Frequency of Detection	26/26	47/47	
	Average (ppm)	430	421**	
Molybdenum	Range (ppm)	*Data not available*[§]	*Data not available*[§]	300 (RMEG , child)
	Frequency of Detection	*Data not available*[§]	*Data not available*[§]	
	Average (ppm)	1.7*	0.5*	
Selenium	Range (ppm)	18	5–44	300 (c-EMEG, child)
	Frequency of Detection	1/26	6/47	
	Average (ppm)	3.1	3.8	
Uranium	Range (ppm)	*Data not available*[§]	*Data not available*[§]	100 (i-EMEG, child for highly soluble salts)
	Frequency of Detection	*Data not available*[§]	*Data not available*[§]	
	Average (ppm)	2.3*	1.6*	

Source: Weston 1998

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.

*The concentrations were statistically higher in irrigated soil samples.
**The calculated averages for cadmium and manganese differ slightly from the reported mean concentrations in Table 3-3.
[†] The raw data for lead are not presented by whether the samples were taken from locations irrigated with contaminated well water. However, Table 3-3 presents the mean concentrations by manner of irrigation.
[§] The raw data for molybdenum and uranium are not presented in the report. Therefore, the range and frequency of detection could not be determined. Table 3-3 presents the mean concentrations.

c-EMEG – chronic environmental media evaluation guide	ppm – parts per million
CREG – cancer risk evaluation guide	RMEG – reference dose media evaluation guide
CV – comparison value	SSL – EPA's soil screening level for residential areas
i-EMEG – intermediate environmental media evaluation guide	

Table 37. Surface soil data (radionuclides) from lawns and gardens in Lincoln Park

Radionuclide		Samples from locations irrigated with contaminated well water	Samples from locations not irrigated with contaminated well water	CV (pCi/g)
Lead-210	Range (pCi/g)	0.8–3.0	0.7–4.2	NA
	Frequency of Detection	11/11	47/47	
	Average (pCi/g)	2.2	2.1*	
Radium-226	Range (pCi/g)	1.3–1.7	1.1–2.2	5 (UMTRCA, surface)
	Frequency of Detection	11/11	47/47	
	Average (pCi/g)	1.4	1.5	
Thorium-230	Range (pCi/g)	1.1–2.2	1.0–4.2	NA
	Frequency of Detection	11/11	47/47	
	Average (pCi/g)	1.6*	1.7	
Uranium, natural	Range (pCi/g)	0.871–3.417	0.6566–2.077	NA
	Frequency of Detection	26/26	47/47	
	Average (pCi/g)	1.514	1.05	
Uranium-234	Range (pCi/g)	0.436–1.709	0.328–1.039	NA
	Frequency of Detection	26/26	47/47	
	Average (pCi/g)	0.755	0.525	
Uranium-238	Range (pCi/g)	0.436–1.709	0.328–1.039	NA
	Frequency of Detection	26/26	47/47	
	Average (pCi/g)	0.755	0.525	

Source: Weston 1998

The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.

*The calculated averages for lead-210 and thorium-230 differ slightly from the reported mean concentrations in Table 3-3.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 38. Sediment sampling data (chemicals) from Sand Creek

Chemical	Location Concentration (ppm)						CV (ppm)
	SD01	SD02*	SD04			SD05	
			1	2	3		
Arsenic	NA	13.7	13	NA	17	<5	20 (c-EMEG, child)
Cadmium	NA	3.9	7.2	NA	7.6	1.5	10 (c-EMEG, child)
Cobalt	NA	11.3	43	NA	21	10	500 (i-EMEG, child)
Copper	19	52.3	46	NA	38	19	500 (i-EMEG, child)
Lead	27	106	93	NA	130	22	400 (SSL)
Molybdenum	4.4	2.6	8	NA	7.9	9.4	300 (RMEG , child)
Nickel	NA	17	63	NA	28	18	1,000 (RMEG, child)
Zinc	NA	343	540	NA	580	106	20,000 (c-EMEG, child)

Source: GeoTrans 1986

SD01 – mouth near the Arkansas River
SD02 – near spring where flow begins (reflects migration of contaminants in the groundwater)
SD04 – below the SCS Dam in
  (1) an abandoned stock watering pond (formed by diversion of runoff water into a depression adjacent to Sand Creek)
  (2) in drainage (reflects historical picture of uncontrolled emissions)
  (3) in drainage above #2 (reflects historical picture of uncontrolled emissions)
SD05 – above the SCS Dam adjacent to the west property edge

Bolded text indicates that the concentration exceeded the comparison value for that chemical.
Samples were collected July 10–20, 1985.

*Values are the mean of three field replicates.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA's soil screening level for residential areas

Table 39. Sediment sampling data (radionuclides) from Sand Creek

Radionuclide	Location Average (pCi/g)						CV
	SD01	SD02	SD04			SD05	
			1	2	3		
Gross Alpha	22±3	47±9	240±40	74±9	39±7	22±5	NA
Gross Beta	29±6	43±8	90±20	34±7	32±7	32±6	NA
Radium-226	1.21±0.06	1.7±1	**12.8±0.6**	3.5±0.2	3.4±0.2	2.3±1	5 (UMTRCA, surface)
Throium-230	4.6±0.3	34±2	82±4	32±2	15.5±0.8	5.2±0.3	NA
Total Uranium	2.4	4.3	11.7	3.4	3.4	3.9	NA

Source: GeoTrans 1986

SD01 – mouth near the Arkansas River
SD02 – near spring where flow begins (reflects migration of contaminants in the groundwater)
SD04 – below the SCS Dam in
(1) an abandoned stock watering pond (formed by diversion of runoff water into a depression adjacent to Sand Creek)
(2) in drainage (reflects historical picture of uncontrolled emissions)
(3) in drainage above #2 (reflects historical picture of uncontrolled emissions)
SD05 – above the SCS Dam adjacent to the west property edge

Bolded text indicates that the concentration exceeded the comparison value for that radionuclide.
Samples were collected July 10–20, 1985.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 40. Chemical sampling for the Sand Creek Cleanup Project

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	CV (ppm)
Arsenic	7/7	2.7	3.9	6.9	20 (c-EMEG, child)
Barium	7/7	69	106	160	10,000 (c-EMEG, child)
Beryllium	7/7	0.2	0.3	0.6	100 (c-EMEG, child)
Chromium	7/7	7.4	9.5	12.8	200 (RMEG, child for hexavalent chromium)
Lead	7/7	17	35	75	400 (SSL)
Manganese	7/7	258	343	502	3,000 (RMEG , child)
Molybdenum	7/7	2.1	2.8	3.5	300 (RMEG , child)
Nickel	7/7	8	10.9	16	1,000 (RMEG , child)
Selenium	0/7	ND*	ND*	ND*	300 (c-EMEG, child)
Vanadium	7/7	16.1	20.3	26.1	200 (i-EMEG, child)

Source: Cotter 2000

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Samples were collected in April and May 1998.

*The selenium detection limit was 5 ppm.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ND – not detected
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Table 41. Surface water sampling data (chemicals) from Sand Creek

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	0/2	ND	ND	ND	--	10 (c-EMEG, child)	1988
Ammonia	N	2/35	0.5	0.43*	0.8	10-Nov-88	30 (LTHA)	1988–1994
Ammonium	T	0/3	ND	ND	ND	--	NA	1995
Chloride	N/T**	92/92	3	8	14	13-May-04	250 (Secondary MCL)	1986–2007
Iron	D	21/55	0.03	0.04	0.26	07-Nov-02	26 (RBC)	1986–1988, 1995–2007
Manganese	D	36/55	0.0084	0.04	**1.3**†	19-Nov-01	0.5 (RMEG, child)	1986–1988, 1995–2007
Molybdenum	D	98/104	0.005	0.02	**0.051**†	01-Dec-87	0.035 (SS); 0.05 (RMEG, child)	1986–2007
Nitrate	N/T**	75/87	0.5	1.1	4.7	03-May-06	10 (MCL)	1988–2007
Selenium	D	0/8	ND	ND	ND	--	0.05 (c-EMEG, child)	1986–1988
Sulfate	N/T**	94/94	12	65	**310**†	11-Oct-96	250 (Secondary MCL)	1986–2007
Total Dissolved Solids	N/T**	99/99	10.7	369	**1,372**‡	22-Aug-91	500 (Secondary MCL)	1986–2007
Uranium	D	101/101	0.006	0.012	0.0267	01-Aug-95	0.03 (MCL)	1986–2007
	S	8/48	0.000098	0.001	0.0031	10-Jan-00		1995–2007

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
† Only the maximum concentration was above the CV.
‡ This appears to be an outlier. The next highest concentration is 460 mg/L. Only the maximum concentration was above the CV.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 42. Surface water sampling data (radionuclides) from Sand Creek

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Date of Maximum	CV (pCi/L)	Years Sampled
Lead-210	D	40/49	-0.2	0.39	3.7	06-Aug-07	NA	1995–2007
	S	40/49	-0.1	0.40	4.6	06-Aug-07		1995–2007
Polonium-210	D	41/49	-0.1	0.15	0.6	28-Nov-06	NA	1995–2007
	S	40/49	0	0.13	1.6	09-Nov-99		1995–2007
Radium-226	D	45/49	0	0.12	0.6	03-May-06	5 (MCL radium-226/228)	1995–2007
	S	42/47	0	0.06	0.4	09-Nov-99, 28-Nov-06		1995–2007
Thorium-230	D	44/49	-0.1	0.13	0.8	28-Nov-06	NA	1995–2007
	S	41/46	0	0.16	0.9	06-Aug-07		1995–2007

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended

Table 43. Surface water sampling data (chemicals) from the DeWeese Dye Ditch

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	1/4	0.02	0.06*	0.02	14-Jun-95	10 (c-EMEG, child)	1981, 1995
Ammonia	N	0/2	ND	ND	ND	--	30 (LTHA)	1989, 1995
Chloride	N/T**	95/102	2	7	18	08-May-01	250 (Secondary MCL)	1981–1989, 1995–2007
Iron	D	22/50	0.029	0.9	**43**[†]	09-Jun-99	26 (RBC)	1981–1987, 1995–2007
Manganese	D	28/50	0.004	0.05	**1.9**[‡]	09-Jun-99	0.5 (RMEG, child)	1981–1987, 1995–2007
Molybdenum	D	10/120	0.001	0.013[§]	0.013	06-Aug-03	0.035 (SS); 0.05 (RMEG, child)	1981–2007
Nitrate	N/T**	7/26	0.1	0.3	0.8	10-May-00, 02-Aug-06	10 (MCL)	1989, 1995–2007
Selenium	D	4/76	0.005	0.003[††]	0.011	22-Jun-87, 25-Apr-88	0.05 (c-EMEG, child)	1981–1988, 1995
Sulfate	N/T**	102/102	6	31	95	28-Apr-82	250 (Secondary MCL)	1981–1989, 1995–2007
Total Dissolved Solids	N/T**	119/119	12.9	231	**1,647**[‡‡]	10-Sep-90	500 (Secondary MCL)	1981–2007
Uranium	D	86/116	0.0004	0.01	**0.11**[§§]	05-May-83	0.03 (MCL)	1981–2007
	S	0/8	ND	ND	ND	--		1996–1999

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.

* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
[†] This appears to be an outlier. The next highest concentration is 0.24 mg/L from the same location in 2003. Only the maximum concentration was above the CV.
[‡] Only the maximum concentration was above the CV.
[§] The calculated average is the same as the maximum detected concentration due to including ½ the detection limit in the calculation.

[††] The calculated average is the lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
[‡‡] This appears to be an outlier. The next highest concentration is 870 mg/L. Only three of the 119 samples were above the CV.
[§§] Only three of the samples were above the CV.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 44. Surface water sampling data (radionuclides) from the DeWeese Dye Ditch

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Date of Maximum	CV (pCi/L)	Years Sampled
Lead-210	D	8/8	0	0.3	1.2	09-May-96	NA	1996–1999
	S	8/8	0	0.09	0.2	12-May-97		1996–1999
Polonium-210	D	8/8	0	0.1	0.2	09-Jun-99, 02-Sep-99	NA	1996–1999
	S	8/8	0	0.05	0.2	09-Jun-99		1996–1999
Radium-226	D	8/8	0	0.04	0.1	09-May-96, 16-Jul-96, 02-Sep-99	5 (MCL radium-226/228)	1996–1999
	S	7/7	0	0.01	0.1	02-Sep-99		1996–1999
Thorium-230	D	8/8	0	0.025	0.2	12-May-97	NA	1996–1999
	S	7/7	0	0.07	0.2	09-Sep-98		1996–1999

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended

Table 45. Surface water sampling data (chemicals) from the Arkansas River

Chemical	Type		Upstream of Sand Creek at 1st Street (907)	Downstream of Sand Creek at Mackenzie Ave (904)	CV (mg/L)
Chloride	T	Range (mg/L)	3–60	3–14	250 (Secondary MCL)
		Frequency of Detection	127/130	127/130	
		Average (mg/L)	8	8	
Molybdenum	D	Range (mg/L)	0.0029–**0.046**	0.003–0.029	0.035 (SS); 0.05 (RMEG, child)
		Frequency of Detection	32/142	46/142	
		Average (mg/L)	0.025	0.025	
Molybdenum	S	Range (mg/L)	0.0019–0.022	0.0017–0.016	0.035 (SS); 0.05 (RMEG, child)
		Frequency of Detection	8/135	6/135	
		Average (mg/L)	0.025	0.025	
Molybdenum	T	Range (mg/L)	0.006	0.005	0.035 (SS); 0.05 (RMEG, child)
		Frequency of Detection	1/7	1/7	
		Average (mg/L)	0.003*	0.003*	
Sulfate	T	Range (mg/L)	10–1,300**	5–4,200**	250 (Secondary MCL)
		Frequency of Detection	130/130	130/130	
		Average (mg/L)	41	84	
Total Dissolved Solids	T	Range (mg/L)	**45–2,880**[†]	62–337	500 (Secondary MCL)
		Frequency of Detection	130/130	130/130	
		Average (mg/L)	172	192	
Uranium	D	Range (mg/L)	0.0003– 0.0135	0.0002–0.0155	0.03 (MCL)
		Frequency of Detection	129/130	130/130	
		Average (mg/L)	0.004	0.005	
Uranium	S	Range (mg/L)	0.0002– 0.014	0.0002–0.0043	0.03 (MCL)
		Frequency of Detection	16/121	14/121	
		Average (mg/L)	0.001	0.001	
Uranium	T	Range (mg/L)	0.0033–0.0056	0.0029–0.0054	0.03 (MCL)
		Frequency of Detection	7/7	7/7	
		Average (mg/L)	0.004	0.004	

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
All samples were collected between 1995 and 2007. The "T" samples for uranium were only collected in 1995.
* The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
** This appears to be an outlier. The next highest concentration is 200 mg/L. Only the maximum concentration was above the CV.
[†] This appears to be an outlier. The next highest concentration is 405 mg/L. Only the maximum concentration was above the CV.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
mg/L – milligrams per liter
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 46. Surface water sampling data (radionuclides) from the Arkansas River

Radionuclide	Type		Upstream of Sand Creek at 1st Street (907)	Downstream of Sand Creek at Mackenzie Ave (904)	CV (pCi/L)
Lead-210	D	Range (pCi/L)	ND	3.7	NA
		Frequency of Detection	0/1	1/1	
		Average (pCi/L)	ND	3.7	
Lead-210	S	Range (pCi/L)	ND	0	NA
		Frequency of Detection	0/1	1/2	
		Average (pCi/L)	ND	0.25*	
Polonium-210	D	Range (pCi/L)	ND	ND	NA
		Frequency of Detection	0/1	0/1	
		Average (pCi/L)	ND	ND	
Polonium-210	S	Range (pCi/L)	ND	0.26–3.3	NA
		Frequency of Detection	0/1	2/2	
		Average (pCi/L)	ND	1.8	
Radium-226	D	Range (pCi/L)	0–0.6	0–0.4	5 (MCL radium-226/228)
		Frequency of Detection	119/128	116/127	
		Average (pCi/L)	0.13	0.07	
Radium-226	S	Range (pCi/L)	0–0.8	0–2.3	5 (MCL radium-226/228)
		Frequency of Detection	114/120	112/119	
		Average (pCi/L)	0.08	0.09	
Radium-226	T	Range (pCi/L)	0.1–0.7	0.1–0.7	5 (MCL radium-226/228)
		Frequency of Detection	7/7	7/7	
		Average (pCi/L)	0.3	0.3	
Thorium-230	D	Range (pCi/L)	-0.1–1	-0.1–1.2	NA
		Frequency of Detection	121/127	116/127	
		Average (pCi/L)	0.1	0.1	
Thorium-230	S	Range (pCi/L)	0–2.5	0–2.4	NA
		Frequency of Detection	115/120	113/119	
		Average (pCi/L)	0.2	0.2	
Thorium-230	T	Range (pCi/L)	0.1–0.7	0–0.6	NA
		Frequency of Detection	7/7	7/7	
		Average (pCi/L)	0.3	0.2	

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
Radium-226 and thorium-230 "D" and "S" samples were collected between 1995 and 2007. The radium-226 and thorium-230 "T" samples were only collected in 1995. Lead-210 and polonium-210 were sampled upstream (907) in 2005 ("D" and "S") and downstream (904) in 2005 ("D") and 2006 ("D" and "S").

* The calculated average is higher than the detected concentration due to including ½ the detection limit in the calculation.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
ND – not detected
pCi/L – picocuries per liter
S – suspended
T – total

Table 47. Sampling data (chemicals) for local and supermarket foods

Chemical	Food Type	Average (mg/kg)	
		Local	Supermarket
Barium*	Vegetables	4.75	NA
Cadmium*	Vegetables	0.215	NA
Chromium*	Vegetables	0.095	NA
Manganese*	Vegetables	11.25	NA
Molybdenum	Chicken	0.19	0.72
	Fruits	0.079	0.017
	Vegetables	0.667	0.023
Selenium	Chicken	0.31	0.18
	Fruits	0.024	0.017
	Vegetables	0.061	0.020
Strontium*	Vegetables	22	NA
Uranium	Chicken	0.061	0.001
	Fruits	0.0056	0.0013
	Vegetables	0.0043	0.0013
Vanadium*	Vegetables	0.105	NA
Zinc*	Vegetables	7.5	NA

Source: Weston 1996

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.
Vegetables were also tested for arsenic, beryllium, cobalt, lead, mercury, nickel, and silver, but none of these chemicals were detected.

*Chicken and fruits were not analyzed for these chemicals.

NA – not available
mg/kg – milligrams per kilogram

Table 48. Sampling data (radionuclides) for local and supermarket foods

Radionuclide	Food Type	Average (pCi/kg)	
		Local	Supermarket
Lead-210	Chicken	1.26	1.70
	Fruits	1.48	1.18
	Vegetables	0.58	0.60
Polonium-210	Chicken	3.79	21.75
	Fruits	2.26	1.30
	Vegetables	1.13	1.56
Radium-226	Chicken	0.64	2.60
	Fruits	1.34	0.05
	Vegetables	1.37	0.07
Thorium-228	Chicken	0.39	ND
	Fruits	0.33	ND
	Vegetables	0.41	1.42
Thorium-230	Chicken	1.01	0.53
	Fruits	1.85	ND
	Vegetables	0.27	0.29
Uranium-234	Chicken	1.10	1.05
	Fruits	1.53	0.34
	Vegetables	0.55	0.76
Uranium-235	Chicken	ND	0.36
	Fruits	0.13	0.13
	Vegetables	0.13	0.14
Uranium-238	Chicken	1.59	0.53
	Fruits	1.41	0.23
	Vegetables	0.44	0.25

Source: Weston 1996

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.

ND – not detected
pCi/kg – picocuries per kilogram

Table 49. Sampling data (chemicals) for local produce irrigated with contaminated well water

Chemical		Fruits	Vegetables
Arsenic	Frequency of Detection	2/16	14/43
	Average (mg/kg)	0.051	0.077
	Maximum (mg/kg)	0.2	0.4
Barium	Frequency of Detection	7/16	33/43
	Average (mg/kg)	0.44	1.6
	Maximum (mg/kg)	0.9	15
Cadmium	Frequency of Detection	2/16	18/43
	Average (mg/kg)	0.041	0.034
	Maximum (mg/kg)	0.23	0.14
Chromium	Frequency of Detection	12/16	39/43
	Average (mg/kg)	0.052	0.056
	Maximum (mg/kg)	0.1	0.19
Cobalt	Frequency of Detection	0/16	6/43
	Average (mg/kg)	ND	0.02
	Maximum (mg/kg)	ND	0.07
Lead	Frequency of Detection	3/16	26/43
	Average (mg/kg)	0.13	0.2
	Maximum (mg/kg)	1.2	1.9
Manganese	Frequency of Detection	16/16	43/43
	Average (mg/kg)	0.87	2.4
	Maximum (mg/kg)	1.8	11
Molybdenum	Frequency of Detection	6/16	41/43
	Average (mg/kg)	0.11	0.68
	Maximum (mg/kg)	0.3	9.8
Nickel	Frequency of Detection	0/16	2/43
	Average (mg/kg)	ND	0.075
	Maximum (mg/kg)	ND	0.2
Strontium	Frequency of Detection	16/16	43/43
	Average (mg/kg)	1.6	4.9
	Maximum (mg/kg)	8.5	33
Uranium	Frequency of Detection	3/16	14/43
	Average (mg/kg)	0.0074	0.0071
	Maximum (mg/kg)	0.035	0.041
Vanadium	Frequency of Detection	0/16	16/43
	Average (mg/kg)	ND	0.046
	Maximum (mg/kg)	ND	0.21

Chemical		**Fruits**	**Vegetables**
Zinc	Frequency of Detection	16/16	43/43
	Average (mg/kg)	1.4	3.1
	Maximum (mg/kg)	4.0	10

Source: Weston 1998

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.

ND – not detected
mg/kg – milligrams per kilogram

Table 50. Sampling data (radionuclides) for local produce irrigated with contaminated well water

Radionuclide		Fruits	Vegetables
Lead-210	Frequency of Detection	3/16	8/43
	Average (pCi/kg)	12	21
	Maximum (pCi/kg)	21	51
Radium-226	Frequency of Detection	1/16	15/43
	Average (pCi/kg)	5.7	6.2
	Maximum (pCi/kg)	18	41
Thorium-230	Frequency of Detection	1/16	8/43
	Average (pCi/kg)	3.9	5.1
	Maximum (pCi/kg)	10	20
Uranium (natural)	Frequency of Detection	3/16	14/43
	Average (pCi/kg)	5.0	4.8
	Maximum (pCi/kg)	23	27

Source: Weston 1998

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.
pCi/kg – picocuries per kilogram

Table 51. Characteristics of Cotter Mill's Ambient Air Monitoring Stations

Monitor Code	*Monitor Location*	*Years of Operation*	*Monitor Type*	*Area Description*
AS-202	East Boundary	1979 – present	Perimeter	Eastern perimeter of Cotter Mill facility
AS-203	South Boundary	1979 – present	Perimeter	Southern perimeter of Cotter Mill facility
AS-204	West Boundary	1979 – present	Perimeter	Western perimeter of Cotter Mill facility
AS-206	North Boundary	1981 – present	Perimeter	Northern perimeter of Cotter Mill facility
AS-209	Mill entrance road	1994 – present	Perimeter	Entrance road to Cotter Mill
AS-210	Shadow Hills Estates	1997 – present	Off-site	Near Shadow Hills Golf Club
AS-212	Nearest resident	1999 – present	Off-site	Residential
LP-1/LP-2	Lincoln Park	1980 – present	Off-site	Residential
CC-1/CC-2	Cañon City	1979 – present	Off-site	Residential
OV-3	Oro Verde	1981 – present	Off-site	Remote (1 mile west of AS-204)

Notes: Both the Lincoln Park and Cañon City monitoring stations moved locations in the 1991-1992 time frame. The original station in Lincoln Park (LP-1) operated from 1980 to 1992, and the new station (LP-2) operated from 1991 to the present. The original station in Cañon City (CC-1) operated from 1979 to 1992, and the new station (CC-2) operated from 1991 to the present.

Table 52. Average Annual ^{nat}U Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	6.19E-15	1.50E-15	2.26E-15	--	--	--	--	--	1.00E-15	--
1980	3.71E-15	1.55E-15	2.82E-15	--	--	--	--	8.36E-16	1.40E-15	--
1981	4.07E-15	1.54E-15	5.28E-15	8.30E-15	--	--	--	1.03E-15	1.02E-15	1.37E-15
1982	2.31E-15	1.26E-15	2.48E-14	2.79E-15	--	--	--	5.28E-16	4.79E-16	5.96E-16
1983	1.26E-15	1.43E-15	1.32E-15	1.63E-15	--	--	--	4.77E-16	6.86E-16	5.03E-16
1984	5.50E-16	7.64E-16	8.36E-16	1.52E-15	--	--	--	2.78E-16	3.27E-16	4.01E-16
1985	1.42E-15	1.22E-15	8.96E-16	1.92E-15	--	--	--	4.56E-16	5.77E-16	6.66E-16
1986	6.71E-16	6.56E-16	4.05E-16	9.36E-16	--	--	--	2.95E-16	2.93E-16	4.84E-16
1987	8.08E-16	1.03E-15	1.09E-15	1.05E-15	--	--	--	4.66E-16	5.12E-16	4.60E-16
1988	6.73E-16	6.96E-16	9.03E-16	5.51E-16	--	--	--	1.85E-16	1.95E-16	1.89E-16
1989	9.58E-17	9.95E-17	2.86E-16	3.62E-17	--	--	--	8.37E-17	9.38E-17	6.38E-17
1990	5.59E-17	3.14E-17	1.06E-16	3.10E-17	--	--	--	6.18E-17	1.26E-16	9.09E-17
1991	1.12E-16	9.18E-17	2.65E-16	1.24E-16	--	--	--	1.70E-16	1.73E-16	2.60E-16
1992	6.55E-17	7.84E-17	1.12E-16	6.48E-17	--	--	--	9.71E-17	9.40E-17	8.23E-17
1993	7.13E-17	9.08E-17	1.61E-16	6.30E-17	--	--	--	8.26E-17	1.20E-16	2.55E-16
1994	1.25E-16	4.68E-17	1.00E-16	3.68E-17	1.55E-16	--	--	9.68E-17	8.12E-17	2.54E-16
1995	2.99E-16	5.86E-17	1.53E-16	5.23E-17	2.11E-16	--	--	9.34E-17	1.26E-16	4.83E-16
1996	2.25E-16	1.43E-16	2.26E-16	8.62E-17	2.44E-16	7.89E-17	--	9.73E-17	1.25E-16	5.93E-17
1997	1.23E-16	1.18E-16	2.20E-16	1.19E-16	1.51E-16	1.75E-16	--	1.27E-16	2.00E-16	9.48E-17
1998	1.32E-16	1.02E-16	3.29E-16	1.06E-16	2.27E-15	2.32E-16	--	8.13E-17	7.50E-17	2.43E-16
1999	4.06E-16	1.49E-16	2.91E-16	3.23E-16	1.46E-15	2.82E-16	4.59E-16	1.16E-16	9.41E-17	7.97E-17
2000	4.33E-16	2.04E-16	2.61E-16	1.63E-16	1.49E-15	1.89E-16	4.82E-16	5.39E-17	5.33E-17	5.39E-17
2001	4.96E-16	6.19E-16	4.96E-16	5.29E-16	1.32E-15	2.06E-16	2.88E-16	4.96E-17	3.80E-17	5.18E-17
2002	6.50E-16	4.93E-16	6.21E-16	3.24E-16	9.91E-16	3.69E-16	4.05E-16	2.46E-16	1.59E-16	2.05E-16
2003	3.55E-16	2.19E-16	2.55E-16	2.01E-16	4.91E-16	2.21E-16	2.20E-16	2.11E-16	2.07E-16	2.62E-16
2004	2.51E-16	1.95E-16	2.40E-16	1.99E-16	6.27E-16	1.40E-16	2.30E-16	9.69E-17	9.68E-17	8.61E-17
2005	4.54E-16	2.77E-16	2.87E-16	1.58E-16	3.97E-15	4.85E-16	5.25E-16	1.68E-16	1.29E-16	1.23E-16
2006	5.14E-16	2.68E-16	3.24E-16	2.12E-16	1.72E-15	6.62E-16	3.40E-16	2.20E-16	1.75E-16	1.87E-16
2007	3.56E-16	1.51E-16	2.03E-16	1.39E-16	3.13E-16	1.46E-16	1.33E-16	1.41E-16	1.43E-16	1.27E-16
2008	4.36E-16	8.61E-17	1.72E-16	8.44E-17	2.17E-16	9.77E-17	9.78E-17	9.02E-17	8.97E-17	6.43E-17

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2.

For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2.

Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating.

Table 53. Average Annual ^{230}Th Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	2.33E-15	1.05E-15	8.08E-15	--	--	--	--	--	3.07E-16	--
1980	2.50E-16	8.76E-16	2.81E-16	--	--	--	--	8.17E-17	1.30E-16	--
1981	2.60E-15	3.50E-15	3.00E-14	6.93E-15	--	--	--	1.42E-16	8.17E-17	3.92E-16
1982	2.12E-14	1.94E-14	8.95E-14	1.26E-14	--	--	--	7.49E-16	9.18E-16	3.15E-15
1983	5.86E-15	9.79E-15	5.64E-15	8.26E-15	--	--	--	3.74E-16	3.12E-16	1.07E-15
1984	1.64E-15	2.98E-15	3.82E-15	6.35E-15	--	--	--	2.69E-16	2.00E-16	2.89E-16
1985	1.84E-15	2.15E-15	4.86E-15	3.73E-15	--	--	--	2.60E-16	2.64E-16	2.84E-16
1986	3.70E-15	5.55E-15	3.13E-15	4.68E-15	--	--	--	3.70E-16	3.08E-16	2.41E-16
1987	1.21E-15	1.29E-15	2.28E-15	1.08E-15	--	--	--	2.06E-16	1.77E-16	9.90E-17
1988	2.58E-15	3.51E-15	5.85E-15	2.05E-15	--	--	--	1.41E-16	1.72E-16	1.70E-16
1989	6.33E-16	3.85E-16	9.17E-16	1.08E-16	--	--	--	8.93E-17	9.03E-17	9.24E-17
1990	7.63E-16	4.00E-16	5.86E-16	1.09E-16	--	--	--	7.40E-17	7.04E-17	7.20E-17
1991	7.25E-16	4.59E-16	8.75E-16	2.83E-16	--	--	--	1.91E-16	1.25E-16	1.33E-16
1992	4.57E-16	2.20E-16	4.71E-16	9.46E-17	--	--	--	6.58E-17	5.98E-17	9.56E-17
1993	4.45E-16	3.03E-16	6.42E-16	9.32E-17	--	--	--	1.06E-16	9.17E-17	2.33E-16
1994	1.18E-15	2.96E-16	1.08E-15	1.24E-16	9.20E-16	--	--	1.54E-16	1.16E-16	2.83E-16
1995	1.65E-15	5.33E-16	1.24E-15	1.18E-16	8.88E-16	--	--	9.80E-17	1.12E-16	3.30E-16
1996	2.21E-15	2.95E-16	8.13E-16	8.85E-17	7.67E-16	2.33E-16	--	7.11E-17	5.08E-17	6.39E-17
1997	7.64E-16	1.31E-16	6.17E-16	6.49E-17	1.99E-15	3.82E-16	--	8.37E-17	7.86E-17	3.24E-17
1998	2.88E-15	2.02E-16	9.34E-16	1.15E-16	2.17E-15	3.32E-16	--	7.70E-17	7.99E-17	7.82E-17
1999	3.76E-15	3.24E-16	1.09E-15	1.84E-16	2.19E-15	4.15E-16	3.02E-16	7.37E-17	9.51E-17	1.11E-16
2000	1.22E-15	2.48E-16	1.01E-15	2.02E-16	4.16E-15	4.71E-16	6.69E-16	1.47E-16	1.57E-16	1.27E-16
2001	8.20E-16	5.19E-16	9.67E-16	2.61E-16	4.15E-15	4.04E-16	4.61E-16	1.56E-16	9.95E-17	1.13E-16
2002	5.84E-16	2.76E-16	5.95E-16	2.57E-16	1.25E-15	2.38E-16	3.13E-16	8.15E-17	8.54E-17	8.55E-17
2003	5.19E-16	2.62E-16	4.90E-16	9.73E-17	1.40E-15	4.11E-16	1.77E-16	8.27E-17	8.91E-17	5.30E-17
2004	2.17E-16	8.26E-17	3.87E-16	8.33E-17	6.57E-16	2.26E-16	1.08E-16	5.36E-17	5.62E-17	6.07E-17
2005	3.17E-16	1.97E-16	3.51E-16	2.64E-16	3.41E-15	4.85E-16	4.81E-16	1.04E-16	1.05E-16	1.08E-16
2006	5.17E-16	2.91E-16	4.74E-16	1.77E-16	1.40E-15	4.73E-16	3.27E-16	2.73E-16	2.04E-16	2.85E-16
2007	6.62E-16	1.90E-16	4.32E-16	1.48E-16	1.05E-15	2.77E-16	2.23E-16	1.68E-16	1.57E-16	1.53E-16
2008	7.21E-16	1.87E-16	5.12E-16	1.32E-16	6.21E-16	2.88E-16	2.05E-16	1.11E-16	1.08E-16	1.16E-16

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2. For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2.

Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating; bold cells are concentrations above Cotter Mill's regulatory limit

Table 54. Average Annual ^{232}Th Concentrations 2001-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP #2	CC #2	OV-3
2001	5.78E-17	7.62E-17	6.97E-17	6.37E-17	8.32E-17	4.58E-17	6.67E-17	6.85E-17	8.33E-17	5.68E-17
2002	4.67E-17	3.81E-17	3.09E-17	4.55E-17	4.34E-17	3.17E-17	3.35E-17	5.36E-17	3.51E-17	4.68E-17
2003	4.57E-17	4.14E-17	4.84E-17	2.06E-17	5.72E-17	4.61E-17	3.71E-17	6.21E-17	4.61E-17	3.96E-17
2004	1.39E-17	2.53E-17	2.53E-17	1.40E-17	1.57E-17	1.99E-17	1.65E-17	3.24E-17	2.28E-17	2.39E-17
2005	2.83E-17	2.40E-17	2.86E-17	3.09E-17	3.36E-17	2.53E-17	3.42E-17	3.99E-17	3.57E-17	3.45E-17
2006	4.11E-17	5.18E-17	4.82E-17	4.29E-17	5.54E-17	4.33E-17	4.79E-17	6.25E-17	4.98E-17	3.65E-17
2007	4.07E-17	3.47E-17	4.60E-17	4.14E-17	4.12E-17	3.99E-17	3.51E-17	5.43E-17	4.48E-17	3.92E-17
2008	1.08E-17	1.63E-17	1.15E-17	9.89E-18	1.57E-17	2.30E-17	1.26E-17	3.13E-17	2.25E-17	2.03E-17

Note: Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating

Table 55. Average Annual ^{226}Ra Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	1.55E-15	3.75E-16	7.89E-15	--	--	--	--	--	3.07E-16	--
1980	3.61E-15	7.81E-16	1.62E-15	--	--	--	--	2.78E-16	1.58E-15	--
1981	4.19E-15	2.35E-15	2.94E-15	2.96E-15	--	--	--	3.79E-16	4.59E-16	6.30E-16
1982	6.53E-15	6.92E-15	3.81E-15	3.82E-15	--	--	--	6.07E-16	4.02E-16	1.25E-15
1983	2.00E-15	5.08E-15	4.95E-15	2.85E-15	--	--	--	9.42E-17	1.76E-16	5.30E-16
1984	1.11E-15	1.84E-15	3.63E-15	2.20E-15	--	--	--	1.18E-16	1.67E-16	1.87E-16
1985	9.63E-15	1.11E-15	1.78E-15	1.97E-15	--	--	--	1.69E-16	1.88E-16	1.89E-16
1986	1.47E-15	1.98E-15	1.61E-15	2.60E-15	--	--	--	1.43E-16	3.45E-16	2.22E-16
1987	5.91E-16	7.52E-16	1.19E-15	4.74E-16	--	--	--	1.83E-16	1.15E-16	1.89E-16
1988	1.29E-15	2.05E-15	2.53E-15	3.60E-16	--	--	--	1.24E-16	5.09E-17	1.09E-16
1989	2.72E-16	1.81E-16	3.30E-16	4.79E-17	--	--	--	1.02E-16	8.89E-17	7.77E-17
1990	1.75E-16	1.68E-16	1.92E-16	4.36E-17	--	--	--	6.69E-17	8.36E-17	7.82E-17
1991	1.19E-16	1.25E-16	2.68E-16	6.17E-17	--	--	--	6.85E-17	7.16E-17	1.37E-16
1992	8.46E-17	7.30E-17	1.50E-15	3.71E-17	--	--	--	5.10E-17	5.80E-17	1.17E-16
1993	9.11E-17	1.14E-16	2.49E-16	5.99E-17	--	--	--	6.14E-17	6.72E-17	2.20E-16
1994	1.03E-16	7.57E-17	1.69E-16	4.96E-17	1.55E-16	--	--	7.80E-17	8.68E-17	2.64E-16
1995	1.21E-16	1.14E-16	2.07E-16	7.46E-17	2.06E-16	--	--	6.88E-17	1.05E-16	3.99E-16
1996	1.78E-16	1.02E-16	2.08E-16	5.33E-17	2.11E-16	5.82E-17	--	5.22E-17	6.67E-17	3.59E-17
1997	1.29E-16	7.55E-17	2.01E-16	5.66E-17	9.45E-16	1.06E-16	--	5.09E-17	5.40E-17	4.84E-17
1998	2.89E-16	8.22E-17	2.95E-16	9.43E-17	1.34E-15	1.21E-16	--	6.21E-17	6.71E-17	4.24E-17
1999	4.18E-16	1.29E-16	3.81E-16	1.02E-16	1.26E-15	1.46E-16	2.13E-16	8.27E-17	9.21E-17	5.90E-17
2000	3.37E-16	1.53E-16	4.64E-16	1.40E-16	2.38E-15	2.21E-16	4.60E-16	7.41E-17	4.64E-17	5.10E-17
2001	2.15E-16	2.09E-16	4.36E-16	1.38E-16	1.92E-15	1.51E-16	1.99E-16	7.01E-17	6.82E-17	5.16E-17
2002	1.55E-16	1.17E-16	2.34E-16	7.51E-17	3.83E-16	1.05E-16	1.14E-16	8.41E-17	6.07E-17	6.72E-17
2003	1.45E-16	1.10E-16	1.75E-16	8.02E-17	2.96E-16	1.23E-16	9.65E-17	9.70E-17	8.40E-17	8.93E-17
2004	7.81E-17	7.35E-17	1.41E-16	6.14E-17	3.30E-16	9.05E-17	8.14E-17	5.79E-17	6.26E-17	4.95E-17
2005	1.78E-16	1.56E-16	1.75E-16	1.97E-16	2.29E-15	2.49E-16	2.95E-16	1.08E-16	1.22E-16	9.58E-17
2006	4.10E-16	1.40E-16	2.17E-16	1.34E-16	7.52E-16	1.69E-16	1.42E-16	1.20E-16	1.03E-16	1.15E-16
2007	8.67E-16	1.11E-16	2.07E-16	1.00E-16	2.31E-16	1.16E-16	9.11E-17	1.09E-16	9.66E-17	1.11E-16
2008	7.92E-16	7.36E-17	2.00E-16	5.16E-17	1.78E-16	7.33E-17	5.71E-17	6.21E-17	5.91E-17	3.28E-17

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2. For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2. Shaded cells are the highest annual averages for the calendar year; “--” indicates that no data are available because the station was not yet operating.

Table 56. Average Annual ^{210}Pb Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	2.11E-14	1.65E-14	2.08E-14	--	--	--	--	--	2.30E-14	--
1980	1.81E-14	1.69E-14	1.25E-14	--	--	--	--	1.86E-14	1.98E-14	--
1981	2.01E-14	1.72E-14	4.71E-14	2.34E-14	--	--	--	1.57E-14	1.70E-14	2.11E-14
1982	3.87E-14	4.35E-14	9.95E-14	4.07E-14	--	--	--	2.50E-14	3.31E-14	4.05E-14
1983	1.70E-14	1.73E-14	1.82E-14	1.95E-14	--	--	--	1.29E-14	1.79E-14	1.44E-14
1984	1.44E-14	1.46E-14	1.60E-14	1.43E-14	--	--	--	1.26E-14	1.15E-14	1.48E-14
1985	9.12E-15	8.12E-15	8.80E-15	9.30E-15	--	--	--	9.97E-15	1.14E-14	9.90E-15
1986	1.26E-14	1.19E-14	1.12E-14	1.22E-14	--	--	--	1.07E-14	1.22E-14	8.81E-15
1987	1.95E-14	1.92E-14	2.22E-14	2.35E-14	--	--	--	2.17E-14	2.01E-14	1.43E-14
1988	2.15E-14	1.94E-14	2.10E-14	1.93E-14	--	--	--	2.04E-14	2.11E-14	1.76E-14
1989	2.28E-14	2.30E-14	1.98E-14	2.34E-14	--	--	--	2.43E-14	2.35E-14	2.40E-14
1990	2.05E-14	2.10E-14	2.07E-14	2.07E-14	--	--	--	2.24E-14	2.00E-14	1.95E-14
1991	2.40E-14	2.15E-14	2.15E-14	2.13E-14	--	--	--	2.23E-14	2.15E-14	1.07E-14
1992	2.16E-14	2.00E-14	2.20E-14	2.19E-14	--	--	--	1.99E-14	1.61E-14	2.20E-14
1993	2.38E-14	2.35E-14	2.35E-14	2.49E-14	--	--	--	2.22E-14	2.13E-14	2.10E-14
1994	2.21E-14	2.07E-14	2.10E-14	2.24E-14	2.18E-14	--	--	2.33E-14	2.38E-14	2.06E-14
1995	2.07E-14	2.07E-14	2.02E-14	2.01E-14	2.11E-14	--	--	1.97E-14	2.03E-14	1.74E-14
1996	2.02E-14	2.01E-14	2.16E-14	2.21E-14	2.11E-14	--	--	2.08E-14	1.96E-14	1.98E-14
1997	2.21E-14	2.07E-14	2.12E-14	2.20E-14	2.26E-14	2.05E-14	--	2.13E-14	2.00E-14	1.98E-14
1998	2.01E-14	2.07E-14	1.98E-14	2.11E-14	2.01E-14	1.93E-14	--	2.01E-14	2.01E-14	1.93E-14
1999	2.14E-14	1.94E-14	1.83E-14	1.84E-14	2.03E-14	1.94E-14	2.03E-14	2.03E-14	1.94E-14	1.78E-14
2000	2.07E-14	2.05E-14	2.01E-14	2.23E-14	2.37E-14	2.00E-14	2.07E-14	2.16E-14	2.08E-14	2.03E-14
2001	3.10E-14	3.04E-14	2.91E-14	3.11E-14	3.06E-14	2.94E-14	3.12E-14	3.06E-14	2.96E-14	2.79E-14
2002	2.36E-14	2.20E-14	2.28E-14	2.25E-14	2.30E-14	2.37E-14	2.40E-14	2.46E-14	2.33E-14	2.17E-14
2003	2.19E-14	2.11E-14	2.16E-14	2.06E-14	2.28E-14	2.12E-14	2.18E-14	2.11E-14	1.94E-14	2.27E-14
2004	1.72E-14	1.64E-14	1.58E-14	1.60E-14	1.66E-14	1.45E-14	1.79E-14	1.56E-14	1.54E-14	1.59E-14
2005	2.45E-14	2.74E-14	2.82E-14	2.54E-14	3.11E-14	2.91E-14	2.92E-14	3.11E-14	3.15E-14	2.94E-14
2006	2.11E-14	2.31E-14	2.47E-14	2.31E-14	2.09E-14	2.08E-14	1.89E-14	1.98E-14	1.89E-14	2.12E-14
2007	1.88E-14	1.64E-14	1.79E-14	1.82E-14	1.54E-14	1.58E-14	1.49E-14	1.66E-14	1.61E-14	1.72E-14
2008	1.65E-14	1.48E-14	1.64E-14	1.93E-14	1.66E-14	1.73E-14	1.57E-14	1.67E-14	1.61E-14	1.61E-14

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2. For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2.

Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating.

Table 57. $^{220}Rn/^{222}Rn$ Concentrations 2002-2008 (pCi/m^3)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	CC-1	LP-1	OV-3
2002	543	975	1125	693	1475	700	698	875	673	625
2003	700	825	775	900	625	675	700	375	800	567
2004	1500	850	1025	950	1100	850	925	825	875	825
2005	925	1025	850	700	1025	675	775	700	900	800
2006	1250	1275	1275	1450	1400	1125	1275	1075	1375	1200
2007	1000	1100	1175	1100	1250	975	825	925	1175	975
2008	850	900	925	950	1075	950	850	800	925	825

Notes: Data are presented for only those years when measurements quantified combined levels of the two isotopes.
Shaded cells are the highest annual averages for the calendar year.

Table 58. Environmental TLD Measurements, 1979-2008 (µR/hr)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	CC-1	LP-1	OV-3
1979	14.0	12.6	12.7	--	--	--	--	11.8	11.4	--
1980	13.4	11.7	12.9	--	--	--	--	10.4	11.4	--
1981	14.3	12.8	12.7	--	--	--	--	10.6	12.3	12.3
1982	13.7	12.6	14.7	20.4	--	--	--	9.9	11.2	12.7
1983	13.6	12.6	14.2	15.6	--	--	--	10.6	11.6	12.0
1984	14.5	14.3	14.6	14.8	--	--	--	12.3	11.2	13.2
1985	14.3	13.5	14.5	14.8	--	--	--	10.5	11.2	12.3
1986	13.9	13.7	14.5	14.2	--	--	--	11.0	10.7	11.8
1987	12.9	12.5	12.6	12.6	--	--	--	9.6	9.7	10.4
1988	15.0	13.6	12.8	13.4	--	--	--	9.3	11.6	10.2
1989	14.7	14.9	15.3	15.9	--	--	--	10.6	13.7	11.9
1990	13.2	13.1	14.8	15.2	--	--	--	9.6	11.5	11.7
1991	14.1	13.2	15.7	17.5	--	--	--	10.0	12.9	12.4
1992	13.7	13.2	16.0	18.3	--	--	--	9.6	12.1	11.3
1993	12.5	12.6	14.4	15.6	--	--	--	8.6	10.7	10.9
1994	14.3	13.8	15.9	16.2	27.8	--	--	10.8	12.1	12.3
1995	12.5	13.7	14.0	15.4	23.0	--	--	9.2	10.3	11.3
1996	13.1	13.2	14.5	16.2	27.2	13.0	--	9.7	10.9	11.4
1997	12.6	13.1	13.8	15.7	29.1	12.3	--	9.1	10.2	11.1
1998	12.3	12.0	13.4	15.9	28.0	12.0	--	9.0	10.3	11.5
1999	12.7	12.0	13.8	16.0	29.6	12.2	9.1	9.3	10.6	10.9
2000	12.7	12.6	14.7	16.6	27.7	12.5	9.3	9.5	10.7	11.4
2001	13.7	14.3	15.4	18.6	26.2	13.9	9.7	10.4	12.0	12.2
2002	14.0	14.4	15.9	17.7	30.3	14.3	10.5	10.5	12.3	12.6
2003	12.8	13.3	14.8	15.5	27.7	13.3	10.0	10.0	11.7	11.8
2004	13.6	14.1	15.5	14.7	25.5	14.2	10.9	10.5	12.2	12.5
2005	12.8	13.5	14.8	13.8	22.9	12.9	9.9	10.1	11.5	11.5
2006	12.7	13.4	14.6	14.2	21.5	12.6	9.5	10.1	11.5	11.7
2007	12.9	13.2	14.6	14.1	17.8	12.7	9.5	10.1	11.5	11.6
2008	13.9	13.5	15.5	14.9	18.7	13.3	10.2	10.8	12.2	12.6

Notes: Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating.

Table 59. TSP Air Concentrations (μg/m^3) from 1969-1987

Year	Cañon City		Lincoln Park	
	Maximum	Average	Maximum	Average
1969	172	64.2	--	--
1970	200	55.9	--	--
1971	148	58.7	--	--
1972	240	69.9	--	--
1973	229	66.1	--	--
1974	187	58	--	--
1975	419	73.7	--	--
1976	174	56.8	--	--
1977	227	62.7	--	--
1978	313	84.7	--	--
1979	286	72.6	--	--
1980	304	70.4	--	--
1981	180	56.8	61*	8.2*
1982	525	84	228	51.7
1983	187	65.2	106	77.6
1984	571	70.9	--	--
1985	334	64.8	--	--
1986	402	66.3	--	--
1987	385	65.2	--	--

Notes: Data downloaded from EPA's Air Quality System database.
EPA's former annual average National Ambient Air Quality Standard for TSP was 75 μg/m^3.
* The TSP monitoring station in Lincoln Park started operating late in 1981; therefore, the statistics reported are not representative of the entire calendar year.

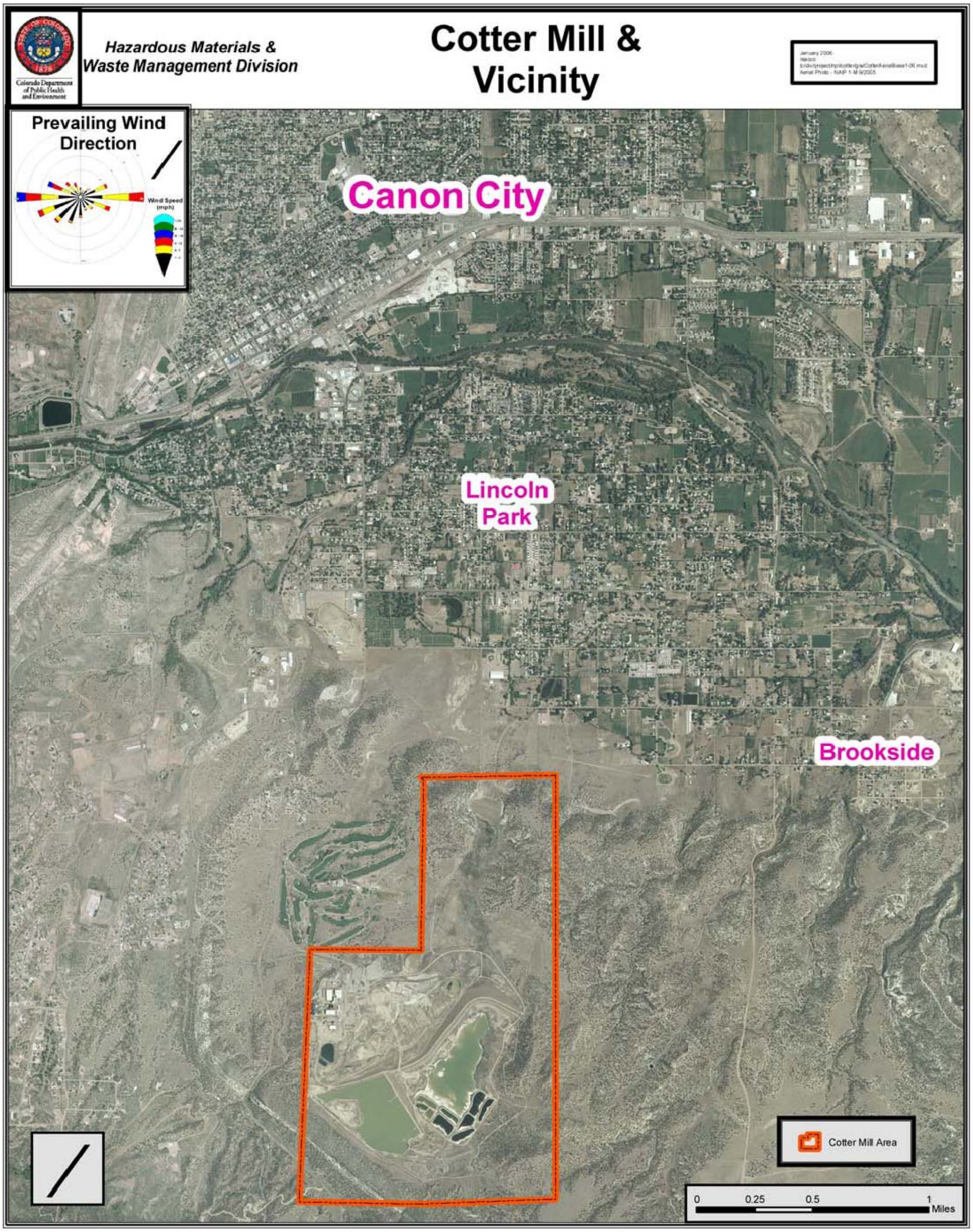
Table 60. Monitoring Data for Constituents in TSP (1978-1987)

Constituent	Location	Years of Data	Concentrations (μg/m^3)	
			Highest 24-Hour Average	Highest Annual Average
Iron	Lincoln Park	1981-1982	1.2	0.8
Lead	Lincoln Park	1981-1982	0.1	0.034
Manganese	Lincoln Park	1981-1982	0.03	0.0185
Nitrate	Cañon City	1978-1987	14.3	2.35
	Lincoln Park	1981-1982	4.7	1.81
Sulfate	Cañon City	1978-1987	18.4	5.99
	Lincoln Park	1981-1982	13	6.48
Zinc	Lincoln Park	1981-1982	0.04	0.0283

Notes Data downloaded from EPA's Air Quality System database.

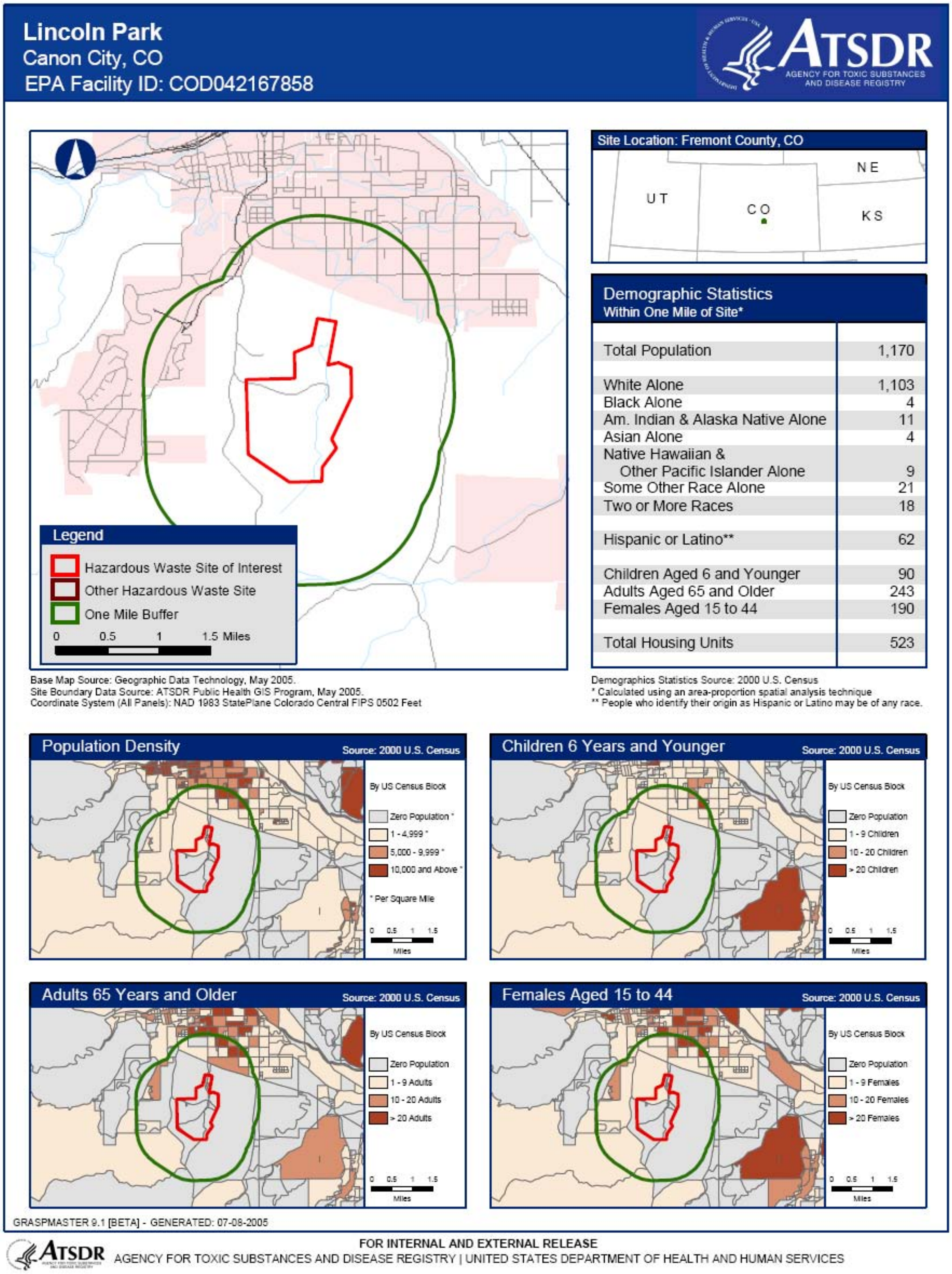
Appendix B - Site Figures

Figure 1. Location of the Cotter Mill, Lincoln Park, and Cañon City



Source: Galant et al. 2007

Figure 2. Demographics within 1 mile of the Cotter Mill property



Demographic Statistics
Within One Mile of Site*

Total Population	1,170
White Alone	1,103
Black Alone	4
Am. Indian & Alaska Native Alone	11
Asian Alone	4
Native Hawaiian & Other Pacific Islander Alone	9
Some Other Race Alone	21
Two or More Races	18
Hispanic or Latino**	62
Children Aged 6 and Younger	90
Adults Aged 65 and Older	243
Females Aged 15 to 44	190
Total Housing Units	523

Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Public Health GIS Program, May 2005.
Coordinate System (All Panels): NAD 1983 StatePlane Colorado Central FIPS 0502 Feet

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.

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Figure 3. Wind Rose for Cotter Mill, 2008

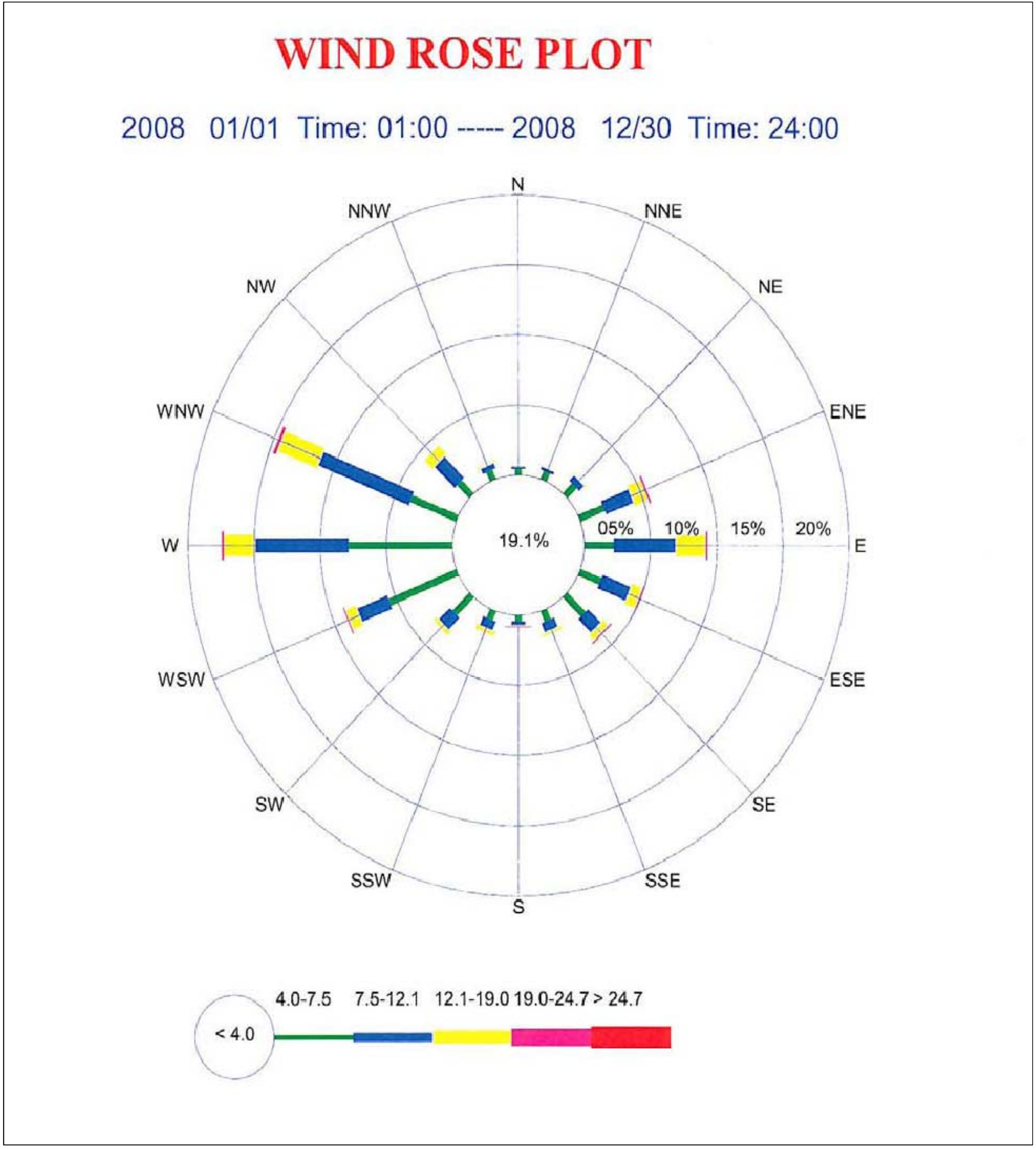
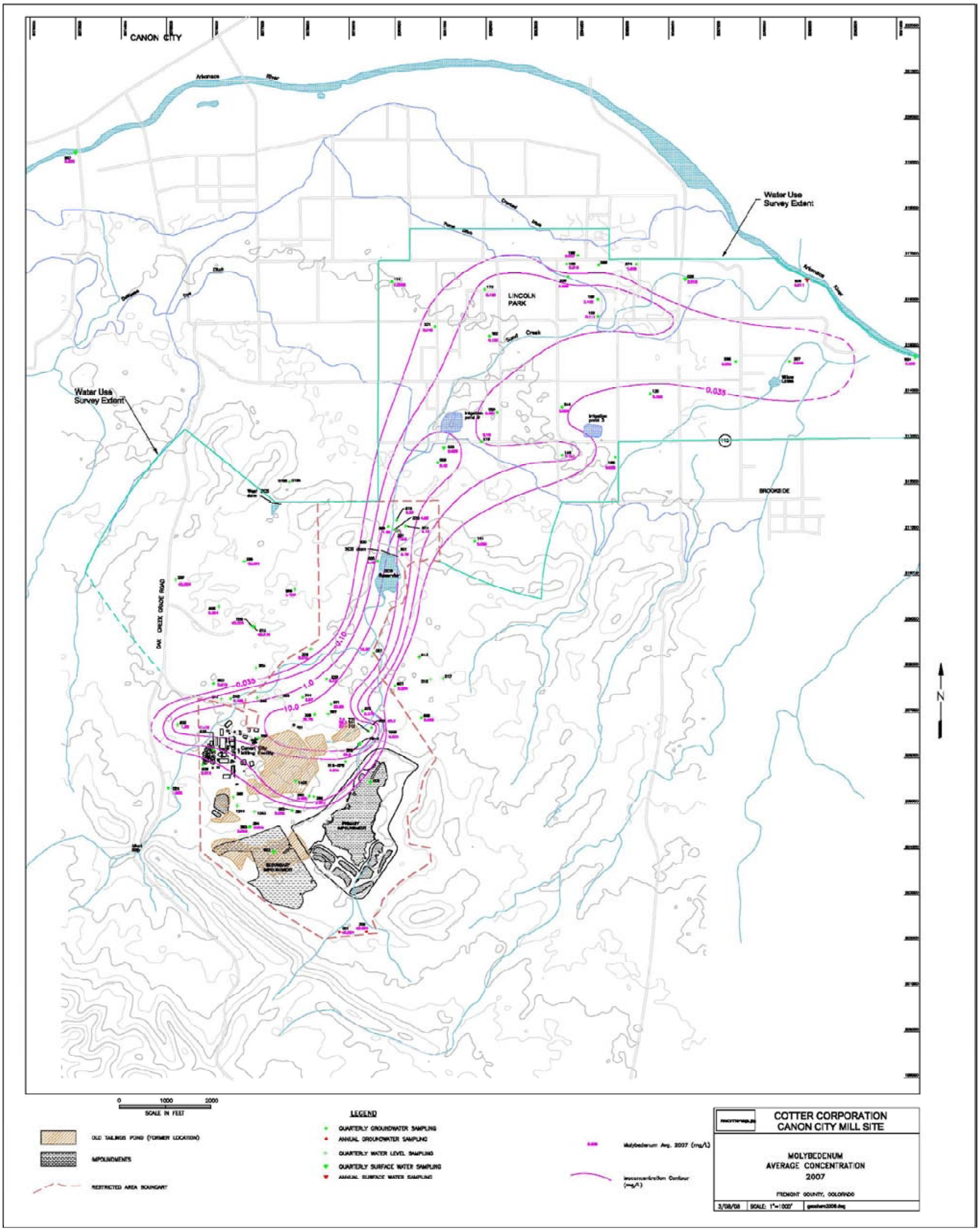
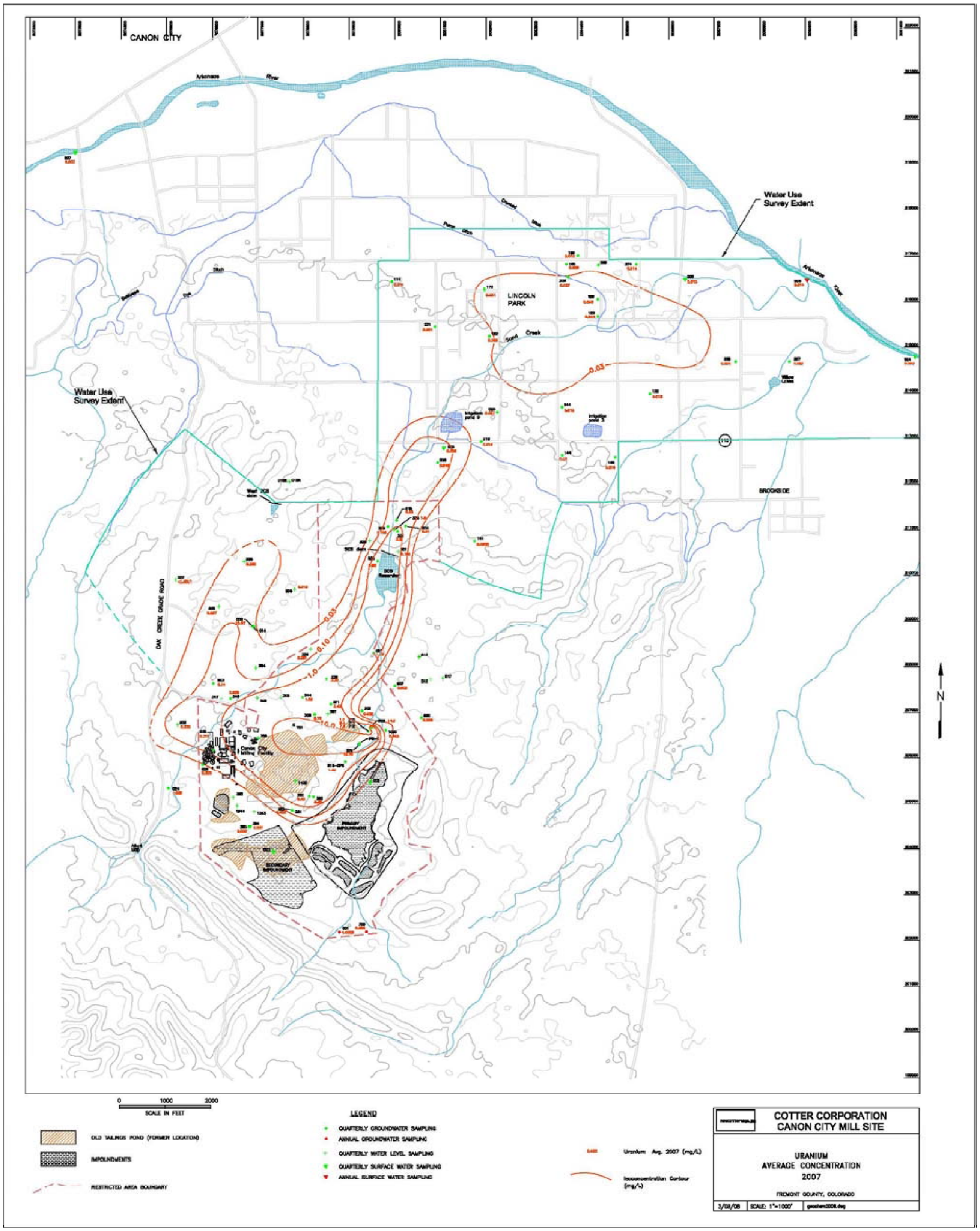


Figure 4. Molybdenum Plume Map



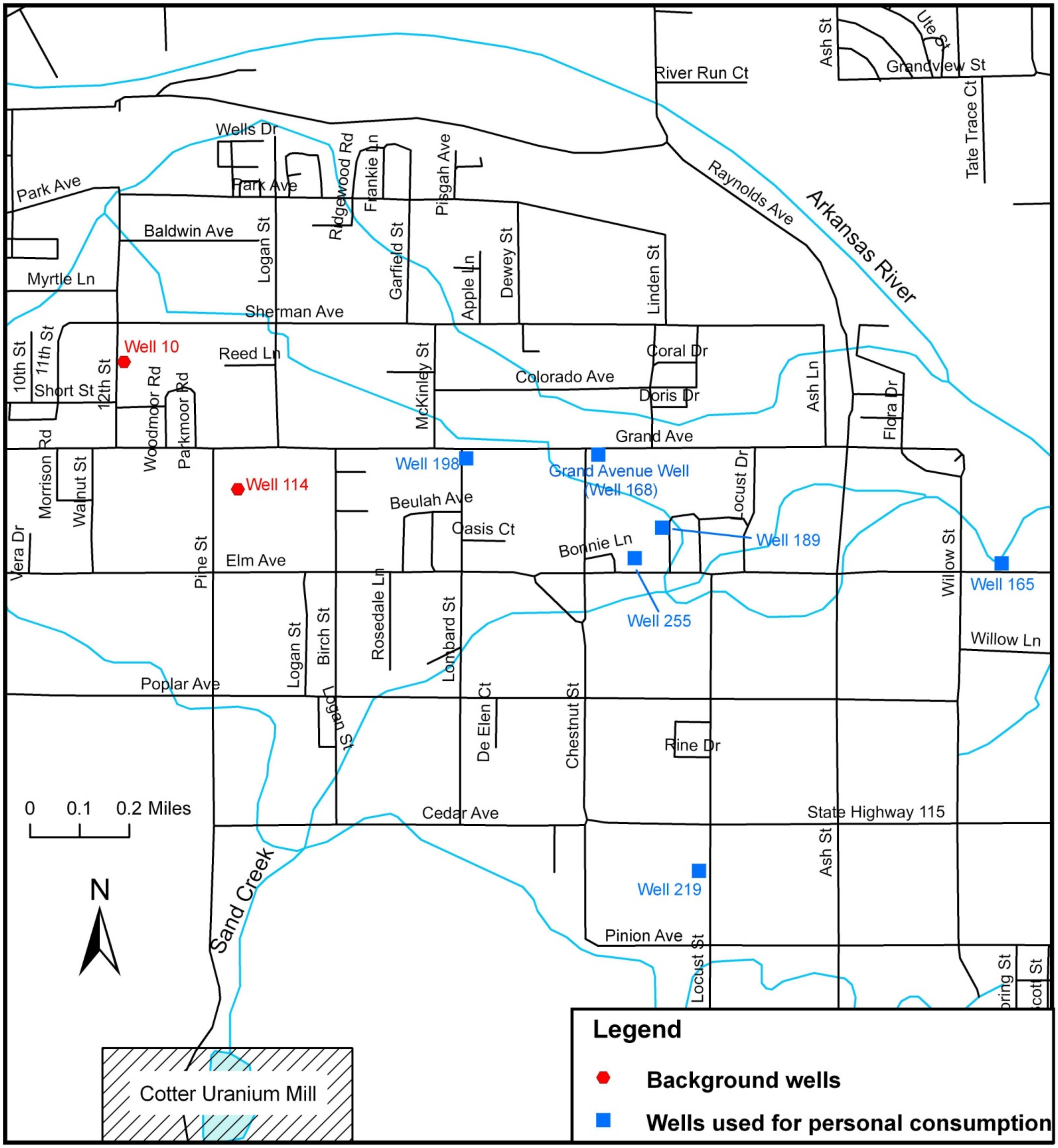
Source: Cotter 2008

Figure 5. Uranium Plume Map



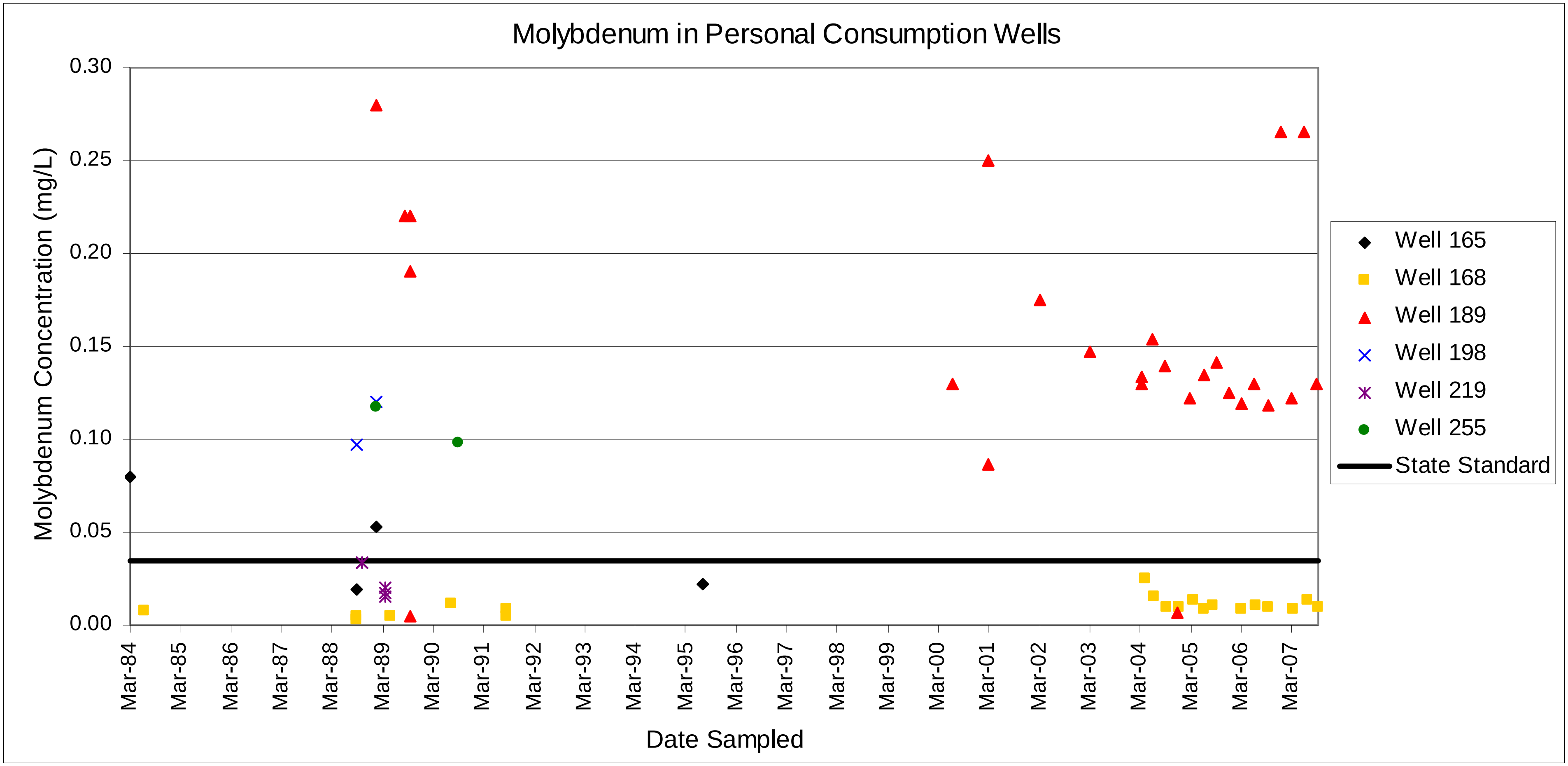
Source: Cotter 2008

Figure 6. Wells in Lincoln Park used for personal consumption



Source: CDPHE 2007b (coordinates)

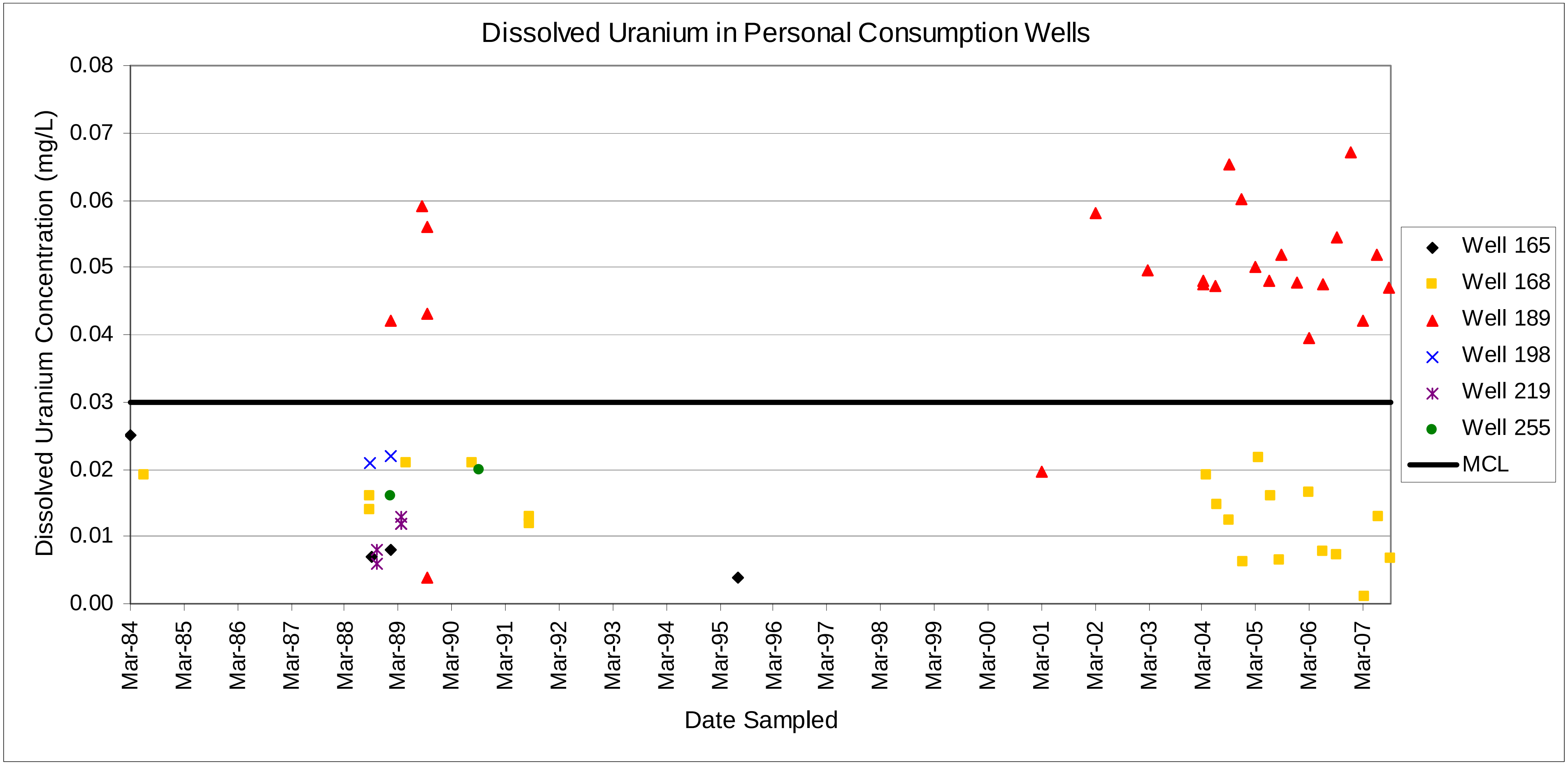
Figure 7. Molybdenum concentrations in wells used for personal consumption



Source: CDPHE 2007b

Non-detected concentrations were plotted as ½ the reporting detection limit.

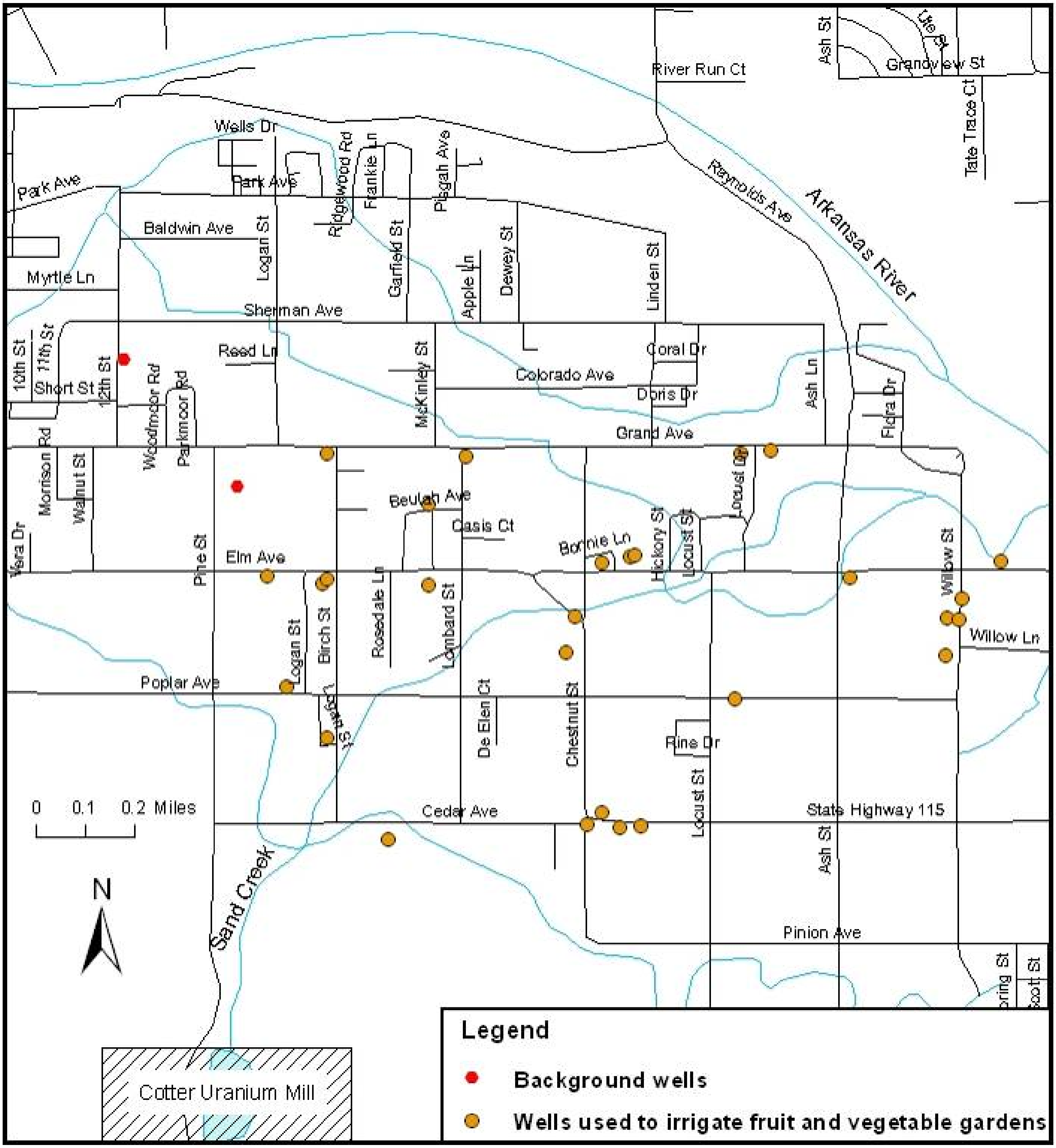
Figure 8. Dissolved uranium concentrations in wells used for personal consumption



Source: CDPHE 2007b

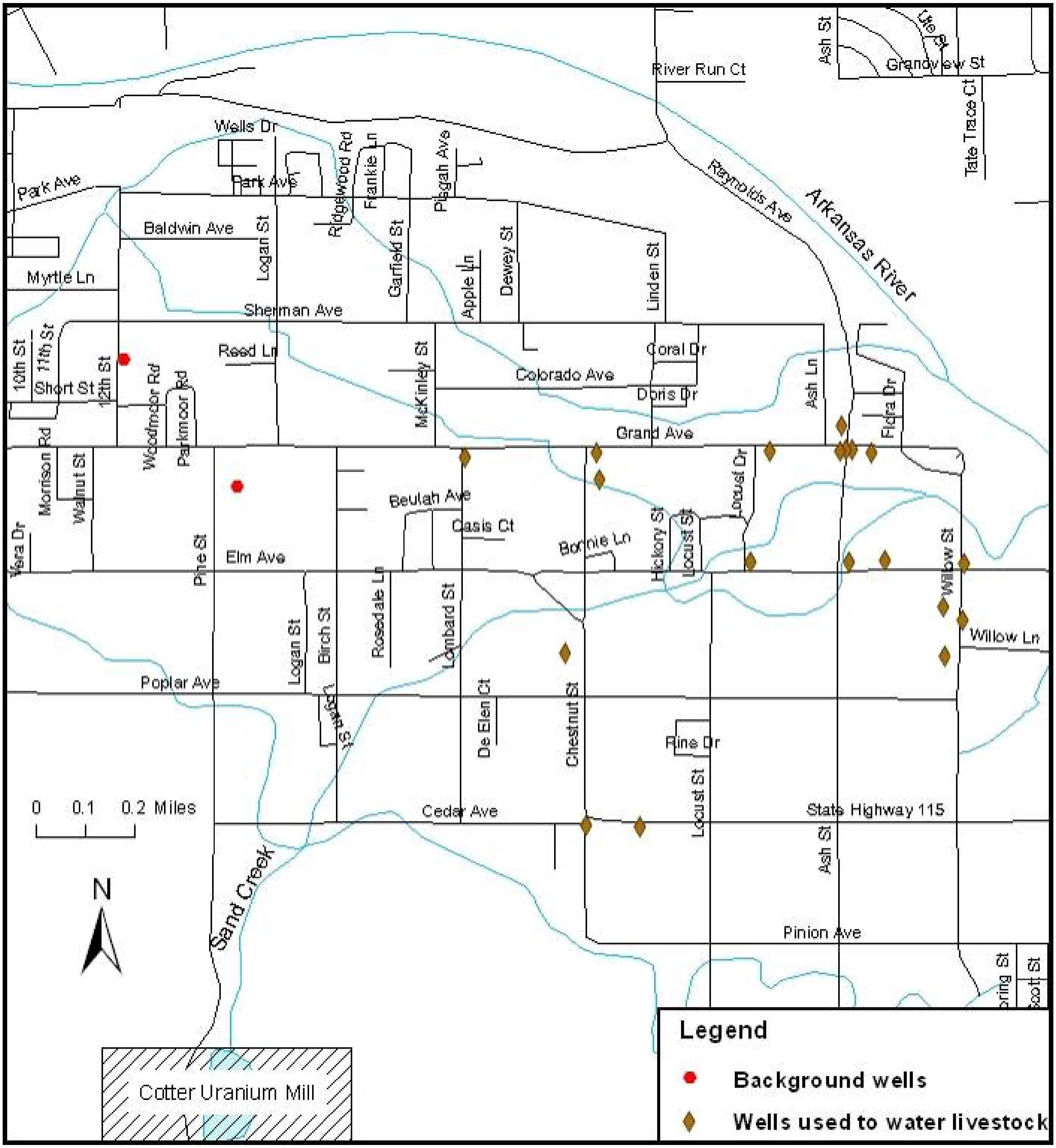
Non-detected concentrations were plotted as ½ the reporting detection limit.

Figure 9. Wells in Lincoln Park used to irrigate fruit and vegetable gardens



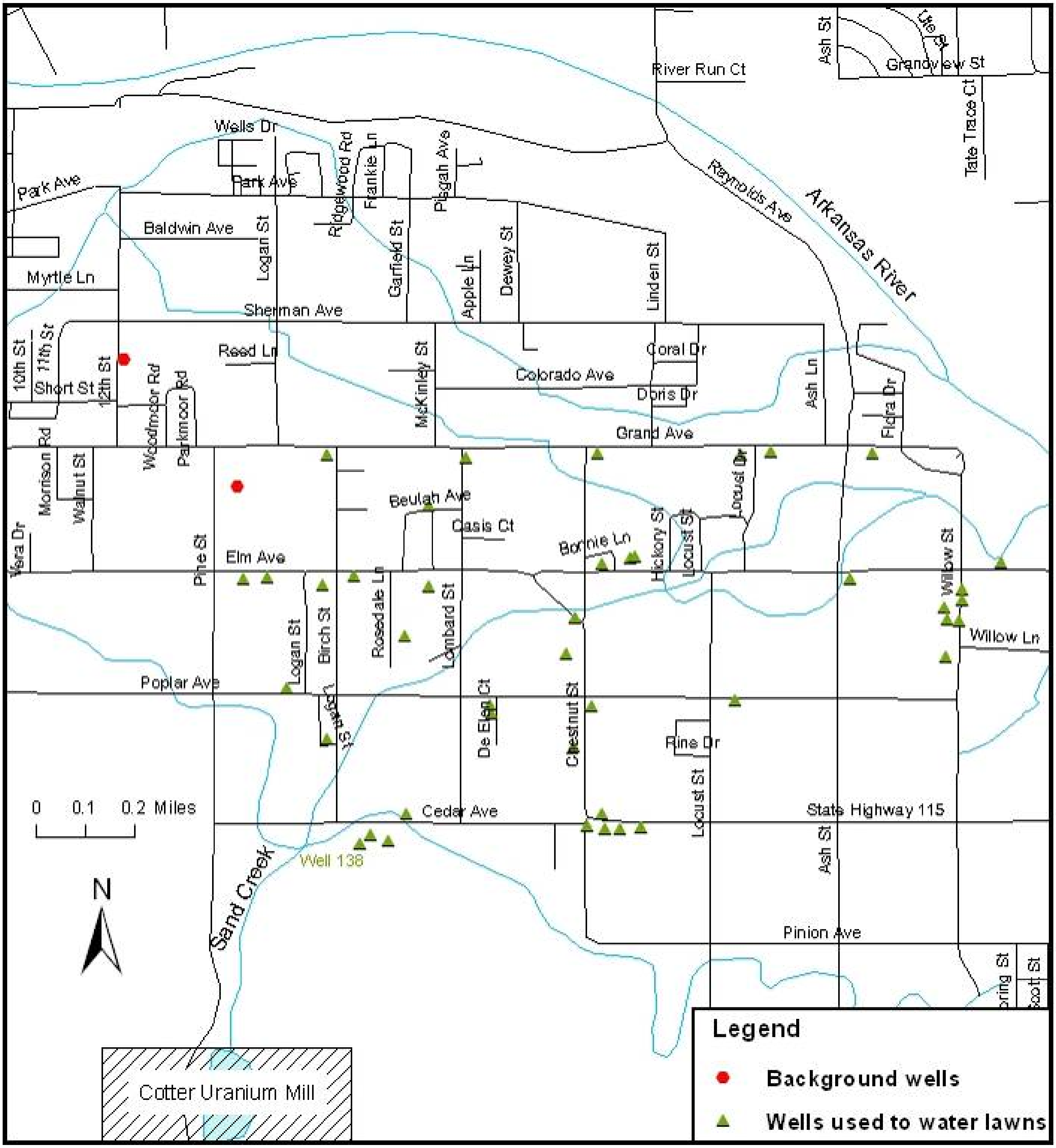
Source: CDPHE 2007b (coordinates)

Figure 10. Wells in Lincoln Park used to water livestock



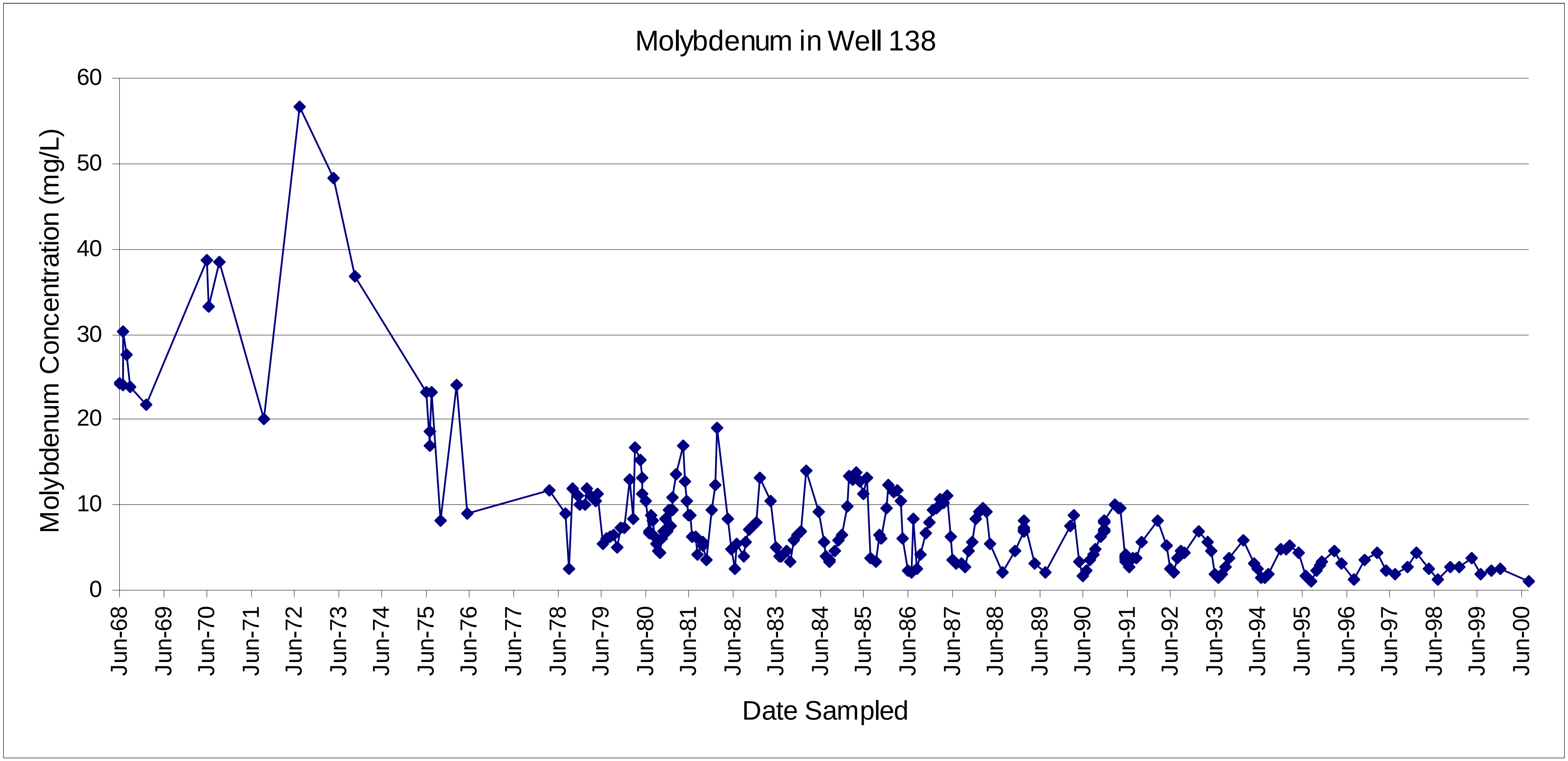
Source: CDPHE 2007b (coordinates)

Figure 11. Wells in Lincoln Park used to water lawns



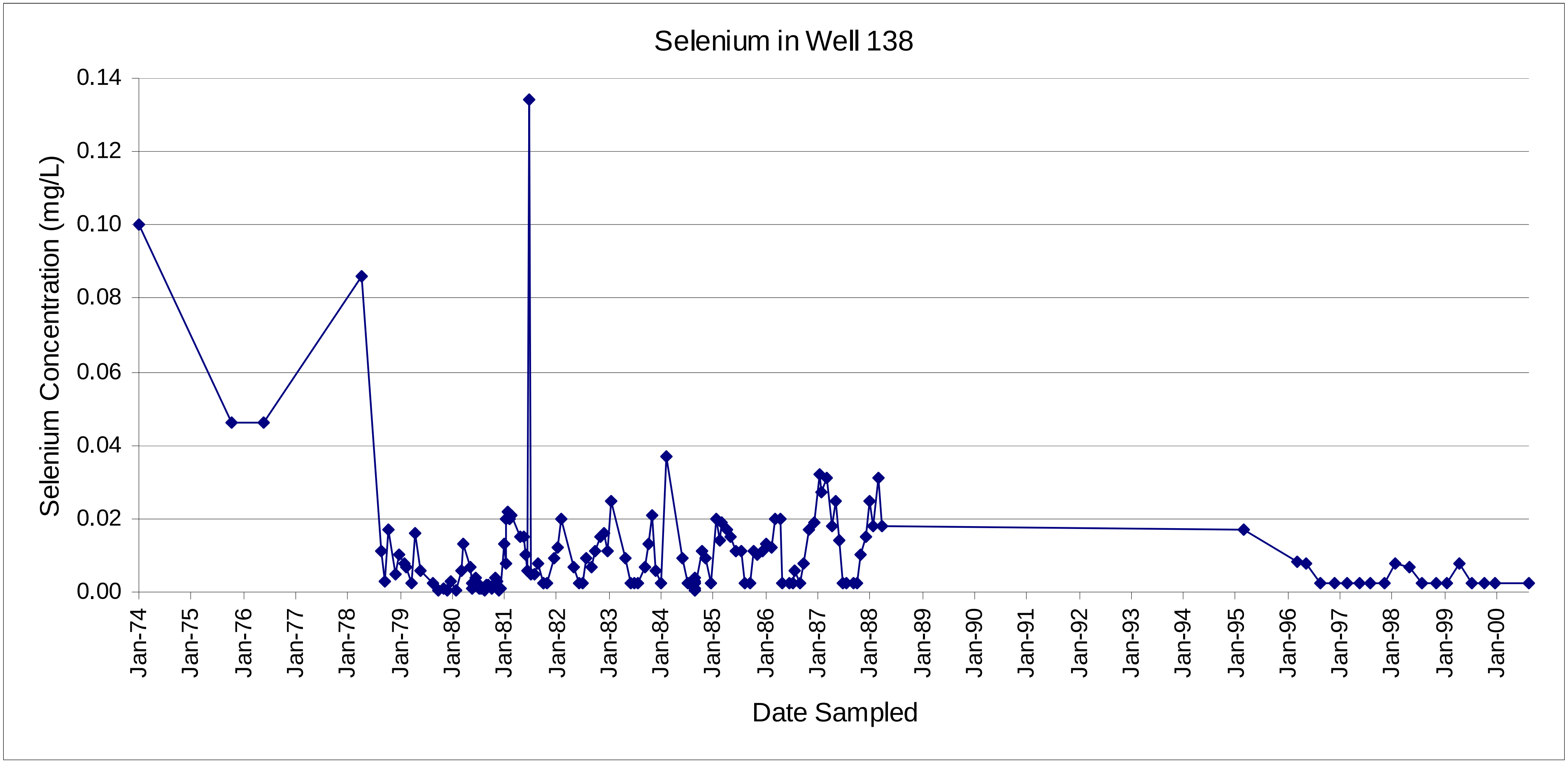
Source: CDPHE 2007b (coordinates)

Figure 12. Molybdenum concentrations in Well 138



Source: CDPHE 2007b

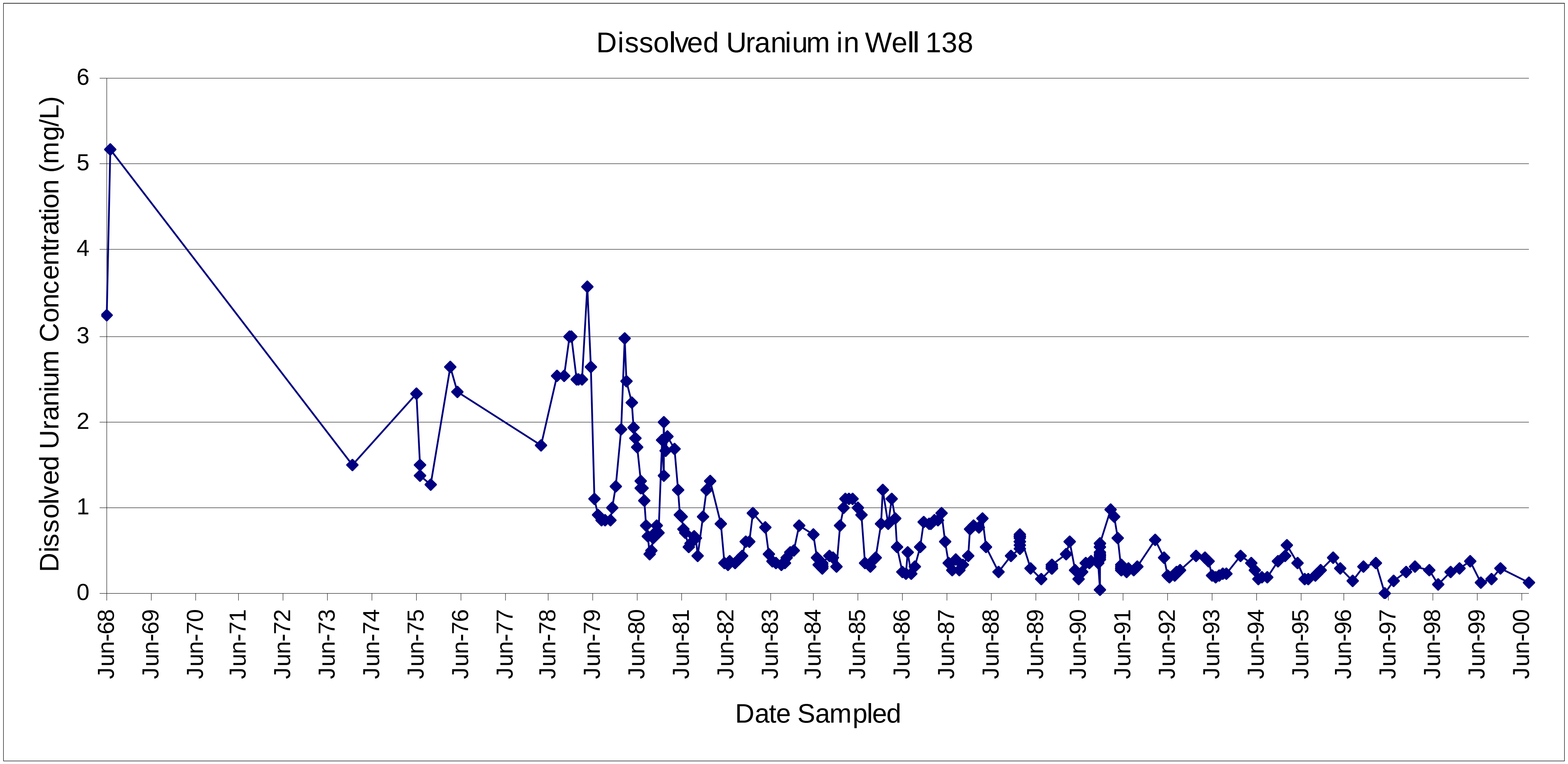
Figure 13. Selenium concentrations in Well 138



Source: CDPHE 2007b

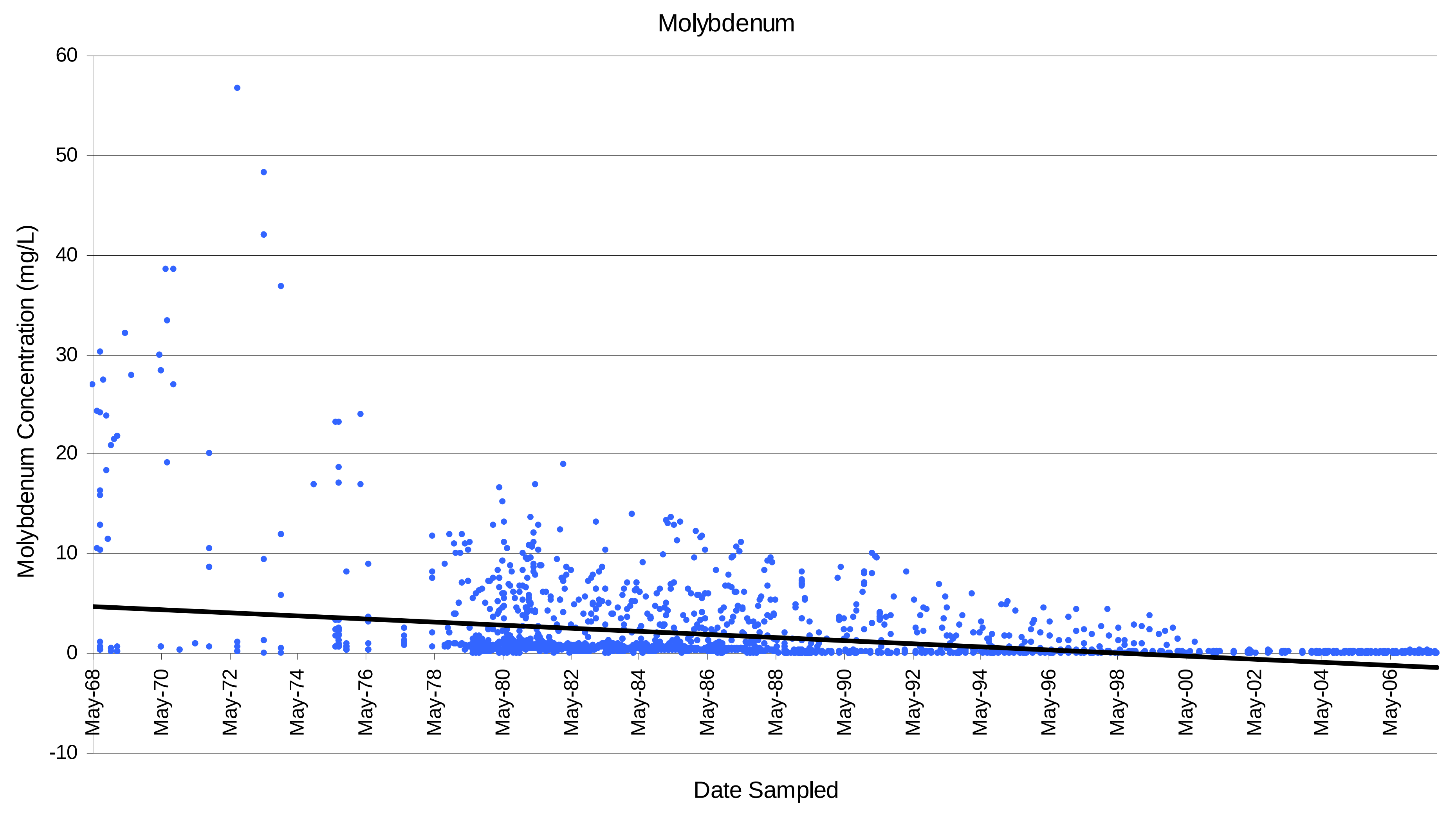
Non-detected concentrations were plotted as ½ the reporting detection limit.

Figure 14. Dissolved uranium concentrations in Well 138



Source: CDPHE 2007b

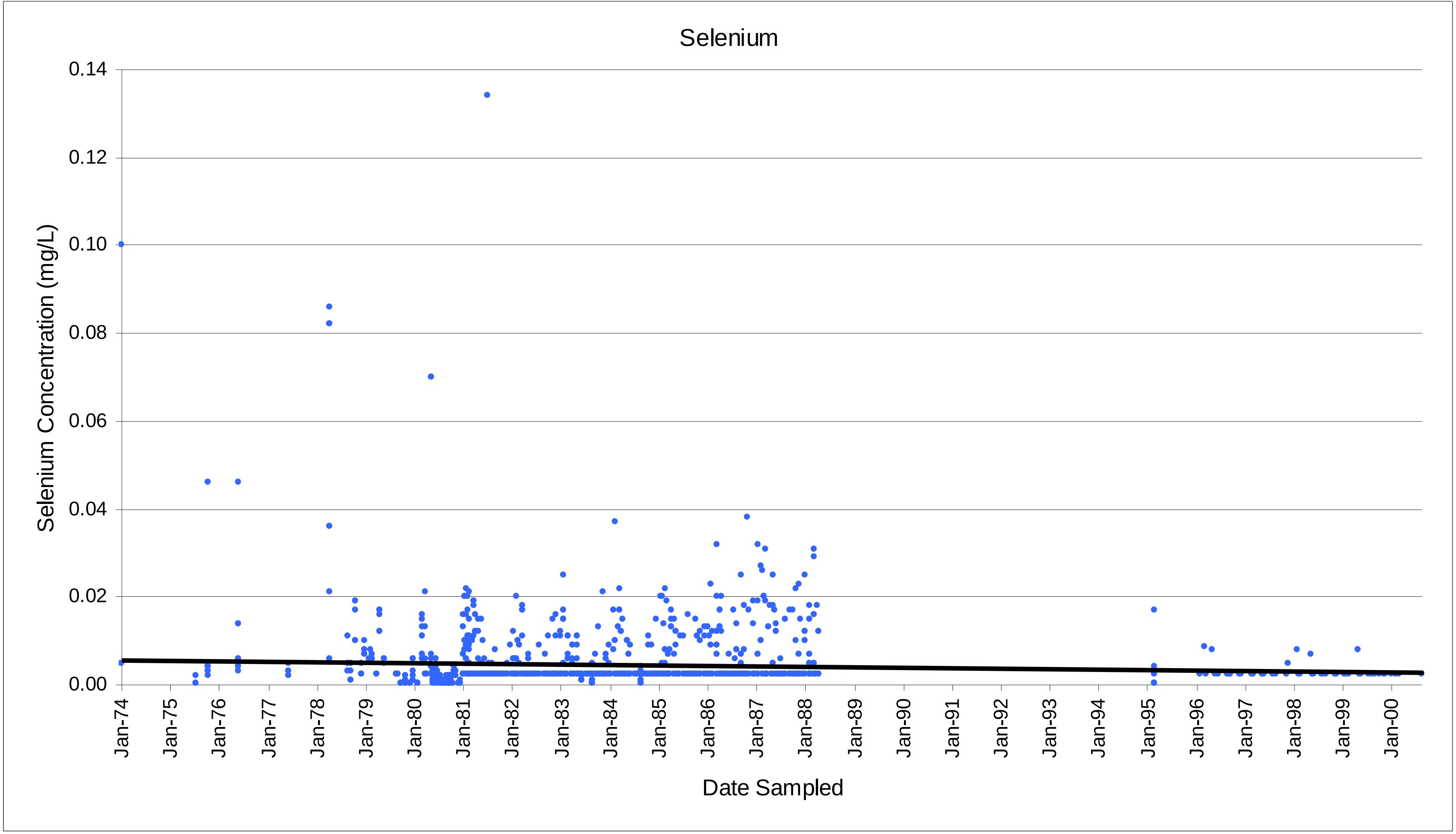
Figure 15. Molybdenum concentrations in all groundwater wells evaluated



Source: CDPHE 2007b

Non-detected concentrations were plotted as ½ the reporting detection limit.

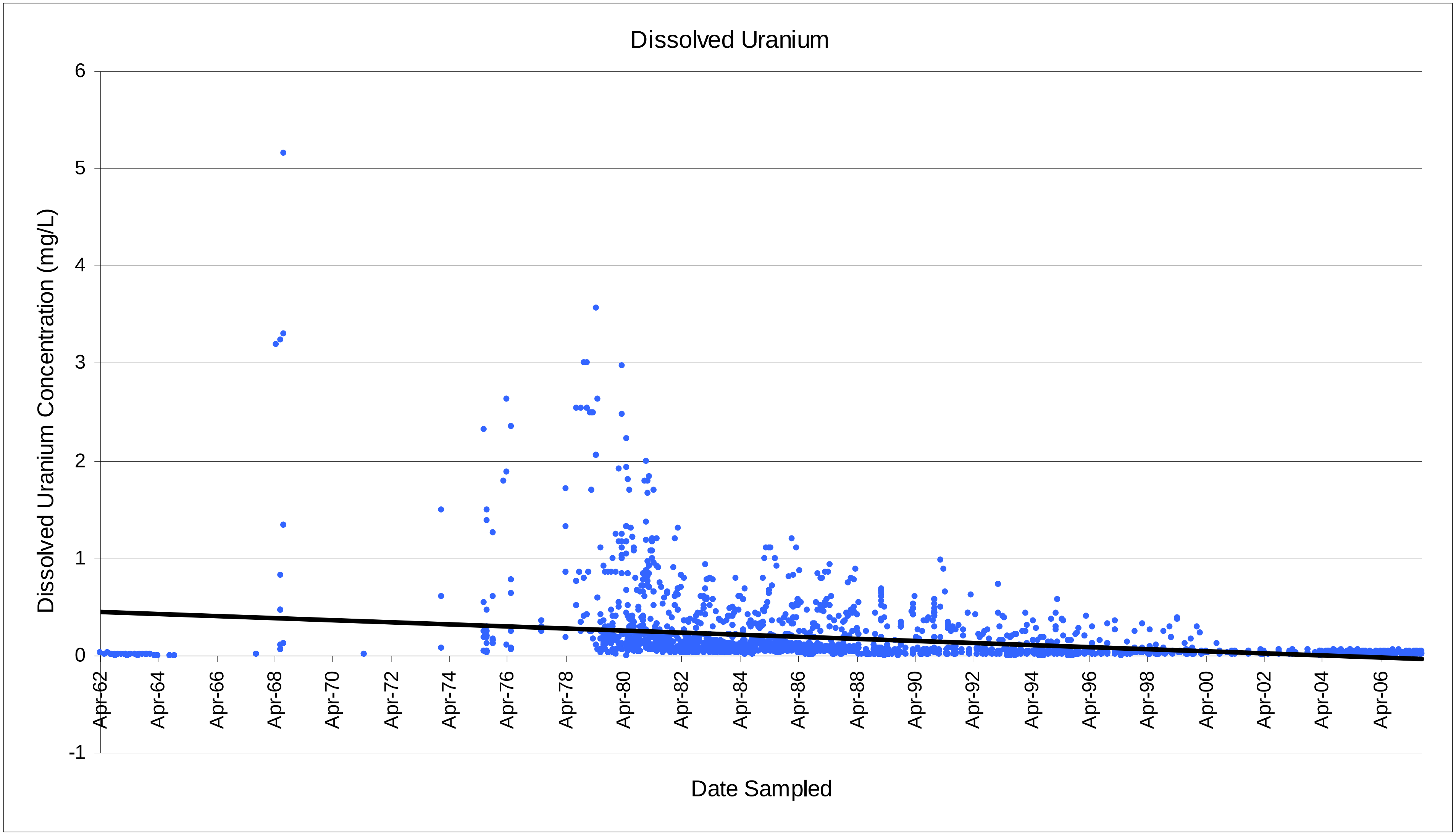
Figure 16. Selenium concentrations in all groundwater wells evaluated



Source: CDPHE 2007b

Non-detected concentrations were plotted as ½ the reporting detection limit.

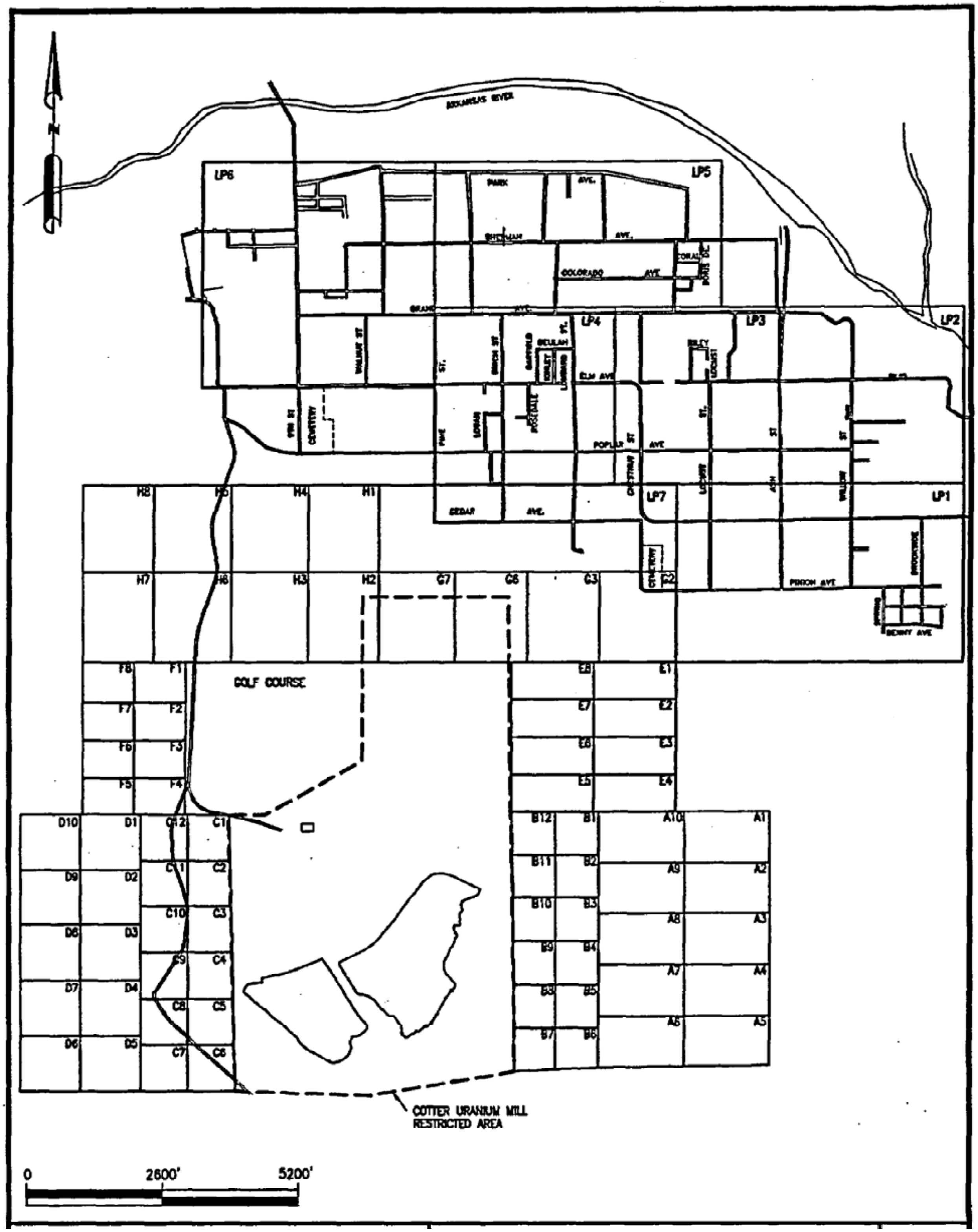
Figure 17. Dissolved uranium concentrations in all groundwater wells evaluated



Source: CDPHE 2007b

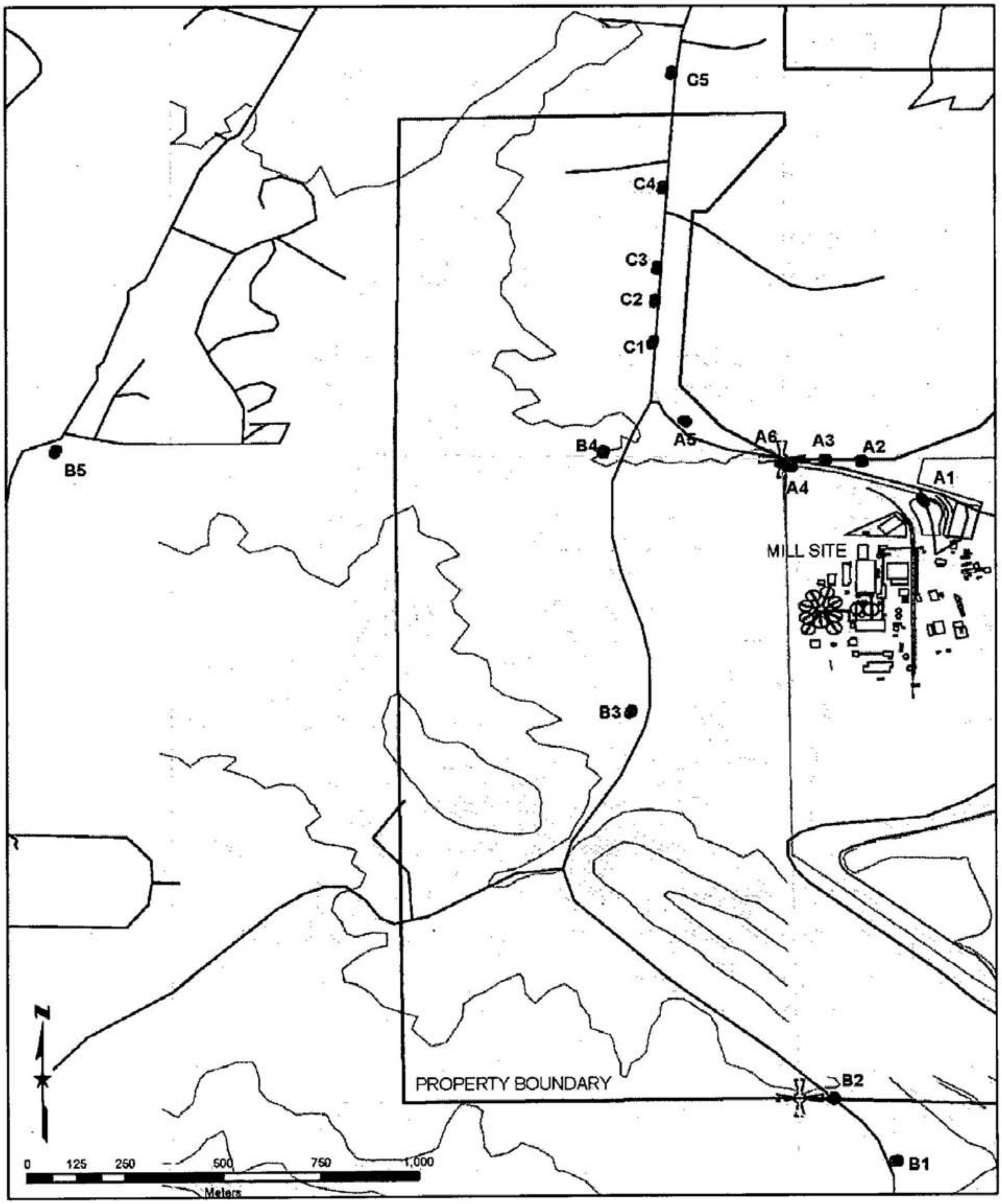
Non-detected concentrations were plotted as ½ the reporting detection limit.

Figure 18. Sampling zones established during the 1998 Supplemental Human Health Risk Assessment



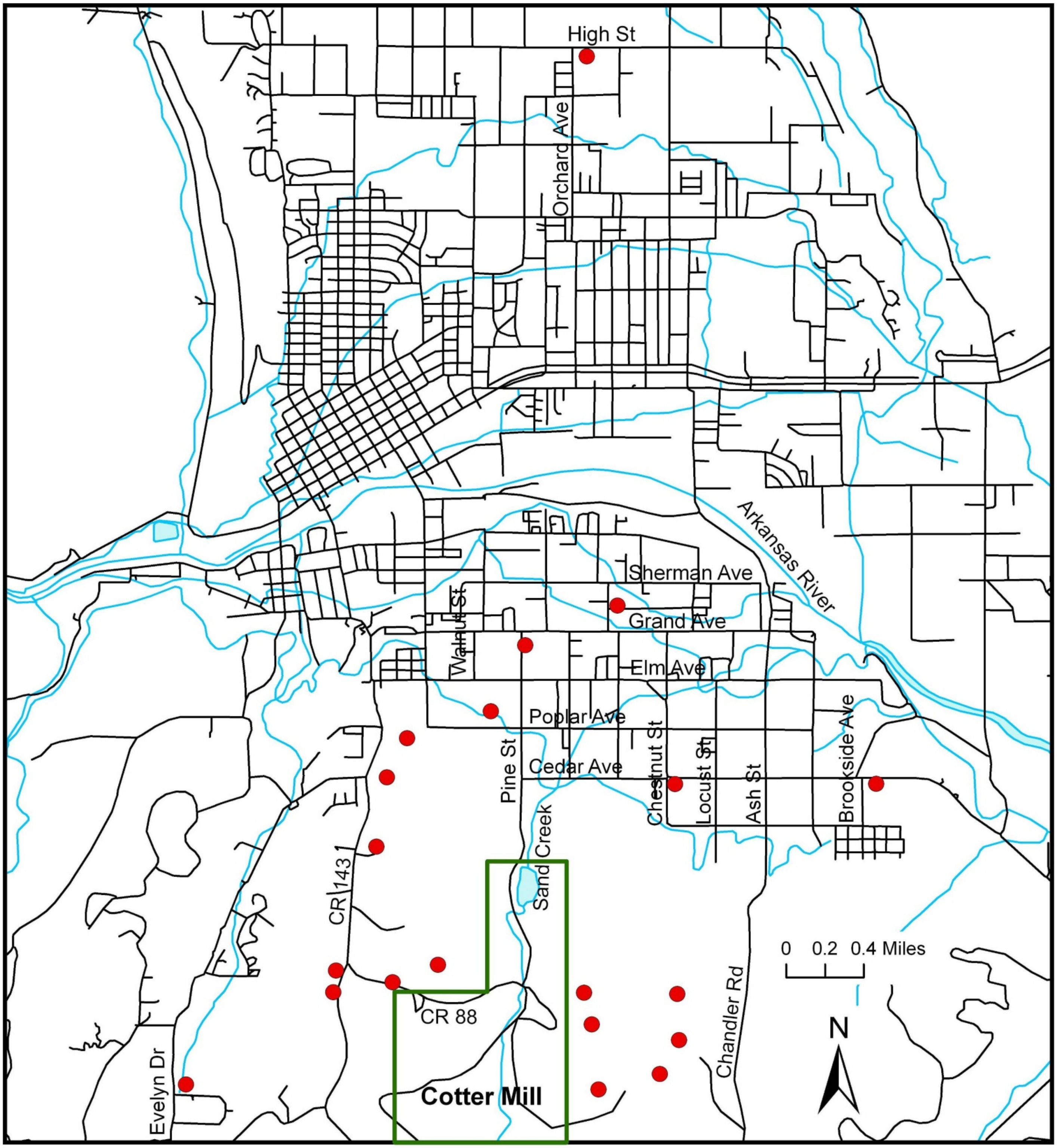
Source: Weston 1998

Figure 19. Locations of soil samples taken along the county road and Cotter Mill's access road



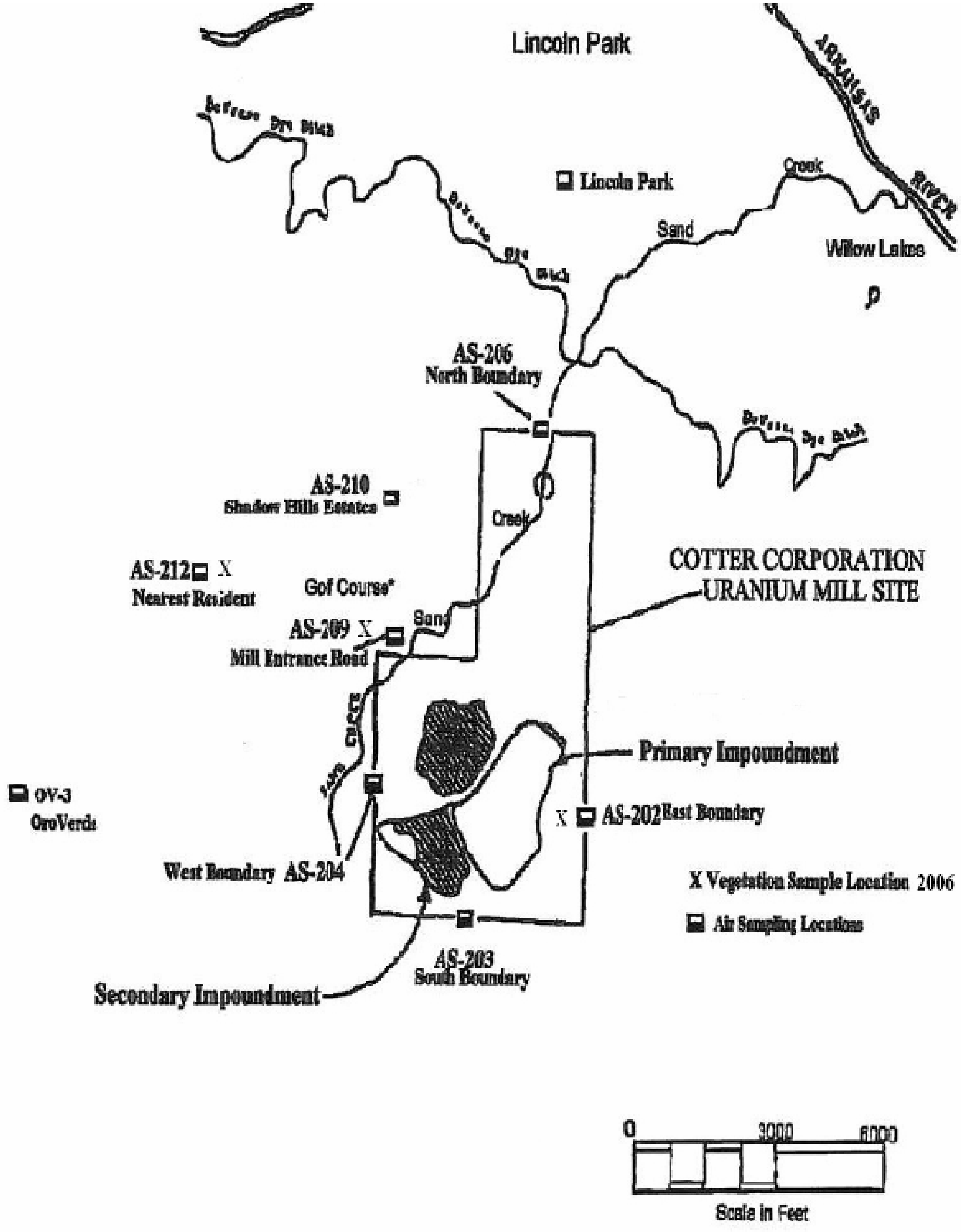
Source: MFG 2005

Figure 20. Locations of soil samples taken by CDPHE in January 2003



Source: CDPHE 2007b (coordinates)

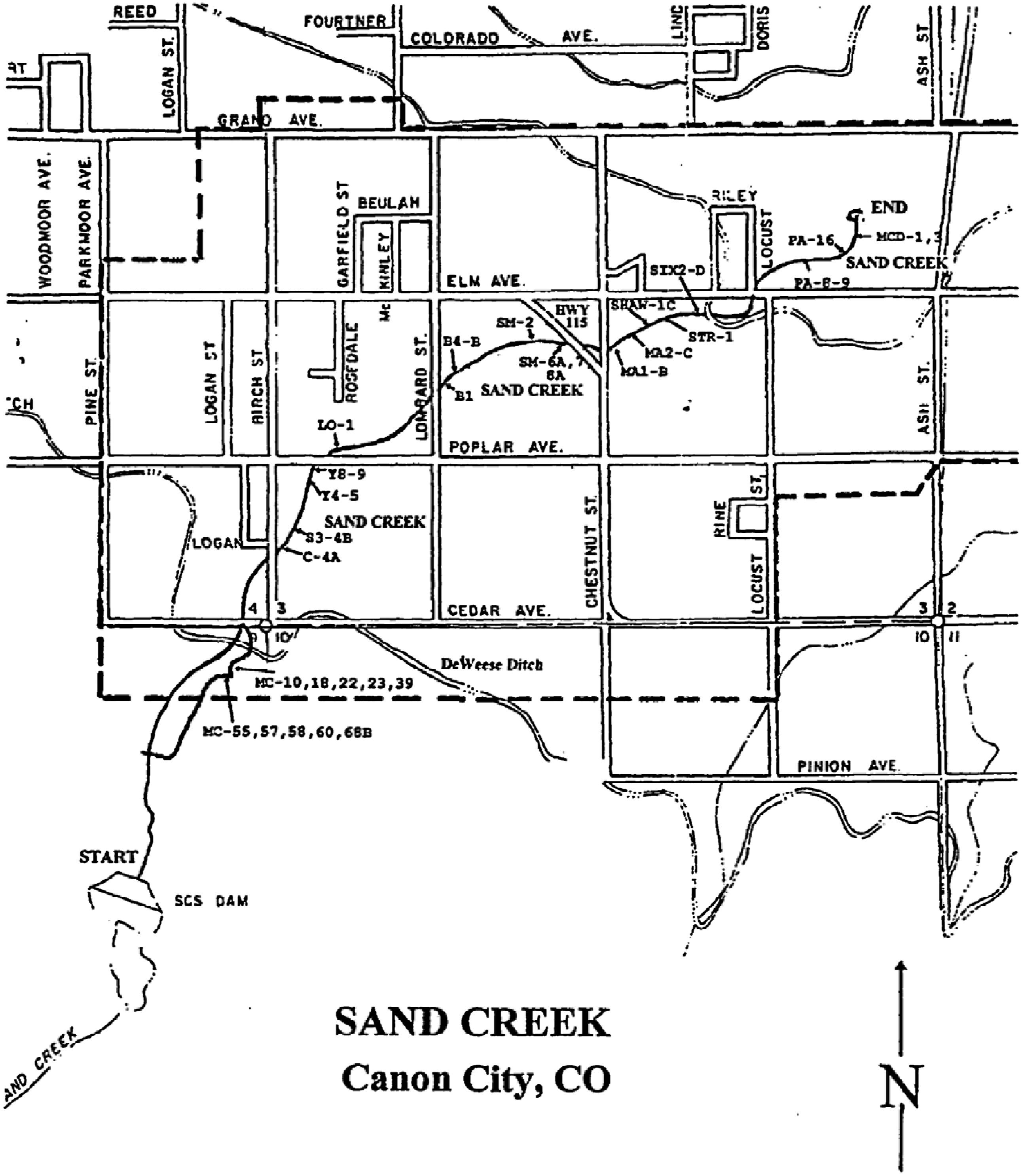
Figure 21. Location of air sampling locations where soil samples are collected



Source: Cotter 2007

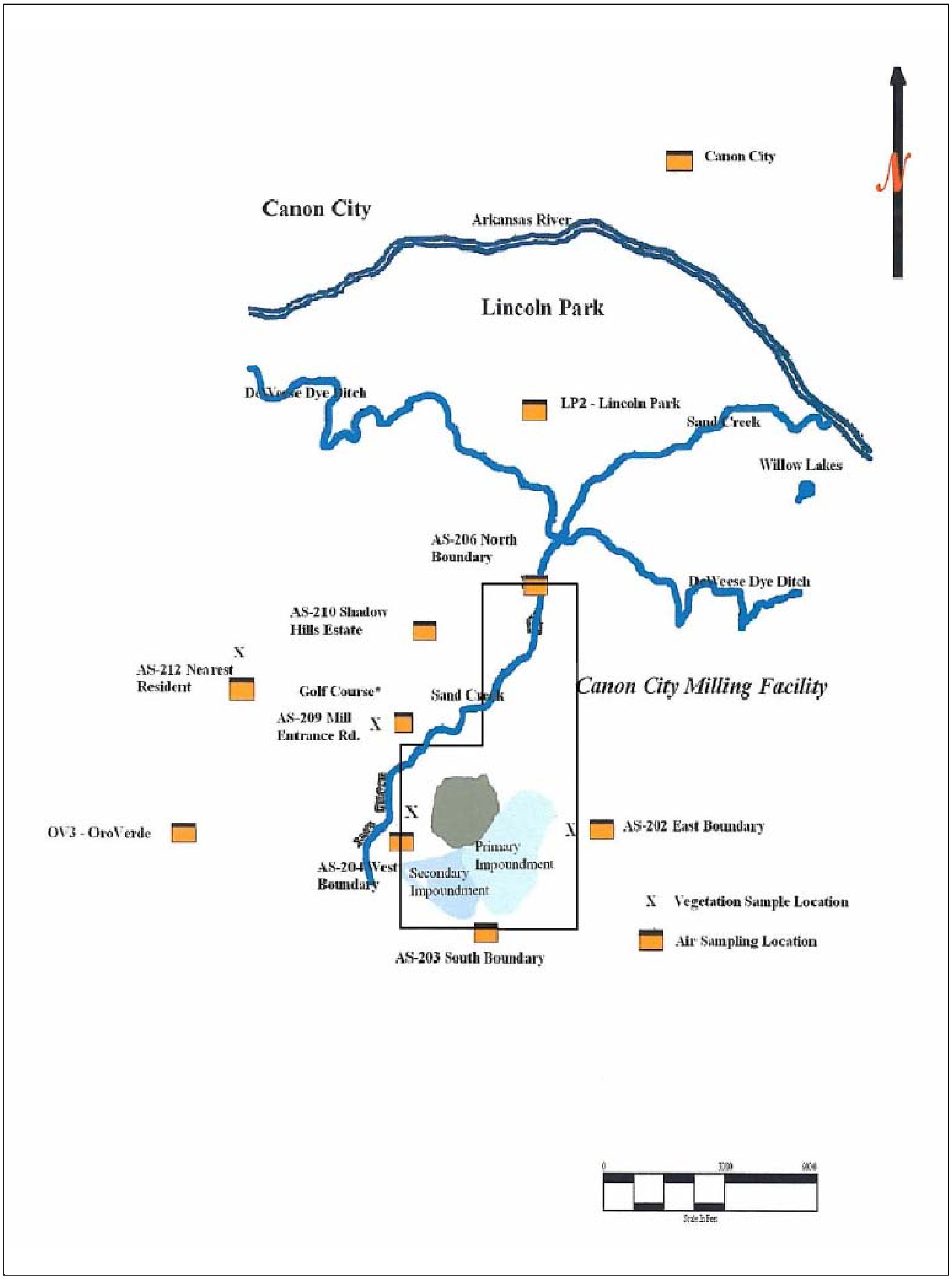
Note: An additional air sampling station is located in Cañon City (not depicted on the figure).

Figure 22. Sand Creek Cleanup Project



Source: Cotter 2000

Figure 23. Approximate Locations of Cotter Mill Monitoring Stations



Notes: Figure reproduced from: Cotter 2008

APPENDIX C:
ATSDR's Evaluation Process
And
Exposure Dose Calculations

ATSDR's Evaluation Process

Step 1 – Comparison Values and the Screening Process

To evaluate the available data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are the contaminant concentrations found in a specific media (for example: air, soil, or water) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water, or soil that someone may inhale or ingest each day. CVs are generated to be conservative and non-site specific. These values are used only to screen out chemicals that do not need further evaluation; CVs are not intended as environmental clean-up levels or to indicate that health effects occur at concentrations that exceed these values.

CVs can be based on either carcinogenic (cancer-causing) or non-carcinogenic effects. Cancer-based comparison values are calculated from the U.S. Environmental Protection Agency's (EPA) oral cancer slope factor (CSF) or inhalation risk unit. CVs based on cancerous effects account for a lifetime exposure (70 years) with an unacceptable theoretical excess lifetime cancer risk of 1 new case per 1 million exposed people. Non-cancer values are calculated from ATSDR's Minimal Risk Levels (MRLs), EPA's Reference Doses (RfDs), or EPA's Reference Concentrations (RfCs). When a cancer and non-cancer CV exists for the same chemical, the lower of these values is used in the comparison for conservatism.

Step 2 – Evaluation of Public Health Implications

The next step in the evaluation process is to take those contaminants that are above their respective CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Separate child and adult exposure doses (or the amount of a contaminant that gets into a person's body) are calculated for site-specific exposure scenarios, using assumptions regarding an individual's likelihood of accessing the site and contacting contamination. A brief explanation of the calculation of estimated exposure doses is presented below. Calculated doses are reported in units of milligrams per kilograms per day (mg/kg/day). Separate calculations have been performed to account for non-cancer and cancer health effects, if applicable, for each chemical based on the health impacts reported for each chemical. Some chemicals are associated with non-cancer effects while the scientific literature many indicate that cancer-related health impacts are not expected from exposure.

Exposure Dose Factors and Calculations

When chemical concentrations at the site exceed the established CVs, it is necessary for a more thorough evaluation of the chemical to be conducted. In order to evaluate the potential for human exposure to contaminants present at the site and potential health effects from site-specific activities, ATSDR estimates human exposure to the site contaminant from different environmental media by calculating exposure doses.

A discussion of the calculations and assumptions used in this assessment is presented below. The equations are based on the EPA Risk Assessment Guidance for Superfund, Part A (1989), or ATSDR's Public Health Guidance Manual (2005), unless otherwise specified. Assumptions used were based on default values, EPA's Exposure Assessment Handbook (1997) or Child-Specific Exposure Factors Handbook (2008), or professional (site-specific) judgment. When available, site-specific information is used to estimate exposures.

Ingestion of Chemicals in Well Water:

The exposure dose formula used for the ingestion of chemicals in well water is:

$$\text{Exposure Dose (ED)} = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= concentration of contaminant in water in milligrams per liter (mg/L)*
IR *= ingestion rate in liters per day (L/day)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
BW *= body weight (kg)*
AT *= averaging time, days (equal to ED for non-carcinogens and 70 year lifetime for carcinogens, i.e., 70 years x 365 days/year)*

Note: In the intake equation, averaging time (AT) for exposure to non-carcinogenic compounds is always equal to ED; whereas, for carcinogens a 70 year AT is still used in order to compare to EPA's cancer slope factors typically based on that value.

This pathway assumes that an adult resident drinks 2 liters (L) of water per day for 350 days per year. In terms of exposure duration (ED), the adult resident is assumed to live in the same home and drink the same well water for 30 years. The drinking water ingestion rate for children was assumed to be 1 L per day for 350 days per year for 6 years. For average body weight, 70 kg and 16 kg were used for adults and children, respectively.

ATSDR used the average chemical concentration in Well 186 to represent a high exposure scenario from a single well. Well 186 was selected because it consistently contained the highest chemical concentrations over time. The average concentration for all private wells was used to represent exposures to a typical well user.

Table C1. Summary of Exposure Factors and Exposure Doses for the Drinking Water Pathway for Chemicals at the Cotter Mill Site

Chemical	Chemical Concentration (mg/L)	Daily Ingestion Rate (L/day)	Exposure Frequency (days/yr)	Exposure Duration (yrs)	Body Weight (kg)	Averaging Time (days)	Exposure Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Drinking Water Pathway: Ingestion – ADULT and CHILD								
Molybdenum ADULT	0.16 *WELL 189** HIGH EXPOSURE	2	350	30	70	10950	0.004	0.005 Chronic Oral RfD
Molybdenum CHILD		1	350	6	16	2190	**0.010**	
Molybdenum ADULT	0.082 All wells TYPICAL EXPOSURE	2	350	30	70	10950	0.002	
Molybdenum CHILD		1	350	6	16	2190	0.005	
Uranium ADULT	0.048 Well 189* HIGH EXPOSURE	2	350	30	70	10950	0.001	0.002 Intermediate Oral MRL
Uranium CHILD		1	350	6	16	2190	**0.003**	
Uranium ADULT	0.028 All wells TYPICAL EXPOSURE	2	350	30	70	10950	0.0008	
Uranium CHILD		1	350	6	16	2190	0.002	

Bolded type exceeds a comparison value.
* "Well 189" represents a high exposure scenario. This well contained the highest level of chemicals in the sampled group.
"All wells" is used to represent an average exposure scenario for the average private well drinker.

Accidental Ingestion of Chemicals in Soil

The exposure dose formula for incidental ingestion of chemicals soil and/or sediment is:

$$\text{Exposure Dose (ED)} = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= concentration of contaminant in soil in milligrams per kilogram (mg/kg or ppm)*
IR *= ingestion rate in milligrams per day (mg/day)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
CF *= conversion factor (10^{-6} kg/mg)*
BW *= body weight (kg)*
AT *= averaging time, days (equal to ED for non-carcinogens and 70 year lifetime for carcinogens, i.e., 70 years x 365 days/year)*

This pathway assumes that the average adolescent (11 to 16 years of age) or adult resident accidentally ingests 100 milligrams of soil per day. Because the area is in a primarily vacant “buffer zone” between the Cotter Mill and residential homes, ATSDR assumed that very young children would not access the area. Adolescent and adults would access the site infrequently. Therefore, exposure duration (ED) for an adolescent and adult resident was assumed to be 2 days per week (or 104 days/year) for 30 years. For average body weight, 57 kg was used for an adolescent and70 kg was used for an adult.

In this evaluation, the bioavailability from incidental ingestion of arsenic in soil was assumed to be 80% because it is protective of health. Cadmium was assumed to be 100% bioavailable, which is also conservative but protective of health.

Direct Skin (Dermal) Contact with Chemicals in Soil

Dermal absorption of chemicals from soil depends on the area of contact with exposed skin, the duration of contact, the chemical and physical attraction between the contaminant and soil, the ability of the chemical to penetrate the skin, and other factors.

The exposure dose formula for dermal absorption of chemicals soil and/or sediment is:

$$\text{Exposure Dose (ED)} = \frac{C \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= chemical concentration (mg/kg)*
SA *= surface area exposed (square centimeters/day or cm^2/day)*

AF *= soil to skin adherence factor (milligrams per square centimeters or mg/cm^2)*
ABS *= Absorption factor (unitless)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
CF *= conversion factor (10^{-6} kg/mg)*
BW *= body weight (kg)*
AT *= averaging time (days)*

Note: Absorption factors (ABS) are used to reflect the desorption of the chemical from soil and the absorption of the chemical across the skin and into the bloodstream.

For the dermal contact pathway, ATSDR assumed that the surface area available in an adolescent for direct skin contact is 4,300 cubic centimeters per day (cm^2/day); the surface area available in an adult is 5,000 cm^2/day. An adherence factor of 0.07 milligrams per cubic centimeter (mg/cm^3) was used. An absorption factor of 0.03 was used for arsenic and 0.01 was used for cadmium. Individuals were assumed to weigh 57 kg as an adolescent and 70 kg as an adult, and to be exposed for 6 and 30 years, respectively.

The total soil oral and dermal non-carcinogenic dose was estimated as follows:

$$\textit{Total Dose (TD)} = \mathbf{ID + DD}$$

Where:

TD *= total soil ingestion and dermal non-carcinogenic dose*
ID *= Soil ingestion non-carcinogenic dose (mg/kg/day)*
DD*= Soil dermal non-carcinogenic dose (mg/kg/day)*

Cancer Risk Estimates

EPA classifies arsenic as a Class A known human carcinogen by the oral and inhalation routes. Cadmium is classified by EPA as a probable human carcinogen, but only via the inhalation route of exposure. Therefore, only arsenic is evaluated for its carcinogenic risk.

The Lifetime Estimated Cancer Risk for arsenic is estimated as follows:

$$\textit{LECR} = \mathbf{TDs \times CSF \times EF}$$

Where:

LECR *= lifetime estimated cancer risk*
TDs *= total soil oral and dermal non-carcinogenic dose (mg/kg/day)*
CSF *= cancer slope factor ((mg/kg-day)$^{-1}$)*
EF *= Exposure factor (unitless) = exposure duration / lifetime = (30 years) / (70 years) = 0.4*

The cancer slope factor for arsenic is 1.5 mg/kg-day. Therefore, the LECR is 1.2 x 10^{-5}.

Table C2. Summary of Exposure Factors and Exposure Doses for the Soil Exposure Pathway for Chemicals at the Cotter Mill Site

Chemical	Chemical Concentration (mg/kg)	Daily Intake Rate (mg/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Exposure Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Soil Exposure Pathway: Accidental Ingestion and Direct Skin Contact - ADULT and ADOLESCENT								
Arsenic (ingestion)	45	100	104	30	70	10950	0.00002	0.0003 MRL
Arsenic (dermal)		NA	104	30	70	10950	0.000002	
TOTAL DOSE ARSENIC - Adult							0.00002	*Below Guideline*
Cadmium (ingestion)	37	100	104	30	70	10950	0.00002	0.0001 MRL
Cadmium (dermal)		NA	104	30	70	10950	0.0000005	
TOTAL DOSE CADMIUM -Adult							0.00002	*Below Guideline*
Arsenic (ingestion)	45	100	104	6	54	2190	0.00002	0.0003 MRL
Arsenic (dermal)		NA	104	6	54	2190	0.000002	
TOTAL DOSE ARSENIC - Adolescent							0.00002	*Below Guideline*
Cadmium (ingestion)	37	100	104	6	54	2190	0.00002	0.0001 MRL
Cadmium (dermal)		NA	104	6	54	2190	0.0000006	
TOTAL DOSE CADMIUM - Adolescent							0.00002	*Below Guideline*

Incidental Ingestion of Chemicals in Surface Water

The ATSDR exposure dose formula used for the ingestion of chemicals in surface water while wading or swimming is:

$$\text{Exposure Dose (ED)} = \frac{C \times IR \times ET \times EF \times ED}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= concentration of contaminant in water in milligrams per liter (mg/L)*
IR *= ingestion rate in liters per day (L/day); based on contact rate of 50 ml/hr*
ET *= exposure time (hours/event)*
EF *= exposure frequency (events/year)*
ED *= exposure duration (years)*
BW *= body weight (kg)*
AT *= averaging time, days (equal to ED for non-carcinogens and 70 year lifetime for carcinogens, i.e., 70 years x 365 days/year)*

This pathway assumes that adult and children residents would accidentally swallow 50 milliliters of water per hour while swimming, wading or recreating in Sand Creek or the DeWeese Dye Ditch. In terms of exposure time and frequency, ATSDR conservatively assumed an adult and child resident would recreate in these waters for 2 hours per day, 2 days per week (or 104 days/year) for 30 years and 6 years, respectively. For average body weight, 70 kg and 16 kg were used for adults and children, respectively.

Direct Skin (Dermal) Contact with Chemicals in Surface Water

ATSDR's exposure dose formula for dermal absorption of chemicals soil and/or sediment is:

$$\text{Exposure Dose (ED)} = \frac{C \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= chemical concentration (mg/L)*
SA *= surface area exposed* (cm^2)
PC *= chemical-specific dermal permeability constant (cm/hr)*
ET *= exposure time (hours/day)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
CF *= volumetric conversion factor for water* ($1L/1000\ cm^3$)
BW *= body weight (kg)*
AT *= averaging time (days)*

The dermal contact pathway assumes that the total body surface area available for contact with water is 20,000 cm^2 for adults and 9,300 cm^2 for children. Adults were assumed to weigh 70 kg and to be exposed for 30 years. Children were assumed to weigh 16 kg and to be exposed for 6 years. Adults and children were conservatively assumed to swim in the contaminated water 2 days per week (104 days per year) for 2 hours per recreating event. A dermal permeability constant of 0.001 cm/hr was used for both manganese and molybdenum.

Table C3. Summary of Exposure Factors and Exposure Doses for the Surface Water Pathway for Chemicals at the Cotter Mill Site

Chemical	Chemical Concentration (mg/L)	Daily Ingestion Rate (L/day)	Exposure Frequency (days/yr)	Exposure Duration (yrs)	Body Weight (kg)	Averaging Time (days)	Exposure Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Surface Water Exposure Pathway: Accidental Ingestion and Direct Skin Contact while Wading or Swimming – ADULT and CHILD								
Manganese* Adult Ingestion	1.9	0.1	104	30	70	10950	3.9 x 10^{-4}	0.05 Chronic Oral RfD
Manganese Adult Dermal		NA	104	30	70	10950	3.1 x 10^{-4}	
		TOTAL DOSE MANGANESE – Adult					7 x 10^{-4}	*Below Guideline*
Manganese Child Ingestion		0.1	104	6	16	2190	1.7 x 10^{-3}	0.05 Chronic Oral RfD
Manganese Child Dermal		NA	104	6	16	2190	6.3 x 10^{-4}	
		TOTAL DOSE MANGANESE - Child					2.3 x 10^{-3}	*Below Guideline*
Molybdenum† Adult Ingestion	0.051	0.1	104	30	70	10950	1.0 x 10^{-5}	0.005 Chronic Oral RfD
Molybdenum Adult Dermal		NA	104	30	70	10950	8.3 x 10^{-6}	
		TOTAL DOSE MOLYBDENUM - Adult					1.8 x 10^{-5}	*Below Guideline*
Molybdenum Child Ingestion		0.1	104	6	16	2190	4.5 x 10^{-5}	0.005 Chronic Oral RfD
Molybdenum Child Dermal		NA	104	6	16	2190	1.7 x 10^{-5}	
		TOTAL DOSE MOLYBDENUM - Child					6.2 x 10^{-5}	*Below Guideline*

*Maximum concentration of manganese in surface water detected in DeWeese Dye Ditch
†Maximum concentration of molybdenum in surface water detected in Sand Creek

Consumption of Homegrown Fruits and Vegetables

The following formula presents the method for calculating an exposure dose for a typical consumer of homegrown fruits and vegetables:

$$\text{Exposure Dose (mg/kg/day)} = \mathbf{C \times IR \times CF}$$

Where:

C *= contaminant concentration (mg/kg)*
IR *= intake rate of fruit or vegetable (g/kg/day)*
CF *= conversion factor* $(1 \times 10^{-3}$ *kg/mg)*

Exposure doses for ingestion of garden vegetables were calculated using the average detected concentration of each contaminant measured in fruit and vegetable samples, in mg/kg, multiplied by average consumption rates of homegrown fruits or vegetables in grams per kilogram of body weight per day (g/kg/day). Intake rates were taken from EPA's Exposure Factors Handbook for adults, and EPA's Child-Specific Exposure Factors Handbook for children, for the Western United States. The average consumption rate was used to represent a "typical" fruit and vegetable consumer. The 95 percentile consumption rate was used to represent an "above average" consumer of fruits and vegetables. The calculated value was multiplied by a conversion factor of 0.001 kilograms per gram.

Table C4. Summary of Exposure Doses for Local Fruits and Vegetables Irrigated with Contaminated Well Water

Chemical	Chemical Concentration/ Exposure Group	Exposure Dose Fruits (mg/kg/day)	Exposure Dose Vegetables (mg/kg/day)	Health Guideline (mg/kg/day)
Arsenic	Average consumer	0.0001	0.0001	0.0003, Chronic Oral MRL
	Above Average Consumer	0.0006	0.0005	
	Child	0.0002	0.0002	
	Infant	0.0004	0.0004	
Barium	Average consumer	0.001	0.003	0.2 Chronic Oral MRL
	Above Average Consumer	0.005	0.010	
	Child	0.002	0.004	
	Infant	0.004	0.008	
Cadmium	Average consumer	0.0001	0.0001	0.001, RfD
	Above Average Consumer	0.0005	0.0002	
	Child	0.0002	0.0001	
	Infant	0.0004	0.0002	
Chromium	Average consumer	0.0001	0.0001	1.5 RfD
	Above Average Consumer	0.0006	0.0003	
	Child	0.0002	0.0001	
	Infant	0.0005	0.0003	
Cobalt	Average consumer	ND	0.00004	0.01 Intermediate MRL
	Above Average Consumer	ND	0.00012	
	Child	ND	0.00005	
	Infant	ND	0.0001	
Lead	Average consumer	0.0003	0.0004	NA
	Above Average Consumer	0.001	0.001	
	Child	0.0005	0.0005	
	Infant	0.001	0.001	
Manganese	Average consumer	0.002	0.004	0.14 RfD
	Above Average Consumer	0.01	0.02	
	Child	0.004	0.006	
	Infant	0.008	0.01	
Molybdenum	Average consumer	0.0003	0.001	0.005 RfD
	Above Average Consumer	0.001	0.004	

Chemical	Chemical Concentration/ Exposure Group	Exposure Dose Fruits (mg/kg/day)	Exposure Dose Vegetables (mg/kg/day)	Health Guideline (mg/kg/day)
	Child	0.0005	0.002	
	Infant	0.001	0.004	
Nickel	Average consumer	ND	0.0001	0.02 RfD
	Above Average Consumer	ND	0.0005	
	Child	ND	0.0002	
	Infant	ND	0.0004	
Strontium	Average consumer	0.004	0.009	0.6 RfD
	Above Average Consumer	0.02	0.03	
	Child	0.007	0.01	
	Infant	0.01	0.03	
Uranium	Average consumer	0.00002	0.00001	0.002 Intermediate MRL
	Above Average Consumer	0.00008	0.00004	
	Child	0.00003	0.00002	
	Infant	0.00006	0.00004	
Vanadium	Average consumer	ND	0.00008	0.003 Intermediate MRL
	Above Average Consumer	ND	0.0003	
	Child	ND	0.0001	
	Infant	ND	0.0002	
Zinc	Average consumer	0.004	0.006	0.3 Chronic Oral MRL
	Above Average Consumer	0.02	0.02	
	Child	0.006	0.008	
	Infant	0.01	0.02	

Bolded text exceeds a health guideline.
ND = not detected
NA = not available

ATSDR's Evaluation of Cancer and Non-Cancer Health Effects

Non-Cancer Health Effects

The doses calculated for exposure to each individual chemical are compared to an established health guideline, such as a MRL or RfD, in order to assess whether adverse health impacts from exposure are expected. These health guidelines, developed by ATSDR and EPA, are chemical-specific values that are based on the available scientific literature and are considered protective of human health. Non-carcinogenic effects, unlike carcinogenic effects, are believed to have a threshold, that is, a dose below which adverse health effects will not occur. As a result, the current practice for deriving health guidelines is to identify, usually from animal toxicology experiments, a No Observed Adverse Effect Level (or NOAEL), which indicates that no effects are observed at a particular exposure level. This is the experimental exposure level in animals (and sometimes humans) at which no adverse toxic effect is observed. The NOAEL is then modified with an uncertainty (or safety) factor, which reflects the degree of uncertainty that exists when experimental animal data are extrapolated to the general human population. The magnitude of the uncertainty factor considers various factors such as sensitive subpopulations (for example; children, pregnant women, and the elderly), extrapolation from animals to humans, and the completeness of available data. Thus, exposure doses at or below the established health guideline are not expected to result in adverse health effects because these values are much lower (and more human health protective) than doses, which do not cause adverse health effects in laboratory animal studies. For non-cancer health effects, the following health guidelines are described below in more detail. It is important to consider that the methodology used to develop these health guidelines does not provide any information on the presence, absence, or level of cancer risk. Therefore, a separate cancer evaluation is necessary for potentially cancer-causing chemicals detected in samples at this site. A more detailed discussion of the evaluation of cancer risks is presented in the following section.

Minimal Risk Levels (MRLs) – developed by ATSDR

ATSDR has developed MRLs for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily exposure to a contaminant below which non-cancer, adverse health effects are unlikely to occur. MRLs are developed for different routes of exposure, such as inhalation and ingestion, and for lengths of exposure, such as acute (less than 14 days), intermediate (15-364 days), and chronic (365 days or greater). At this time, ATSDR has not developed MRLs for dermal exposure. A complete list of the available MRLs can be found at http://www.atsdr.cdc.gov/mrls.html.

References Doses (RfDs) – developed by EPA

An estimate of the daily, lifetime exposure of human populations to a possible hazard that is not likely to cause non-cancerous health effects. RfDs consider exposures to sensitive sub-populations, such as the elderly, children, and the developing fetus. EPA RfDs have been developed using information from the available scientific literature and have been calculated for oral and inhalation exposures. A complete list of the available RfDs can be found at http://www.epa.gov/iris.

If the estimated exposure dose for a chemical is less than the health guideline value, the exposure is unlikely to result in non-cancer health effects. Non-cancer health effects from dermal exposure were evaluated slightly differently that ingestion and inhalation exposure. Since health guidelines are not available for dermal exposure, the calculated dermal dose was compared with the oral health guideline value (RfD or MRL).

If the calculated exposure dose is greater than the health guideline, the exposure dose is compared to known toxicological values for the particular chemical and is discussed in more detail in the text of the PHA. The known toxicological values are doses derived from human and animal studies that are presented in the ATSDR Toxicological Profiles and EPA's Integrated Information System (IRIS). A direct comparison of site-specific exposure doses to study-derived exposures and doses found to cause adverse health effects is the basis for deciding whether health effects are likely to occur. This in-depth evaluation is performed by comparing calculated exposure doses with known toxicological values, such as the no-observed adverse-effect-level (NOAEL) and the lowest-observed-adverse-effect-level (LOAEL) from studies used to derive the MRL or RfD for a chemical.

Cancer Risks

Exposure to a cancer-causing compound, even at low concentrations, is assumed to be associated with some increased risk for evaluation purposes. The estimated excess risk of developing cancer from exposure to contaminants associated with the site was calculated by multiplying the site-specific adult exposure doses, with a slight modification, by EPA's chemical-specific Cancer Slope Factors (CSFs or cancer potency estimates), which are available at http://www.epa.gov/iris. Calculated dermal doses were compared with the oral CSFs.

An increased excess lifetime cancer risk is not a specific estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime during his or her lifetime following exposure to a particular contaminant. Therefore, the cancer risk calculation incorporates the equations and parameters (including the exposure duration and frequency) used to calculate the dose estimates, but the estimated value is divided by 25,550 days (or the averaging time), which is equal to a lifetime of exposure (70 years) for 365 days/year.

There are varying suggestions among the scientific community regarding an acceptable excess lifetime cancer risk, due to the uncertainties regarding the mechanism of cancer. The recommendations of many scientists and EPA have been in the risk range of 1 in 1 million to 1 in 10,000 (as referred to as 1×10^{-6} to 1×10^{-4}) excess cancer cases. An increased lifetime cancer risk of one in one million or less is generally considered an insignificant increase in cancer risk. Cancer risk less than 1 in 10,000 (or 1×10^{-5}) are not typically considered a health concern. An important consideration when determining cancer risk estimates is that the risk calculations incorporate several very conservative assumptions that are expected to overestimate actual exposure scenarios. For example, the method used to calculate EPA's CSFs assumes that high-dose animal data can be used to estimate the risk for low dose exposures in humans. As previously stated, the method also assumes that there is no safe level for exposure. Lastly, the method computes the 95% upper bound for the risk, rather than the average risk, suggesting that the cancer risk is actually lower, perhaps by several orders of magnitude.

Because of the uncertainties involved with estimating carcinogenic risk, ATSDR employs a weight-of-evidence approach in evaluating all relevant data. Therefore, the carcinogenic risk is also described in words (qualitatively) rather than giving a numerical risk estimate only. The numerical risk estimate must be considered in the context of the variables and assumptions involved in their derivation and in the broader context of biomedical opinion, host factors, and actual exposure conditions. The actual parameters of environmental exposures have been given careful and thorough consideration in evaluating the assumptions and variables relating to both toxicity and exposure. A complete review of the toxicological data regarding the doses associated with the production of cancer and the site-specific doses for the site is an important element in determining the likelihood of exposed individuals being at a greater risk for cancer.

Appendix D. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-800-CDC-INFO (1-800-232-4636).

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems

Aerobic
Requiring oxygen [compare with anaerobic].

Ambient
Surrounding (for example, ambient air).

Anaerobic
Requiring the absence of oxygen [compare with aerobic].

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect
A biologic response to exposure to multiple substances that is less than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study
A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP [see Community Assistance Panel.]

Cancer
Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic
Occurring over a long time [compare with acute].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people from a community and from health and environmental agencies who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause

harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect
A disease or an injury that happens as a result of exposures that might have occurred in the past.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention
Measures used to prevent a disease or reduce its severity.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD
United States Department of Defense.

DOE
United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

EPA
United States Environmental Protection Agency.

Epidemiologic surveillance [see Public health surveillance].

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often

and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Exposure registry
A system of ongoing followup of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Half-life (t½)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to evaluate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period

(acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, a condition, or an injury) is stated.

Mutagen
A substance that causes mutations (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

National Toxicology Program (NTP)
Part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public availability session
An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public health surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD [see reference dose]

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or an environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Substance-specific applied research
A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)]

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Surveillance [see public health surveillance]

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen
A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people’s sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Urgent public health hazard
A category used in ATSDR’s public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other glossaries and dictionaries:
Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)
National Library of Medicine (NIH)
(http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

"Marion Loomis"
<loomis@vcn.com>
10/01/2010 11:35 AM

To Reid Rosnick
cc
bcc
Subject Conference Call re Subpart W

1 attachment

Public Health Assessment for Cotter Corp.pdf

Mr. Rosnick

The Wyoming Mining Association (WMA) is very concerned about claims that uranium mining and processing may contribute to health impairment from the release of radon from uranium processing facilities. WMA would like to draw your attention to the attached report entitled Public Health Assessment for LINCOLN PARK/COTTER URANIUM MILLCAÑON CITY, FREMONT COUNTY, COLORADO EPA FACILITY ID: COD042167585 SEPTEMBER 9, 2010. In summary the study *concludes that ambient air emissions of particle bound radionuclides have not resulted in exposures to the public at levels that could cause adverse health outcomes.* The ATSDR looked at all of the air data collected from 1979 to present related to Cotter Corporation's Canon City Mill and concluded that outdoor concentration of radon contributed zero dust to the public, because it is a noble gas and does not stay in the lungs long enough to radioactively decay.
I understand that there will be a conference call on October 6 to discuss 40 CFR Part 61 Subpart W which deals with this issue. WMA requests that this study be on the agenda for discussion during that conference call.

Thank you.

Marion Loomis

Public Health Assessment for

LINCOLN PARK/COTTER URANIUM MILL
CAÑON CITY, FREMONT COUNTY, COLORADO
EPA FACILITY ID: COD042167585
SEPTEMBER 9, 2010

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

NOVEMBER 9, 2010

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Agency for Toxic Substances and Disease Registry....................................Thomas R. Frieden, M.D., M.P.H., Administrator
Christopher J. Portier, Ph.D., Director

Division of Health Assessment and Consultation………………………………………..William Cibulas, Jr., Ph.D., Director
Sharon Williams-Fleetwood, Ph.D., Deputy Director

Health Promotion and Community Involvement Branch………………………………Hilda Shepeard, Ph.D., M.B.A., Chief

Exposure Investigations and Consultation Branch……………………….……………………..Susan M. Moore, M.S., Chief

Federal Facilities Assessment Branch……………………………………………………….....Sandra G. Isaacs, B.S., Chief

Superfund and Program Assessment Branch .... Richard E. Gillig, M.C.P., Chief

Use of trade names is for identification only and does not constitute endorsement by the Public Health Service or the U.S. Department of Health and Human Services.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
Attn: Records Center
1600 Clifton Road, N.E., MS F-09
Atlanta, Georgia 30333

You May Contact ATSDR Toll Free at
1-800-CDC-INFO or
Visit our Home Page at: http://www.atsdr.cdc.gov

PUBLIC HEALTH ASSESSMENT

LINCOLN PARK/COTTER URANIUM MILL

CAÑON CITY, FREMONT COUNTY, COLORADO

EPA FACILITY ID: COD042167585

Prepared by:

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Site and Radiological Assessment Branch

This information is distributed by the Agency for Toxic Substances and Disease Registry for public comment under applicable information quality guidelines. It does not represent and should not be construed to represent final agency conclusions or recommendations.

Foreword

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as the Superfund law. This law set up a fund to identify and clean up hazardous waste sites. The Environmental Protection Agency (EPA) and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment process allows ATSDR scientists and public health assessment cooperative agreement partners flexibility in document format when presenting findings about the public health impact of hazardous waste sites. The flexible format allows health assessors to convey to affected populations important public health messages in a clear and expeditious way.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high-risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to evaluate possible the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals, and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the public comments that related to the document are addressed in the final version of the report.

Conclusions: The report presents conclusions about the public health threat posed by a site. Ways to stop or reduce exposure will then be recommended in the public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA or other responsible parties. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also recommend health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Rolanda Morrison
ATSDR Records Center (MS F-09)
4770 Buford Hwy, NE
Building 106, Room 2108
Atlanta, GA 30341

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APPENDIX C - ATSDR'S EVALUATION PROCESS AND EXPOSURE DOSE CALCULATIONS

Acronyms and Abbeviations

CCAT	Colorado Citizens Against Toxic Waste
CDPHE	Colorado Department of Public Health and Environment
CREG	cancer risk evaluation guide
CV	comparison value
D	dissolved
EMEG	environmental media evaluation guide
EPA	US Environmental Protection Agency
LPWUS	Lincoln Park Water Use Survey
LTHA	lifetime health advisory for drinking water
MCL	maximum contaminant level
mg/L	milligrams per liter
µR/hr	microroentgen per hour
N	not defined in the CDPHE database
NA	not available
ND	not detected
NPL	National Priorities List
OU	operable units
pCi/g	picocuries per gram
pCi/L	picocuries per liter
ppm	parts per million
RAP	Remedial Action Plan
RBC	risk based concentration
RMEG	reference dose media evaluation guide
S	suspended
SCS	Soil Conservation Service
SSL	soil screening level
T	total
UMTRCA	1978 Uranium Mill Tailings Radiation Control Act
USGS	United States Geological Survey

I. SUMMARY

Introduction

ATSDR's top priority is to ensure that the community of Lincoln Park and surrounding communities have the best information possible to safeguard their health.

The purpose of this public health assessment (PHA) is to evaluate available data and information on the release of hazardous substances from the Cotter Uranium Mill to determine if people could be harmed by coming into contact with those substances. This PHA will also list actions, as needed, to be taken to protect the public's health.

Background

The Cotter Uranium Mill (Cotter) is located approximately two miles south of downtown Cañon City in Fremont County, Colorado. The community of Lincoln Park borders the site to the north and the housing developments of Dawson Ranch, Wolf Park, and Eagle Heights are located along Cotter's western boundary. The nearest residence is about 0.25 miles from the mill (Galant et al. 2007).

The 2,500-acre site includes two inactive mills, ore stockpile areas, a partially reclaimed tailings pond disposal area (i.e., the old ponds area), and a current tailings pond disposal area (i.e., the lined "main impoundment area"). A large portion of the site is used to store waste products in the impoundment area. The former mill area is fenced and is known as the "restricted area".

The Cotter Mill began operations in 1958, extracting uranium ore using an alkaline leach process. In 1979, the facility switched to an acid leach process for extracting uranium. Cotter suspended primary operations in 1987, and only limited and intermittent processing occurred until the facility resumed operations in 1999 with a modified alkaline-leaching capability until 2001. Cotter refabricated the mill circuits between 2002 and 2005 to operate using an acid process when it went into stand down in March 2006. Cotter is currently evaluating whether to re-engineer the mill for future operation.

Wastes containing metals and radionuclides were released from Cotter and entered the nearby environment. People could potentially be exposed to these wastes if they come into contact with them in drinking water, soil, sediment, biota (fruits and vegetables) or ambient air.

Conclusions

After evaluating the available data, ATSDR reached four important conclusions in this public health assessment:

Conclusion 1

ATSDR concludes that drinking water from contaminated private wells could harm people’s health. This is a public health hazard.

Basis for Conclusion

Private well sampling data collected from 1984 to 2007 revealed the presence of molybdenum at levels that could harm people’s health. A water use survey conducted in Lincoln Park in 1989 revealed that at least seven people used groundwater (from their private wells) for personal consumption. These and other residents whose private wells were affected by the highest molybdenum contamination may be at increased risk for health effects such as gout-like conditions. Individuals who do not take in enough dietary copper or who cannot process it correctly will be affected the most.

The lack of consistent monitoring over the years and the unknown usage of wells before the installation of the public water supply makes these past exposures difficult to accurately assess.

Most town residents are now connected to the public water supply and have thus eliminated their exposure to contaminated water. However, some residents are reported to have refused public water supply connections, and many may still have operational private wells. Additionally, no formal institutional controls exist to control groundwater use in Lincoln Park. Therefore, current and future uses of private wells for domestic purposes are still possible.

Conclusion 2

ATSDR concludes that accidentally eating or touching soil and sediment near the Cotter Mill property or in Lincoln Park will not harm people’s health. However, ATSDR cannot make conclusions about whether lead in soils near Cotter Mill could harm people’s health in the future.

Basis for Conclusion

Currently, the property near the Cotter Mill property is restricted access, vacant or used for industrial purposes; therefore, contact with soils near the property should be minimal. The soil sampling conducted at the site does not allow ATSDR to accurately assess potential exposures if the area is ever developed for residential, commercial or recreational uses. Therefore, a conclusion regarding future exposures cannot be made because not enough information is available about future development of this area.

ATSDR recommends that lead contamination in soil be re-evaluated if

Next Steps	the area is considered for development for residential or non-industrial uses.
Conclusion 3	ATSDR concludes that eating locally-grown fruits and vegetables irrigated with private well water will not harm most people's health. However, a person eating above-average amounts of fruits and vegetables (4 times the average consumer) might have a low increased risk for developing cancer over a lifetime. As a precaution, residents should limit their use of contaminated well water to irrigate their crops. In all cases, the crops should be thoroughly cleaned prior to eating.
Basis for Conclusion	Sampled locally-grown fruits and vegetables did not indicate the presence of contaminants at levels that would cause non-cancer health effects. The increased cancer risk is based on a person consuming more fruits and vegetables (95th percentile range) than a typical consumer. The cancer estimate is conservative because it assumes that a person would grow and eat fruits and vegetables that contain arsenic every day for 30 years. The amount of fruits and vegetables eaten will likely be much less than estimated, mainly because the growing season is not year-round. The amount of a contaminant ingested would depend upon the type of crop eaten, the likelihood of the crop bioaccumulating any of the contaminants, how often the crop is eaten, if contaminated well water is used to irrigate the crop, and if the crop is thoroughly cleaned prior to eating them.
Conclusion 4	ATSDR concludes that ambient air emissions of particle bound radionuclides have not resulted in exposures to the public at levels that could cause adverse health outcomes.
Basis for Conclusion	With the exception of thorium-230 levels observed in 1981 and 1982, associated with excavation of contaminated tailings, every radionuclide monitored has been more than a factor of ten below annual dose based health limits to the public. The excavation releases appear to have only exposed on-site workers, but still below occupational limits at that time.
	ATSDR is taking the following follow-up actions at this site:
Next Steps	ATSDR's Health Promotion and Community Involvement Branch (HPCIB) will conduct health-related educational activities in the community, as necessary.

ATSDR's HPCIB will coordinate community outreach and community involvement activities for the site.

ATSDR will continue to work with appropriate state and federal agencies and review additional relevant environmental data (including the water use survey) as it becomes available.

ATSDR will update the action plan for this site as needed. New environmental, toxicological, health outcome data, or implementing the above proposed actions may necessitate the need for additional or alternative actions at this site.

For More Information

If you have concerns about your health, you should contact you health care provider. You can also call ATSDR at 1-800-CDC-INFO for more information on the Lincoln Park/Cotter Uranium Mill site.

II. BACKGROUND

A. Site description and operational history

The Cotter Mill is located approximately two miles south of downtown Cañon City in Fremont County, Colorado (see Figure 1) [Galant et al. 2007]. The community of Lincoln Park borders the site to the north and the housing developments of Dawson Ranch, Wolf Park, and Eagle Heights are located along Cotter's western boundary. The nearest residence is about 0.25 miles from the mill [Galant et al. 2007].

The 2,500-acre site includes two inactive mills, ore stockpile areas, a partially reclaimed tailings pond disposal area (i.e., the old ponds area), and a current tailings pond disposal area (i.e., the lined "main impoundment area"). A large portion of the site is used to store waste products in the impoundment area. The former mill area is fenced and is known as the "restricted area" [Galant et al. 2007].

The Cotter Mill began operations in 1958, extracting uranium ore using an alkaline leach process. In 1979, the facility switched to an acid leach process for extracting uranium. Cotter suspended primary operations in 1987 [Weston 1998], and only limited and intermittent processing occurred until the facility resumed operations in 1999 with a modified alkaline-leaching capability until 2001 [EPA 2002]. Cotter refabricated the mill circuits between 2002 and 2005 to operate using an acid process when it went into stand down in March 2006 [Cotter 2007]. Cotter is currently evaluating whether to re-engineer the mill for future operation [CDPHE 2008].

Additional information about the history and licensing of the Cotter Mill can be found on the Colorado Department of Public Health and Environment's (CDPHE) and the US Environmental Protection Agency's (EPA) Web sites at http://www.cdphe.state.co.us/hm/cotter/sitedescript.htm and http://www.epa.gov/region8/superfund/co/lincolnpark/.

B. Remedial and regulatory history

Originally, mill tailings (i.e., solid ore processing waste), raffinate (liquid waste that remains after extraction), and other liquids from the alkaline leach process were stored in ten on-site unlined ponds. In 1978, lined impoundments were built on site to store process waste products. The main impoundment contained two cells to segregate acid-leach tailings and liquids in the primary impoundment cell from alkaline-leach tailings in the secondary impoundment cell (EPA 2002). By 1983, more than 2.5 million cubic yards of waste products from historic operations were transferred from the original unlined ponds to the secondary impoundment. All new process wastes are stored in the lined primary impoundment [Galant et al. 2007].

Because Cotter Mill operations released radionuclides and metals into the environment, soil around the mill and groundwater in the nearby Lincoln Park community became contaminated, primarily with molybdenum and uranium [CDPHE 2008]. In 1984, the Lincoln Park/Cotter Mill Site was added to the Superfund National Priorities List (NPL) [EPA 2008]. EPA divided the site into two operable

According to a signed Memorandum of Understanding, CDPHE is the lead regulatory agency overseeing cleanup at the Cotter Mill.

units (OUs)—OU1 consists of the on-site contamination and OU2 is the neighborhood of Lincoln Park (i.e., the off-site impacted area) [CDPHE 2008; EPA 2007]. Together, the Lincoln Park/Cotter Mill Superfund Site encompasses about 7.8 square miles (5,000 acres) [EPA 2004].

In 1988, the Cotter Corporation and CDPHE signed a Consent Decree and Remedial Action Plan (RAP) [Galant et al. 2007]. The purpose of the court-ordered action was to assess and mitigate human and environmental impacts from the Cotter Mill. As part of the settlement, Cotter agreed to clean up the site at the corporation's expense [EPA 2008]. The cleanup was estimated to take 16 years and cost $11 million [Galant et al. 2007]. EPA and the US Department of Energy have also contributed to cleanup costs [DOE 2003]. Remedial activities have focused on eliminating the sources of contamination at the Cotter Mill and eliminating exposures to Lincoln Park residents [CDPHE 2008]. Many of the activities outlined in the 1988 RAP have been completed, including the following:

- Connecting Lincoln Park residents to city water;
- Constructing a groundwater barrier at the Soil Conservation Service (SCS) Flood Control Dam to minimize migration of contaminated groundwater into Lincoln Park;
- Moving tailings and contaminated soils into a lined impoundment to eliminate them as a source of contamination; and
- Excavating contaminated stream sediments in Sand Creek.

The old ponds area was undergoing reclamation in late 2008 [Pat Smith, EPA Region 8, personal communication, August 2008]. Remaining activities include groundwater remediation and final site cleanup [CDPHE 2008; Galant et al. 2007]. Groundwater remediation activities have shown some positive results. However, the balance of the remedial activities listed in the Consent Decree have not been successful enough in mitigating the plume, and most have been discontinued (e.g., barrier wall, dam to ditch flushing, calcium-polysulfide fix/flush, and permeable reactive treatment wall). Table 1 below lists a timeline of process events, remedial activities, and government actions for the Lincoln Park/Cotter Mill Superfund Site.

Table 1. Lincoln Park/Cotter Mill Superfund Site Activity Timeline

Date	Type of Event[1]	Event[2]
July 1958	Process	Cotter Corporation began alkali leach process operations (licensing by the Atomic Energy Commission)
June 1965	Event	Flood that caused the unlined tailings ponds at the Cotter Mill to overflow into Lincoln Park
1971	Remediation	SCS Dam completed; dam pumps impounded surface water back to the main impoundment (groundwater barrier completed at a later date after 1988 RAP)
July 1972	Remediation	Pond 2 lined
June 1976	Remediation	Pond 10 lined
1978–1979	Remediation	A new lined impoundment consisting of two cells (primary and secondary) constructed adjacent to the old ponds area for management of wastes from the new mill (alkali process)
1979	Remediation	The old mill was demolished and new mill construction began
1979–present	Remediation	Impounded water at the SCS Dam pumped back to the main impoundment
1979–1998	Process	Operations switched from an alkali leach process to an acid leach mill; continuing operations intermittently
1980	Remediation	Old upstream method tailings ponds replaced by a full-height compacted earth embankment
1980	Remediation	Construction of Well 333 just north of Cotter; well removes contaminated water flowing from the old ponds area
June 1981	Remediation	Pond 3 lined
1981–1983	Remediation	Tailings from the unlined old ponds area (~2.5 million cubic yards) removed and placed in the new impoundment
December 9, 1983	Government Action	State of Colorado files a complaint against Cotter under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
September 21, 1984	Government Action	Cotter (OU1) and Lincoln Park (OU2) added to the NPL
1985–1986	Investigation	Remedial Investigation and Feasibility Study (GeoTrans 1986)
April 1986	Government Action	Memorandum of Agreement between EPA and the state of Colorado
April 8, 1988	Government Action	Consent decree signed, including a RAP that required cleanup activities
1988	Remediation	An additional 2 feet of soil was removed from the old ponds area and placed in the lined primary impoundment
1988	Remediation	Lined water distribution/surge pond constructed over Pond 7
1988	Remediation	Installation of a hydrologic clay barrier upgradient from the SCS Dam
1989	Remediation	The secondary impoundment cell was covered with liquid for dust control and to create evaporative capacity; additional contaminated soils were removed from the old ponds area and placed in the primary impoundment cell

Date	Type of Event[1]	Event[2]
1989–2000	Remediation	Installation of two hydraulic barriers (injection/withdrawal systems) to control groundwater flow from the old ponds area; discontinued in 2000 because the system was unproductive
1990–1996	Remediation	SCS Dam to DeWeese ditch flushing project
1990–1998	Remediation	Four pilot tests to evaluate the effectiveness of active flushing of vadose zone and aquifer for contaminant removal in OU1
October 29, 1991	Report	Health Risk Assessment of the Cotter Uranium Mill Site: Phase I (HRAP 1991)
January 7, 1993	Report	RAP final report, Willow Lakes (Cotter)
1993–1999	Remediation	Sand Creek Soil Cleanup Action identified and removed approximately 9,000 cubic yards of tailings, soil, and sediment from Sand Creek (Cotter 2000)
1995	Licensing	Cotter filed a license amendment with the state for alkaline leach processing of uranium ore (approved 2/97)
November 19, 1996	Report	Supplemental Human Health Risk Assessment: Phase II Final Report (Weston 1996)
1996–1998	Remediation	Flush/fixation process using Calcium Polysulfide in surface infiltration cells
February 1997	Government Action	Radioactive materials license amendment became effective
1998	Process	Mill reconverted to an alkaline leach process
September 29, 1998	Report	Ecological Risk Assessment, Lincoln Park Superfund Site (Stoller Corporation and Schafer & Associates)
1998	Report	Supplemental Human Health Risk Assessment, Phase III Final Report (Weston 1998)
1999	Remediation	Old ponds area surface soils (~100,000 cubic yards) were removed and placed in the lined primary impoundment
May 1999	Process	Cotter resumed operations (which had been intermittent since 1979) with modified alkaline-leaching capability
September 30, 1999	Investigation	Final Focused Feasibility Study, Lincoln Park
June 2000	Remediation	Installation of a permeable reactive treatment wall across Sand Creek channel, north of SCS Dam in DeWeese Dye Ditch flush (to fulfill EPA requirement to address contaminated groundwater that was bypassing the SCS Dam barrier)
2000–2005	Process	Cotter proposes modifications to the circuit to process zircon ore. Process was not successful and discontinued by 2005.
January 2002	Government Action	EPA issued a Record of Decision for Lincoln Park requiring “No Further Action” for surface soils within Lincoln Park (EPA 2002)
April 2002	Government Action	The governor of Colorado passed an emergency bill requiring an Environmental Assessment be conducted before shipping out-of-state radioactive waste to Cotter
July 9, 2002	Government Action	CDPHE denied Cotter’s license amendment request, preventing receipt of shipments for direct disposal

Date	Type of Event[1]	Event[2]
September 13, 2002	Government Action	State of Colorado allowed Cotter to receive limited amounts of waste material as a test of its handling/storage capability
2002/2003	Investigation	Sampling for plutonium, uranium, lead and molybdenum in the Canon City vicinity (CDPHE 2003)
January 3, 2003	Government Action	EPA issued a notice of unacceptability under the Off-Site Rule regarding the five Proposed Units and impoundments previously found acceptable
2003	Remediation	Permeable reactive treatment wall not functioning as designed
September 9, 2004	Investigation	Cotter submits Feasibility Study for Old Ponds Area with six alternatives
December 15, 2004	Government Action	State health officials approved a 5-year extension of Cotter's uranium-processing license but denied requests to become a disposal facility for off-site radioactive materials
February 1, 2005	Government Action	Cotter filed a request for a hearing regarding the conditions of the license renewal
October 2005	Investigation	Survey of lead in indoor dust, soils, and blood in Lincoln Park to investigate potential impacts of historic smelters (ATSDR 2006a, 2006b, 2006c, 2006d)
April 2006	Government Action	A judge recommended in CDPHE's favor and Cotter filed an exception on the direct disposal issue only
2006	Remediation	To replace the permeable reactive treatment wall, water building up behind barrier is pumped back to the impoundments
January 2007	Government Action	CDPHE signed a Final Agency Decision, affirming the judge's Decision on the license. Cotter filed an appeal to be able to dispose of out-of-state soils in its primary impoundment.
2008	Process	Cotter decides not to take the case to the Court of Appeals, effectively ending the licensing issues from the 2004 renewal.

[1] Describes the general nature of events/actions relating to the Lincoln Park/Cotter Mill Superfund Site.

[2] Includes events/actions most pertinent to ATSDR's evaluation of exposures and potential health effects. Not all site-related events and reports are included.

C. Demographics

ATSDR examines demographic data to identify sensitive populations, such as young children, the elderly, and women of childbearing age, and to determine whether these sensitive populations are exposed to any potential health risks. Demographics also provide details on population mobility and residential history in a particular area. This information helps ATSDR evaluate how long residents might have been exposed to contaminants. According to the 2000 census, 1,170 people live within one mile of the Cotter Mill property—90 of whom are age 6 or younger, 190 are women of childbearing age (15–44 years), and 243 are age 65 or older. Figure 2 in Appendix B shows the demographics within one mile of the mill.

Cañon City is the largest population center in Fremont County with 15,760 residents (see Table 2 below). The Cañon City Metro area includes Cañon City, North Cañon, Lincoln Park, Brookside, Prospect Heights, Four Mile Ranch, Shadow Hills, Dawson Ranch, and the Colorado State Correctional Facilities. Florence is the second largest community in the area with a population of 3,816. The unincorporated portions of Fremont County represent 55% of the population and include Lincoln Park, Prospect Heights, and Shadow Hills [Cotter 2007].

Table 2. Population of communities near the Cotter Mill

Community	2000 Census Population	2006 Population Estimate
Brookside	219	218
Cañon City	15,431	15,760
Coal Creek	303	380
Florence	3,653	3,816
Lincoln Park	3,904	Not available
Rockvale	426	432
Williamsburg	714	700
Fremont County	46,145	47,727

Source: Cotter 2007; Galant et al. 2007

The unincorporated community of Lincoln Park is located in the greater Cañon City area, south of the Arkansas River and north of the Cotter Mill (see Figure 1). The community consists of single and multi-family homes, trailer parks, and rural single family homes. Many of the residents are retired and own their homes. The Lincoln Park area is currently experiencing growth [Galant et al. 2007].

The largest employers in Fremont County are the Colorado Department of Corrections and the Federal Bureau of Prisons. Tourism is the second largest employer in the Cañon City area [Cotter 2007; Galant et al. 2007]. Additional industry and manufacturing employers in Fremont County include Portec, Inc.; Holcim, Inc.; Thermal Ceramics; and Cañon Industrial Ceramics [Cotter 2007]. The health care and school systems also employ a substantial number of people in the county [CCAT, personal communication, August 2008].

D. Land use and natural resources

The Cotter Mill is located within an industrial zone. All abutting lands are zoned for agriculture-forestry. The semi-rural community of Lincoln Park is comprised predominantly of residential developments, agricultural plots and orchards, and small grazing parcels. The Shadow Hills Golf Course is located to the north of the Cotter Mill complex. The land to the south and east of the site is largely undeveloped. Recently, several high end homes have been built near the golf course and in the Wolf Park and Dawson Ranch areas. The distance from Cotter Mill's restricted area to the nearest home is about 0.25 mile [Galant et al. 2007].

Fremont County contains a large amount of public land managed by the US Department of the Interior Bureau of Land Management and the US Department of Agriculture Forest Service. Some of these areas are leased for livestock grazing, aggregate mining, and firewood removal. Visiting the many scenic attractions in Colorado's High Country (e.g., the Royal Gorge Bridge) and rafting in the Arkansas River are popular recreational activities [Cotter 2007].

1. Hydrogeology

In the vicinity of the Cotter Mill, contaminated groundwater primarily migrates along the near surface alluvium and fractured, weathered bedrock immediately underlying the alluvium (<100 feet deep) [USGS 1999a]. Groundwater migration is generally in northerly directions from the mill area, along the Sand Creek drainage area, through a gap in Raton Ridge, and into Lincoln Park. However, groundwater contamination has also been found in the vicinity of the Shadow Hills Golf Course, which is west of the Sand Creek drainage [EPA 2007]. The hydrogeology of the Lincoln Park/Cotter Mill Superfund Site can be conceptually divided into two areas: the upgradient area near the mill and the downgradient area to the north-northeast in Lincoln Park [USGS 1999a].

- In the upgradient area near the mill, the rate of groundwater flow is limited by small hydraulic conductivities [USGS 1999a]. However, cracks in the bedrock, fractures, and weathering enhance water transmission and allow groundwater to travel at considerable rates. Monitoring wells in the upgradient area, specifically in the Poison Canyon Formation, yield small amounts of water.

- The downgradient area in Lincoln Park is characterized by an "alluvial aquifer" comprised of alluvium and terrace alluvium, to a depth of 0–60 feet, and the underlying weathered and/or fractured bedrock below the alluvium. In this area, groundwater can be transmitted at substantial rates. The mix of gravel, sand, silt, and clay in this aquifer yields 10 to 400 gallons per minute to wells in Lincoln Park. The aquifer discharges to Sand Creek, as well as to multiple springs and seeps as far downgradient as the Arkansas River, approximately 2.5 miles downgradient from the Cotter site.

2. Geology

The Cotter Mill is located in a topographic depression resulting from an underlying structure called the Chandler syncline. The core of the syncline is the Poison Canyon formation, which is the uppermost bedrock unit beneath the site. Soils near the mill are shallow and well drained.

The top layer consists of brown loam. The subsoil is a pale brown loam, grading into a yellowish brown sandy loam. Areas north of the mill are covered with Quaternary alluvium consisting of gravel, cobble, boulders, and sand [EPA 2002].

3. Hydrology

The Cotter Mill lies within the Sand Creek watershed [HRAP 1991]. The main hydrologic feature of the Lincoln Park/Cotter Mill Superfund Site is Sand Creek, a primarily ephemeral creek [EPA 2007]. The creek originates at Dawson Mountain (south of the Cotter Mill), travels north through the Cotter Mill, intersects the DeWeese Dye Ditch, and runs north-northeast through Lincoln Park. It becomes perennial for the last 0.25–0.5 mile before its confluence with the Arkansas River. The DeWeese Dye Ditch is one irrigation ditch that flows between the Cotter Mill and Lincoln Park.

An ephemeral creek has flowing water only during, and for a short duration after, precipitation. A perennial creek has flowing water year-round.

Alluvial material (sediment deposited by flowing water) associated with Sand Creek is the predominant migration pathway for mill-derived contaminants in groundwater. Sand Creek carved a channel into the Vermejo formation at the Raton outcrop in the vicinity of the SCS Dam, which filled with permeable sediments, creating a preferential pathway for alluvial groundwater into Lincoln Park. The alluvial aquifer in Lincoln Park receives recharge from the DeWeese Dye Ditch, Crooked Ditch, Pump Ditch, ditch laterals, and ponds filled by the DeWeese Dye Ditch [EPA 2007].

4. Prevailing Wind Patterns

Cotter’s monitoring network includes an on-site meteorological station that continuously measures a standard set of meteorological parameters (e.g., wind speed, wind direction, temperature, and relative humidity). The wind rose in Figure 3 in Appendix B depicts the statistical distribution of measured wind speeds and wind directions. During 2008, wind patterns at the station were principally westerly (i.e., winds out of the southwest to northwest) and accounted for 55% of the total winds [Cotter 2008b]. Easterly winds (i.e., winds out of the southeast to northeast) accounted for a smaller, but still significant, portion (26%) of the observed wind directions. Southerly and northerly winds were much less common. A nearly identical profile was observed in 2007. Other average parameters measured in 2008 follow: air temperature of 53.4 °F; relative humidity of 41%; and rainfall of 5.18 inches.

The prevailing westerly and easterly wind patterns are reasonably consistent with trends in the observed concentrations. Ambient air concentrations of selected site-related pollutants were highest at the perimeter monitoring stations directly east and west of the primary operations. There is a hilly ridge that straddles the western border of the site, blocking much east/west wind flow. However, it should be noted that prevailing wind patterns measured at Cotter Mill may not be representative of surface winds throughout the area, especially considering the proximity of nearby terrain features.

E. Past ATSDR involvement

ATSDR has been involved with the Lincoln Park site in the past. In October 1983, ATSDR completed a Public Health Assessment for the site. After reviewing available groundwater data, ATSDR concluded that the potential long term health effects from consumption of the contaminated water were:

- cancer and kidney damage, from uranium;
- gout-like symptoms, from molybdenum; and
- possibly a group of physiological and psychological symptoms, from selenium.

None of the potential health effects were definitive.

Numerous questions and concerns have been voiced by residents of Lincoln Park regarding the historical sites of numerous milling and smelting facilities in the Cañon City area. Among the various concerns were specific concerns about residual lead contamination from these milling and smelting operations. In response to these concerns, and after a specific request by the EPA, ATSDR evaluated the health risks associated with lead contamination in the area. ATSDR focused on two primary issues: 1) the blood lead level of children living in the area and 2) lead contaminated dust in homes in the Lincoln Park area.

In September and October 2005, ATSDR conducted an Exposure Investigation (EI) to answer the questions presented by the community and EPA. Previously, ATSDR concluded that lead levels in house dust and lead exposures to children represented an indeterminate health hazard because of a lack of available data. ATSDR conducted the EI to gather data on blood lead levels in the children, and soil and indoor dust level from homes.

The activities of the EI included:

- Collecting 44 indoor dust samples from 21 homes in Lincoln Park
- Collecting 80 composite soil samples from 22 properties (sampling conducted by EPA)
- Obtaining 45 blood samples from 21 households (42 blood samples were analyzed)

After evaluating the data obtained during the EI, ATSDR concluded that blood lead levels in adults and children, lead levels in dust in homes, and lead levels in soil did not represent a public health harard. ATSDR recommended no further actions related to lead in dust in homes, but did recommend routine monitoring of children’s blood lead levels in the Lincoln Park area.

In September 2005, ATSDR conducted a blood lead testing program as a service to the community of Lincoln Park. A total of 115 children from a local school were tested for blood lead. None of the children tested had elevated blood lead levels. Therefore, ATSDR concluded that the children tested did not have unusual exposures to lead at the time of testing. ATSDR recommended that local and state agencies continue routine monitoring of lead levels in area children.

Full reports discussed above may be obtained by contacting any of the contacts listed at the end of this report, by visiting our website at www.atsdr.cdc.gov or by calling our toll-free hotline at 800-232-4636.

III. EVALUATION OF EXPOSURE PATHWAYS

A. What is meant by exposure?

An exposure pathway has five elements: (1) a source of contamination, (2) an environmental media, (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population. The *source* is the place where the chemical or radioactive material was released. The *environmental media* (such as groundwater, soil, surface water, or air) transport the contaminants. The *point of exposure* is the place where people come into contact with the contaminated media. The *route of exposure* (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. The people actually exposed are the *receptor population*.

ATSDR's public health assessments are driven by exposure to, or contact with, environmental contaminants. Contaminants released into the environment have the potential to cause harmful health effects. Nevertheless, *a release does not always result in exposure*. People can only be exposed to a contaminant if they come in contact with that contaminant—if they breathe, eat, drink, or come into skin contact with a substance containing the contaminant. If no one comes in contact with a contaminant, then no exposure occurs, and thus no health effects could occur. Often the general public does not have access to the source area of contamination or areas where contaminants are moving through the environment. This lack of access to these areas becomes important in determining whether people could come in contact with the contaminants.

The route of a contaminant's movement is the *pathway*. ATSDR identifies and evaluates exposure pathways by considering how people might come in contact with a contaminant. An exposure pathway could involve air, surface water, groundwater, soil, dust, or even plants and animals. Exposure can occur by breathing, eating, drinking, or by skin contact with a substance containing the chemical contaminant. ATSDR identifies an exposure pathway as completed or potential, or eliminates the pathway from further evaluation.

- *Completed exposure pathways* exist for a past, current, or future exposure if contaminant sources can be linked to a receptor population. All five elements of the exposure pathway must be present. In other words, people have or are likely to come in contact with site-related contamination at a particular exposure point via an identified exposure route. As stated above, a release of a chemical or radioactive material into the environment does not always result in human exposure. For an exposure to occur, a completed exposure pathway must exist.

- *Potential exposure pathways* indicate that exposure to a contaminant could have occurred in the past, could be occurring currently, or could occur in the future. It exists when one or more of the elements are missing but available information indicates possible human exposure. A potential exposure pathway is one which ATSDR cannot rule out, even though not all of the five elements are identifiable.

- An *eliminated exposure pathway* exists when one or more of the elements are missing. Exposure pathways can be ruled out if the site characteristics make past, current, and future human exposures extremely unlikely. If people do not have access to contaminated areas, the pathway is eliminated from further evaluation. Also, an exposure pathway is eliminated if site monitoring reveals that media in accessible areas are not contaminated.

Contact with contamination at the Cotter Mill is an eliminated exposure pathway.

Because the mill site itself is fenced and access is restricted, exposure to on-site contamination by the public at the Cotter Mill is limited. Further, remediation efforts have removed some of the on-site soil contamination, including moving millions of cubic yards of tailings and contaminated soils from unlined ponds to lined impoundments (EPA 2002). In some areas, contaminated soil was removed down to bedrock. In addition, various process changes reduced the release of contaminated materials (EPA 2002). Any potential exposure by the occasional trespasser to remaining impacted soils at the Cotter Mill would be too infrequent to present a health hazard.

B. How does ATSDR determine which exposure situations to evaluate?

ATSDR scientists evaluate site conditions to determine if people could have been, are, or could be exposed (i.e., exposed in a past scenario, a current scenario, or a future scenario) to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated media (soil, sediment, water, air, or biota) has occurred, is occurring, or will occur through ingestion, dermal (skin) contact, or inhalation.

If exposure was, is, or could be possible, ATSDR scientists consider whether contamination is present at levels that might affect public health. ATSDR scientists select contaminants for further evaluation by comparing them to health-based comparison values. These are developed by ATSDR from available scientific literature related to exposure and health effects. Comparison values are derived for each of the different media and reflect an estimated contaminant concentration that is *not likely* to cause adverse health effects for a given chemical, assuming a standard daily contact rate (e.g., an amount of water or soil consumed or an amount of air breathed) and body weight.

Comparison values are not thresholds for adverse health effects. ATSDR comparison values establish contaminant concentrations many times lower than levels at which no effects were observed in experimental animals or human epidemiologic studies. If contaminant concentrations are above comparison values, ATSDR further analyzes exposure variables (for example, duration and frequency of exposure), the toxicology of the contaminant, other epidemiology studies, and the weight of evidence for health effects.

Some of the comparison values used by ATSDR scientists include ATSDR's environmental media evaluation guides (EMEGs), reference dose media evaluation guides (RMEGs), and cancer risk evaluation guides (CREGs) and EPA's maximum contaminant levels (MCLs). EMEGs, RMEGs, and CREGs are non-enforceable, health-based comparison values developed by ATSDR for screening environmental contamination for further evaluation. MCLs are enforceable drinking water regulations developed to protect public health. Effective May 2008, Colorado established state groundwater standards for uranium and molybdenum.

You can find out more about the ATSDR evaluation process by calling ATSDR's toll-free telephone number, 1-800-CDC-INFO (1-800-232-4636) or reading ATSDR's Public Health Assessment Guidance Manual at http://www.atsdr.cdc.gov/HAC/PHAManual/.

C. If someone is exposed, will they get sick?

Exposure does not always result in harmful health effects. The type and severity of health effects a person can experience because of contact with a contaminant depend on the exposure concentration (how much), the frequency (how often) and/or duration of exposure (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants). Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how the individual absorbs, distributes, metabolizes, and excretes the contaminant. Together, these factors and characteristics determine the health effects that may occur.

In almost any situation, there is considerable uncertainty about the true level of exposure to environmental contamination. To account for this uncertainty and to be protective of public health, ATSDR scientists typically use worst-case exposure level estimates as the basis for determining whether adverse health effects are possible. These estimated exposure levels usually are much higher than the levels that people are really exposed to. If the exposure levels indicate that adverse health effects are possible, ATSDR performs more detailed reviews of exposure and consults the toxicologic and epidemiologic literature for scientific information about the health effects from exposure to hazardous substances.

D. What exposure situations were evaluated for residents living near the Cotter Mill?

ATSDR obtained information to support the exposure pathway analysis for the Lincoln Park/Cotter Mill Superfund Site from multiple site investigation reports; state, local, and facility documentation; and communication with local and state officials. The analysis also draws from available environmental and exposure data for groundwater, soil, surface water and sediment, and biota. Throughout this process, ATSDR examined concerns expressed by the community to ensure exposures of special concern are adequately addressed. ATSDR identified the following exposure pathways for further evaluation:

1. Exposure to site-related contaminants in groundwater in Lincoln Park.

2. Contact with site-related contaminants in soil adjacent to the Cotter Mill and in Lincoln Park.

3. Contact with site-related contaminants in surface water downstream from the Cotter Mill.

4. Exposure from eating produce locally grown in Lincoln Park.

5. Exposure from site-related soil contaminants in windborne dust.

6. Exposure from air emission sources (stacks and uncontrolled fugitive dust)

This exposure pathway analysis focuses on past, current, and future exposures for residents living near the Cotter Mill, with a focus on the community of Lincoln Park. Some attention is also paid to exposures at the Shadow Hills Golf Course and along the county road. Table 3 below provides a summary of exposure pathways evaluated in this public health assessment.

1. *Exposure to groundwater in Lincoln Park*

In the past, a number of residences used wells[1] on their property (GeoTrans 1986; IMS 1989). Based on a 1989 water use survey in Lincoln Park, 60 out of 104 wells, springs, and cisterns were used to obtain water for domestic purposes, including consumption and irrigation (IMS 1989). See Table 14 in Appendix A for the reported groundwater uses in the Lincoln Park area. Seven survey respondents indicated that they used groundwater for domestic consumption, accounting for 5 to 100% of their total water consumption. Based on the survey, five residents had private wells that were affected by contaminated groundwater; these residents were connected to the municipal water supply between 1989 and 1993 [EPA 2002]. The 1988 RAP requires Cotter to connect eligible affected users with legal water rights for a well to the town water supply [CDPHE 2005]. Cotter checks the State of Colorado's Engineer's Office database for new water permits and reports their findings in their annual ALARA reports [Pat Smith, EPA Region 8, personal communication, August 2008].

The use of private groundwater wells in the past was a completed exposure pathway. Most residences are now connected to the public water supply. The current and future use of these wells is a potential exposure pathway because the extent to which these wells are used is not well documented.

While the majority of town residents are now connected to the public water supply [Galant et al. 2007], several residences also have operational private wells. A 2005 summary of the RAP status reports that some residents have refused public water supply connections [CDPHE 2005]. Additionally, no formal institutional controls exist to control groundwater use in Lincoln Park [EPA 2007]. The United States Geological Survey (USGS) reports that existing private wells are used primarily for stock watering and irrigation [USGS 1999a]. However, a newspaper article reports that at least one residence, located on Grand Avenue in Lincoln Park, used private well water for consumption as recently as 2002 [Plasket 2002]. Based on a 2007 review of Colorado State well permits for residences in the plume configuration, at least one well is permitted for irrigation and domestic use, but no details of actual use are documented [EA 2007]. On properties that continue to use private wells, new purchasers are offered connection to the town's municipal water system [Galant et al. 2007]. In late 2008, EPA conducted another water use survey to verify whether groundwater is being utilized by residences in Lincoln Park. Well water samples were also collected and analyzed. Once available, ATSDR will review the information and will revise the public health assessment, if needed.

2. *Contact with soil adjacent to the Cotter Mill and in Lincoln Park*

People (especially children) might accidentally ingest soil or exposed sediment, and dust generated from these materials, during normal activities. Everyone ingests some soil or dust every day. Small children (especially those of preschool age) tend to swallow more soil or dust than any other age group because children of this age tend to have more contact with soil through play activities and have a tendency for more hand-to-mouth activity. Children in elementary school, teenagers, and adults swallow much smaller amounts of soil or dust. The amount of grass

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[1] The term "well" is used to represent all groundwater sources, and includes both wells and springs.

cover in an area, the amount of time spent outdoors, and weather conditions also influence how much contact people have with soil.

a) Contact with soil near the Cotter Mill

Contact with contaminated soil near the Cotter Mill (i.e., in the buffer zone) is a past, current, and future potential exposure pathway.

Soils adjacent to the Cotter Mill have been contaminated by wind-blown particulates [CDPHE 2005]. Elevated levels are primarily detected in soils directly east and west of the facility [Weston 1998]. This distribution of contaminated soils is consistent with wind patterns in the area, which blow mainly from west to east with occasional flows from east to west. The primarily vacant areas directly east and west of the facility are referred to as a "buffer zone" between the Cotter Mill and residential developments [EPA 2002]. Therefore, limited opportunities for exposure to impacted site-adjacent soils exist—people are not expected to be in this area on a daily basis and for an extended period of time. One exception may be at the Shadow Hills Golf Course, located immediately north of the Cotter mill complex. Exposure to potentially impacted soil at this public golf course is unlikely due to grass cover.

For nearly 50 years, Cotter has intermittently hauled materials by truck, possibly losing some materials along the county road leading to the facility and along the access road entering the mill site [MFG 2005]. The public could be exposed to potentially impacted soils along the county road. However, there is limited potential for exposure to contaminants along the access road, since access to the Cotter Mill is restricted and Cotter remediated soil adjacent to the access road in 2007 and 2008.

b) Contact with soil and sediment in the community of Lincoln Park

The community of Lincoln Park is located approximately 1.5 miles north-northeast of the restricted area of the Cotter Mill. Contaminated materials from the Cotter Mill may have contributed to soil contamination in Lincoln Park in two ways:

1. Dust from soil or tailings associated with site operations could be transported by wind to Lincoln Park. However, wind patterns in the area suggest that wind-blown contamination is not likely a considerable source of soil contamination in Lincoln Park (Weston 1998). Additionally, on-site remediation at the Cotter Mill substantially reduced the sources of soil contamination.

2. Potentially impacted groundwater used for irrigation could lead to the accumulation of chemicals in town soils [Weston 1998].

Contact with contaminated sediment in Sand Creek was a past potential exposure pathway. Due to the remediation of Sand Creek, current and future contact is an eliminated exposure pathway.

Further, in the past, contaminated surface water runoff from the Cotter Mill entered Sand Creek, where it was transported downstream toward Lincoln Park [EPA 2002]. However, Sand Creek is not believed to be used for recreational activities—the creek is ephemeral and on private land until it goes under the river walk and enters the Arkansas River [Phil Stoffey, CDPHE, personal communication, June 2007].

Contact with contaminated soil in Lincoln Park was a past completed exposure pathway. Cotter has performed all required off-site soil cleanup activities, as outlined in the RAP [EPA 2002]. CDPHE reports that the Cotter Mill poses no risk to the residents of Lincoln Park by exposure to soil [Weston 1998], and EPA and CDPHE have advised "No Further Action" in regards to Lincoln Park soils [EPA 2002]. EPA's Record of Decision states that surface-soil cleanup activities have eliminated or reduced risks to "acceptable" levels [EPA 2002, 2007]. Therefore, current and future contact with soil and sediment is an eliminated exposure pathway.

3. *Contact with surface water downstream from the Cotter Mill*

In the past, people could have come in contact with contamination in surface water during recreational activities. The Arkansas River is used primarily for fishing and boating or rafting, as well as some swimming [Phil Stoffey, CDPHE, personal communication, June 2007]. Sand Creek is on private land until it goes under the river walk and enters the Arkansas River, and is generally not used for recreational activities [Phil Stoffey, CDPHE, personal communication, June 2007]. Many Lincoln Park residents use water from the DeWeese Dye Ditch to irrigate their orchards and gardens [Galant et al. 2007].

Contact with contaminated surface water near the Cotter Mill was a past potential exposure pathway. Due to the construction of the SCS Dam and the remediation of Sand Creek, current and future contact is an eliminated exposure pathway.

4. *Exposure from eating locally grown produce*

Many Lincoln Park residents have orchards and gardens. Water from the DeWeese Dye Ditch is primarily used to irrigate the orchards and gardens, however, some residents use water from their groundwater wells [Galant 2007; IMS 1989]. If fruits and vegetables are grown in contaminated soil and/or irrigated with contaminated water, the people who eat this produce could be exposed to contamination.

5. *Exposure from breathing windborne dust*

Many Lincoln Park residents are concerned about the arid environment and the risks of breathing in contaminated dust from the site. The profile of air emission sources at Cotter Mill has changed considerably over the years. These sources include both releases through stacks and uncontrolled (or fugitive) dust emissions. Stack emissions occurred during times of active processing at Cotter Mill; however, the magnitude of these stack emissions has varied, depending on production rates and effectiveness of air pollution controls. The sources of fugitive dust emissions have also changed. In the past, the site had many uncontrolled sources of wind-blown dust, which would cause particulate matter (along with any chemical and radiological constituents) to be emitted into the air. Examples of these sources include ore handling operations, stockpiles, and the previous unlined holding ponds. Many of these sources of wind-blown dust have since been controlled or eliminated, causing facility-wide fugitive dust emissions to decrease considerably over the years, though some fugitive dust emissions (e.g., from unpaved roads) continue to occur.

Table 3. Exposure pathways for residents living near the Cotter Mill

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Groundwater							
Completed Exposure Pathway							
Private groundwater wells	Tailings and other wastes from the Cotter Mill (heavy metals and radionuclides)	Migration of groundwater into the Lincoln Park area	Residential tap water drawn from private wells	Residents, including children, who are not connected to the public water supply and rely on private wells	Ingestion, Dermal contact	Past	Past consumption of groundwater from private wells has been documented and was, therefore, a completed exposure pathway.
Potential Exposure Pathway							
Private groundwater wells	Tailings and other wastes from the Cotter Mill (heavy metals and radionuclides)	Migration of groundwater into the Lincoln Park area	Residential tap water drawn from private wells	Residents, including children, who are not connected to the public water supply and rely on private wells	Ingestion, Dermal contact	Current Future	The extent to which private wells are currently used in Lincoln Park is uncertain. Although most residents are supplied with town water, documents indicate that residents have been drinking private well water as recently as 2002, and are permitted to use wells for unspecified domestic purposes. However, it is believed that water from wells is used primarily for irrigation and other non-drinking purposes. Therefore, current and future use of water from private wells is a potential exposure pathway.

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Soil and Sediment							
Completed Exposure Pathway							
Surface soil and dust in Lincoln Park	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust; soil irrigated by contaminated groundwater	Residences and public areas	Residents, including children	Dermal contact, Incidental ingestion, Inhalation	Past	Prior to remediation, contaminants were detected in soil from residential lawns and gardens. Therefore, contact with contaminated soil in Lincoln Park was a past completed exposure pathway.
Potential Exposure Pathways							
Surface soil near the Cotter Mill	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust	The Shadow Hills Golf Course west of the Cotter Mill; along the county road leading to the Cotter Mill	Golfers at the public golf course; people on the county road	Dermal contact, Incidental ingestion, Inhalation	Past Current Future	Soils adjacent to the Cotter Mill have been contaminated by wind-blown particulates. Therefore, contact with soil near the Cotter Mill, especially at the public golf course and along the county road, is a past, current, and future potential exposure pathway.
Sediment in Sand Creek	Tailings, dusts, and other wastes from the Cotter Mill	Tailings carried in surface water runoff	Along Sand Creek	Recreational users; children playing along Sand Creek	Dermal contact, Incidental ingestion	Past	There were limited opportunities for exposure since Sand Creek was not used for recreational purposes. Therefore, exposure to sediments prior to the Sand Creek Cleanup project was a past potential exposure pathway.
Eliminated Exposure Pathways							
Surface soil at the Cotter Mill	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust; surface water runoff	Unauthorized access is not allowed	None	None	Past Current Future	Because the mill site itself is fenced and access is restricted, contact with on-site contamination is an eliminated exposure pathway. Further, remediation efforts have removed some impacted soils.

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Surface soil and dust in Lincoln Park	Tailings, dusts, and other wastes from the Cotter Mill	Windblown dust; soil irrigated with contaminated groundwater	Cleanup activities have eliminated or reduced risks to acceptable levels	None	None	Current Future	Due to the sampling and remediation in Lincoln Park, current and future contact with soil and dust is an eliminated exposure pathway.
Sediment in Sand Creek	Tailings, dusts, and other wastes from the Cotter Mill	Tailings carried in surface water runoff	Contaminated sediment was removed from Sand Creek	None	None	Current Future	Sediment in Sand Creek is no longer a hazard since the completion of the Sand Creek Cleanup project. Therefore, current and future contact with sediment in Sand Creek is an eliminated exposure pathway.
Surface Water							
Potential Exposure Pathway							
Surface water near the Cotter Mill	Tailings and other waste from the Cotter Mill	Surface water runoff; transport from Sand Creek to the Arkansas River	Along Sand Creek between the Cotter Mill and the Arkansas River; the DeWeese Dye Ditch; the Arkansas River	Recreational users (mostly in the Arkansas River, limited recreational use in Sand Creek); people irrigating with water from the DeWeese Dye Ditch	Incidental ingestion, Dermal contact	Past	In the past, surface water in Sand Creek was found to contain elevated levels of metals and radionuclides. Therefore, past contact with contaminated surface water near the Cotter Mill was a potential exposure pathway.
Eliminated Exposure Pathway							
Surface water near the Cotter Mill	Tailings and other waste from the Cotter Mill	Surface-water runoff; transport from Sand Creek to the Arkansas River	Contamination was removed from Sand Creek	None	None	Current Future	Due to the construction of the SCS Dam and the remediation of Sand Creek, current and future contact with contaminated surface water is an eliminated exposure pathway.

Exposure Pathway	Exposure Pathway Elements					Time Frame	Comments
	Sources of Contamination	Fate and Transport	Point of Exposure	Exposed Population	Route of Exposure		
Locally Grown Produce							
Potential Exposure Pathway							
Produce grown in Lincoln Park	Tailings, dusts, and other wastes from the Cotter Mill	Produce grown in contaminated soil or irrigated with contaminated water	Orchards and gardens in Lincoln Park	People who eat locally grown produce	Ingestion	Past Current Future	Because many Lincoln Park residents have orchards and gardens, eating locally grown produce is a past, current, and future potential exposure pathway.
Air Emissions							
Completed Exposure Pathway							
Ambient air near the Cotter Mill facility	Ground-level fugitive emissions (e.g., wind-blown dust) and elevated point sources (e.g., stacks)	Windblown dust; stack emissions into the air and transport to off-site locations	Off-site or down-wind locations	People who live in the vicinity of Cotter Mill or downwind of the stacks	Inhalation	Past Future Present	Cotter's air monitoring network monitors air concentrations at off-site locations. With the facility currently in "stand down" status, facility emissions are now predominantly fugitive; air quality impacts should be characterized by perimeter monitoring stations.

IV. EVALUATION OF ENVIRONMENTAL CONTAMINATION

A. Groundwater

Prior to 1980, Cotter disposed of waste in unlined ponds, which allowed contaminated liquids to leach into the groundwater [EPA 2002]. Groundwater was shown to be contaminated as far away as the Arkansas River, which is approximately 2.5 miles downgradient from the mill [EPA 2002]. Results from the 1984–1985 Remedial Investigation found that despite attempts at remediation, the new, lined impoundments were leaking and the old ponds area was a continuing source of groundwater contamination [GeoTrans 1986]. This study also found that a gap in the ridge at the SCS Dam, built in 1971 across Sand Creek on the Cotter property, was allowing shallow groundwater to move downgradient towards Lincoln Park, resulting in concentrations of molybdenum and uranium that were 2,000 times above background levels at that time.

Groundwater concentrations of molybdenum and uranium have decreased in recent years, but concentrations have not yet returned to background levels in some wells [Weston 1998]. Figures 4 and 5 show the extent of the molybdenum and uranium concentrations, respectively, above water quality standards (0.035 milligrams per liter [mg/L] for molybdenum and 0.03 mg/L for uranium). The highest levels in Lincoln Park were detected nearest to the Cotter property in the vicinity of the DeWeese Dye Ditch [Weston 1998]. Additionally, despite remediation efforts, the physical and chemical groundwater data suggest minor leakage from the primary impoundment at the Cotter site [CDPHE 2007a; EPA 2002; USGS 1999b].

1. Remedial actions for controlling groundwater contamination

Since the early- to mid-1980s, remedial actions aimed at controlling groundwater contamination and the spread of the resulting plume have taken place. Remediation has targeted the area along the primary surface groundwater migration pathway, which runs parallel to Sand Creek [USGS 1999a]. Remediation has included the following:

- In the early 1980s, contaminated materials were moved into lined impoundments [EPA 2002].
- In 1988, a hydrologic clay barrier was installed on the Cotter property to help contain the contaminated groundwater plume associated with the Cotter Mill.
- In 1989, a network of injection and withdrawal wells were constructed downgradient of the lined impoundment to reverse the hydraulic gradient and prevent the northward migration of contaminated groundwater. This system was discontinued in 2000, because the system had little or no discernable effect on groundwater conditions [CDPHE 2005].
- Dam to ditch flushing began in 1990. However, this effort was discontinued in 1996 due to citizens' concerns about contaminant concentrations rising in groundwater wells as the plume was being flushed [CDPHE 2005].
- In 2000, a permeable reactive treatment wall was constructed across Sand Creek channel in the DeWeese Dye Ditch flush, downstream of the SCS Dam [EPA 2002]. Although the

permeable reactive treatment wall has not performed as anticipated, it is acting as a barrier to additional groundwater flowing into Lincoln Park [Phil Egidi, CDPHE, personal communication, July 2008].

These efforts have reduced groundwater contamination downgradient of the Cotter Mill [CDPHE 2008; EPA 2002; USGS 1999a], although the rate at which groundwater quality is being restored is slower than anticipated [EPA 2007]. Cotter and CDPHE continue to explore options for cleaning the groundwater. Until a solution is reached, contaminated groundwater is captured at the SCS Dam and pumped back to the on-site lined impoundments [CDPHE 2008].

2. Nature and extent of groundwater contamination in Lincoln Park

CDPHE maintains a database containing environmental sampling data from various sources dating back to 1961. The most recent data entered into the database are from September 2007. To evaluate exposures to residents of Lincoln Park, ATSDR identified data within the CDPHE database for the wells reported to be in use during the 1989 water use survey (see Table 14 in Appendix A). After discussions with a CDPHE representative, the following assumptions were made while summarizing the data within the database.

- For chemicals, samples that were designated “Y” in the detect flag column and contained a zero in the result value column, but no value in the reporting detection limit column were excluded from the summary statistics. For radionuclides, however, these samples were included in the summary statistics since zero is considered a valid result.
- Samples that were designated “N” in the detect flag column and had the same value in the result value column as the reporting detection limit column were included in the summary statistics as ½ the reporting detection limit.
- Negative result values for manganese and iron were assumed to be not detected and were included in the summary statistics as ½ the reporting detection limit.
- Negative values[2] for radionuclides were included in the summary statistics.

a) Wells used for personal consumption

The 1989 *Lincoln Park Water Use Survey* identified seven wells used for personal consumption (IMS 1989). Data for six of the wells are available in the CDPHE database (see Table 14). The seventh well had a broken pump at the time of the survey [IMS 1989]; no data for this well appear to be in the database. The data for wells reportedly used for personal consumption in 1989 are summarized in Table 15. Samples were collected intermittently from 1984 to 2007. The locations of these wells are shown in Figure 6. With the exception of molybdenum and uranium, the data are limited (e.g., only two wells were sampled for the majority of the chemicals and none were sampled for radionuclides).

When this document was written, data from EPA’s 2008 water use survey were not yet available. ATSDR will update well use information when the data are available.

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[2] Negative values for radionuclides occur when samples are not much different from background, since standard protocol is to subtract background radioactivity from the sample count.

However, all six wells were repeatedly tested for molybdenum and uranium, which were the only chemicals detected above comparison values (see Table 15). Of the personal consumption wells, Well 189 contains the highest molybdenum and uranium concentrations. Well 189 is the only well with levels of uranium consistently detected above the comparison value (see Figure 6).

It is difficult to evaluate the molybdenum and uranium data over time, because of the limited sampling data for these wells and the inconsistency of sampling the same wells over time. The molybdenum and uranium concentrations in the personal consumption wells over time are graphically shown in Figure 7 and Figure 8 in Appendix B, respectively. Well 168 (house well on Grand Avenue)[3] and Well 189 (house well on Hickory)[4] were sampled the most frequently. No clear pattern of decreasing concentrations from 1984 to 2007 exists.

The USGS identified Well 10 (So. 12th St.) and Well 114 (Pine) as representative of background for the Lincoln Park area [Weston 1998]. The data available in the CDPHE database for these two wells are summarized in Table 16.[5] The average concentration of molybdenum in the wells used for personal consumption (0.082 mg/L; see Table 15) is higher than the average concentration found in the background wells (0.023 mg/L; see Table 16). The average uranium concentration in the wells used for personal consumption (0.028 mg/L; see Table 15) is only slightly higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

(1) Grand Avenue Well

In a 2002 newspaper article, a resident on Grand Avenue reported drinking water from their well [Plasket 2002]. Limited data (1 to 20 samples) are available in the CDPHE database for this location (see Figure 6). Samples were collected and analyzed for most chemicals in 1984, and then from either 2004 or 2005 to 2007. Samples from this well were also tested for molybdenum and uranium from 1988 to1991. The water from this well was tested for several chemicals, but not for radionuclides. None of the samples detected chemicals above comparison values (see Table 17).

b) Wells used to irrigate fruit and vegetable gardens

When this document was written, data from EPA's 2008 water use survey were not yet available. ATSDR will update well use information when the data are available.

The 1989 *Lincoln Park Water Use Survey* identified 22 wells used to irrigate fruit and 21 wells used to irrigate vegetable gardens [IMS 1989].[6] Data for 28 of these wells are available in the CDPHE database (see Table 14). Samples were sporadically collected from these wells and analyzed for various chemicals between 1962 and 2007. Samples were collected and analyzed for radionuclides from

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[3] There are five non-detected molybdenum values for Well 168. Four of them are most likely due to the detection limit being too high for the level of molybdenum in that well. The detection limits were 0.01 mg/L for three of the samples and 0.05 mg/L for one of the samples. The concentrations in that well hover around 0.01 mg/L.

[4] One of the non-detected molybdenum concentrations in Well 189 is unexplainable. The detection limit (0.01 mg/L) is low enough to have detected the level of molybdenum typically found in the well. The detection limit (0.5 mg/L) for the other non-detected concentration is too high for the level of molybdenum typically found in the well.

[5] Groundwater samples from the background wells were not tested for radionuclides.

[6] Some wells were used for both purposes.

1995 to 2000. The data for wells reportedly used to irrigate fruit and vegetable gardens in 1989 are summarized in Table 18 (chemicals) and Table 19 (radionuclides). The locations of these wells are shown in Figure 9. The data for these wells are much more robust than the data available for the wells used for personal consumption, in part due to the increased number of wells. Molybdenum and uranium were sampled in all 28 wells used for irrigation. Five wells were tested for radionuclides.

The maximum concentrations in the wells used to irrigate fruit and vegetable gardens exceeded the comparison values for molybdenum, selenium, sulfate, total dissolved solids, and uranium. The average concentrations exceeded comparison values only for molybdenum, total dissolved solids, and uranium. Looking at data from 2000 to 2007, only the average molybdenum concentration (0.1 mg/L) continued to exceed the comparison value.

The average concentration of molybdenum in the wells used to irrigate fruit and vegetable gardens (0.99 mg/L; see Table 18) is higher than the average concentration found in the wells that USGS identified as background for Lincoln Park (0.023 mg/L; see Table 16). Similarly, the average uranium concentration in the wells used to irrigate fruit and vegetable gardens (0.13 mg/L; see Table 13) is higher than the average concentration in the background wells (0.021 mg/L; see Table 16). The average concentration for total dissolved solids in the wells used to irrigate fruit and vegetable gardens (550 mg/L; see Table 18) is also higher than the average concentration found in the background wells (429 mg/L; see Table 16).

c) Wells used to water livestock

When this document was written, data from EPA's 2008 water use survey were not yet available. ATSDR will update well use information when the data are available

The 1989 *Lincoln Park Water Use Survey* identified 22 wells used to water livestock [IMS 1989]. Data for 19 of these wells are available in the CDPHE database (see Table 14). Samples were sporadically collected from these wells and analyzed for various chemicals between 1962 and 2007. Samples were collected and analyzed for radionuclides from 1995 and 1996. The data for wells reportedly used to water livestock in 1989 are summarized in Table 20 (chemicals) and Table 21 (radionuclides). The locations of these wells are shown in Figure 10. Only one to four wells were sampled for the majority of the chemicals, however, molybdenum and uranium were sampled in all 19 wells used to water livestock. Two wells were tested for radionuclides.

The maximum concentrations exceeded the comparison values for molybdenum, sulfate, total dissolved solids, and uranium. The average concentrations only exceeded comparison values for molybdenum and uranium. Looking at data from 2000 to 2007, only the average molybdenum concentration (0.08 mg/L) continued to exceed the comparison value.

The average concentration of molybdenum in the wells used to water livestock (0.212 mg/L; see Table 20) is an order of magnitude higher than the average concentration found in the wells that USGS identified as background for Lincoln Park (0.023 mg/L; see Table 16). The average uranium concentration in the wells used to water livestock (0.034 mg/L; see Table 20) is higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

d) *Wells used to water lawns*

When this document was written, data from EPA's 2008 water use survey were not yet available. ATSDR will update well use information when the data are available.

The 1989 *Lincoln Park Water Use Survey* identified 42 wells used to water lawns [IMS 1989]. Data for all 42 wells are available in the CDPHE database (see Table 14). Samples were sporadically collected from these wells and analyzed for various chemicals between 1962 and 2007. Samples were collected and analyzed for radionuclides from 1995 to 2000. The data for wells reportedly used to water lawns in 1989 are summarized in Table 22 (chemicals) and Table 23 (radionuclides). The locations of these wells are shown in Figure 11. Several wells were sampled for each chemical, and molybdenum and uranium were tested in all 42 wells used to water lawns. Seven wells were sampled for radionuclides.

The maximum concentrations exceeded the comparison values for chloride, molybdenum, selenium, sulfate, total dissolved solids, and uranium. The average concentrations exceeded comparison values for molybdenum, sulfate, total dissolved solids, and uranium. Looking at data from 2000 to 2007, only the average molybdenum concentration (0.1 mg/L) continued to exceed the comparison value from 2000 to 2007, while the average uranium concentration (0.03 mg/L) was at the comparison value.

The average concentration of molybdenum in wells used to water lawns (2.2 mg/L; see Table 22) is two orders of magnitude higher than the average concentration found in the wells that USGS identified as background for Lincoln Park (0.023 mg/L; see Table 16). The average sulfate concentration in wells used to water lawns (351 mg/L; see Table 22) is almost six times higher than the average concentration in the background wells (61 mg/L; see Table 16). The average concentration for total dissolved solids in wells used to water lawns (746 mg/L; see Table 22) is higher than the average concentration found in the background wells (429 mg/L; see Table 16). The average dissolved uranium concentration in wells used to water lawns (0.233 mg/L; see Table 22) is an order of magnitude higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

(1) Well 138

Well 138 (field well on Cedar Street; see Figure 11) was identified during the *1998 Supplemental Human Health Risk Assessment* as the maximally impacted off-site well [Weston 1998]. In 1989, Well 138 was used only to water the lawn [IMS 1989]. Adequate data for this well are available in the CDPHE database. Samples were collected from Well 138 and analyzed for various chemicals between 1968 and 2000. Samples were collected and analyzed for radionuclides from 1995 to 2000. The data for Well 138 are summarized in Table 24 (chemicals) and Table 25 (radionuclides).

The maximum concentrations exceeded the comparison values for chloride, molybdenum, selenium, sulfate, total dissolved solids, and uranium. The average concentrations also exceeded comparison values for molybdenum, sulfate, total dissolved solids, and uranium. A clear decrease in concentrations occurred over time for molybdenum (see Figure 12), selenium (see Figure 13), and uranium (see Figure 14).

Well 138 has higher levels of contamination than the wells that USGS identified as background for Lincoln Park. The average concentration of molybdenum in Well 138 (8.0 mg/L; see Table 244) is hundreds of times higher than the average concentration found in the background wells (0.023 mg/L; see Table 16). The average sulfate concentration in Well 138 (1,059 mg/L; see Table 24) is considerably higher than the average concentration in the background wells (61 mg/L; see Table 16). The average concentration for total dissolved solids in Well 138 (1,530 mg/L; see Table 24) is three times higher than the average concentration found in the background wells (429 mg/L; see Table 16). The average dissolved uranium concentration in Well 138 (0.73 mg/L; see Table 24) is more than an order of magnitude higher than the average concentration in the background wells (0.021 mg/L; see Table 16).

e) Groundwater trends over time

To evaluate the levels of molybdenum, selenium, and uranium in groundwater over time, ATSDR combined and graphed all the groundwater data for the wells used for personal consumption, irrigating fruit and vegetables, watering livestock, and watering lawns (Figures 15 through 17 in Appendix B). Figure 15 shows a pattern of decreasing concentrations of molybdenum in groundwater over time. The concentrations of selenium seem to hold steady, but do decrease slightly over time (see Figure 16). The concentrations of uranium also clearly decrease over time (see Figure 17).

B. Soil and sediment

1. Background levels

Cotter was required by the 1988 RAP to establish background levels of certain elements in soils and sediments. Twenty soil samples were collected from five sub-basins considered free from mill-related contamination to represent natural background typical of the area near the mill [HRAP 1991]. Table 4 below presents the results of that study, which were further supported by additional sampling [CDPHE 2005].

Table 4. Background soil and sediment levels

	Soil		Sediment	
	Average	Upper Confidence Limit	Average	Upper Confidence Limit
Molybdenum	2.4 ppm	4.6 ppm	2.3 ppm	4.7 ppm
Uranium	2.1 ppm	2.9 ppm	2.0 ppm	3.4 ppm
Radium-226	1.3 pCi/g	1.9 pCi/g	1.1 pCi/g	1.7 pCi/g
Thorium-230	1.8 pCi/g	3.2 pCi/g	1.5 pCi/g	3.1 pCi/g
Gamma Exposure Rates	9.4 µR/hr	--	--	--

Source: CDPHE 2005; HRAP 1991
pCi/g – picocuries per gram
ppm – parts per million
µR/hr – microroentgen per hour

2. *Off-site soil contamination and remediation*

As part of the 1988 RAP, Cotter was required to survey soils outside the restricted area (the fenced active mill site) and to remediate contaminated soils with levels of radium and molybdenum that are above the established background [CDPHE 2005].

As part of the *1998 Supplemental Human Health Risk Assessment* [Weston 1998], Weston (a contractor for Cotter) collected surface soil samples (0-2 inches) from eight zones around the mill property (see Figure 18 in Appendix B). Each zone was divided into 8 to 12 grids. Four samples were collected near the center of each grid and were composited (i.e., combined and homogenized) to form a single representative sample [Weston 1998]. The results of this sampling are shown in Table 26 (chemicals) and Table 27 (radionuclides). The maximum concentrations exceeded the comparison values for arsenic[7] in all eight zones, for cadmium in all zones except one (D), for lead in three zones (F, G, and H), and for radium-226 in four zones (A, B, C, and E). The average concentrations also exceeded comparison values for arsenic[7] in all eight zones, for cadmium in one zone (F), for lead in one zone (H), and for radium-226 in two zones (A and B). The average radium-226 and thorium-230 concentrations were higher than the established average background levels in all eight zones (see 4 for background).

There is limited potential for exposure to contaminants along the access road since access to the Cotter Mill is restricted and soils along the access road were remediated in 2007 and 2008.

Cotter has occasionally hauled ore and other materials by truck to the site for processing at their facility. To assess the potential that material has been lost alongside the county road leading to the mill and the access road entering the mill site, MFG (a contractor to Cotter) scanned the county road (assuming CR 143) from the road leading to the Shadow Hills Golf Course to the Cotter Mill access road for gamma radiation (see Figure 19). They also collected soil samples to establish a correlation between the gamma exposure rate and the concentration of gamma emitters in the soil. A total of 16 locations were sampled—five along the county road, five along the mill's access road, and six from background locations. The locations were not chosen to estimate an average concentration, but rather to provide data for a range of gamma exposure rates. Each sample was a composite of 10 aliquots within a 100 x 100 meter area [MFG 2005]. The results of this sampling are shown in Table 28. The maximum and average radium-226 and natural uranium concentrations exceeded the comparison values for samples taken along the mill's access road. The maximum and average radium-226 concentrations also exceeded the comparison value for samples taken along the county road. Average concentrations of all radionuclides sampled were higher along the county road and the mill's access road than from those areas designated as background (see Table 28).

To address public concerns about the impact of the Cotter Mill on the health of Cañon City residents, CDPHE collected 21 soil samples in January 2003 [CDPHE 2003]. Each sample was a composite of 30–40 scrape samples[8] from each location. Seven samples from Lincoln Park were

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[7] The *1998 Supplemental Human Health Risk Assessment* found no discernible spatial pattern for arsenic around the Cotter Mill, indicating that arsenic levels have not been measurably altered by airborne releases from the mill (Weston 1998).

[8] Surface soil samples were collected using a method developed specifically to look for airborne contamination that settled to the ground (CDPHE 2003).

collected, including one sample of suspected flood sediment (Pine Street near Elm Avenue), two samples of dust (one from a barn loft and one from a residential attic), and four samples of surface soil (one from the McKinley Elementary School playground). Seven samples were collected from areas east of the mill, including the Brookside Head Start School. Six samples were collected from areas west of the mill, including a private residence. One sample was collected from the extreme northern part of Cañon City to represent the regional background (corner of Orchard Avenue and High Street). The sampling event was intentionally biased toward finding the highest amounts of contamination possible [CDPHE 2003]. Sample locations are shown in Figure 20. The data from this sampling event are summarized in Table 29 (chemicals) and Table 30 (radionuclides). The maximum concentrations for lead and radium-226 exceeded the comparison values. The average concentration for lead also exceeded the comparison value. The average concentration for radium-226 did not exceed the comparison value.

Since 1994, Cotter has been annually collecting surface soil samples (0–6 inches) at 10 environmental air monitoring stations that are located along the facility’s boundary and in residential areas (see Figure 21). From 1979 to 1993, soils were collected every 9 months. The data from this effort are summarized in Table 31. The maximum concentration for radium-226 exceeded the comparison value; however, the average concentration of samples over the timeframe did not.

a) The nearest resident

The nearest resident is located 0.25 mile from the restricted area [Galant et al. 2007]. One of the air monitoring stations annually monitored by Cotter was established as “the nearest resident” (AS-212). This location is between the Cotter Mill and an actual residence [Cotter 2007]. The limited data for this location are shown in Table 32 (chemicals) and Table 33 (radionuclides). The maximum concentration for radium-226 exceeded the comparison value; however, the average concentration did not.

b) Lincoln Park

EPA determined that sediment and soil in Lincoln Park are no longer an issue since the completion of the Sand Creek Cleanup project in 1998 [EPA 2002, 2007].

As part of the 1988 RAP, Cotter was required to conduct a gamma scintillometer survey in Lincoln Park to evaluate whether soils had been contaminated by windblown and waterborne contaminants from the facility. In December 1988, 127 scintillometer readings were taken near intersections in Lincoln Park. The average external gamma radiation for Lincoln Park was 9.8 microroentgen per hour (µR/hr), which is considered to show “no elevated gamma in Lincoln Park” [CDPHE 2005; HRAP 1991].

As part of the *1996 Supplemental Human Health Risk Assessment* [Weston 1996], Weston compiled data from several past soil studies, including the following:

- Samples collected at the air monitoring location in Lincoln Park in 1987 and 1988

- Samples collected from yards of 10 participants in the Lincoln Park water use survey in 1989
- Samples collected from residential gardens in Lincoln Park in 1990
- Samples collected from lawns and gardens in Lincoln Park in 1996

The data from these studies are collectively summarized in Table 34 (chemicals) and Table 35 (radionuclides). Only the maximum and average concentrations for arsenic exceeded the comparison value.

The soil samples collected from yards of the participants in the 1989 *Lincoln Park water use survey* were also analyzed for molybdenum and uranium. The average molybdenum concentration was 2.0 ppm and the average uranium concentration was 2.8 ppm [HRAP 1991]. The samples collected as part of the 1990 residential garden soil survey were also analyzed for molybdenum. The average concentration was 0.13 ppm [HRAP 1991]. These concentrations are well below the comparison values for molybdenum (300 ppm) and uranium (100 ppm).[9]

As part of the *1998 Supplemental Human Health Risk Assessment* [Weston 1998], 73 surface soil samples were collected from lawns (0–2 inches) and gardens (0–6 inches) in Lincoln Park. For sampling purposes, Lincoln Park was divided into seven areas and 6–16 samples were taken from each area [Weston 1998]. The results of this sampling are shown in Table 26 (chemicals) and Table 27 (radionuclides). Only the maximum and average arsenic concentrations exceeded the comparison value.

The effect of irrigation with contaminated well water on the levels in the soil was also examined during the *1998 Supplemental Human Health Risk Assessment* [Weston 1998]. The soil samples from Lincoln Park were divided into two categories—those irrigated with well water that had been impacted by mill releases and those not believed to have been irrigated with contaminated well water. These data are shown in Table 36 (chemicals) and Table 37 (radionuclides). The concentrations of arsenic, molybdenum, and uranium were statistically higher in soil samples irrigated with impacted well water [Weston 1998].

(1) Lead in Lincoln Park

Residents of Lincoln Park expressed concerns about lead contamination in soil and dust due to historical and current mining and milling operations in the area. Six potential sources of lead are located near the community of Lincoln Park—the Cotter Mill, the Empire Zinc Smelter (also known as New Jersey Zinc and the College of the Cañons), the US Smelter Facility, the Cañon City Copper Smelter, the Ohio Zinc Company, and the Royal Gorge Smelter [EPA 2004]. The Lincoln Park neighborhood is located generally east-southeast of these facilities and the general wind direction is west to east.

To address the residents’ concerns, EPA requested that ATSDR assess the health risk associated with lead contamination in Lincoln Park. After a site visit and discussions with the community,

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[9] The data for molybdenum and uranium are not summarized in Table because the raw data for these two chemicals are not presented in the *1996 Supplemental Human Health Risk Assessment* (Weston 1996).

ATSDR focused assessments on two primary issues—1) blood lead levels in children living in Lincoln Park and 2) lead contaminated dust in homes in Lincoln Park.

ATSDR reviewed the available data on blood lead levels in children and concluded that the rate of elevated blood lead levels for Fremont County is below the state average. However, it was not possible to evaluate whether area children, including "high risk" children, were being adequately screened for blood lead levels [ATSDR 2006a]. To further assess blood lead levels, ATSDR tested the blood level of 115 "at risk" school children in 2005. None of the children had elevated blood lead levels [ATSDR 2006b].

ATSDR reviewed the available data on lead levels in household dust and found the data to be sparse and/or lacking. ATSDR conducted a screening level evaluation of the available dust samples and concluded that the data were not sufficient to determine the magnitude or extent of the potential hazard associated with levels of lead in household dust [ATSDR 2006c]. To further assess the health impacts in Lincoln Park, ATSDR, in collaboration with the Colorado Citizens Against Toxic Waste (CCAT) and EPA, collected and analyzed 44 indoor dust samples, 80 surface soil samples (0–2 inches or 0–6 inches) from 22 properties, and 45 blood samples. The results of this exposure investigation did not indicate the presence of unusual levels of lead in residential indoor dust samples, the soil at those homes, or in the blood of occupants of those homes [ATSDR 2006d].

EPA's report documenting the residential soils sampling project can be accessed at the following site: http://www.epa.gov/region8/superfund/co/lincolnpark/.

c) Sand Creek

Sand Creek is primarily an ephemeral creek that passes through the Cotter Mill and runs north-northeast through Lincoln Park. It becomes perennial for the last 0.25–0.5 mile before its confluence with the Arkansas River. Prior to the construction of the SCS Dam north of the Cotter Mill in 1971, surface water and sediment from the facility flowed down the Sand Creek drainage into Lincoln Park [CDPHE 2005; GeoTrans 1986]. Mill tailings in the Old Tailings Pond Area are the source of the mill-derived contaminants (primarily radium-226 and thorium-230) in Sand Creek [Cotter 2000].

During the *1986 Remedial Investigation* [GeoTrans 1986], sediment samples were collected from the following locations in Sand Creek to evaluate present (i.e., 1985) and historical loadings from the Cotter Mill.

- SD01 – mouth near the Arkansas River
- SD02 – near spring where flow begins (reflects migration of contaminants in the groundwater)
- SD04 – below the SCS Dam in
    (1) an abandoned stock watering pond (formed by diversion of runoff water into a depression adjacent to Sand Creek)
    (2) in drainage (reflects historical picture of uncontrolled emissions)
    (3) in drainage above #2 (reflects historical picture of uncontrolled emissions)

- SD05 – above the SCS Dam adjacent to the west property edge

The results of this sampling are presented in Table 38 and Table 39. Only the concentrations for arsenic and radium-226 exceeded ATSDR's comparison values.

As part of the 1988 RAP, Cotter was required to evaluate the mill's potential impacts to Sand Creek and remove sediments that exceeded the radium-226 cleanup goal of 4.0 picocuries per gram (pCi/g), which allows unrestricted use of the creek [Cotter 2000]. A total of 721 samples were systematically collected along the 1.25 mile stretch from just north of the Cotter Mill to where Sand Creek becomes perennial (see Figure 22). Surveying and cleanup began in the spring of 1993 and continued until remediation was completed in December 1998. Approximately 9,000 cubic yards of soil were removed from Sand Creek and disposed of on Cotter property [Cotter 2000]. The excavated areas were backfilled with clean soil [CDPHE 2005]. Thirty confirmatory samples established that the average site-wide radium-226 concentration was 1.5 pCi/g (below the cleanup goal of 4.0 pCi/g) and the average site-wide thorium-230 concentration was 3.9 pCi/g after remediation [Cotter 2000]. In addition to the sampling and remediation for radium-226, seven of the confirmation samples were analyzed for 10 chemicals in 1998 [Cotter 2000]. These results are presented in Table 40. Only the maximum and average concentrations for arsenic exceeded ATSDR's comparison value.

At the time of mill closure, Cotter was required by the 1988 RAP to survey molybdenum and radium-226 in sediments in the perennial stream segments of Sand Creek and Willow (Plum) Creek to determine whether these areas have been impacted by the mill. If necessary, sediments above background will be removed and properly disposed of (CDPHE 2005).

d) The Fremont Ditch

The Fremont Ditch system is downstream of Sand Creek. It diverts water from near the confluence of Sand Creek and the Arkansas River downgradient toward Florence. The ditch receives substantial amounts of water from Sand Creek during low flows in the Arkansas River. During these periods, any contaminants moving down Sand Creek would likely be transported to Fremont Ditch [GeoTrans 1986].

As part of the 1988 RAP, Cotter was also required to conduct a gamma survey of the dry beds of the Fremont Ditch. Cotter sampled sediment in Fremont Ditch from its head gate near Sand Creek to about a quarter mile downstream. The average radium-226 level was 1.86 pCi/g, which was below the cleanup standard of 4 pCi/g. The state agreed with Cotter that the Fremont Ditch did not require remediation because the concentrations of gross alpha (3.8 pCi/g), uranium (6.6 ppm), and molybdenum (2.2 ppm) were also low [CDPHE 2005].

C. Surface water

1. Nature and extent of contamination

The Cotter Mill is a non-discharge facility, meaning that Cotter does not release wastewater to the surface water system. All remediation water is pumped to on-site impoundments for evaporation or recycling. However, prior to construction of the SCS Dam in 1971, storm events carried contaminated surface water and sediments from the facility down the Sand Creek drainage [CDPHE 2005]. One event in particular, a flood in June 1965, caused the unlined tailings ponds at the Cotter Mill to overflow into Lincoln Park. Sediment in the Lincoln Park portion of Sand Creek was contaminated with tailings that were carried in surface water runoff from the mill [EPA 2007].

CDPHE maintains a database containing surface water monitoring data dating back to 1962. The most recent data entered into the database are from September 2007. To evaluate exposures to people living near the Cotter Mill, ATSDR extracted surface water data collected from Sand Creek, the DeWeese Dye Ditch, and the Arkansas River. After discussions with a CDPHE representative, the following assumptions were made while summarizing data within the database.

The SCS Dam was built to prevent surface water and sediment from flowing into Lincoln Park during storm-generated floods. Since the construction of the dam, Lincoln Park no longer receives runoff from the Cotter Mill. Additionally, since 1979, impounded water collected at the dam has been pumped back to the lined impoundment on site [EPA 2002; GeoTrans 1986; HRAP 1991].

- Samples that were designated “N” in the detect flag column and had the same value in the result value column as the reporting detection limit column were included in the summary statistics as ½ the reporting detection limit.

- Negative result values for manganese and iron were assumed to be not detected and were included in the summary statistics as ½ the reporting detection limit.

- Negative values[10] for radionuclides were included in the summary statistics.

a) Sand Creek

From 1993 to 1998, Cotter conducted the Sand Creek Cleanup project to identify and remove mill tailings that had moved into the creek bed as the result of surface water runoff from the Cotter Mill prior to the construction of the SCS Dam. Sediments above the radium-226 cleanup goal of 4.0 pCi/g were removed, which allows unrestricted use of the creek [Cotter 2000; EPA 2002].

Two locations in Sand Creek—one at Ash Street (008) and one at the confluence with the Arkansas River (506)—are sampled as part of the surface water monitoring program (Cotter 2007). The CDPHE database contains surface water monitoring data from these two locations, which are summarized in Table 41 (chemicals) and Table 42 (radionuclides). The maximum concentrations for manganese, molybdenum, sulfate, and total dissolved solids exceeded the comparison values. However, for all four of these chemicals, only the maximum concentrations exceeded comparison values—the second highest detected concentrations were below comparison values. None of the average concentrations exceeded comparison values.

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[10] Negative values for radionuclides occur when samples are not much different from background, since standard protocol is to subtract background radioactivity from the sample count.

As part of the *1991 Health Risk Assessment of the Cotter Uranium Mill Site* [HRAP 1991], the Health Risk Assessment Panel (HRAP) reviewed over 18,000 samples collected from 1976–1989, from 55 different surface water locations. More than 95% of the surface water data were collected from 10 main locations. The location in Sand Creek at Ash Street (008, formerly known as 555) was one of these locations. The average molybdenum (0.009 mg/L) and uranium (0.016 mg/L) concentrations from this location were well below the comparison values (molybdenum: 0.035 mg/L; uranium: 0.03 mg/L).[11]

b) DeWeese Dye Ditch

The DeWeese Dye Ditch is an irrigation ditch that flows between the Cotter Mill and Lincoln Park. The ditch diverts water from Grape Creek to irrigate about 1,200 acres during the summer growing period [GeoTrans 1986]. The ditch crosses Sand Creek downstream from the SCS Dam, but does not join it. Seepage from the ditch recharges groundwater within the Sand Creek drainage. This process dilutes and flushes the contaminated groundwater under Lincoln Park [EPA 2002].

The CDPHE database contains surface water monitoring data from two locations in the DeWeese Dye Ditch—one upstream of the confluence with Forked Gulch (520) and one at Cedar Avenue (526). The location at Cedar Avenue is sampled as part of the surface water monitoring program [Cotter 2007]. The data for both locations are summarized in Table 43 (chemicals) and Table 44 (radionuclides). The maximum concentrations exceeded the comparison values for iron, manganese, total dissolved solids, and dissolved uranium. However, for iron and manganese, only the maximum concentrations exceeded comparison values—the second highest detected concentrations were below comparison values. Only three of the total dissolved solids samples and three of the dissolved uranium samples were detected above comparison values. None of the average concentrations exceeded comparison values.

Molybdenum and uranium data from 1984 to 1989, from the same two locations in the DeWeese Dye Ditch (520 and 526), are summarized in the *1991 Health Risk Assessment of the Cotter Uranium Mill Site* (HRAP 1991). The average molybdenum and uranium concentrations were well below the comparison values (see Table 5 below).

Table 5. Average molybdenum and uranium concentrations in the DeWeese Dye Ditch

Chemical	Average concentration at Location 520 (mg/L)	Average concentration at Location 526 (mg/L)	Comparison Value (mg/L)
Molybdenum	0.003	0.003	0.035
Uranium	0.002	0.0019	0.03

Source: HRAP 1991

Molybdenum data that were several orders of magnitude greater than any other observed sample (i.e., outliers) were not used to calculate the average concentrations (HRAP 1991).

It was not possible to determine whether these data are included in the CDPHE database.

c) Arkansas River

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[11] It was not possible to determine whether these data are included in the CDPHE database.

The Arkansas River sampling plan was approved by the CDPHE Water Quality Control Division [CDPHE 2005].

From April 1989 to June 1990, Cotter and their consultant, Western Environmental Analysts, conducted bi-weekly sampling in the Arkansas River at the following five locations:

1. Parkdale (background)
2. Grape Creek
3. 1st Street (upstream of where Sand Creek enters the Arkansas River)
4. Mackenzie Avenue Bridge (downstream from where Sand Creek enters the Arkansas River)
5. Where Highway 67 to Florence crosses the river

Water, sediment, autotrophs (algae), primary consumers/detrivores (tadpoles, macroinvertebrates), and carnivores (fish) were collected and tested for molybdenum, uranium, radium-226, and thorium-230. Extremely low concentrations were detected, which indicated no statistical evidence of an increase in contamination downstream on the Arkansas River [CDPHE 2005].

In addition, four synoptic sampling events (i.e., sampling of water in-flows) were conducted between Canyon Mouth and Highway 67. The purpose of the synoptic sampling was to determine whether tributary flows reflect unusual sources of uranium or molybdenum. The sampling showed that other sources such as Fourmile Creek, as well as Sand Creek and Plum Creek, contribute to increases in the Arkansas River [CDPHE 2005].

Two locations in the Arkansas River—one upstream of Sand Creek at 1st Street (907) and one downstream of Sand Creek at Mackenzie Avenue (904)—are sampled as part of the surface water monitoring program [Cotter 2007]. The CDPHE database contains surface water monitoring data from these two locations, which are summarized in Table 45 (chemicals) and Table 46 (radionuclides). At both locations, the maximum concentrations exceeded the comparison value for sulfate. The maximum concentration for total dissolved solids exceeded the comparison value for the upstream location, but not the downstream location. In all three instances, these maximum concentrations appear to be outliers and are the only concentrations that exceeded comparison values—the second highest detected concentrations were below comparison values. The maximum concentration for molybdenum also exceeded the Colorado state groundwater standard for the upstream location, but not the downstream location. None of the average concentrations exceeded comparison values.

Data from 1984 to 1989, from two locations in the Arkansas River—one upstream of Sand Creek near Grape Creek (502) and one downstream of Sand Creek near Fourmile Bridge (504)—are summarized in the *1991 Health Risk Assessment of the Cotter Uranium Mill Site* [HRAP 1991]. The average molybdenum and uranium concentrations were well below the comparison values (see Table 6 below).

Table 6. Average molybdenum and uranium concentrations in the Arkansas River

Chemical	Average concentration upstream of Sand Creek near Grape Creek (502) (mg/L)	Average concentration downstream of Sand Creek near Fourmile Bridge (504) (mg/L)	Comparison Value (mg/L)
Molybdenum	0.00391	0.0056	0.035
Uranium	0.00532	0.00574	0.03

Source: HRAP 1991

Molybdenum data that were several orders of magnitude greater than any other observed sample (i.e., outliers) were not used to calculate the average concentrations (HRAP 1991).

d) Willow Lakes

The Willow Lakes are comprised of several small ponds near the Arkansas River in the Willow Creek watershed, which lies directly to the east of the Sand Creek watershed. The Willow Lakes receive water from shallow groundwater and surface runoff [HRAP 1991].

Cotter was required by the 1988 RAP to evaluate whether the Willow Lakes had been contaminated by the mill. Water, sediment, autotrophs (algae), primary consumers/detrivores (tadpoles, macroinvertebrates), and carnivores (fish) from the Willow Lakes and three comparison lakes were collected and tested for molybdenum, uranium, and radium. The information showed that the Willow Lakes had not been contaminated by the Cotter Mill [CDPHE 2005].

D. Locally grown produce

1. Nature and extent of contamination

As part of the *1996 Supplemental Human Health Risk Assessment* (Weston 1996), Weston compiled available food data from several past studies. Samples included chicken meat, fruit (apples, cherries, grapes), and vegetables (asparagus, carrots, lettuce, tomatoes, turnips). The local samples were compared to food collected from supermarkets. The data are presented in Table 47 and Table 48 in Appendix A. The limited sample data suggest that the chemicals and radionuclides found in the foods are probably natural in origin, however, it was not possible to exclude the possibility that some food types may be influenced by mill-related contaminants [Weston 1996].

To further evaluate exposures to residents who eat locally grown fruits and vegetables, a sampling program was initiated in Lincoln Park during the *1998 Supplemental Human Health Risk Assessment* [Weston 1998]. People were asked to donate locally grown produce samples for analysis. The fruits and vegetables sampled are presented in the table below. The samples were tested for heavy metals and radionuclides. The analytical results of the sampling program are summarized in Table 49 and Table 50 in Appendix A.

Fruits Sampled

Apples
Cantaloupe
Grapes
Honey dew melon
Plums
Watermelon

Vegetables Sampled

Acorn squash
Beets
Carrots
Celery
Corn
Cucumbers
Green Beans
Green Onions
Kohlrabi
Patty pan squash
Peppers
Pumpkin
Rhubarb
Squash
Tomatoes
Turnip Greens
Turnips
Winter squash

The samples were divided into two categories—(1) produce that was grown in soil known to have been irrigated with contaminated well water (fruits n = 16; vegetables n = 43) and (2) produce that was grown in soil not believed to have been irrigated with contaminated well water (fruits n = 1; vegetables n = 6). A statistical comparison of the data for the two categories of vegetables indicated that irrigation with contaminated well water did not cause a significant increase in contaminant levels (Weston 1998). The following trends were also noted:

- The concentrations of most metals were higher in root vegetables than other types of vegetables and fruit.
- Concentrations were much lower in peeled turnips than in whole turnips, suggesting that most of the contamination was on or in the surface layer.
- There was high variability both within and between the different types of produce.
- Concentration values were below the limit of detection for many of the samples.

E. Ambient Air

ATSDR reviewed ambient air monitoring data and air sampling data collected from the following two sources:

- Cotter Mill has operated an ambient air monitoring program to characterize air quality impacts of radioactive particulates and radon for more than 20 years. ATSDR accessed summaries of the monitoring data from Cotter Mill's annual Environmental and Occupational Performance Reports, which are posted to the CDPHE's web site; and
- The state of Colorado operated three particulate monitoring stations in Fremont County, one each in Lincoln Park, Cañon City, and Florence. The station in Cañon City continues to operate today. ATSDR downloaded measured concentrations of particulate matter, and some chemical constituents of particulate matter, from EPA's Air Quality System (AQS) database—a publicly accessible online clearinghouse of ambient air monitoring data. Some of the measurements collected by these monitors date back 40 years.

Historically, Cotter Mill had two general types of air emission sources: ground-level fugitive emissions (e.g., wind-blown dust) that would be expected to have greatest air quality impacts nearest the source; and elevated point sources (e.g., stacks) that have the potential for having peak ground-level impacts at downwind locations. With the facility currently in "stand down" status, facility emissions are now predominantly fugitive and their air quality impacts should be adequately characterized by the perimeter monitoring stations.

1. Nature and extent of air contamination

ATSDR compiled and evaluated ambient air monitoring data to assess potential air quality impacts from Cotter Mill's past and ongoing operations. As will be discussed later, ambient air concentrations of some substances changed considerably from one year to the next—in some cases, annual average concentrations vary by more than a factor of 250 over the period of record. These substantial changes in measured air contamination levels can sometimes be traced back to site-specific activities.

To provide background information and context for the air quality trends documented later in this report, the following list identifies key milestones over the history of Cotter Mill's operations. The timeline is not intended to be a comprehensive listing of site-specific events, but rather focuses on events and activities expected to be *associated with notable changes in the facility's air emissions*.

- 1958: Cotter Corporation begins its uranium milling operations at the Cotter Mill site
- 1979: Continuous operations cease, but intermittent operations continue
- 1981-1983: Cotter excavates 2,500,000 cubic yards of contaminated tailings from unlined holding ponds and places the material in a newly constructed, lined surface impoundment
- 1987: Cotter suspends its primary milling operations and only limited and intermittent ore processing occurs for the next 12 years
- 1993-1999: Cotter excavates 9,000 cubic yards of contaminated tailings, soil, and sediment from 1.25 miles of Sand Creek near the facility
- 1999: Cotter excavates 100,000 cubic yards of contaminated soil in "near surface soils" from the on-site Old Pond Area and places this material into the lined, surface impoundment
- 1999: Milling operations using a different production process begin
- 2005: Cotter ceases its routine operations and enters "stand down" status; site remediation activities continue; stack emissions from most sources continue into 2006, after which the main operational stack is for the laboratory baghouse
- 2009: Cotter submits letter to CDPHE announcing its intent to refurbish the mill, rather than decommission it

The following sections summarize the data and air quality trends for particulate matter, selected particle-bound radionuclides, radon gas and gamma radiation.

a) Ambient Air Monitoring for Radioactive Substances

The Cotter Mill monitoring network is operated by Cotter Mill in accordance with guidelines and requirements set forth by the U.S. Nuclear Regulatory Commission (USNRC 1980) and the Radioactive Materials License established between Cotter Mill and the state of Colorado [CDPHE 2009]. The purpose of the network is to characterize the extent to which Cotter Mill's operations affect off-site air quality.

Cotter Mill's ambient air monitoring network has been operating from 1979 to the present, but the number of monitoring stations included in the network has changed over time. In 1979, four stations were fully operational; this increased to seven by 1981 and to ten by 1999. These ten monitoring stations continue to operate today. Each station is equipped with the same monitoring equipment: an environmental air sampler used to collect particulates for analysis of particle-bound radionuclides; a radon track etch measurement device; and an environmental thermoluminescent dosimeter (TLD) for measuring gamma exposure. The height of the sampling inlet probes was not specified in the reports that ATSDR reviewed to prepare this health assessment. Table 51 in Appendix A identifies the monitoring stations and their periods of operation. Figure 23 in Appendix B shows the approximate locations of the monitoring stations. For purposes of this evaluation, ATSDR has classified the ten monitoring stations as being either "perimeter" or "off-site." The five "perimeter" monitoring stations are located along or just within Cotter Mill's property line; and the five "off-site" monitoring stations are located off-site, anywhere from 0.5 mile to 4 miles from the Cotter Mill property line.

(1) Particulate Matter

At each of the 10 monitoring stations described above, Cotter Mill operates a high-volume total suspended particulate (TSP) sampling device. For each sampling period, the devices are loaded with glass fiber filters that collect airborne particulates as ambient air passes through the sampling apparatus. The TSP sampling devices collect 1-week integrated samples; when the sampling period ends, field personnel remove filters, record observations on chain-of-custody forms, and store filters for subsequent laboratory analysis.

Cotter prepares annual summary reports for its environmental monitoring network, and those reports document monthly average TSP concentrations measured at each station. ATSDR had access to the summary reports for 2006, 2007, and 2008. TSP data from earlier years can be accessed through data reports that CDPHE has on compact disk. Over the last three years, annual average TSP concentrations were consistently higher in the more populated areas (Lincoln Park and Cañon City) than at the perimeter monitoring stations. In 2008, for instance, the annual average TSP levels at Lincoln Park and Cañon City were 29.9 $\mu g/m^3$ and 26.5 $\mu g/m^3$, respectively; in contrast, annual average concentrations at the five perimeter monitoring stations ranged from 15.5 $\mu g/m^3$ to 21.4 $\mu g/m^3$.

Although quantitative quality control information was not available when summarizing Cotter's TSP data, these measurements can be compared to CDPHE's PM_{10} monitoring results in Cañon City during the same time frame. From 2006 to 2008, the annual average TSP levels measured by Cotter Mill in Cañon City were 26.6 $\mu g/m^3$, 26.3 $\mu g/m^3$, and 26.5 $\mu g/m^3$, respectively; the annual average PM_{10} levels measured by CDPHE in Cañon City during these same years were

16.5 µg/m^3, 16.4 µg/m^3, and 15.0 µg/m^3. The difference between the TSP and PM_{10} annual average concentrations in Cañon City are within the expected range and direction (i.e., TSP levels exceeding PM_{10} levels), which gives some assurance in the quality of the underlying data sets.

(2) Particle-Bound Radionuclides

Weekly particulate filters collected at the 10 stations mentioned in the previous section are not only weighed for mass loading but are also analyzed at Cotter Mill's analytical laboratory for concentrations of five radionuclides, identified below. All laboratory analyses are conducted according to methodologies approved by CDPHE.

Field sampling and laboratory analyses for particle-bound radionuclides are conducted according to specifications outlined in Cotter Mill's Quality Assurance Program Plan (QAPP). This document is revised periodically and submitted to CDPHE for review. The QAPP outlines many quality control and quality assurance procedures implemented to ensure that the network's measurements are of a known and high quality. Examples of specific procedures followed include: routine collection and analysis of blank samples to ensure sampling media and laboratory equipment are not contaminated; quarterly calibration of flow rates for the "high volume" samplers; audit of sampler flow rates using special equipment; collection of duplicate samples that are analyzed in replicate to quantify measurement precision; and participation in a "laboratory exchange program" through which a subset of environmental samples (mostly water samples, by all appearances) are split and sent to Cotter Mill's laboratory and two commercial laboratories for analyses. While these and other quality control procedures give some assurance that samples are collected and analyzed with fine attention to data quality, the reports available to ATSDR during this review generally did not present the actual data quality metrics (e.g., the relative percent difference in duplicate samples or for inter-laboratory audits, contamination levels found in blanks) for the particle-bound radionuclides.

The key findings from the monitoring program for the five radionuclides measured are below. For each substance, a section compares the measured concentrations to regulatory limits or health-based comparison values, comments on temporal and spatial variations, and then presents a brief summary.

- **Natural uranium (^{nat}U).** Table 52 in Appendix A presents the history of annual average ^{nat}U concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.
    - *Screening.* Cotter Mill compares measured concentrations of ^{nat}U to an "effluent concentration" (9.0×10^{-14} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 52 exceed this derived concentration guide. The highest annual average concentration over the period of record (2.5×10^{-14} µCi/ml at a perimeter monitoring station in 1982) is 3.6 times below this screening value. The highest annual average in 2008 (4.4×10^{-16} µCi/ml at a

    perimeter monitoring station) was approximately 200 times below the screening value, and larger margins are observed for the off-site monitoring stations.

  - *Spatial and temporal variations.* Generally, the highest annual average concentrations of ^{nat}U were observed at perimeter monitoring stations, with lower levels observed at the off-site stations. During most years, the annual average values did not vary considerably (by more than an order of magnitude) across all of the stations. As an exception, the 1982 annual average ^{nat}U concentration observed at the west boundary monitoring station was roughly 50 times greater than the annual averages observed at the other monitoring stations during the same year; this "spike" at one station during one year was most likely caused by air emissions associated with an on-site tailings excavation project. As another exception, in several years between 1998 and 2006, annual average ^{nat}U concentrations at the mill entrance road monitoring station were more than an order of magnitude higher than those recorded at all other stations, which most likely reflects contributions from clean-up of the site entry road and delivery of ores (which mostly ended in 2006). As noted above, the highest annual average concentration of ^{nat}U was observed in 1982, and more recent (2004-2008) annual average levels are considerably lower.

  - *Summary.* Every annual average concentration of ^{nat}U recorded to date has been lower than Cotter Mill's health-based regulatory limit. In the last five years, the annual average concentrations at every station have been at least 20 times below this limit. It seems unlikely that air emissions from the mill would lead to an off-site "hot spot" of ^{nat}U concentrations that could be considerably higher than the levels measured by the monitoring network.

- **Thorium-230 (^{230}Th).** Table 53 in Appendix A presents the history of annual average ^{230}Th concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{230}Th to an "effluent concentration" (2.0×10^{-14} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. The annual average concentration at the west boundary monitoring station exceeded this value in 1981 and 1982, as did the annual average concentration in 1981 at the east boundary monitoring station. The highest annual average concentration recorded by this network (9.0×10^{-14} µCi/ml at the west boundary in 1982) was 4.5 times higher than the derived concentration guide. Concentrations decreased over the years, and the highest annual average in 2008 (7.2×10^{-16} µCi/ml at a perimeter monitoring station) was a factor of 28 times lower than the screening value, and larger margins are observed for the off-site monitoring stations.

  - *Spatial and temporal variations.* Without exception, the highest annual average concentrations of ^{230}Th were observed at perimeter monitoring stations, with considerably lower levels observed at the off-site stations—a spatial trend suggesting that Cotter Mill's emissions very likely account for a considerable portion of the measured levels. As with natural uranium, the ^{230}Th concentrations exhibited a notable "spike" in 1981-1982, when 2.5 million cubic yards of on-site tailings were excavated from the unlined ponds. As an illustration of this effect, the highest annual average concentration in 1981 (3.0×10^{-14} µCi/ml at a perimeter monitoring station) was nearly 370 times higher than the annual average concentration measured in Cañon City. Moreover, the highest concentrations were observed at the monitoring station closest to, and downwind from, the excavation activity. Average concentrations of ^{230}Th decreased markedly after the 1981-1982 peak: the most recent (2004-2008) annual average concentrations at perimeter stations are all at least 20 times lower than the highest levels from 1981-1982.

  - *Summary.* In 1981 and 1982, annual average concentrations of ^{230}Th at two perimeter monitoring stations exceeded Cotter Mill's health-based regulatory limit; however, for every other calendar year, every station's annual average concentration was lower than this limit. In the last five years, the annual average concentrations at every station were between six and 30 times below this limit. For the off-site monitoring stations, however, all annual average concentrations during this 5-year time frame were at least a factor of 40 below Cotter Mill's health-based regulatory limit.

- **Thorium-232 (^{232}Th).** Table 54 in Appendix A presents the history of annual average ^{232}Th concentrations measured in Cotter Mill's monitoring network. Laboratory analyses for this radionuclide first began in 2001. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{232}Th to an "effluent concentration" (4.0×10^{-15} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 54 exceed this derived concentration guide. In 2008, the highest annual average concentration (3.1×10^{-17} µCi/ml in Lincoln Park) was a factor of 128 lower than the screening value.

  - *Spatial and temporal variations.* Unlike ^{nat}U and ^{230}Th, for which measured concentrations were consistently (if not always) highest at perimeter monitoring stations, the highest annual average concentrations of ^{232}Th have always been observed at off-site monitoring stations, most commonly at the Lincoln Park monitoring station. Moreover, of all the radionuclides measured, annual average concentrations of ^{232}Th exhibited the least variability from station to station. For any given year between 2001 and 2008, annual average concentrations at the ten monitoring stations fell within a factor of three of each other. The annual average concentrations did not exhibit considerable variability from one year to the next.

  - *Summary.* Over the last five years, annual average concentrations of ^{232}Th at every monitoring station were more than 60 times lower than Cotter Mill's health-based regulatory limit. The spatial variations in ^{232}Th concentrations have been limited, suggesting that air emissions from Cotter Mill may be relatively insignificant for this radionuclide.

- **Radium-226 (^{226}Ra).** Table 55 in Appendix A presents the history of annual average ^{226}Ra concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{226}Ra to an "effluent concentration" (9.0 x 10^{-13} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 55 exceed this derived concentration guide. In 2008, the highest annual average concentration (7.9 x 10^{-16} µCi/ml at a perimeter monitoring station) was three orders of magnitude lower than the screening value.

  - *Spatial and temporal variations.* In almost every year between 1979 and 2008, the highest annual average concentrations of ^{226}Ra were measured at perimeter monitoring stations, and primarily at the west boundary and mill entrance road locations. For most years, the highest annual average value at the facility's perimeter was usually between one and two orders of magnitude greater than the lowest annual average concentration at off-site locations—a pattern that points to facility emissions as a likely source for contributing to at least part of the measured concentrations. At the four perimeter stations with the longest period of record, the highest annual average concentrations occurred prior to 1985, and the current (2008) levels at these stations are between 10 and 100 times lower than those peaks.

  - *Summary.* The spatial variations in ^{226}Ra concentrations suggest that Cotter Mill's emissions contribute to the measured levels. However, over the last five years, annual average concentrations of ^{226}Ra at every monitoring station were more than 390 times lower than Cotter Mill's health-based regulatory limit.

- **Lead-210 (^{210}Pb).** Table 56 in Appendix A presents the history of annual average ^{210}Pb concentrations measured in Cotter Mill's monitoring network. The shaded cells in the table are the highest annual average concentration for the year.

  - *Screening.* Cotter Mill compares measured concentrations of ^{210}Pb to an "effluent concentration" (6.0 x 10^{-13} µCi/ml), which is defined (10 CFR 20, Appendix B) as the radionuclide concentration which, if inhaled continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem. None of the annual average concentrations in Table 56 exceed this derived concentration guide. In 2008, the highest annual average concentration (1.9 x 10^{-14} µCi/ml at a perimeter monitoring station) was more than a factor of 30 lower than the screening value.

- *Spatial and temporal variations.* The main distinguishing feature of the ^{210}Pb monitoring data (when compared to data for the other radionuclides) is the low variability, both spatially and temporally. Since 1983, annual average concentrations across the ten monitoring stations tended to fall within a factor of two; and year-to-year variability was of a comparable magnitude. This lack of variability points to a "background effect" (i.e., the measured concentrations likely are not the result of Cotter Mill's emissions, but reflect typical atmospheric levels for this part of the country). In 1981-1982, annual average concentrations at a perimeter monitoring station were slightly higher than what was routinely measured at all other locations and years; and these slightly elevated levels likely reflected air quality impacts from the excavation of the unlined holding ponds.

- *Summary.* Of all the radionuclides considered, ^{210}Pb showed the least variability in annual average concentrations, suggesting that the monitoring data characterize background levels and not a site-specific contribution. From 1983 to the present, annual average concentrations during every year and at every station were generally at least 20 times below Cotter Mill's health-based regulatory limit.

With one exception, the five radioactive substances measured by Cotter Mill's network were below their corresponding health-based regulatory limits at all 10 monitoring stations and for the entire 30 years of record. As the exception, annual average ^{230}Th concentrations exceeded health-based regulatory limits during a tailing pond excavation project, but this was limited to a short time frame (1981-1982) and the immediate proximity of the facility (two fenceline monitoring locations). The spike in measured concentrations during this time frame was far less pronounced (if not completely imperceptible) at monitoring stations in Lincoln Park or Cañon City. Another spatial variation linked to site activities is the relatively elevated readings (e.g., for ^{nat}U) observed at the "mill entrance road" monitoring station between roughly 1997 and 2006.

Over the last five years, annual average concentrations of every radionuclide were at least 20 times lower than health-based screening limits at the five off-site monitoring stations. This large margin provides some assurance that the monitoring network has adequate coverage in terms of monitors—it is quite possible that annual average ambient air concentrations of radionuclides at some un-monitored off-site locations exceed what has been measured to date, but it is far less likely that the network is failing to capture a "hot spot" with concentrations more than 20 times higher than the levels that are currently measured.

b) *Radon Gas*

Cotter measures radon gas concentrations at the same ten monitoring stations where particle-bound radionuclides are sampled. The annual environmental monitoring reports provide very limited information on the sampling methodology, other than noting that the detectors are apparently exposed to ambient air for a calendar quarter and then retrieved for laboratory analysis. Recent data summary reports suggest that a new sampling and analytical method was implemented in the second quarter of 2002. This new method outputs combined ^{220}Rn (from natural thorium) and ^{222}Rn (from natural uranium). However, the report does not describe what the previous sampling and analytical method measured.

According to Cotter's radon sampling procedures (Cotter 2004b), the sampling devices are "Landauer Type DRNF Radon Detectors." The reports provided to ATSDR suggest that various quality control measures have been implemented for this sampling (e.g., collection and analysis of duplicate samples to characterize precision), but they do not document quantitative data quality metrics. The method detection limit for the combined ^{220}Rn/^{222}Rn measurement is 70 pCi/m^3 (Cotter 2004b). This appears to offer adequate measurement sensitivity, because most quarterly average concentrations measured since this method was implemented are at least an order of magnitude greater than the detection limit.

Table 57 presents the annual average ^{220}Rn/^{222}Rn concentrations that Cotter has measured from 2002 to the present. Data are not presented for earlier years (1979 to 2001), as they may not be directly comparable due to the use of different measurement technologies. Cotter has recently concluded that its radon monitoring data "demonstrate slightly elevated readings at boundary locations [when compared to] readings in residential areas at background levels" (Cotter 2008b). This statement seems to be supported, in a general sense, by the monitoring results, though the difference between the perimeter and the off-site concentrations is much lower in certain years, particularly in 2008.

The approach used for screening the ^{220}Rn/^{222}Rn concentrations differs from that used for other radionuclides. Cotter screens the ^{220}Rn/^{222}Rn using an approach approved by CDPHE. In this approach, Cotter derives an "effective effluent limit" based on a baseline regulatory limit, an equilibration factor for the measurements, and average background concentrations that are calculated semi-annually. The details of this derivation are documented in a letter that CDPHE sent to Cotter in June, 2004. The net effect of this calculation approach is that the "effective effluent limit" (i.e., the concentration used for screening purposes) can vary across the monitoring stations and years. To illustrate this point, between 2006 and 2008, the "effective effluent limit" of ^{220}Rn/^{222}Rn concentrations ranged from 1,290 to 1,981 pCi/m^3, depending on the magnitude of the background concentrations at the time. During this time frame, measured concentrations at perimeter monitoring stations reached as high as 85% of the "effective effluent limit."

c) *Gamma Radiation*

Cotter measures gamma radiation levels at the same ten monitoring stations where particle-bound radionuclides are sampled. Measurements are made using thermoluminescent dosimeters (TLDs) that are exposed for 3-month periods before being sent off-site for analysis. Every calendar quarter, an additional duplicate TLD is deployed to at least one monitoring station to assess measurement precision, and a control TLD is placed in a lead-shielded box at another location to serve as a "blank" sample. However, the site reports provided to ATSDR did not contain any quantitative metrics of data quality (e.g., relative percent difference in co-located samples).

Table 58 presents annual average gamma radiation exposure rates between 1979 and 2008, by monitoring station; these annual averages were calculated from the quarterly TLD measurements from each calendar year. For every year on record, the highest annual average exposure rate was observed at one of the perimeter monitoring stations. Since Cotter installed the monitoring station at the mill's entrance road in 1994, this station has recorded the highest annual average exposure rates every year through the present. The relatively high readings at this location are believed to result primarily from past spillage or incoming materials entering the facility (Cotter 2008b). Under oversight from CDPHE, Cotter removed contamination alongside the entrance road in 2006 and 2007, with exposure rates decreasing thereafter.

Cotter's monitoring reports do not include health-based screening evaluations for these measurements, but they do acknowledge that the exposure rates near the facility perimeter (and particularly along the entrance road) exceed background levels. Specifically, the reports assume that the Cañon City station's measurements reflect "background" contributions from all external sources. The report indicates that the reported background level at this station (10.2 µR/hr) is equivalent to a dose of 89 mrem/year.

d) Ambient Air Monitoring for non-Radioactive Substances

To prepare this summary, ATSDR accessed all ambient air monitoring data that the state of Colorado collected in Fremont County and reported to EPA's Air Quality System (AQS), an online clearinghouse of monitoring data that states collect to assess compliance with federal air quality standards. The AQS database included monitoring results for three locations in Fremont County: one in Cañon City, one in Lincoln Park, and one in Florence. This section summarizes only those data collected in Cañon City and in Lincoln Park given their closer proximity to Cotter Mill. However, the monitoring summarized in this section was not conducted to characterize air quality impacts associated with Cotter Mill's emissions; the measured concentrations at these locations likely reflect contributions from many different local emission sources (e.g., mobile sources, wind-blown dust, wood-burning stoves). The AQS database does not specify quality control parameters for the monitoring results; however, state agencies that submit data to AQS are supposed to thoroughly validate measured concentrations before entering them into the database.

(1) Particulate Matter (TSP, PM_{10}, and $PM_{2.5}$)

The state-operated Cañon City and Lincoln Park monitoring stations measured three different size fractions of particulate matter between 1969 and the present. Following standard practice, all three size fractions were measured in 24-hour average integrated samples that were typically collected once every 6 days, though more frequent monitoring occurred during some years. Measurements were collected using either standard technologies (e.g., high-volume samplers for TSP and PM_{10}) or EPA-approved Federal Reference Method devices. A brief summary of the measurements follows:

- **TSP measurements.** From 1969 through 1987, high-volume sampling devices were used to measure TSP. Table 59 in Appendix A presents the maximum and annual average TSP concentrations measured by the two monitoring stations over the period of record. Annual average TSP in Cañon City did not change considerably from 1969-1987. In Lincoln Park, only two calendar years have complete data sets; the annual average concentration in 1982 was below the range of annual averages observed at Cañon City.

The fact that TSP levels were lower in Lincoln Park than in Cañon City suggests that Cotter Mill's emissions are not the primary contribution to TSP levels in the area.

- **PM_{10} measurements.** The state of Colorado began monitoring PM_{10} in Cañon City in 1987 and continues this monitoring today. The monitoring station was originally located at the courthouse in Cañon City, but the state moved the monitoring equipment in 1987 to a less obstructed site at city hall. Annual average PM_{10} concentrations throughout the period of record range from 15 to 23 µg/m^3, well below EPA's former National Ambient Air Quality Standard for annual average levels (50 µg/m^3). Between 1987 and 2009, only one measured 24-hour average concentration exceeded EPA's current health-based standard; that occurred in 1988 and likely reflected contributions from many different local sources and should not be attributed solely to Cotter Mill's emissions.

- **$PM_{2.5}$ measurements.** In 1991 and 1992, the state conducted $PM_{2.5}$ monitoring at its Cañon City station. All measured 24-hour average concentrations and both annual average concentrations were lower than the health-based standards that EPA would develop later in the 1990s. This monitoring occurred before EPA designated Federal Reference Methods for $PM_{2.5}$ measurement devices.

(2) Constituents of Particulate Matter

Between 1978 and 1987, the state of Colorado analyzed some of the TSP filters collected in Cañon City and Lincoln Park for chemical constituents. This included analyses for metals (iron, lead, manganese, and zinc) and ions (nitrate and sulfate). Table 60 summarizes these measurements by presenting the highest 24-hour average concentration and the highest annual average concentration for the period of record.

V. PUBLIC HEALTH EVALUATION

A. Introduction

This section of the public health assessment evaluates the health effects that could possibly result from exposures to site-related contaminants at or near the Cotter Mill site. For a public health hazard to exist, people must contact contamination at levels high enough and for long enough time to affect their health. The environmental data and conditions at the site revealed five completed exposure pathways:

1. Exposure to site-related contaminants in groundwater in Lincoln Park.
2. Contact with site-related contaminants in soil adjacent to the Cotter Mill and in Lincoln Park.
3. Contact with site-related contaminants in surface water downstream from the Cotter Mill.
4. Exposure from eating produce locally grown in Lincoln Park
5. Exposure to ambient air near the Cotter Mill facility

B. How Health Effects are Evaluated

The potential health effects associated with completed exposure pathways (listed above) will be evaluated in this section. For chemicals found to exceed comparison values, ATSDR calculated exposure doses and estimated non-cancer and cancer risks, where applicable. The calculations estimate the amount of the chemical to which a person may have been exposed. Calculated exposure doses are then compared to the available health guidelines to determine whether the potential exists for adverse non-cancer health effects. In the event that calculated exposure doses exceed established health guidelines (e.g., ATSDR's Minimal Risk Levels or EPA's Reference Doses), an in-depth toxicological evaluation is necessary to determine the likelihood of harmful health effects. ATSDR also may compare the estimated amount of exposure directly to human and animal studies, which are reported in ATSDR's chemical-specific toxicological profiles. Not only do the toxicological profiles provide health information, they also provide information about environmental transport, human exposure, and regulatory status.

ATSDR's **Minimal Risk Level (MRL),** which is derived from human and animal studies, is an estimate of daily exposure to a contaminant below which non-cancer health effects are unlikely to occur.

EPA's **Reference Dose** An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used. Generally used in EPA's noncancer health assessments.

A detailed explanation of ATSDR's evaluation process for determining cancer and non-cancer health effects is contained in Appendix C of this document. The equations to calculate exposure doses, the exposure scenarios, and the exposure assumptions used to estimate exposures at this site are also in Appendix C.

C. Groundwater Pathway: Private wells used for personal consumption

As discussed above, the data from the 1989 *Lincoln Park Water Use Survey* survey indicated approximately 7 wells are used for personal consumption; sampling data for 6 of the 7 wells were available to ATSDR for evaluation. Samples were collected intermittently from 1984 to 2007.

Although most residents in Lincoln Park currently use municipal water for drinking purposes, the survey reveals that residents at 7 locations still use their private wells for drinking purposes. It is not verified whether residents who reported using their well water for personal consumption also use their well water for other household purposes, such as bathing and showering. Some residents report that they and others used their private wells for personal consumption and other household uses in the past (before the installation of the municipal water line). Therefore, it is reasonable to assume that many more people obtained their drinking water from private wells in the past, and that some people are continuing to use their private wells for drinking, and possibly, household purposes.

Very little quantitative information is known about what levels of contamination residents may have been exposed to in the past. However, ATSDR attempted to address this issue by assuming that the average resident would have been exposed to the average chemical concentration (i.e., temporal average per well) detected in the 6 private wells for which we have sampling data. There is some uncertainty in using this estimate because some people may have been exposed to more, and some to less, than the estimated amount. To capture the resident who may have been more highly exposed (or a worst case scenario), ATSDR used the average chemical concentration from the single private well that consistently contained the highest chemical concentrations (Well 189). ATSDR assumed that adults and children drank the water from this well for 350 days per year for 30 years (adults) and 6 years (children), respectively.

Molybdenum was the only chemical in private wells that had an average detected level (0.082 mg/L) that exceeded its comparison value (0.05 mg/L). The average level of molybdenum in Well 189 (0.16 mg/L) also exceeded the comparison value for molybdenum in drinking water. Therefore, molybdenum was retained as a chemical of concern and evaluated for possible adverse health effects. The maximum detected level of uranium (0.067 mg/L), but not the average detected level (0.028 mg/L), also exceeded the comparison value of 0.03 mg/L for uranium. Additionally, the average detected level of uranium in Well 189 (0.048 mg/L) exceeded the comparison value for uranium. Therefore, ATSDR evaluated uranium more closely for potential adverse health effects. Table 7 below summarizes the estimated child and adult doses for molybdenum and uranium that guide the health discussion below. (See Table C1 in Appendix C for a detailed discussion of how these values were derived.)

Table 7. Estimated Child and Adult Doses for Molybdenum and Uranium in Drinking Water

Chemical	Exposure Group	Adult Estimated Dose (mg/kg/day)	Child Estimated Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Molybdenum	Well 189 (high exposures)	0.004	**0.010**	0.005 Chronic Oral RfD
	All wells (average exposures)	0.002	0.005	
Uranium	Well 189 (high exposures)	0.001	**0.003**	0.002 Intermediate Oral MRL
	All Wells (average exposures)	0.0008	0.002	

1. *Molybdenum*

Molybdenum is a naturally occurring element found in various ores. Molybdenum is also considered an essential dietary nutrient in humans and animals. Foods such as legumes, leafy vegetables, nuts and cereals tend to be higher in molybdenum than meats, fruits, and root and stem vegetables [WHO 2003]. The Food and Nutrition Board (FNB) of the Institute of Medicine has determined the Tolerable Upper Intake Level[12] (UL) for molybdenum in children and adults [FNB 2001] as follows:

- children 1 to 3 years of age - 0.3 mg/kg/day;
- children 4 to 8 years of age - 0.6 mg/kg/day;
- children 9 to 13 years of age - 1.1 mg/kg/day;
- adolescents 14 to 18 years of age - 1.7 mg/kg/day; and
- adults - 2.0 mg/kg/day.

a) Health Evaluation of Molybdenum

Drinking water from a private well contaminated with molybdenum would result in an estimated dose of 0.002 mg/kg/day for an average adult and 0.005 mg/kg/day for an average child. The adult dose is lower than the oral RfD of 0.005 mg/kg/day for molybdenum. The estimated child dose is equal to the oral RfD (0.005 mg/kg/day) for molybdenum. Therefore, adverse health

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[12] UL = maximum level of daily nutrient intake that is likely to pose no risk of adverse health effects in all individuals. The UL represents the total intake from food, water, and supplements.

effects are not expected for the average adult or child who drank from a private well contaminated with molybdenum.

Adults who may have had high exposures, such as those similar to Well 189, have an estimated dose of 0.004 mg/kg/day, and children who may have had high exposures have an estimated dose of 0.010 mg/kg/day. The adult high dose is less than the oral RfD for molybdenum. However, the estimated child high exposure dose is 2 times greater than the oral RfD of 0.005 mg/kg/day for molybdenum. Because the estimated exposure dose for children exceeds the long-term health guidelines for molybdenum, the possibility of health consequences from this exposure was evaluated further.

To further evaluate the possibility of adverse health effects, ATSDR divides the lowest observed adverse effect level (LOAEL) and/or the no observed adverse effect level (NOAEL) by the site-specific exposure doses. Interpretation of the resulting value is subjective and depends on a host of toxicological factors. Further evaluation consists of a careful comparison of site-specific exposure doses and circumstances with the epidemiologic and experimental data on the chemical. The purpose of the comparison is to evaluate how close the estimated exposure doses are to doses that cause health effects in humans or animals.

The oral RfD for molybdenum is based on a human epidemiological study that found a LOAEL of 0.14 mg/kg/day for increased serum uric acid levels and prevalence of gout-like condition in Armenian villagers [Koval'skiy 1961]. A higher incidence (18-31%) of a gout-like disease was associated with high intake of molybdenum (10-15 mg/day) from soil and plants. The gout-like condition was characterized by pain, swelling, inflammation and deformities of the joints, and, in all cases, an increase in the uric acid content of the blood. In a number of cases, illnesses of the GI tract, liver, and kidneys accompanied the condition [EPA IRIS]. In deriving the oral RfD, an uncertainty factor of 3 was used for protection of sensitive human populations and a factor of 10 was used for the use of a LOAEL instead of a NOAEL for a long-term study in a human population. The estimated child high dose (0.010 mg/kg/day) for molybdenum at the Cotter Mill/Lincoln Park site is 14 times lower than the LOAEL from this study. There was no NOAEL determination for molybdenum from this study.

Molybdenum is known to interfere with copper metabolism in ruminant animals (grazing animals that "chew their cud," such as sheep or cows); the resulting copper deficiency is reported to cause the animal's hair/wool to turn white [FNB 2001]. This is a problem with ruminant animals in particular because high dietary molybdenum reacts with moderate to high dietary sulfur in the rumen (the first stomach) to form thiomolybdates. These compounds greatly reduce copper absorption, and certain thiomolybdate species can be absorbed and interfere systemically with copper metabolism [Spear 2003]. This interaction between thiomolybdates and copper is not expected to occur to a significant degree in humans [Turnlund 2002]. Although the exact effect of molybdenum intake on copper status in humans remains to be clearly established, individuals who do not take in enough dietary copper or cannot process it correctly could be at increased risk of molybdenum toxicity [FNB 2001].

In conclusion, children who drink water containing high concentrations of molybdenum could be at increased risk of adverse health effects such as gout-like symptoms. However, molybdenum is not stored at high levels in the body, so it is unlikely that children will suffer long-term health effects once the exposure is stopped [FNB 2001]. In healthy people, excess molybdenum is not associated with adverse health outcomes. However, individuals who do not take in enough dietary copper or cannot process it correctly could be at increased risk for adverse health effects. The actual risk of adverse health effects occurring depends on the concentration of molybdenum in the water and how much water is drunk. Therefore, private wells known to be contaminated with molybdenum should not be used for drinking purposes.

b) Additional Comments about Molybdenum in Drinking Water

- ATSDR did not evaluate potential exposures to molybdenum that could occur if well water is used for other household purposes such as showering or bathing. If it is confirmed that residents are using their wells for other potable purposes, then exposure levels would increase, as well as the likelihood of adverse health effects. However, exposure to airborne and/or dermal molybdenum is not likely to be a major exposure pathway because of the physicochemical properties of molybdenum.

- The estimated dose for children and adults at this site did not exceed the Tolerable Upper Intake Level (UL) for molybdenum established by the Institute of Medicine. However, ATSDR's evaluation did not consider molybdenum intake from other sources, including food and supplements, which would increase total intake.

- Molybdenum is often found naturally in the geology of this region. The wells identified and sampled as background for the Lincoln Park area contained an average molybdenum concentration of 0.023 mg/L. This concentration is lower than the average of 0.082 mg/L found in private wells used for personal consumption. The maximum concentration of molybdenum in a background well (0.3 mg/L) was about the same as that in a private well (0.28 mg/L) used for personal consumption.

- Overall molybdenum levels in groundwater decreased over time. Molybdenum levels measured from 1968 to 2000 show a clear pattern of decrease in molybdenum concentrations. Therefore, exposures to molybdenum in groundwater were likely higher in the past, and may continue to decrease in the future.

People who currently own private wells are not prevented from using their private wells for any purpose. New residents who move to the area may install new wells in the contaminated zone and use their well for any purpose. Therefore, this exposure pathway will continue to exist as a potential exposure pathway in the future.

2. Uranium

Throughout the world uranium is a natural and common radioactive element. Uranium is a silver-white, extremely dense, and weakly radioactive metal. It is typically extracted from ores containing less than 1% natural uranium. Natural uranium is a mixture of three isotopes: 238U (99.2739%), 235U (0.7204%), and 234U (0.0057%). It usually occurs as an inorganic compound with oxygen, chlorine, or other elements [NHANES 2005]. Rocks, soil, surface and ground water, air, plants, and animals all contain varying amounts of uranium. Colorado ranks third, behind Wyoming and New Mexico, tied with Arizona and Utah, as the state with the most uranium reserves in the United States [EIA 2001].

a) Health Evaluation of Uranium

Natural uranium is radioactive but poses little radioactive danger—it releases only small amounts of radiation that cannot travel far from its source. Moreover, unlike other types of radiation, alpha radiation released by natural uranium cannot pass through solid objects, such as paper or human skin. You have to eat, drink, or breathe natural uranium in order to be exposed to the alpha radiation; however, no adverse effects from natural uranium's radiation properties have been observed in humans. The National Academy of Sciences determined that bone sarcoma is the most likely cancer from oral exposure to uranium; its report noted, however, that this cancer has not been observed in exposed humans and concluded that exposure to natural uranium may have no measurable effect [BEIR IV].

Scientists have seen chemical effects in people who have ingested large amounts of uranium. Kidney disease has been reported in both humans and animals that were exposed to large amounts of uranium; however, the available data on soluble (more bioavailable) and insoluble uranium compounds are sufficient to conclude that uranium has a low order of metallotoxicity in humans [Eisenbud and Quigley 1955].

When uranium is ingested most of it leaves the body through the feces and a small portion (approximately 2% for an adult) will be absorbed into the blood stream through the gastrointestinal (GI) tract. Most of the uranium in the blood is excreted from the body through urine excretion within a few days; however, a small amount will be retained in the kidneys, bone, and soft tissue for as long as several years. The percentage of the uranium retained in the kidneys over time is different for acute and chronic ingestion of uranium (as long as the individual continues to drink the water). When an individual discontinues drinking the uranium contaminated water, the percentage of retention in the kidney decreases similar to an acute exposure. In the case of chronic ingestion of drinking water containing uranium, the kidney retention (or kidney burden) increases rapidly in the first two weeks. After approximately 100 days, the amount present in the kidney is approximately 5% of the daily intake for an infant and approximately 3% for all other ages. After 25 years of chronic ingestion, the uranium kidney burden reaches equilibrium for all age groups at approximately 6.6% of the daily intake [Chen et al 2004].

Nephrotoxicity (kidney toxicity) occurs when the body is exposed to a drug or toxin such as uranium that causes temporary or permanent damage to the kidneys. When kidney damage occurs, blood electrolytes (such as potassium and magnesium) and chemical wastes in the blood (such as creatinine) become elevated indicating either a temporary condition or the development of kidney failure. Creatinine is a chemical waste molecule that is generated from muscle metabolism. The kidneys maintain the blood creatinine in the normal range. Creatinine is a fairly reliable indicator of kidney function. As the kidneys are impaired, the creatinine level in the blood will rise because of the poor clearance by the kidney. If detected early, permanent kidney problems may be avoided.

Several mechanisms for uranium-induced kidney toxicity have been proposed. In one of these, uranium accumulates in specialized (epithelial) cells that enclose the renal tubule, where it reacts chemically with ion groups on the inner surface of the tubule. This interferes with ion and chemical transport across the tubular cells, causing cell damage or cell death. Cell division and regeneration occur in response to cell damage and death, resulting in enlargement and decreased kidney function. Heavy metal ions, such as uranyl ions, may also delay or block the cell division process, thereby magnifying the effects of cell damage [Leggett 1989, 1994; ATSDR 1999].

Animal and human studies conducted in 1940s and 1950s provide evidence that humans can tolerate certain levels of uranium, suffering only minor effects on the kidney [Leggett 1989]. Most of these studies involved inhalation exposures to uranium; however, the kidney is the target organ for inhaled as well as ingested uranium. On the basis of this tolerance, the International Council on Radiologic Protection (ICRP) adopted a maximal permissible concentration of 3 μg of uranium per gram of kidney tissue for occupational exposure in 1959 [Spoor and Hursh 1973]. This level has often been interpreted as a threshold for chemical toxicity.

More recent papers have been published on effects of uranium at levels below 3 μg/g, and those papers have discussed possible mechanisms of uranium toxicity [Diamond 1989; Leggett 1989, 1994; Zhao and Zhao 1990; Morris and Meinhold 1995]. It is thought that the kidney may develop an acquired tolerance to uranium after repeated doses; however, this tolerance involves detectable histological (structural) and biochemical changes in the kidney that may result in chronic damage. Cells of the inner surface of the tubule that are regenerated in response to uranium damage are flattened, with fewer energy-producing organelles (mitochondria). Transport of ions and chemicals across the tubule is also altered in the tubule cells [Leggett 1989, 1994; McDonald-Taylor et al. 1997]. These effects may account for the decreased rate of filtration through the kidney and loss of concentrating capacity by the kidney following uranium exposure. Biochemical changes include diminished activity of important enzymes (such as alkaline phosphatase), which can persist for several months after exposure has ended. Therefore, acquired tolerance to uranium may not prevent chronic damage, because the kidney that has developed tolerance is not normal [Leggett 1989]. Acting on the basis of this recent information for uranium, researchers have suggested that exposure limits be reduced to protect against these chronic effects on the kidney.

Renal damage appears to be definite at concentrations of uranium per gram of kidney tissue above 3 μg/g for a number of different animal species, but mild kidney injury can occur at uranium concentrations as low as 0.1 to 0.4 μg/g in dogs, rabbits, guinea pigs, and rats after they inhale uranium hexafluoride or uranium tetrachloride over several months [Maynard and Hodge 1949; Hodge 1953; Stokinger et al. 1953; Diamond 1989]. Zhao and Zhao proposed a limit of uranium to the kidney of 0.26 μg/g based on renal effects in a man who was exposed to high concentrations of uranyl tetrafluoride dust for 5 minutes in a closed room [Zhao and Zhao 1990]. The man showed signs of kidney toxicity, including increased protein content in the urine (proteinuria) and nonprotein nitrogen. These signs persisted for 4.6 years, gradually returning to normal values. The kidney content 1 day after the accident was estimated to be 2.6 μg/g.

A study conducted in Finland and published in 2002 observed 325 people that had used their drilled wells for drinking water over a period of 13 years on average (range 1 – 34 years) [Kurttio et. al 2002]. The median uranium concentration in the water was 28 ppb (range 0.001 –

1,920 ppb). The study showed an association between increased uranium exposure through drinking water and tubular function, but not between uranium exposure and indicators of glomerular injury. The primary target is the proximal convoluted tubule of the kidney which is where most of the sodium, water, glucose, and other filtered substances are reabsorbed and returned to the blood. The authors of the study indicated that tubular dysfunction may merely represent a manifestation of subclinical toxicity, and it is unclear if it carries a risk of development into kidney failure or overt illness. This study concluded that "The public health implications of these findings remain uncertain, but suggest that the safe concentration of uranium in drinking water may be close to the guideline values proposed by the WHO and the U.S.EPA." However, this study found that altered tubular function was statistically significant at water uranium concentrations exceeding 300 μg/L [Kurttio et. al 2002], or 0.3 mg/L, which is an order of magnitude higher than EPA's guideline (0.035 mg/l) and the highest average concentration at the Lincoln Park site (0.048 mg/L). At 300 μg/L and assuming ingestion of two liters of water per day, the kidney burden after 25 years of chronic ingestion would be 39.6 μg of uranium with a uranium concentration per gram of kidney tissue of 0.13 μg/g.

A review of studies of uranium effects on the kidney [Morris and Meinhold 1995] suggests a probability distribution of threshold values for kidney toxicity ranging from 0.1 to 1 μg/g, with a peak at about 0.7 μg/g. The researchers proposed that the severity of effects increases with increasing dose to the kidney with probably no effects below 0.1 to 0.2 μg/g, possible effects on the kidney at 0.5 μg/g, more probable effects at 1 μg/g, and more severe effects at 3 μg/g and above [Morris and Meinhold 1995; Killough et al. 1998b].

If an adult in Lincoln Park drank 2 liters (L) of uranium-contaminated water per day (at the highest average exposure concentration of 0.048 mg/L, or 48 μg/L) for 25 years or longer, then the maximum daily ingestion would be 96 μg of uranium, resulting in a uranium kidney burden of 6.3 μg (96 μg × 0.066). The weight of both kidneys in adults is about 300 g [Madsden et al 2007]. Thus, the uranium concentration per gram of kidney tissue for an adult would be 0.02 μg/g. If a child drank 1 L of uranium-contaminated water per day (at the highest average exposure concentration of 0.048 mg/L, or 48 μg/L) for 100 days to 25 years, then the maximum daily ingestion would be 48 μg of uranium, resulting in a uranium kidney burden of 1.4 μg (48 μg x 0.03). The weight of both kidneys in a child is about 100 g; therefore, the uranium concentration per gram of kidney tissue to be 0.01 μg/g. The calculated kidney uranium concentration for adults and children is below the level found to cause harm in published studies.

ATSDR's health-based guidelines for ingested (and inhaled) uranium are lower than the lower limit threshold for kidney toxicity proposed by Morris and Meinhold (1995). ATSDR's guidelines are derived by use of levels of toxicity observed in animal studies, and those guidelines incorporate safety factors to account for uncertainty in extrapolating from animals to humans and to protect the most sensitive human individuals [ATSDR 1999].

Note that urinalysis has limitations as a test for kidney toxicity. First, the presence of substances in urine may indicate that kidney damage has occurred, but it cannot be used to determine whether the damage was caused by uranium. Second, most uranium leaves the body within a few days of exposure, so that urine tests can be used only to determine whether exposure has occurred in the past week or two. Finally, the tests may be used to detect mild effects on the kidney, but such effects are generally transient in nature and may not result in permanent damage. More severe effects involve greater damage to the kidney that is likely to be clinically manifest and longer lasting. The kidney has incredible reserve capacity and can recover even after showing pronounced clinical symptoms of damage; however, biochemical and functional changes can persist in a kidney that appears to have recovered structurally [Leggett 1989, 1994; CDC 1998].

The maximum average uranium concentration detected in a private well was 0.048 mg/L, or 48 µg/L. The residence where this concentration was detected is not connected to the municipal water supply and is noted to use a private well for personal consumption. Drinking water from this private well containing uranium would result in an estimated dose of 0.001 mg/kg/day for an adult and 0.003 mg/kg/day for a child. The adult dose is lower than the intermediate oral MRL. The estimated child dose slightly exceeds the MRL of 0.002 mg/kg/day for an intermediate-duration oral exposure. The MRL level for intermediate-duration oral exposure is also protective for chronic-duration oral exposure because the renal toxicity of uranium exposure is more dependent on the dose than on the duration of the exposure. The MRL is based on a LOAEL of 0.05 mg U/kg/day for renal effects in rabbits. The estimated child dose is an order of magnitude lower than the LOAEL; therefore, adverse health effects are not likely.

Although older evaluations suggested carcinogenicity of uranium among smokers, the U.S. EPA has withdrawn its classification for carcinogenicity for uranium; the International Agency for Research on Cancer (IARC) and the National Toxicology Program (NTP) have no ratings [NHANES 2005].

D. Soil Pathway: Surface Soil near Cotter Mill and Lincoln Park

As discussed above, surface soil samples were collected from areas around the Cotter Mill property, from property access roads and in the Lincoln Park area. Surface soil sampling data were available from eight designated zoned areas around Cotter Mill and in Lincoln Park. People who live or recreate in these areas could accidentally ingest some contaminated soil or get it on their skin. ATSDR evaluated these potential exposure scenarios to determine if concentrations of chemicals and radionuclides in soil are high enough to cause adverse health effects.

ATSDR assumed that the average adult would accidentally ingest 100 milligrams of soil per day and would also contact the contaminated soil with their skin (dermal). Small children were not assumed to access the soil around Cotter Mill because these areas are primarily industrial or vacant. The vacant area has been designated as a “buffer zone” between the Cotter Mill property and the residential areas. Therefore, it is unlikely that small children would access the area. A residential exposure scenario was used to evaluate potential exposures in Lincoln Park. For Lincoln Park, we assumed that a small child would ingest 200 mg of soil per day, and an adult would ingest 100 mg/day, for 350 days per year.

Concentrations of arsenic, cadmium and lead exceeded their comparison values in soil taken from the area surrounding Cotter Mill. The concentration of radium-226 was the only radionuclide to exceed its comparison value in soil near Cotter Mill. Arsenic was the only chemical to exceed its comparison value in soil in Lincoln Park. The highest zonal average concentration of arsenic, cadmium, lead and radium-226 was used to estimate exposure doses. If the highest zonal average concentration of a chemical would not result in adverse health effects, it follows that lower concentrations of the chemical would not as well.

1. Soil Near Cotter Mill

a) Arsenic

Arsenic is a naturally occurring element that is widely distributed throughout the earth's crust and may be found in air, water, and soil [ATSDR 2000]. Arsenic in soil exists as inorganic and organic arsenic. Generally, organic arsenic is less toxic than inorganic arsenic, with some forms of organic arsenic being virtually non-toxic. Inorganic arsenic occurs naturally in soil, and children may be exposed to arsenic by eating soil or by direct skin contact with soil containing arsenic [ATSDR 2007].

The estimated dose of arsenic for adolescents and adults at this site is 0.00002 mg/kg/day. This dose is lower than the Minimal Risk Level (MRL) of 0.0003 mg/kg/day for arsenic; therefore, non-cancer health effects are not likely from being exposed to arsenic in surface soil near Cotter Mill (Zones A through H). The chronic oral MRL of 0.0003 mg/kg/day for inorganic arsenic was derived by dividing the identified chronic No Observable Adverse Effect Levels (NOAEL) of 0.0008 mg/kg/day (obtained from human epidemiologic studies) by an uncertainty factor of three to account for the lack of data on reproductive toxicity and to account for some uncertainty as to whether the NOAEL accounts for all sensitive individuals [ATSDR 2007]. The Lowest Observed Adverse Effect Level (LOAEL) associated with these epidemiologic studies was 0.014 mg/kg/day, where exposure to arsenic above this level resulted in hyperpigmentation of the skin, keratosis (patches of hardened skin), and possible vascular complications [ATSDR 2007].

The U.S. Environmental Protection Agency (EPA), the International Agency for Research on Cancer (IARC), and the National Toxicology Program (NTP) classify arsenic as a human carcinogen. The EPA has developed an oral cancer slope factor to estimate the excess lifetime risk for developing cancer. Using EPA's cancer slope factor for arsenic, and based on a 30 year exposure scenario, ATSDR calculated a lifetime estimated cancer risk level of 1×10^{-5} for exposure to arsenic in soil near Cotter Mill. Qualitatively, we interpret this as a very low increased lifetime risk of developing cancer.

b) Cadmium

The estimated dose for adolescents and adults for cadmium is 0.00002 mg/kg/day, which is lower than the MRL of 0.0001 mg/kg/day for cadmium; therefore, non-cancer adverse health effects are not likely. The U.S. Department of Health and Human Services (DHHS), IARC, and EPA have determined that cadmium is carcinogenic to humans. Although cadmium can be carcinogenic when inhaled, human or animal studies have not provided sufficient evidence to show that cadmium is a carcinogen by oral routes of exposure (ATSDR 1999b). Therefore, a cancer evaluation for cadmium was not done as part of this assessment.

c) Lead

The highest average concentration of lead detected in any of the zones (Zone H) is 445 ppm, which is only slightly higher than the soil screening value of 400 ppm for lead. A value of 400 ppm is commonly used to evaluate lead in soil in residential properties. The property near the Cotter Mill site is currently restricted, vacant or used for industrial purposes; therefore contact with these soils should be minimal. Adverse health effects are not expected to occur from these limited exposures to soils near the site. Exposures to lead, however, should be re-evaluated should the area ever be considered for residential or other non-industrial use.

Maximum lead concentrations in zones F, G and H are 800 ppm, 450 ppm, and 1,400 ppm, respectively. To protect children from exposure to lead, it is important to know the average lead level in a yard or other frequent play area. The *1998 Supplemental Human Health Risk Assessment* provides the only characterization of surface soils adjacent to the Cotter Mill property (See Figure 17, Zones A through H). The soil sample results in this report were generated by collecting four samples from the center of a grid and compositing the samples to form a single representative sample. The size of each sampled grids, however, appears to be larger than 100 x 100 feet, which is the size that triggers additional sampling for lead (EPA 1995). Although the sampling in the *1998 Supplemental Human Health Risk Assessment* measured contamination in soils at several properties near Cotter Mill, it does not allow ATSDR to evaluate contamination in individual exposure units (yards, playgrounds, etc), as would be required to accurately assess exposures in a residential setting, commercial or recreational setting. The sample design is sufficient for making general public health decisions about exposure to lead in soil based on current use patterns. However, any future public health decision regarding the soil near the Cotter Mill property must be made with the limitations of the current sampling design in mind.

The Centers for Disease Control and Prevention (CDC) has established a level of concern for case management of 10 micrograms lead per deciliter of blood (µg/dL). This means that when blood lead levels in children exceed 10 µg/dL, CDC recommends that steps be taken to lower their blood lead levels. However, some agencies and public health officials have mistakenly used this level in blood as a safe level of exposure or as a no effect level. Recent scientific research has shown that blood lead levels below 10 µg/dL cause serious harmful effects in young children, including neurological, behavioral, immunological, and development effects. Specifically, lead causes or is associated with decreases in intelligent quotient (IQ), attention deficit hyperactivity disorder (ADHD), deficits in reaction time, visual-motor integration, fine motor skills, withdrawn behavior, lack of concentration, sociability, deceased height, and delays in puberty, such as breast and pubic hair development, and delays in menarche [CDC].

d) Radium-226

The average concentrations of radium-226 detected in Zones A and B are higher than allowed by the Uranium Mill Tailing Act (UMTRA). That standard does not apply in this case, since the Cotter Mill is still considered active.

The highest average soil concentration of 9.2 pCi/g in surface soil would result in a dose from radium's decay gammas of 58 mrem per year above background, assuming that residents spend 12 hours per day 365 days per year sitting or lying on the highest measured radium concentration of 9.2 pCi/g on the haul road. Since Zones A and B are buffer areas (actually haul roads), the time spent in these areas would be much lower (less than 2 hours per day) and the resulting dose would be roughly 10 mrem per year above background, to a maximally exposed individual.

2. Soil in Lincoln Park

a) Arsenic

The estimated arsenic dose for an adult in Lincoln Park is 0.00003 mg/kg/day, which is an order of magnitude lower than the MRL of 0.0003 mg/kg/day for arsenic. The estimated arsenic dose for a child in Lincoln Park is 0.0003 mg/kg/day, which is equal to the MRL of 0.0003 mg/kg/day for arsenic. Children are estimated to have higher arsenic doses than adults because they tend to engage in activities that increase their soil ingestion exposure, and because they weigh less than adults. Neither children nor adults should experience adverse health effects from exposure to arsenic in soil in Lincoln Park.

Arsenic is a naturally occurring element in soil. Arsenic has also historically been used in a variety of industrial applications, including bronze plating, electronics manufacturing, preserving animal hides, purifying industrial gases, and mining, milling and smelting activities. Studies of background levels of arsenic in soils have revealed that background concentrations range from 1 ppm to 40 ppm, with average values around 5 ppm [ATSDR 2007]. The average arsenic concentration detected in Lincoln Park was 31 ppm, a concentration within the observed background range but higher than the average background concentration. The maximum concentration of arsenic detected in Lincoln Park was 50 ppm.

Although the maximum arsenic concentration is higher than the observed background concentration, this fact alone does not definitely point to an anthropogenic source for the arsenic found in soil in Lincoln Park. Uncertainty exists regarding whether the arsenic levels detected are a natural occurrence or from past milling operations in the area.

Several factors contribute to whether people have contact with contaminated soil, including:

- grass cover, which is likely to reduce contact with contaminated soil when grass cover is thick but increase contact with soil when grass cover is sparse or bare ground is present,
- weather conditions, which is likely to reduce contact with outside soil during cold months because people tend to stay indoors more often,
- the amount of time someone spends outside playing or gardening, and
- people's personal habits when outside, for instance, children whose play activities involve playing in the dirt are likely to have greater exposure than other children

Using EPA’s cancer slope factor for arsenic, and based on a 30 year exposure scenario, ATSDR calculated a lifetime estimated cancer risk level of 5×10^{-5} for exposure to arsenic in Lincoln Park. Qualitatively, we interpret this as no apparent increased lifetime risk of developing cancer.

E. Surface Water: Sand Creek, DeWeese Dye Ditch, and the Arkansas River

People who swim or wade in the surface waters of Sand Creek, the DeWeese Dye Ditch, or the Arkansas River will get surface water on their skin and they might also accidentally ingest some of the surface water. To estimate exposures to adults and children who may have come into contact with contaminated surface water, ATSDR assumed that adults and children will swallow 50 mL of water per hour while swimming or wading, for 104 days per year for 30 and 6 years, respectively. Molybdenum exceeded its comparison value in Sand Creek and the Arkansas River. Manganese exceeded its comparison value in Sand Creek and the DeWeese Dye Ditch. ATSDR conservatively selected the maximum concentration for each chemical to estimate exposures.

1. *Manganese*

The estimated exposure dose for manganese is 0.0007 mg/kg/day for adults and 0.0006 mg/kg/day for children. Both adult and child doses are considerably lower than the reference dose of 0.05 mg/kg/day for manganese. Therefore, no adverse health effects are expected to occur as a result of exposure to manganese in surface waters.

2. *Molybdenum*

The estimated exposure dose for molybdenum is 0.00002 mg/kg/day for adults and 0.00006 mg/kg/day for children. Both adult and child doses are below the chronic oral reference dose (RfD) of 0.005 mg/kg/day for molybdenum. Therefore, no adverse health effects are expected to occur as a result of exposure to molybdenum in surface waters.

F. Homegrown Fruits and Vegetables

Ingestion of contaminated foods is a potential exposure pathway for this site. Residents may have been exposed to contaminants when they ate homegrown fruits and vegetables after using contaminated groundwater (either surface water or private well water) to irrigate their crops, or after growing their crops in contaminated soil. The soil may become contaminated from contaminated water or from tailings, dusts and other wastes deposited in the soil in the past.

Eating fruits, vegetables, herbs, or other produce grown in gardens with contaminated soil can cause exposure. This type of exposure occurs because some plants slowly absorb small amounts of the chemicals found in soil into their plant tissue or because contaminated soil can adhere to the exterior surface of produce, particularly low-growing leafy produce or produce where the underground portion is eaten. Some of these absorbed chemicals are essential nutrients and are actually good for humans to eat, but other chemicals can present health hazards if they are found at high enough levels and are consumed on a regular basis.

Generally, there is not a strong relationship between levels of heavy metals in soils and plants [Vousta 1996]. The uptake of heavy metal concentration depends on speciation of metal, soil characteristics, the type of plant species and other characteristics [Laizu 2007]. Table 8 below developed by Sauerbeck (1988) provides a qualitative guide for assessing heavy metal uptake into a number of plants.

Table 8. Plant Uptake of Heavy Metals

High	Moderate	Low	Very Low
Lettuce	Onion	Corn	Beans
Spinach	Mustard	Cauliflower	Peas
Carrot	Potato	Asparagus	Melons
Endive	Radish	Celery	Tomatoes
Crest		Berries	Fruit
Beet			
Beet leaves			

Source: USEPA (1991), Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors."

To address the concern regarding contaminated crops, residents contributed locally grown produce for sampling analysis. ATSDR used the sampling results to estimate an exposure dose for each contaminant using typical consumption rates for the average and above-average (95th percentile) consumer in the Western United States. Child and infant consumption rates were also used to assess exposures to these vulnerable populations. Table 9 below provides the consumption rates used by ATSDR for homegrown fruits and vegetables.

Table 9. Homegrown Fruit and Vegetable Consumption Rates for the Western United States

Food	Consumer Type†	Intake Rate (g/kg/day)	Standard Error
Homegrown fruits	Average consumer	2.62	0.3
	Above-average consumer	10.9	
	Child	4.1	NA
	Infant (1 to 2 years)	8.7	
Homegrown vegetables	Average consumer	1.81	0.1
	Above-average consumer	6.21	
	Child	2.5	NA
	Infant (1 to 2 years)	5.2	

Sources: EPA Exposure Factors Handbook, Volume II, 1997; Child-Specific Exposure Factors Handbook, 2008
g/kg/day: grams per kilogram per day
NA = not applicable
†An average consumer is represented here as a person who eats fruits and vegetables in the typical range (mean intake). An above average consumer is a person who eats more fruits and vegetables than is typical, represented here by the 95th percentile intake.

All of the estimated fruit and vegetable doses were below health guideline values except for those for arsenic (See Table C4 in Appendix C). The estimated doses for fruits for the above-average consumer (95th percentile intake rate) and for infants exceed the chronic health guideline for arsenic. The above-average consumer and infant doses for fruit are 0.0006 mg/kg/day and 0.0004 mg/kg/day, respectively. Also, the estimated doses for vegetables for the above-average consumer (95th percentile intake rate) and for infants exceed the chronic health guideline for arsenic. The vegetable doses are 0.0005 mg/kg/day for an above-average consumer and 0.0004 mg/kg/day for an infant. These doses exceed the chronic oral MRL of 0.0003 mg/kg/day for arsenic.

Next, ATSDR assumed that a person will eat both fruits and vegetables daily. To do this, we added the calculated doses for fruits and vegetables to derive a single dose. The estimated fruit and vegetable doses for the above-average consumer, child and infant exceed the health guideline of 0.0003 mg/kg/day for arsenic. The above-average consumer dose is 0.001 mg/kg/day; the child dose is 0.0004 mg/kg/day; and the infant dose is 0.0008 mg/day/day.

The chronic oral MRL of 0.0003 mg/kg/day for inorganic arsenic was derived by dividing the chronic No Observable Adverse Effect Level (NOAEL) of 0.0008 mg/kg/day (obtained from human epidemiologic studies) by an uncertainty factor of 3 to account for the lack of data on reproductive toxicity and to account for some uncertainty as to whether the NOAEL accounts for all sensitive individuals [ATSDR 2007]. The Lowest Observed Adverse Effect Level (LOAEL) associated with these epidemiologic studies was 0.014 mg/kg/day, where exposure to arsenic above this level resulted in hyperpigmentation of the skin, keratosis (patches of hardened skin), and possible vascular complications [ATSDR 2007]. The child and infant doses are below or equal to the NOAEL, and the above-average consumer dose is 14 times lower than the dose that caused adverse health effects in epidemiologic studies. Therefore, adverse health effects are not expected in infants, children or the above-average consumer.

Using EPA's cancer slope factor for arsenic and the above consumer exposure dose, and based on a 30 year exposure scenario, ATSDR calculated a lifetime estimated cancer risk level of 6 x 10^{-4} for exposure to arsenic in fruits and vegetables. Qualitatively, we interpret this as a low to moderate increased risk of developing cancer over a lifetime.

ATSDR conservatively assumed that every consumer ate homegrown fruits and vegetables every day for 30 years. In reality, it is likely that most people only eat homegrown fruits and vegetables during a defined season, usually a 3 to 4 month period during the summer/fall growing season. Therefore, the true risk to consumers is likely overestimated.

ATSDR also noted that the highest arsenic level detected in lawns and gardens in Lincoln Park was 50 ppm. This level is near what is typically observed as background arsenic levels (1 ppm to 40 ppm) in soil. This suggests that the contaminated well water used to irrigate crops is not contributing significantly to arsenic soil levels, or other soil additives may have been added that dilute soil contamination [ODEQ 2003]. The highest arsenic level detected in soil at the site was 86 ppm. There were no sampling data for arsenic in drinking or irrigation water. ATSDR is unsure if the arsenic found in soil at this site is a natural occurrence or from an anthropogenic (man-made) source.

Plants vary in the amount of arsenic they absorb from the soil and where they store arsenic. Some plants move arsenic from the roots to the leaves, while others absorb and store it in the roots only [Peryea 1999]. The best method of reducing exposure to external arsenic from homegrown vegetables is to soak and wash residual soil from produce before bringing it into the home and washing the produce again thoroughly indoors before eating [ATSDR 2007]. It is always a good health practice to wash all fruits and vegetables thoroughly before eating, whether they are bought or homegrown.

Molybdenum was the only other contaminant to approach a health guideline when calculating a single dose for fruits and vegetables. The above-average consumer and infant doses are 0.005mg/kg/day, which is equal to the chronic health guideline of 0.005mg/kg/day for molybdenum.

G. Air Pathway

ATSDR looked at all the air data collected from 1979 to present. Concentrations of radionuclides in air from direct release or re-suspension of radioactive contaminants in soil were less than a tenth of ATSDR's health based comparison value (100 millirem per year) at all off-site sampling locations (CC-1/2, LP-2, AS-210, AS-212, OV-3). ATSDR evaluated doses to all age groups and found that adults would have received the highest doses, because of their higher breathing rate. Infants only received one quarter the dose of an adult.

Table 10 below breaks down the dose estimates by age group and by the highest annual concentration measured for each radionuclide and by the highest location. The two highest doses were both in 1982, during the excavation of the unlined settling ponds and were measured at the on-site sampling location AS-204, that was directly adjacent to the dewatered ponds. Neither of those doses would have been to the public. The combined dose to a worker near AS-204 would have been less than a third of the sum in the table since the worker was there less than 8 hours per day for 5 days a week, or 70 mrem of inhalation dose for the year 1982, while the numbers in Table 10 reflect 24/7 exposure through the year. Doses listed in Table 10 did not result in any elevated exposures to the public.

Table 10. Annual Effective Doses by Highest Concentration, Location and Age Group

Radionuclide	Highest Year	Highest Location	Concentration (µCi/ml)	Dose to Infant (mrem/yr)	Annual Dose to Adult	Notes
Natural Uranium (µCi/ml)	1979	AS-204	2.48E-14	2.72	5.97	
Thorium-230 (µCi/ml)	1982	AS-204	8.95E-14	71.57	272.68	
Thorium-232 (µCi/ml)	2001	CC#2	8.33E-17	0.07	0.27	
Radium-226 (µCi/ml)	1985	AS-202	9.63E-15	1.25	2.75	
Lead-210 (µCi/ml)	1982	AS-204	9.95E-14	7.01	16.77	Dose from Radon Progeny
Radon-220/222 (pCi/l)	2004	AS-202	1.50E+00	NA	NA	No dose from Radon

Most of the calculated inhalation dose was from the isotope Thorium-230 (Th-230). Table 11 below lists just the dose from Th-230 for the highest annual average concentration at each sampling station. Again it can be seen that the on-site concentrations are consistently orders of magnitude higher than at off-site locations in Cañon City, Lincoln Park and west of the site boundary.

Outdoor concentrations of radon contributed zero dose to the public, because it is a noble gas and does not stay in the lungs long enough to radioactively decay. On the other hand, the dose from radon decay products (e.g., lead-210) attached to respirable dust held constant year over year and accounted for an annual inhalation dose of four to seven millirem annually. Radon decay product concentration off-site did not appear to be related to releases from the site. Radon and its decay products appear to be from natural background and do not represent any health threat at the reported concentrations.

Table 11. Annual Doses from Thorium-230 by Location and Year

Year	Highest Location	Concentration (µCi/ml)	Annual Dose to Infant (mrem/yr)	Annual Dose to Adult(mrem/yr)
1982	AS-204	8.95E-14	71.57	272.68
1982	AS-202	2.12E-14	16.95	64.59
1983	AS-203	9.79E-15	7.83	29.83
1982	AS-206	1.26E-14	10.08	38.39
2000	AS-209	4.16E-15	3.33	12.67
2005	AS-210	4.85E-16	0.39	1.48
2000	AS-212	6.69E-16	0.53	2.04
1982	LP-1/2	7.49E-16	0.60	2.28
1982	CC-1/2	9.18E-16	0.73	2.80
1982	OV-3	3.15E-15	2.52	9.60

VI. COMMUNITY HEALTH CONCERNS

Responding to community health concerns is an essential part of ATSDR's overall mission and commitment to public health. The community associated with a site is both an important resource for and a key audience in the public health assessment process. Community members can often provide information that will contribute to the quality of the health assessment. Therefore, during site visits and telephone conversations with community members, ATSDR obtained information from the community regarding their specific health concerns related to the site.

In some cases, ATSDR was unable to address a community health concern because 1) adequate scientific information on the particular health effect is not available or is limited or 2) the available scientific data are insufficient to assess whether the specific health effect is related to exposure to a particular chemical. Where feasible, ATSDR addressed the health concerns identified by the community. Below is a summary of the community concerns and ATSDR's response to those concerns.

1. How did the 1965 flood event affect my health?

In June 1965, prior to the construction of the SCS Dam in 1971, a flood caused the unlined tailings ponds at the Cotter Mill to overflow into Lincoln Park. According to the residents, the waters flowed north through the gap in the ridge, down Pine Street, and ultimately down 12th Street (Sharyn Cunningham, CCAT, personal communication, February 2008). There is concern that this flood event contaminated groundwater wells and that dust from soil or tailings may have been resuspended by wind and distributed in Lincoln Park. Community members are very concerned that current illnesses may be a result of this tailings pond flood event.

> There is documentation that ponds at the Cotter Mill historically overflowed, which led to the construction of the SCS Dam. Aerial photography from October 1970 indicates that one of the evaporation ponds overflowed into an alluvial channel tributary to Sand Creek (Wilder et al. 1983). A chronology compiled by CDPHE states that in October 1970 and January 1971, an evaporation pond overflowed with high levels of total dissolved solids, sodium, molybdenum, sulfate, and high radiation (CDPHE 1975).However, since the construction of the SCS Dam, there are no recorded surface water discharges past the dam (GeoTrans 1986).

ATSDR tried to locate data to evaluate the potential health effects resulting from this flood event. No data from 1965 or 1966 exist in the CDPHE database. The *1986 Remedial Investigation* (GeoTrans 1986) states that off-site groundwater contamination in the Lincoln Park areas was first identified in 1968; therefore, any data prior to 1968 are unlikely to exist. The only data ATSDR found related to this flood event were from a sediment sample collected in January 2003 (CDPHE 2003). To address community concerns, CDPHE collected a sample of suspected flood sediment from Pine Street near Elm Avenue. This area was identified by a property owner who was present during the flood. The sample was collected from two locations. About 250 grams of soil were collected from each location to a depth of approximately 18 inches. No obvious soil horizons were identified, and no significant differences in gamma radiation were noted between shallow and deep soils. The results are presented in Table 12 below. All concentrations from this one sample are below comparison values.

The results of the sediment sample from the flood did not exceed any comparison values. If this sample was representative of the material moved by the floodwaters, it would not cause any adverse health effects.

Table 12. Concentrations found in a suspected flood sediment sample, January 2003

Chemical	**Concentration (ppm)**	**Comparison Value (ppm)**
Lead	87	400
Molybdenum	Not detected	300
Uranium	1.6	100
Radionuclide	**Concentration (pCi/g)**	**Comparison Value (pCi/g)**
Cesium-137	0.12	Not available
Lead-210	2.2	Not available
Plutonium-239, 240	Not detected	Not available
Potassium-40	22.5	Not available
Radium-226	2.2	15
Radium-228	1.3	15

Source: CDPHE 2003

2. Were an adequate number of soil samples collected during the *1998 Supplemental Human Health Risk Assessment*?

The community expressed concern that not enough samples were collected during the *1998 Supplemental Human Health Risk Assessment*. Weston, a contractor for Cotter, collected surface soil samples (0-2 inches) from eight zones around the mill property (see Figure). Each zone was divided into 8 to 12 grids. Four samples were collected near the center of each grid and were composited (i.e., combined and homogenized) to form a single representative sample (Weston 1998). The dates the samples were collected were not specified in the report; however, it is assumed to be in the 1994–1996 timeframe. In 1995, EPA released guidance for obtaining representative soil samples at Superfund sites (EPA 1995). The systematic grid sampling approach used by Weston conforms with EPA's guidance for delineating the extent of contamination. The number of samples taken from each grid for compositing, however, is not entirely consistent with EPA's guidance. For grids larger than 100 x 100 feet, which it appears that the grids established by Weston are, EPA recommends collecting nine aliquots from each grid. Compositing four aliquots from each grid is recommended for grids smaller than 100 x 100 feet (EPA 1995). Because the timeframe of the sampling is unclear, it is not known whether EPA's 1995 guidance was available during Weston's sampling effort.

3. Are there high levels of thorium near the Black Bridge?

The community expressed concern that high thorium levels were detected in surface water near the Black Bridge. This bridge is located where a railroad spur crosses the Arkansas River between the 4th Street and 9th Street bridges. The closest sampling location in the Arkansas River is upstream at 1st Street (907). Thorium-230 was sampled at this location as part of the surface water monitoring program between 1995 and 2007. These data are summarized below in Table 13. The highest thorium-230 concentration detected was 2.5 picocuries per liter (pCi/L) (suspended sample) in August 2007. This concentration is below levels known to cause adverse health effects. It should also be noted that the Black Bridge is located upstream of the confluence with Sand Creek.

Table 13. Thorium-230 data upstream of the Black Bridge

Chemical	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)
Thorium-230 (D)	121/127	-0.1	0.1	1
Thorium-230 (S)	115/120	0	0.2	2.5
Thorium-230 (T)	7/7	0.1	0.3	0.7

Source: CDPHE 2007b
Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
Thorium-230 “D” and “S” samples were collected between 1995 and 2007. Thorium-230 “T” samples were only collected in 1995.

D – dissolved
pCi/L – picocuries per liter
S – suspended
T – total

4. **I grew up near the Cotter plant. Does this increase my risk of getting cancer?**

Soil sampling data from the nearest residence to the Cotter plant did not indicate the presence of chemicals at levels above established guidelines. Soil sampling data from the Lincoln Park community did not reveal the presence of contaminants at levels associated with adverse health effects, including cancer. Air data do not indicate the presence of chemicals at levels associated with adverse health effects, including cancer. If you drank water from a contaminated private well, you might be at increased risk for gout-like conditions, such as pain, swelling, inflammation and deformities of the joints. However, once exposure is stopped, the risk of adverse health effects goes down.

5. **I used water from my private well or surface water to irrigate my crops and garden vegetables. Am I going to get sick?**

According to our evaluation, people who ate fruits or vegetables irrigated with contaminated well water are not at increased risk for non-cancer health effects. However, people who eat more than the average amount of fruits and vegetables (95th percentile consumers) might be at increased risk for developing cancer over a lifetime. This conclusion is based on a person eating approximately 4 times more fruits and vegetables than the average person every day for 30 years.

People who grew fruits and vegetables at their home and used their well water to irrigate their crops submitted crop samples for analysis. The analysis revealed that vegetables irrigated with well water did not cause a significant increase in contaminant levels (Weston 1998). As a precaution, however, we recommend washing all homegrown fruits and vegetables before eating them.

6. **I have lived in Lincoln Park since the 1960s. I know of many neighbors and family members who are sick. Is uranium from the mill making us sick?**

Uranium primarily acts as a heavy metal toxin. Renal toxicity is the hallmark effect of uranium exposure, specifically to the proximal tubules of the kidney. We looked at CDC's Compressed Mortality Database "WONDER" looking specifically at specific modes of kidney failure that could be associated with uranium toxicity. Fremont County in Colorado had an age adjusted rate for renal failure as the cause of death of 7.1 per 100,000, for the years 1999-2006. The state average during that same period was 12.1 per 100,000[13]. From the available health outcome data, it does not appear that residents in the area have elevated rates of kidney disease, which could be associated with uranium exposure.

7. **My husband worked at the plant. Was I possibly exposed when he brought his dirty work clothes home?**

Workers in industrial settings have the potential to expose their household members to work-related chemicals if residues attach to the worker's clothing, skin, shoes, or in their vehicles and is inadvertently brought into the home. Whether and to what magnitude these take-home exposures actually occur depends on a number of factors, including the nature of the job held by the worker, the occupational practices of the industrial facility (e.g., providing workers with disposable gowns and gloves), and the precautions/practices of the worker and other family members. ATSDR did not evaluate potential exposures to workers' families because the data needed to quantitatively or qualitatively make a determination on potential health effects were not available.

8. **I used contaminated water from my private well water for many years as a potable source of water for my family. Are we now at risk for adverse health effects?**

The levels of molybdenum were high enough in some wells to cause adverse health effects in individuals who were exposed for many years. Once exposure is stopped, the risk of adverse health effects goes down. Residents, particularly individuals who do not take in enough dietary copper or cannot process copper correctly, might be at increased risk for gout-like conditions. The levels of other contaminants are too low to cause adverse health effects.

9. **CCAT conducted a health survey and submitted it to ATSDR. Why didn't ATSDR use the results of this survey to determine if people are experiencing adverse health effects in the community?**

The community organization CCAT conducted a health survey in 2004–2005. The survey included responses from 239 individuals in the Lincoln Park area. Volunteers went door-to-door in Lincoln Park and the surrounding areas to administer the health surveys. Each person filled out a survey and submitted it to a volunteer. A tabulation of self-reported illnesses reported by respondents included occurrences of cancer; lung, health, skin, central nervous system, kidney, and thyroid problems; reproductive issues, including chromosomal and congenital defects;

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[13] Centers for Disease Control and Prevention, National Center for Health Statistics. Compressed Mortality File 1999-2006. CDC WONDER On-line Database, compiled from Compressed Mortality File 1999-2006 Series 20 No. 2L, 2009. Accessed at http://wonder.cdc.gov/cmf-icd10.html on Sep 30, 2009 10:42:05 AM

autoimmune disease, psychological disorders, and gout. Although ATSDR could not use the survey to make conclusions about disease associations, we did use the survey results to focus our attention and pursue a more in-depth scientific analysis of the health conditions identified by the community.

While the CCAT health survey was a good effort by the community to examine the frequency of their various health concerns, there are many issues that make it of limited use in determining the prevalence of adverse health effects present in the entire community and their potential associations with exposure to environmental contaminants. Some of these issues include the use of a relatively small convenience sample, the lack of medical verification of self-reported health outcomes, and the need for individual-level exposure data. Convenient samples are typically not representative of the entire population, so results cannot be extrapolated to the community. People who participate in nonrandomized surveys such as this may provide biased information because of perceived relationships between environmental contamination or other risk factors and their health. Many of the self-reported health outcomes measured in the survey are present in most populations and are related to several different potential causes beyond environmental exposures, such as lifestyle or genetics. Therefore, without any assessment of exposure, it is not possible to link the occurrence of disease to environmental concerns.

10. CDPHE previously ordered Cotter to have all environmental samples analyzed by an external laboratory until Cotter could demonstrate that its laboratory had addressed various deficiencies. Why was this done and how did it affect the data used by ATSDR?

Cotter’s license requires the company to collect and report a wide range of environmental measurements. Cotter’s own analytical laboratory conducted most of the measurements between the late 1970s and the present. The main exception is that an external analytical laboratory measured contamination levels in most of the samples collected in 2005 and 2006.

For many years, Cotter has participated in so-called “round robin” inter-laboratory performance evaluations. As part of these evaluations, selected environmental samples are split every calendar quarter and simultaneously sent to Cotter’s laboratory and to three external analytical laboratories for analysis. The measurement results are then compared to assess the performance of Cotter’s laboratory. CDPHE’s website presents data from these inter-laboratory comparisons from 2007 to the present. Earlier comparisons are not readily available, mostly because Cotter’s laboratory was not analyzing samples throughout much of 2005 and 2006 and data from earlier years have since been archived from CDPHE’s website.

In September 2008, Cotter submitted a letter to CDPHE documenting five quarters of inter-laboratory comparisons for groundwater samples [Cotter 2008]. These comparisons presented “round robin” data for more than two dozen substances or indicators, including uranium, molybdenum, selenium, nitrate, and selected radionuclides. In some cases, Cotter’s laboratory tended to measure higher concentrations than the other participating laboratories; but in other cases, the opposite was observed. With one exception, the differences between the measurements made by the various laboratories fell within the range typically observed or expected.

The exception is for molybdenum, for which Cotter's laboratory did not meet pre-established comparability limits for the "round robin" sampling. Specifically, in two out of the five quarters of samples that were collected, Cotter's laboratory did not meet the acceptable limits.[14] In contrast, the three external laboratories' molybdenum measurements met the pre-established comparability limits for all five quarters considered in this report. The table below presents the specific concentration measurements for the two quarters of interest, and these measurements show that (in these two instances) the molybdenum levels measured by Cotter were less than 50 percent of the average concentrations calculated from the three external laboratories' measurements.

After CDPHE requested that Cotter investigate the issue further, Cotter prepared a written response to the issue [Cotter 2009]. The response suggests that the poor performance on these samples resulted from the analytical method used. Cotter uses atomic adsorption to measure molybdenum levels in groundwater samples, and the external laboratories used a different method (inductively coupled plasma with mass spectrometry). When molybdenum concentrations are below roughly 0.5 mg/L, Cotter measures molybdenum by atomic adsorption *graphite furnace* analysis; but at higher concentrations, analysis is by atomic adsorption *flame* analysis. The two quarters with the poor comparisons both had concentration levels below 0.5 mg/L, leading Cotter to infer that the underreporting was associated with the graphite furnace analyses. In January 2009, Cotter proposed several measures that were believed to cause the graphite furnace analyses to perform better, and CDPHE approved of the proposed remedy.

Overall, the "round robin" studies have demonstrated that Cotter's analytical laboratory met pre-specified performance criteria for almost every one of the substances considered. Only for molybdenum was a performance issue noted, and it appears that Cotter's laboratory previously used a method that would understate molybdenum concentrations, but typically only when those concentrations were less than approximately 0.5 mg/L. This issue was observed for samples collected between January 2007 and March 2008, but it likely also affected earlier samples that Cotter's laboratory analyzed; and this negative bias should be considered in any uses of these data. Measurements collected since this timeframe likely do not exhibit the same negative bias, given the changes that Cotter proposed to its analytical methods.

Inter-Laboratory Comparison Results for Molybdenum: First Quarter 2007 & First Quarter 2008

Parameter	Analytical Laboratory			
	Cotter	Laboratory #1	Laboratory #2	Laboratory #3
Inter-Laboratory Comparison for First Quarter 2007				
Measurement 1 (mg/L)	0.012	0.0263	0.027	0.024
Measurement 2 (mg/L)	0.012	0.025	0.027	0.0232
Average (mg/L)	0.012	0.0257	0.027	0.0236
Avg across three comparison laboratories (mg/L)		0.025		
Inter-Laboratory Comparison for First Quarter 2008				
Measurement 1 (mg/L)	0.01	0.0281	0.029	0.0267
Measurement 2 (mg/L)	0.011	0.0274	0.029	0.0274
Average (mg/L)	0.011	0.0278	0.029	0.0271
Avg across three comparison laboratories (mg/L)		0.028		

Note: Every laboratory was supposed to analyze each sample twice, thus providing data allowing for intra-laboratory and inter-laboratory comparisons.

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[14] CDPHE actually voiced concern about three quarters of Cotter's molybdenum data, even though only two of these three quarters did not meet the pre-established comparability limits.

VII. CONCLUSIONS

ATSDR reached four important conclusions in this public health assessment:

1. ATSDR concludes that drinking water for many years from contaminated private wells could harm people's health. This is a public health hazard.

   Private well sampling data collected from 1984 to 2007 revealed the presence of molybdenum at levels that could harm people's health. A water use survey conducted in Lincoln Park in 1989 revealed that at least seven people used groundwater (from their private wells) for personal consumption. These and other residents whose private wells were affected by the highest molybdenum contamination may be at increased risk for health effects such as gout-like conditions, particularly individuals who do not take in enough dietary copper or cannot process copper correctly.

   The lack of consistent monitoring over the years and the unknown usage of wells before the installation of the public water supply make these past exposures difficult to accurately assess.

   Most town residents are now connected to the public water supply and have eliminated their exposure to the contaminated well water. However, some residents are reported to have refused public water supply connections, and many may still have operational private wells. Additionally, no formal institutional controls exist to control groundwater use in Lincoln Park. Therefore, current and future uses of private wells for domestic purposes are still possible.

2. ATSDR concludes that accidentally eating or touching soil and sediment near the Cotter Mill property or in Lincoln Park will not harm people's health. However, ATSDR cannot make conclusions about soils near Cotter Mill if the properties closest to the facility are developed for residential or other non-industrial uses in the future.

3. ATSDR concludes that eating locally-grown fruits and vegetables irrigated with private well water will not harm most people's health. However, a person eating above-average amounts of fruits and vegetables (4 times the average consumer) might have a low increased risk for developing cancer over a lifetime. As a precaution, residents should limit their use of contaminated well water to irrigate their crops. In all cases, the crops should be thoroughly cleaned prior to eating.

4. ATSDR concludes that ambient air emissions of particle bound radionuclides have not resulted in completed exposures to the public at levels that could cause adverse health outcomes. With the exception of thorium-230 levels observed in 1981 and 1982, associated with excavation of contaminated tailings, every radionuclide monitored has been more than a factor of ten below annual dose based health limits to the public. The excavation releases appear to have only exposed on-site workers, but still below occupational limits at that time.

VIII. RECOMMENDATIONS

Based upon ATSDR's review of the environmental data and the concerns expressed by community members, the following recommendations are appropriate and protective of the health of residents in and around the Lincoln Park area.

- Residents should be informed about the health risks associated with contaminated private wells and advised to connect to the public water supply if possible. Local officials should advise new residents who move to the area of the groundwater contamination and that they should have their water supply tested before using groundwater for household purposes.

- Residents should discontinue of use of any impacted private wells for household purposes, including watering livestock and crops.

- CDPHE should continue to monitor the groundwater contaminant plume to assess whether additional wells may be impacted in the future.

- CDPHE should conduct a water use survey in the affected area to determine how groundwater is being utilized by residents in Lincoln Park.

- CDPHE should evaluate the need for further analysis of lead in soil should the areas adjacent to the Cotter Mill property change current use patterns.

- ATSDR in the short-term, and CDPHE in the long-term, should advise residents who have fruit and vegetable gardens to wash the crops thoroughly before eating them. This measure is just a precaution to remove soil adhering to the surface of the crop.

IX. PUBLIC HEALTH ACTION PLAN

The public health action plan for the site contains a description of actions that have been taken or will be taken by ATSDR or other government agencies at the site. The purpose of the public health action plan is to ensure that this document both identifies public health hazards and provides a plan of action designed to mitigate and prevent harmful human health effects resulting from exposure to the hazardous substances at this site.

Public health actions COMPLETED:

- ATSDR conducted site visits to gather community health concerns, to communicate to identified stakeholders, and to gather relevant site-related data;
- ATSDR's Exposure Investigations and Site Assessment Branch (EISB) performed two Exposure Investigations to 1) evaluate blood lead levels in children living in the Lincoln Park area and 2) evaluate lead in dust in homes in the Lincoln Park area. (These documents are available on our website at www.atsdr.cdc.gov.)

Public health actions PLANNED:

- ATSDR's Health Promotion and Community Involvement Branch (HPCIB) will conduct health-related educational activities in the community, as necessary.
- ATSDR's HPCIB will coordinate community outreach and community involvement activities for the site.
- ATSDR will continue to work with appropriate state and federal agencies and review, if requested, additional relevant environmental data (including the water use survey) as it becomes available.
- ATSDR will re-evaluate and revise the public health action plan if needed. New environmental, toxicological, health outcome data, or implementing the above proposed actions may necessitate the need for additional or alternative actions at this site.

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Appendix A - Tables

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Table 14. Well Use in Lincoln Park, 1989

Well Number	Description	Reported Well Use				
		Personal Consumption	Irrigating Fruit	Irrigating Vegetable Gardens	Watering Livestock	Watering Lawns
117	Logan (LPWUS)		✓			✓
119	Birch (LPWUS)			✓		✓
122	Elm (LPWUS)					✓
123	Cedar (LPWUS)					✓
124	Elm (LPWUS)			✓		✓
129	Elm (LPWUS)		✓	✓		✓
130	Poplar (LPWUS)		✓			✓
138	Field well, Cedar (LPWUS)					✓
139	House well, Cedar (LPWUS)					✓
140	C. R. Ransom house well, Cedar (LPWUS)		✓	✓		✓
144	Cedar (LPWUS)		✓	✓	✓	✓
165	Spring, Elm (LPWUS)	✓		✓		✓
166	Willow (LPWUS)				✓	✓
168	Grand (house well) (LPWUS)	✓			✓	✓
173	Beulah (LPWUS)		✓			✓
174	Chestnut (LPWUS)		✓		✓	✓
189	Hickory (LPWUS)	✓				
198	Grand (LPWUS)	✓	✓	✓	✓	✓
206	Grand (field well) (LPWUS)				✓	
212	Cedar (LPWUS)		✓	✓		✓
219	Locust (LPWUS)	✓				
221	Elm (LPWUS)					✓
222	Elm (LPWUS)					✓

Well Number	Description	Reported Well Use				
		Personal Consumption	Irrigating Fruit	Irrigating Vegetable Gardens	Watering Livestock	Watering Lawns
223	Elm (LPWUS)				✓	
224	Elm (LPWUS)		✓			✓
226	Chestnut (LPWUS)					✓
229	Grand (LPWUS)				✓	✓
230	Birch (LPWUS)		✓			✓
231	Birch (LPWUS)		✓	✓		
235	Elm (LPWUS)				✓	
237	Elm (LPWUS)				✓	
239	Grand (LPWUS)		✓	✓	✓	✓
241	Grand (LPWUS)				✓	
243	Chestnut (LPWUS)					✓
245	Elm (LPWUS)				✓	
246	Elm (LPWUS)		✓			✓
252	Poplar (cistern* in barn) (LPWUS)					✓
255	Riley Dr. (LPWUS)	✓	✓			✓
261	Elm (LPWUS)		✓	✓		✓
262	Cedar (LPWUS)		✓	✓		✓
263	Willow (LPWUS)					✓
264	Chestnut (LPWUS)		✓	✓		✓
266	Willow (LPWUS)		✓	✓		✓
267	Willow (spring) (LPWUS)		✓	✓	✓	✓
269	Birch			✓		✓
273	Willow (cistern #1) (LPWUS)			✓		✓
274	Grand (LPWUS)		✓	✓		✓
278	Cedar (LPWUS)					✓

Well Number	Description	Reported Well Use				
		Personal Consumption	Irrigating Fruit	Irrigating Vegetable Gardens	Watering Livestock	Watering Lawns
280	Grand (LPWUS)				✓	
284	Spring - Grand St. (LPWUS)				✓	
285	Grand (LPWUS)				✓	
286	Willow (cistern #2) (LPWUS)				✓	
287	Willow (LPWUS)			✓		✓
288	Poplar (cistern* on porch)					✓
293	Cedar (LPWUS)		✓	✓	✓	✓
	Totals	6	22	20	19	42

Source: IMS 1989

*Modified from the original spelling: “cystern”
Street numbers have been excluded for privacy reasons.

LPWUS – Lincoln Park Water Use Survey

Table 15. Groundwater sampling data (chemicals) from wells used for personal consumption

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Chloride	N/T*	11/11	4.5	8.8	14	Spring, Elm [165]	13-Mar-84	250 (Secondary MCL)	165, 168	1984, 2005–2007
Iron	D	2/12	0.04	0.06	0.1	Grand (house well) [168]	19-Aug-05	26 (RBC)	165, 168	1984, 2004–2007
Manganese	D	2/12	0.002	0.008	0.01	Grand (house well) [168]	13-Dec-04	0.5 (RMEG, child)	165, 168	1984, 2004–2007
Molybdenum	D	52/59	0.007	**0.082**	**0.28**	Hickory [189]	19-Jan-89	0.035 (SS); 0.05 (RMEG, child)	165, 168, 189, 198, 219, 255	1984, 1988–1991, 1995, 2000–2007
Nitrate	T	8/8	0.5	2.9	7.7	Grand (house well) [168]	19-Mar-07	10 (MCL)	168	2005–2007
Selenium	D	0/2	ND	ND	ND	--	--	0.05 (c-EMEG, child)	165, 168	1984
Sulfate	N/T*	11/11	15	62	214	Grand (house well) [168]	19-Aug-05	250 (Secondary MCL)	165, 168	1984, 2005–2007
Total Dissolved Solids	N/T*	11/11	240	330	410	Spring, Elm [165]	13-Mar-84	500 (Secondary MCL)	165, 168	1984, 2005–2007
Uranium	D	56/57	0.001	0.028	**0.067**	Hickory [189]	15-Dec-06	0.03 (MCL)	165, 168, 189, 198, 219, 255	1984, 1988–1991, 1995, 2001–2007

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The source of water used for personal consumption at 1935 Elm [165] was a spring.

* For chloride, sulfate, and total dissolved solids, 1984 data were designated “N” and 2005–2007 data were designated “T”.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
SS – Colorado state groundwater standard
T – total

Table 16. Groundwater sampling data (chemicals) from background wells

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	0/25	ND	ND	ND	--	10 (c-EMEG, child)	1981, 1988–1994
Ammonia	N	3/45	0.02	0.4	4.2	26-Jan-90	30 (LTHA)	1988–1994
Ammonium	T	0/3	ND	ND	ND	--	NA	1995
Chloride	N/T*	168/168	3	12	110.3	07-Jan-80	250 (Secondary MCL)	1975, 1976, 1978–2007
Iron	D	24/79	0.02	0.03	0.3	16-May-89	26 (RBC)	1981–2007
Manganese	D	13/79	0.005	0.007	0.05	16-Mar-99	0.5 (RMEG, child)	1981–2007
Molybdenum	D	116/193	0.005	0.023	**0.3**	09-Nov-82, 09-Jun-76	0.035 (SS); 0.05 (RMEG, child)	1975, 1976, 1979–2007
Nitrate	N/T*	70/79	0.4	2.5	**50.4****	10-Feb-89	10 (MCL)	1988–2007
Selenium	D	10/103	0.001	0.003	0.015	15-Apr-80	0.05 (c-EMEG, child)	1975, 1977–1988, 1996–2000
Sulfate	N/T*	171/171	10	61	**434§**	18-Aug-80	250 (Secondary MCL)	1975–2007
Total Dissolved Solids	N/T*	171/171	286	429	**1,580†**	18-Aug-80	500 (Secondary MCL)	1980–2007
Uranium	D	155/193	0.004	0.021	**0.29**	07-Aug-79	0.03 (MCL)	1975–1977, 1979–2007

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The USGS identified Well 10 (1220 So. 12th St.) and Well 114 (1408 Pine) as representative of background for the Lincoln Park area (Weston 1998).

* For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated "N" and post-1995 data were designated "T".
** Only two of 79 samples were above the CV.

[§] Only one of 171 samples was above the CV.
[†] The maximum concentration appears to be an outlier. The next highest concentration is 590 mg/L.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
SS – Colorado state groundwater standard
T – total

Table 17. Groundwater sampling data (chemicals) from the Grand Avenue Well

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Chloride	N/T*	10/10	4.5	8.250	11	20-Jun-84, 20-Jun-05	250 (Secondary MCL)	1984, 2005–2007
Iron	D	2/11	0.04	0.06	0.1	19-Aug-05	26 (RBC)	1984, 2004–2007
Manganese	D	2/11	0.002	0.009	0.01	13-Dec-04	0.5 (RMEG, child)	1984, 2004–2007
Molybdenum	D	15/20	0.008	0.01	0.015	21-Jun-04	0.035 (SS); 0.05 (RMEG, child)	1984, 1988–1991, 2004–2007
Nitrate	T	8/8	0.5	2.9	7.7	19-Mar-07	10 (MCL)	2005–2007
Selenium	D	0/1	ND	ND	ND	--	0.05 (c-EMEG, child)	1984
Sulfate	N/T*	10/10	15	58	214	19-Aug-05	250 (Secondary MCL)	1984, 2005–2007
Total Dissolved Solids	N/T*	10/10	240	322	402	19-Mar-07	500 (Secondary MCL)	1984, 2005–2007
Uranium	D	20/20	0.001	0.013	0.0218	28-Mar-05	0.03 (MCL)	1984, 1988–1991, 2004–2007

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
* For chloride, sulfate, and total dissolved solids, 1984 data were designated “N” and 2005–2007 data were designated “T”.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database

ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
SS – Colorado state groundwater standard
T – total

Table 18. Groundwater sampling data (chemicals) from wells used to irrigate fruit and vegetable gardens

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Aluminum	D	3/120	0.01	0.186*	0.02	Elm [124] & Elm [129]	15-Mar-95	10 (c-EMEG, child)	117, 119, 124, 129, 130, 140, 144	1981, 1988–1995
Ammonia	N	10/53	0.01	0.3	0.6	house well, Cedar [140]	23-Aug-88	30 (LTHA)	119, 124, 129, 130, 140, 144	1988–1995
Ammonium	T	0/3	ND	ND	ND	--	--	NA	119, 140, 144	1995
Cadmium	D	0/3	ND	ND	ND	--	--	0.002 (c-EMEG, child)	119, 140, 144	1995
Chloride	N/T**	784/793	2.5	19.6	232	house well, Cedar [140]	05-Apr-79	250 (Secondary MCL)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1975, 1976, 1978–2007
Copper	D	0/3	ND	ND	ND	--	--	0.1 (i-EMEG, child)	119, 140, 144	1995
Iron	D	114/398	0.011	0.029	0.31	Elm [129]	21-Apr-03	26 (RBC)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1981–2007
Manganese	D	69/397	0.0007	0.008	0.13	house well, Cedar [140]	09-Sep-94	0.5 (RMEG, child)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1981–2007
Molybdenum	D	1,052/1,077	0.004	0.99	42	house well, Cedar [140]	12-May-73	0.035 (SS); 0.05 (RMEG, child)	All 28 wells (see Table 14)	1968–2007
Nickel	D	0/3	ND	ND	ND	--	--	0.2 (RMEG, child)	119, 140, 144	1995

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Nitrate	N/T**	159/185	0.1	1.7	9.8	Cedar [144]	14-May-70	10 (MCL)	119, 124, 129, 130, 140, 144, 174, 224	1970, 1988–2007
Selenium	D	115/626	0.001	0.003	**0.082**[†]	house well, Cedar [140]	21-Apr-78	0.05 (c-EMEG, child)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224, 264	1974–1988, 1995–2000
Sulfate	N/T**	798/800	8	214	**25,460**[‡]	house well, Cedar [140]	07-May-79	250 (Secondary MCL)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1975–2007
Total Dissolved Solids	N/T**	767/767	31	**550**	**3,438**	house well, Cedar [140]	20-Apr-81	500 (Secondary MCL)	117, 119, 124, 129, 130, 140, 144, 165, 174, 224	1970, 1980–2007
Uranium	D	1,048/1,088	0.0003	**0.13**	**2.54**	house well, Cedar [140]	05-Jan-79	0.03 (MCL)	All 28 wells (see Table 14)	1962–1964, 1967, 1968, 1971, 1974–2007
	S	1/20	0.081	0.005[§]	**0.081**	house well, Cedar [140]	27-May-97		140, 174, 224	1995–2000
Vanadium	D	0/3	ND	ND	ND	--	--	0.03 (i-EMEG, child)	119, 140, 144	1995
Zinc	D	2/3	0.005	0.01	0.022	Birch [119]	25-Aug-95	3 (c-EMEG, child)	119, 140, 144	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The source of water used to water fruits and vegetable gardens at 1935 Elm [165] was a spring.

* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated "N" and post-1995 data were designated "T".
[†] Only two of 626 samples were above the CV.
[‡] The maximum concentration appears to be an outlier. The next highest concentration is 1,948 mg/L from the same well [140] in 1981.
[§] The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 19. Groundwater sampling data (radionuclides) from wells used to irrigate fruit and vegetable gardens

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Location of Maximum	Date of Maximum	CV (pCi/L)	Wells Sampled	Years Sampled
Lead-210	D	29/29	-0.2	0.22	1.5	Birch [119]	21-Jun-95	NA	119, 140, 144, 174, 224	1995–2000
	S	20/20	-0.1	0.15	0.6	house well, Cedar [140]	22-Feb-96, 05-May-99		140, 174, 224	1995–2000
Polonium-210	D	29/29	-0.1	0.13	0.6	Cedar [144]	08-Mar-95, 21-Jun-95,	NA	119, 140, 144, 174, 224	1995–2000
	S	20/20	0	0.12	0.6	house well, Cedar [140]	22-Feb-96, 05-Dec-96		140, 174, 224	1995–2000
Radium-226	D	29/29	0	0.12	0.5	house well, Cedar [140]	12-May-95	5 (MCL radium-226/228)	119, 140, 144, 174, 224	1995–2000
	S	19/19*	0	0	0	--	--		140, 174, 224	1995–2000
Thorium-230	D	28/28	-0.1	0.08	0.3	Birch [119] house well, Cedar [140]	25-Aug-95 21-Feb-95	NA	119, 140, 144, 174, 224	1995–2000
	S	17/17	0	0.08	0.3	house well, Cedar [140]	05-May-99		140, 174, 224	1995–2000

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
*The detect flag is "Y" for all 19 samples, however, the result value is zero for all 19 samples.

CV – comparison value
D – dissolved
MCL – maximum contaminant level

NA – not available
pCi/L – picocuries per liter
S – suspended

Table 20. Groundwater sampling data (chemicals) from wells used to water livestock

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Aluminum	D	0/19	ND	ND	ND	--	--	10 (c-EMEG, child)	144	1981, 1988–1995
Ammonia	N	0/10	ND	ND	ND	--	--	30 (LTHA)	144	1988–1995
Ammonium	T	0/1	ND	ND	ND	--	--	NA	144	1995
Cadmium	D	0/1	ND	ND	ND	--	--	0.002 (c-EMEG, child)	144	1995
Chloride	N/T*	160/160	2.5	14	185	Cedar [144]	24-Aug-83	250 (Secondary MCL)	144, 166, 168, 174	1970, 1975, 1976, 1979–1989, 1991–2007
Copper	D	0/1	ND	ND	ND	--	--	0.1 (i-EMEG, child)	144	1995
Iron	D	27/97	0.03	0.04	0.19	Cedar [144]	18-Oct-01	26 (RBC)	144, 166, 168, 174	1970, 1981–2007
Manganese	D	14/96	0.0007	0.007	0.02	Cedar [144]	13-Jul-81, 13-Sep-83, 17-May-01, 06-Jun-02, 23-Oct-03	0.5 (RMEG, child)	144, 166, 168, 174	1981–2007
Molybdenum	D	271/286	0.006	0.212	1	Cedar [144]	12-May-71	0.035 (SS); 0.05 (RMEG, child)	All 19 wells (see Table 14)	1968–1971, 1975–1977, 1979–2007
Nickel	D	0/1	ND	ND	ND	--	--	0.2 (RMEG, child)	144	1995

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Nitrate	N/T*	55/58	0.1	1.8	9.8	Cedar [144]	14-May-70	10 (MCL)	144, 168, 174	1970, 1988–2007
Selenium	D	10/119	0.001	0.003	0.011	Cedar [144]	19-Mar-80	0.05 (c-EMEG, child)	144, 166, 168, 174	1975–1977, 1979–1988, 1995–2000
Sulfate	N/T*	162/162	10	95	**1,650****	Cedar [144]	18-Aug-80	250 (Secondary MCL)	144, 166, 168, 174	1970, 1975–1977, 1979–1989, 1991–2007
Total Dissolved Solids	N/T*	162/162	195	465	**860**	Cedar [144]	18-Aug-80	500 (Secondary MCL)	144, 166, 168, 174	1970, 1980–2007
Uranium	D	283/302	0.001	**0.034**	**0.46**	Cedar [144]	28-Jun-68	0.03 (MCL)	All 19 wells (see Table 14)	1962–1964, 1967, 1968, 1971, 1975–1977, 1979–2007
	S	0/1	ND	ND	ND	--	--		174	1996
Vanadium	D	0/1	ND	ND	ND	--	--	0.03 (i-EMEG, child)	144	1995
Zinc	D	0/1	ND	ND	ND	--	--	3 (c-EMEG, child)	144	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
** The maximum concentration appears to be an outlier. The next highest concentration is 340 mg/L from the same well [144] in 1984.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 21. Groundwater sampling data (radionuclides) from wells used to water livestock

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Location of Maximum	Date of Maximum	CV (pCi/L)	Wells Sampled	Years Sampled
Lead-210	D	4/4	-0.1	0.1	0.3	Cedar [144]	08-Mar-95	NA	144, 174	1995, 1996
	S	1/1	0.2	0.2	0.2	Chestnut [174]	19-Sep-96		174	1996
Polonium-210	D	4/4	-0.1	0.3	0.6	Cedar [144]	08-Mar-95, 21-Jun-95	NA	144, 174	1995, 1996
	S	1/1*	0	0	0	Chestnut [174]	19-Sep-96		174	1996
Radium-226	D	4/4	0.1	0.1	0.1	--**	--**	5 (MCL radium-226/228)	144, 174	1995, 1996
	S	1/1*	0	0	0	Chestnut [174]	19-Sep-96		174	1996
Thorium-230	D	4/4	0	0.05	0.1	Cedar [144] Chestnut [174]	20-Sep-95 19-Sep-96	NA	144, 174	1995, 1996
	S	1/1*	0	0	0	Chestnut [174]	19-Sep-96		174	1996

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
* The detect flag is "Y" for the one sample, however, the result value is zero.
** All four result values were 0.1 pCi/L.

CV – comparison value
D – dissolved
MCL – maximum contaminant level

NA – not available
pCi/L – picocuries per liter
S – suspended

Table 22. Groundwater sampling data (chemicals) from wells used to water lawns

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Aluminum	D	11/239	0.01	0.19*	0.13	Field well, Cedar [138]	18-Dec-90	10 (c-EMEG, child)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144	1981, 1988–1995
Ammonia	N	21/112	0.01	0.3	0.9	Field well, Cedar [138]	23-Aug-88	30 (LTHA)	119, 122, 123, 124, 129, 130, 138, 139, 140, 144	1988–1995
Ammonium	T	0/5	ND	ND	ND	--	--	NA	119, 138, 139, 140, 144	1995
Cadmium	D	0/5	ND	ND	ND	--	--	0.002 (c-EMEG, child)	119, 138, 139, 140, 144	1995
Chloride	N/T**	1,362/1,372	2.5	30	450	Field well, Cedar [138]	12-Aug-80	250 (Secondary MCL)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1975, 1976, 1978–2007
Copper	D	0/5	ND	ND	ND	--	--	0.1 (i-EMEG, child)	119, 138, 139, 140, 144	1995
Iron	D	205/683	0.005	0.031	0.31	Field well, Cedar [138] Elm [129]	09-Mar-95 21-Apr-03	26 (RBC)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1981–2007

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Manganese	D	134/683	0.0005	0.008	0.13	house well, Cedar [140]	09-Sep-94	0.5 (RMEG, child)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1979, 1981–2007
Molybdenum	D	1,755/1,790	0.004	**2.2**	**56.7**	Field well, Cedar [138]	11-Aug-72	0.035 (SS); 0.05 (RMEG, child)	All 42 wells (see Table 14)	1968–2007
Nickel	D	0/5	ND	ND	ND	--	--	0.2 (RMEG, child)	119, 138, 139, 140, 144	1995
Nitrate	N/T**	277/314	0.1	1.8	9.8	Cedar [144]	14-May-70	10 (MCL)	119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 168, 174, 224	1970, 1988–2007
Selenium	D	320/1,105	0.001	0.005	**0.134**	Field well, Cedar [138]	13-Jul-81	0.05 (c-EMEG, child)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224, 264	1974–1976, 1978–1988, 1995–2000
Sulfate	N/T**	1,382/1,384	8	**351**	**25,460**†	house well, Cedar [140]	07-May-79	250 (Secondary MCL)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1975–2007

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Location of Maximum	Date of Maximum	CV (mg/L)	Wells Sampled	Years Sampled
Total Dissolved Solids	N/T**	1,311/1,311	31	**746**	**4,373**	Field well, Cedar [138]	06-Mar-81	500 (Secondary MCL)	117, 119, 122, 123, 124, 129, 130, 138, 139, 140, 144, 165, 166, 168, 174, 224	1970, 1980–2007
Uranium	D	1,733/1,789	0.0003	**0.233**	**5.161**	Field well, Cedar [138]	01-Aug-68	0.03 (MCL)	All 42 wells (see Table 14)	1962–1964, 1967, 1968, 1971, 1974–2007
	S	4/38	0.0067	0.010	**0.26**	Field well, Cedar [138]	27-May-97		138, 140, 174, 224	1995–2000
Vanadium	D	0/5	ND	ND	ND	--	--	0.03 (i-EMEG, child)	119, 138, 139, 140, 144	1995
Zinc	D	3/5	0.005	0.007	0.022	Birch [119]	25-Aug-95	3 (c-EMEG, child)	119, 138, 139, 140, 144	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated "N" and post-1995 data were designated "T".
† The maximum concentration and the second highest concentration (23,200 mg/L from Well 138 in 1978) appear to be outliers. The third highest concentration is 3,360 mg/L from Well 138 in 1979.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 23. Groundwater sampling data (radionuclides) from wells used to water lawns

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Location of Maximum	Date of Maximum	CV (pCi/L)	Wells Sampled	Years Sampled
Lead-210	D	53/53	-0.2	0.2	1.5	Birch [119]	21-Jun-95	NA	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	38/38	-0.1	0.1	0.6	house well, Cedar [140]	22-Feb-96, 05-May-99		138, 140, 174, 224	1995–2000
	T	1/1*	0	0	0	Field well, Cedar [138]	06-Sep-96		138	1996
Polonium-210	D	53/53	-0.1	0.2	0.9	Field well, Cedar [138]	04-May-99	NA	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	38/38	0	0.1	0.6	house well, Cedar [140]	22-Feb-96, 05-Dec-96		138, 140, 174, 224	1995–2000
	T	1/1	0.5	0.5	0.5	Field well, Cedar [138]	06-Sep-96		138	1996
Radium-226	D	51/51	0	0.1	0.5	house well, Cedar [140]	12-May-95	5 (MCL radium-226/228)	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	37/37**	0	0.003	0.1	Field well, Cedar [138]	30-Oct-95		138, 140, 174, 224	1995–2000
	T	2/2	0	0.05	0.1	Field well, Cedar [138]	06-Sep-96		138	1995–1996
Thorium-230	D	51/51	-0.1	0.08	0.4	Field well, Cedar [138]	06-Aug-98	NA	119, 138, 139, 140, 144, 174, 224	1995–2000
	S	34/34	0	0.06	0.3	house well, Cedar [140]	05-May-99		138, 140, 174, 224	1995–2000
	T	1/1	0.1	0.1	0.1	Field well, Cedar [138]	06-Sep-96		138	1996

Source: CDPHE 2007b
Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
* The detect flag is "Y" for the one sample, however, the result value is zero.
** For all but one sample, the result value is zero.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available

pCi/L – picocuries per liter
S – suspended
T – total

Table 24. Groundwater sampling data (chemicals) from Well 138

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	8/57	0.05	0.23*	0.13	18-Dec-90	10 (c-EMEG, child)	1981, 1988–1995
Ammonia	N	10/42	0.02	0.29	0.9	23-Aug-88	30 (LTHA)	1988–1995
Ammonium	T	0/1	ND	ND	ND	--	NA	1995
Cadmium	D	0/1	ND	ND	ND	--	0.002 (c-EMEG, child)	1995
Chloride	N/T**	199/199	5.5	70	450	12-Aug-80	250 (Secondary MCL)	1975, 1976, 1978–2000
Copper	D	0/1	ND	ND	ND	--	0.1 (i-EMEG, child)	1995
Iron	D	21/106	0.01	0.025	0.31	09-Mar-95	26 (RBC)	1981–2000
Manganese	D	21/107	0.01	0.008§	0.06	11-Jun-91	0.5 (RMEG, child)	1979, 1981–2000
Molybdenum	D	253/253	1.1	8.0	56.7	11-Aug-72	0.035 (SS); 0.05 (RMEG, child)	1968–1973, 1975, 1976, 1978–2000
Nickel	D	0/1	ND	ND	ND	--	0.2 (RMEG, child)	1995
Nitrate	N/T**	59/62	0.7	2.3	4.1	11-Jun-91	10 (MCL)	1988–2000
Selenium	D	102/151	0.001	0.011	0.134†	13-Jul-81	0.05 (c-EMEG, child)	1974–1976, 1978–1988, 1995–2000
Sulfate	N/T**	200/200	71	1,059	23,200‡	01-Nov-78	250 (Secondary MCL)	1975, 1976, 1978–2000
Total Dissolved Solids	N/T**	202/202	290	1,530	4,373	06-Mar-81	500 (Secondary MCL)	1980–2000

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Uranium	D	253/253	0.0005	**0.73**	**5.161**	01-Aug-68	0.03 (MCL)	1968, 1974–1976, 1978–2000
	S	3/18	0.007	0.016	**0.26**	27-May-97		1995–2000
Vanadium	D	0/1	ND	ND	ND	--	0.03 (i-EMEG, child)	1995
Zinc	D	0/1	ND	ND	ND	--	3 (c-EMEG, child)	1995

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
§ The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
† Only three of 151 samples were above the CV.
‡ The maximum concentration appears to be an outlier. The next highest concentration is 3,360 mg/L in 1979.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
i-EMEG – intermediate environmental media evaluation guide
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 25. Groundwater sampling data (radionuclides) from Well 138

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Date of Maximum	CV (pCi/L)	Years Sampled
Lead-210	D	21/21	-0.2	0.22	1.1	03-Aug-95	NA	1995–2000
	S	18/18	0	0.08	0.2	27-May-97, 06-Feb-98, 29-Jul-99, 19-Oct-99		1995–2000
	T	1/1*	0	0	0	06-Sep-96		1996
Polonium-210	D	21/21	0	0.28	0.9	04-May-99	NA	1995–2000
	S	18/18	0	0.11	0.4	28-Aug-00		1995–2000
	T	1/1	0.5	0.5	0.5	06-Sep-96		1996
Radium-226	D	19/19	0	0.13	0.4	21-Mar-96	5 (MCL radium-226/228)	1995–2000
	S	18/18	0	0.006	0.1	30-Oct-95		1995–2000
	T	2/2	0	0.05	0.1	06-Sep-96		1995, 1996
Thorium-230	D	20/20	0	0.07	0.4	06-Aug-98	NA	1995–2000
	S	17/17	0	0.04	0.2	04-May-99, 29-Jul-99		1995–2000
	T	1/1	0.1	0.1	0.1	06-Sep-96		1996

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
*The detect flag is “Y” even though the result value is zero.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended
T – total

Table 26. Surface soil sampling data (chemicals) from eight zones around the Cotter Mill and from Lincoln Park

Chemical		Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G	Zone H	Lincoln Park	CV (ppm)
Arsenic	Range (ppm)	**33–69**	**19–39**	**14–42**	**10–40**	**16–38**	**17–60**	**17–33**	**19–86**	**13–50**	0.5 (CREG), 20 (c-EMEG, child)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (ppm)	**45**	**30**	**25**	**26**	**28**	**35**	**26**	**42**	**31**	
Beryllium	Range (ppm)	0.5–1.6	0.5–0.9	0.6–1	0.5–1.2	0.6–1.7	0.5–0.7	0.6–0.7	0.5–0.9	0.5–1.7	100 (c-EMEG, child)
	Frequency of Detection	9/10	11/12	9/12	10/10	6/8	8/8	4/4	7/8	72/73	
	Average (ppm)	0.8	0.7	0.7	0.6	0.7	0.6	0.7	0.6	0.7	
Cadmium	Range (ppm)	**1.2–15**	**2.1–13**	**2.2–16**	2.5–6.8	**5.3–18**	**8.9–110**	**1.6–20**	**4.4–51**	0.5–5	10 (c-EMEG, child)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	68/73	
	Average (ppm)	6.9	6.4	6.4	4.1	9.8	**36.5**	7.9	**21.1**	1.4	
Lead	Range (ppm)	43–270	45–240	46–260	47–130	100–280	**68–800**	**37–450**	**61–1,400**	17–270	400 (SSL)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (ppm)	132	104	113	74	173	380	201	**445**	120	
Manganese	Range (ppm)	180–480	320–630	200–500	110–750	150–420	140–400	200–370	210–770	290–640	3,000 (RMEG , child)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (ppm)	336	422	356	391	298	268	290	439	424	
Selenium	Range (ppm)	5–7	39	7–16	5	ND	ND	ND	7	5–44	300 (c-EMEG, child)
	Frequency of Detection	5/10	1/12	2/12	1/10	0/8	0/8	0/4	1/8	7/73	
	Average (ppm)	4.2*	5.5*	4*	2.8*	ND	ND	ND	3.1*	3.5*	

Source: Weston 1998

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.

Each sample is a composite of four subsamples collected from the corners of a 10x10 square established near the center of the grid.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.
See Figure for a map of the sampling zones.

* The calculated averages are lower than the minimum detected concentrations due to including ½ the detection limit in the calculation.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
ND – not detected
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Table 27. Surface soil sampling data (radionuclides) from eight zones around the Cotter Mill and from Lincoln Park

Radionuclide		Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G	Zone H	Lincoln Park	CV (pCi/g)
Lead-210	Range (pCi/g)	1.6–9.7	3.0–14.4	2.5–6.0	2.3–4.5	2.6–6.1	2.7–4.9	1.2–4.4	1.5–4.7	0.7–4.2	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	58/58	
	Average (pCi/g)	6.3	8.2	4.1	3.4	4.4	3.9	2.9	2.6	2.1	
Radium-226	Range (pCi/g)	2.4–10.7	3.6–16.5	1.3–5.7	1.4–2.3	2.5–5.6	1.9–3.0	1.4–1.9	1.2–2.2	1.1–2.2	5 (UMTRCA, surface)
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	58/58	
	Average (pCi/g)	6.6	9.2	2.6	1.8	3.9	2.5	1.7	1.5	1.5	
Thorium-230	Range (pCi/g)	3.6–35.3	5.8–40.1	1.6–21.7	1.8–4.4	4.3–12.1	3.6–8.3	1.7–2.8	1.6–11.9	1.0–4.2	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	58/58	
	Average (pCi/g)	17.7	20.9	5.9	2.5	7.7	5.2	2.4	3.3	1.7	
Uranium, natural	Range (pCi/g)	0.871–4.288	1.541–5.427	0.737–5.628	0.737–1.64	1.005–2.412	0.6432–1.943	0.5561–1.005	0.536–1.206	0.6566–3.417	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (pCi/g)	2.45	3.29	1.98	1.17	1.52	1.21	0.83	0.73	1.215	
Uranium-234	Range (pCi/g)	0.436–2.14	0.771–2.71	0.369–2.81	0.369–0.82	0.503–1.21	0.322–0.972	0.278–0.503	0.268–0.603	0.328–1.709	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (pCi/g)	1.23	1.65	0.991	0.584	0.758	0.606	0.413	0.366	0.607	

Radionuclide		Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G	Zone H	Lincoln Park	CV (pCi/g)
Uranium-238	Range (pCi/g)	0.436–2.14	0.771–2.71	0.369–2.81	0.369–0.82	0.503–1.21	0.322–0.972	0.278–0.503	0.268–0.603	0.328–1.709	NA
	Frequency of Detection	10/10	12/12	12/12	10/10	8/8	8/8	4/4	8/8	73/73	
	Average (pCi/g)	1.23	1.65	0.991	0.584	0.758	0.606	0.413	0.366	0.607	

Source: Weston 1998

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that radionuclide.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.
Each sample is a composite of four subsamples collected from the corners of a 10x10 square established near the center of the grid.
See Figure for a map of the sampling zones.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 28. Surface soil sampling data (radionuclides) from the county road and the Cotter Uranium Mill access road

Radionuclide		Samples from background areas	Samples along the county road	Samples along the access road*	CV
Radium-226	Range (pCi/g)	0.8–2.1	3.8–14	2.7–**351**	5 pCi/g (UMTRCA, surface)
	Frequency of Detection	5/5	5/5	6/6	
	Average (pCi/g)	1.42	7.7	**65**	
Thorium-230	Range (pCi/g)	0.2–2.4	9.7–25	10–395	NA
	Frequency of Detection	3/5	5/5	6/6	
	Average (pCi/g)	1.53	20	87	
Uranium, natural	Range (ppm)	1.18–3.05	5.28–29.2	4.31–**922**	100 ppm (i-EMEG, child for highly soluble salts)
	Frequency of Detection	5/5	5/5	6/6	
	Average (ppm)	1.87	13.6	**161**	
Uranium-238**	Range (pCi/g)	0.39–1.01	1.74–9.64	1.42–304	NA
	Frequency of Detection	5/5	5/5	6/6	
	Average (pCi/g)	0.62	4.5	53	
Gamma Exposure Rates	Range (µR/hr)	NA	13.8–55.3	18.6–893	NA
	Frequency of Detection	NA	NA	NA	
	Average (µR/hr)	15.7	25.8	73.7	

Source: MFG 2005

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value.
Each sample consists of 10 aliquots taken from 0–6 inches within a 100 m^2 area.
See Figure for a map of the sampling locations.

*There is limited potential for exposure to contaminants along the access road since access to the Cotter Mill is restricted and soils along the access road were remediated in 2007 and 2008.
**Uranium-238 concentrations were calculated by multiplying the natural uranium concentrations by 0.33.

CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
µR/hr – microroentgen per hour
NA – not available
pCi/g – picocuries per gram
ppm – parts per million
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 29. Soil data (chemicals) from samples taken by CDPHE, January 2003

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Location of Maximum	CV (ppm)
Lead	20/20	23	**410**	**3,651***	Private barn in Lincoln Park (dust sample)	400 (SSL)
Molybdenum	0/20	ND**	ND**	ND**	--	300 (RMEG , child)
Uranium	20/20	1.2	6.0	31	Mill Entrance Road	100 (i-EMEG, child for highly soluble salts)

Source: CDPHE 2003, 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
See Figure for a map of the sampling locations.
The sampling event was intentionally biased toward finding the highest amounts of contamination possible (CDPHE 2003).

*The second highest lead concentration is 908 ppm from a location northwest of the Cotter Mill.
**The molybdenum detection limit was 25 ppm.
§ Concentrations from the background location on the corner of Orchard Avenue and High Street were not included in the table.

CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ND – not detected
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Concentrations from the Background Location§

Lead	36 ppm
Molybdenum	ND
Uranium	1.3 ppm

Table 30. Soil data (radionuclides) from samples taken by CDPHE, January 2003

Radionuclide	Frequency of Detection	Minimum (pCi/g)	Average (pCi/g)	Maximum (pCi/g)	Location of Maximum	CV (pCi/g)
Cesium-137	20/20	0	0.64	1.33	Private residence in Lincoln Park (dust sample)	NA
Lead-210	20/20	1.9	9.7	22.8	East of the Cotter Mill	NA
Plutonium-239, 240	9/20	0.03	0.03*	0.06	East of the Cotter Mill & a private residence in Lincoln Park (dust sample)	NA
Potassium-40	20/20	17.6	22.6	31.9	East of the Cotter Mill	NA
Radium-226	20/20	1.4	7.8	21.2	East of the Cotter Mill	15 (UMTRCA, subsurface)
Radium-228	20/20	0.6	1.0	1.3	Private barn in Lincoln Park (dust sample), private residence in Lincoln Park (dust sample), Pine St near Elm Ave in Lincoln Park (sediment sample), Northwest of the Cotter Mill	15 (UMTRCA, subsurface)

Source: CDPHE 2003, 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that radionuclide.
Averages were calculated using ½ the reporting detection limit for non-detects.
See Figure for a map of the sampling locations.
The sampling event was intentionally biased toward finding the highest amounts of contamination possible (CDPHE 2003).

* The calculated average is the same as the minimum detected concentration due to including ½ the detection limit in the calculation.
** Concentrations from the background location on the corner of Orchard Avenue and High Street were not included in the table.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

<u>Concentrations from the Background Location</u>**

Cesium-137	0.2 pCi/g
Lead-210	3.2 pCi/g
Plutonium-239, 240	ND
Potassium-40	19.5 pCi/g
Radium-226	1.9 pCi/g
Radium-228	1.0 pCi/g

Table 31. Surface soil sampling data from 10 air monitoring locations

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Location of Maximum	Date of Maximum	Years Sampled	CV (ppm)
Molybdenum	106/134	0.6	15.1	251.3	AS-204 (West Boundary)	2002	1992–2006*	300 (RMEG, child)
Radionuclide	**Frequency of Detection**	**Minimum (pCi/g)**	**Average (pCi/g)**	**Maximum (pCi/g)**	**Location of Maximum**	**Date of Maximum**	**Years Sampled**	**CV (pCi/g)**
Radium-224**	10/10	-5.7	-2.9	0.3	Lincoln Park	2006	2006	5 (UMTRCA, surface)
Radium-226	246/251	<0.5	3.9	**53.5**	AS-209 (Mill Entrance Road)	2002	1979–2006†	5 (UMTRCA, surface)
Thorium-230	107/107	0.4	22.2	354	AS-209 (Mill Entrance Road)	2002	1996–2006	NA
Thorium-232	60/60	0.5	1.4	7.9	AS-209 (Mill Entrance Road)	2002	2001–2006	NA
Uranium	258/262	<0.001	4.6	73.6	AS-209 (Mill Entrance Road)	2002	1979–2006	NA

Source: Cotter 2007; GeoTrans 1986

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value.
Uranium and radium-226 were also tested in soil from two additional off-site locations (Oro Verde #1 and Oro Verde #2) in 1983 and 1984.
See Figure for a map of the air monitoring locations.

*Data from 2006 are unavailable.
**Data are blank corrected.
†Results from 2005 were not reported based on quality assurance analysis (Cotter 2007).

CV – comparison value
NA – not available
pCi/g – picocuries per gram
ppm – parts per million
RMEG – reference dose media evaluation guide
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 32. Soil sampling data (chemicals) from location AS-212 (the Nearest Resident)

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Date of Maximum	Years Sampled	CV (ppm)
Lead	1/1	199	199	199	15-Jan-03	2003	400 (SSL)
Molybdenum	7/8	1.6	11.3	42.4	2005	1999–2005	300 (RMEG , child)
Uranium	1/1	4.9	4.9	4.9	15-Jan-03	2003	100 (i-EMEG, child for highly soluble salts)

Source: CDPHE 2007b, Cotter 2007

Averages were calculated using ½ the reporting detection limit for non-detects.
See Figure for the location of AS-212, the nearest resident.

CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Table 33. Soil sampling data (radionuclides) from location AS-212 (the Nearest Resident)

Radionuclide	Frequency of Detection	Minimum (pCi/g)	Average (pCi/g)	Maximum (pCi/g)	Date of Maximum	Years Sampled	CV (pCi/g)
Cesium-137	1/1	0.61	0.61	0.61	15-Jan-03	2003	NA
Lead-210	1/1	8	8	8	15-Jan-03	2003	NA
Plutonium-239, 240	1/1	0.03	0.03	0.03	15-Jan-03	2003	NA
Potassium-40	1/1	17.7	17.7	17.7	15-Jan-03	2003	NA
Radium-224*	1/1	-3.6	-3.6	-3.6	2006	2006	5 (UMTRCA, surface)
Radium-226	8/8	1.4	3.3	7.5	2004	1999–2004, 2006	5 (UMTRCA, surface)
Radium-228	1/1	0.9	0.9	0.9	15-Jan-03	2003	5 (UMTRCA, surface)
Thorium-230	8/8	3.3	10.1	20	2004	1999–2006	NA
Thorium-232	6/6	0.7	1.0	1.1	2001, 2002	2001–2006	NA
Uranium	8/8	2.0	5.2	13	2004	1999–2006	NA

Source: CDPHE 2007b, Cotter 2007

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that radionuclide.
See Figure for the location of AS-212, the nearest resident.

*Data are blank corrected.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 34. Surface soil sampling data (chemicals) from lawns and gardens in Lincoln Park

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Location of Maximum	Years Sampled	CV (ppm)
Arsenic	15/15	31	44	50	garden soil	1996	0.5 (CREG), 20 (c-EMEG, child)
Beryllium	14/15	0.5	0.7	1.1	lawn soil	1996	100 (c-EMEG, child)
Cadmium	14/15	0.5	1.2	1.9	lawn soil	1996	10 (c-EMEG, child)
Manganese	15/15	290	428	640	lawn soil	1996	3,000 (RMEG , child)
Selenium	1/32	18	1.7*	18	garden soil	1990, 1996	300 (c-EMEG, child)

Source: Weston 1996 (some or all of these data may also be included in Table)

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.

* The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
ppm – parts per million
RMEG – reference dose media evaluation guide

Table 35. Surface soil sampling data (radionuclides) from yards, gardens, and air monitoring locations in Lincoln Park

Radionuclide	Frequency of Detection	Minimum (pCi/g)	Average (pCi/g)	Maximum (pCi/g)	Source of Maximum	Years Sampled	CV (pCi/g)
Lead-210	17/17	0.4	1.6	2.5	0–2” garden sample	1990	NA
Polonium-210	17/17	1.1	1.7	2.6	0–2” garden sample	1990	NA
Radium-226	19/19	0.8	1.5	2.0	0–2” garden sample	1987, 1988, 1990	5 (UMTRCA, surface)
Thorium-228	17/17	1.0	1.4	1.8	0–2” garden sample	1990	NA
Thorium-230	17/17	1.0	1.5	2.3	0–2” garden sample	1990	NA
Uranium-234	29/29	0.355	1.23	1.95	Soil from the yard of a participant in the LPWUS	1987–1990	NA
Uranium-235	0/17	ND*	ND*	ND*	--	1990	NA
Uranium-238	29/29	0.355	1.21	1.95	Soil from the yard of a participant in the LPWUS	1987–1990	NA

Source: Weston 1996

*The uranium-235 detection limit was 0.2 pCi/g.

CV – comparison value
LPWUS – Lincoln Park Water Use Survey
NA – not available
ND – not detected
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 36. Surface soil data (chemicals) from lawns and gardens in Lincoln Park

Chemical		Samples from locations irrigated with contaminated well water	Samples from locations not irrigated with contaminated well water	CV (ppm)
Arsenic	Range (ppm)	14–50	13–38	0.5 (CREG), 20 (c-EMEG, child)
	Frequency of Detection	26/26	47/47	
	Average (ppm)	**36***	**28***	
Beryllium	Range (ppm)	0.5–1.1	0.6–1.7	100 (c-EMEG, child)
	Frequency of Detection	25/26	47/47	
	Average (ppm)	0.7	0.8	
Cadmium	Range (ppm)	0.6–1.9	0.5–5	10 (c-EMEG, child)
	Frequency of Detection	23/26	45/47	
	Average (ppm)	1.2	1.5**	
Lead	Range (ppm)	17–270[†]		400 (SSL)
	Frequency of Detection	73/73[†]		
	Average (ppm)	122	121	
Manganese	Range (ppm)	290–640	320–580	3,000 (RMEG , child)
	Frequency of Detection	26/26	47/47	
	Average (ppm)	430	421**	
Molybdenum	Range (ppm)	*Data not available*[§]	*Data not available*[§]	300 (RMEG , child)
	Frequency of Detection	*Data not available*[§]	*Data not available*[§]	
	Average (ppm)	1.7*	0.5*	
Selenium	Range (ppm)	18	5–44	300 (c-EMEG, child)
	Frequency of Detection	1/26	6/47	
	Average (ppm)	3.1	3.8	
Uranium	Range (ppm)	*Data not available*[§]	*Data not available*[§]	100 (i-EMEG, child for highly soluble salts)
	Frequency of Detection	*Data not available*[§]	*Data not available*[§]	
	Average (ppm)	2.3*	1.6*	

Source: Weston 1998

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.

*The concentrations were statistically higher in irrigated soil samples.
**The calculated averages for cadmium and manganese differ slightly from the reported mean concentrations in Table 3-3.
[†] The raw data for lead are not presented by whether the samples were taken from locations irrigated with contaminated well water. However, Table 3-3 presents the mean concentrations by manner of irrigation.
[§] The raw data for molybdenum and uranium are not presented in the report. Therefore, the range and frequency of detection could not be determined. Table 3-3 presents the mean concentrations.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Table 37. Surface soil data (radionuclides) from lawns and gardens in Lincoln Park

Radionuclide		Samples from locations irrigated with contaminated well water	Samples from locations not irrigated with contaminated well water	CV (pCi/g)
Lead-210	Range (pCi/g)	0.8–3.0	0.7–4.2	NA
	Frequency of Detection	11/11	47/47	
	Average (pCi/g)	2.2	2.1*	
Radium-226	Range (pCi/g)	1.3–1.7	1.1–2.2	5 (UMTRCA, surface)
	Frequency of Detection	11/11	47/47	
	Average (pCi/g)	1.4	1.5	
Thorium-230	Range (pCi/g)	1.1–2.2	1.0–4.2	NA
	Frequency of Detection	11/11	47/47	
	Average (pCi/g)	1.6*	1.7	
Uranium, natural	Range (pCi/g)	0.871–3.417	0.6566–2.077	NA
	Frequency of Detection	26/26	47/47	
	Average (pCi/g)	1.514	1.05	
Uranium-234	Range (pCi/g)	0.436–1.709	0.328–1.039	NA
	Frequency of Detection	26/26	47/47	
	Average (pCi/g)	0.755	0.525	
Uranium-238	Range (pCi/g)	0.436–1.709	0.328–1.039	NA
	Frequency of Detection	26/26	47/47	
	Average (pCi/g)	0.755	0.525	

Source: Weston 1998

The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.

*The calculated averages for lead-210 and thorium-230 differ slightly from the reported mean concentrations in Table 3-3.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 38. Sediment sampling data (chemicals) from Sand Creek

Chemical	Location Concentration (ppm)						CV (ppm)
	SD01	SD02*	SD04			SD05	
			1	2	3		
Arsenic	NA	13.7	13	NA	17	<5	20 (c-EMEG, child)
Cadmium	NA	3.9	7.2	NA	7.6	1.5	10 (c-EMEG, child)
Cobalt	NA	11.3	43	NA	21	10	500 (i-EMEG, child)
Copper	19	52.3	46	NA	38	19	500 (i-EMEG, child)
Lead	27	106	93	NA	130	22	400 (SSL)
Molybdenum	4.4	2.6	8	NA	7.9	9.4	300 (RMEG , child)
Nickel	NA	17	63	NA	28	18	1,000 (RMEG, child)
Zinc	NA	343	540	NA	580	106	20,000 (c-EMEG, child)

Source: GeoTrans 1986

SD01 – mouth near the Arkansas River
SD02 – near spring where flow begins (reflects migration of contaminants in the groundwater)
SD04 – below the SCS Dam in
  (1) an abandoned stock watering pond (formed by diversion of runoff water into a depression adjacent to Sand Creek)
  (2) in drainage (reflects historical picture of uncontrolled emissions)
  (3) in drainage above #2 (reflects historical picture of uncontrolled emissions)
SD05 – above the SCS Dam adjacent to the west property edge

Bolded text indicates that the concentration exceeded the comparison value for that chemical.
Samples were collected July 10–20, 1985.

*Values are the mean of three field replicates.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Table 39. Sediment sampling data (radionuclides) from Sand Creek

Radionuclide	Location Average (pCi/g)						CV
	SD01	SD02	SD04			SD05	
			1	2	3		
Gross Alpha	22±3	47±9	240±40	74±9	39±7	22±5	NA
Gross Beta	29±6	43±8	90±20	34±7	32±7	32±6	NA
Radium-226	1.21±0.06	1.7±1	**12.8±0.6**	3.5±0.2	3.4±0.2	2.3±1	5 (UMTRCA, surface)
Throium-230	4.6±0.3	34±2	82±4	32±2	15.5±0.8	5.2±0.3	NA
Total Uranium	2.4	4.3	11.7	3.4	3.4	3.9	NA

Source: GeoTrans 1986

SD01 – mouth near the Arkansas River
SD02 – near spring where flow begins (reflects migration of contaminants in the groundwater)
SD04 – below the SCS Dam in
  (1) an abandoned stock watering pond (formed by diversion of runoff water into a depression adjacent to Sand Creek)
  (2) in drainage (reflects historical picture of uncontrolled emissions)
  (3) in drainage above #2 (reflects historical picture of uncontrolled emissions)
SD05 – above the SCS Dam adjacent to the west property edge

Bolded text indicates that the concentration exceeded the comparison value for that radionuclide.
Samples were collected July 10–20, 1985.

CV – comparison value
NA – not available
pCi/g – picocuries per gram
UMTRCA – 1978 Uranium Mill Tailings Radiation Control Act

Table 40. Chemical sampling for the Sand Creek Cleanup Project

Chemical	Frequency of Detection	Minimum (ppm)	Average (ppm)	Maximum (ppm)	CV (ppm)
Arsenic	7/7	2.7	3.9	6.9	20 (c-EMEG, child)
Barium	7/7	69	106	160	10,000 (c-EMEG, child)
Beryllium	7/7	0.2	0.3	0.6	100 (c-EMEG, child)
Chromium	7/7	7.4	9.5	12.8	200 (RMEG, child for hexavalent chromium)
Lead	7/7	17	35	75	400 (SSL)
Manganese	7/7	258	343	502	3,000 (RMEG , child)
Molybdenum	7/7	2.1	2.8	3.5	300 (RMEG , child)
Nickel	7/7	8	10.9	16	1,000 (RMEG , child)
Selenium	0/7	ND*	ND*	ND*	300 (c-EMEG, child)
Vanadium	7/7	16.1	20.3	26.1	200 (i-EMEG, child)

Source: Cotter 2000

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Samples were collected in April and May 1998.

*The selenium detection limit was 5 ppm.

c-EMEG – chronic environmental media evaluation guide
CREG – cancer risk evaluation guide
CV – comparison value
i-EMEG – intermediate environmental media evaluation guide
ND – not detected
ppm – parts per million
RMEG – reference dose media evaluation guide
SSL – EPA’s soil screening level for residential areas

Table 41. Surface water sampling data (chemicals) from Sand Creek

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	0/2	ND	ND	ND	--	10 (c-EMEG, child)	1988
Ammonia	N	2/35	0.5	0.43*	0.8	10-Nov-88	30 (LTHA)	1988–1994
Ammonium	T	0/3	ND	ND	ND	--	NA	1995
Chloride	N/T**	92/92	3	8	14	13-May-04	250 (Secondary MCL)	1986–2007
Iron	D	21/55	0.03	0.04	0.26	07-Nov-02	26 (RBC)	1986–1988, 1995–2007
Manganese	D	36/55	0.0084	0.04	**1.3**[†]	19-Nov-01	0.5 (RMEG, child)	1986–1988, 1995–2007
Molybdenum	D	98/104	0.005	0.02	**0.051**[†]	01-Dec-87	0.035 (SS); 0.05 (RMEG, child)	1986–2007
Nitrate	N/T**	75/87	0.5	1.1	4.7	03-May-06	10 (MCL)	1988–2007
Selenium	D	0/8	ND	ND	ND	--	0.05 (c-EMEG, child)	1986–1988
Sulfate	N/T**	94/94	12	65	**310**[†]	11-Oct-96	250 (Secondary MCL)	1986–2007
Total Dissolved Solids	N/T**	99/99	10.7	369	**1,372**[‡]	22-Aug-91	500 (Secondary MCL)	1986–2007
Uranium	D	101/101	0.006	0.012	0.0267	01-Aug-95	0.03 (MCL)	1986–2007
	S	8/48	0.000098	0.001	0.0031	10-Jan-00		1995–2007

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
* The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated "N" and post-1995 data were designated "T".
[†] Only the maximum concentration was above the CV.
[‡] This appears to be an outlier. The next highest concentration is 460 mg/L. Only the maximum concentration was above the CV.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
NA – not available
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 42. Surface water sampling data (radionuclides) from Sand Creek

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Date of Maximum	CV (pCi/L)	Years Sampled
Lead-210	D	40/49	-0.2	0.39	3.7	06-Aug-07	NA	1995–2007
	S	40/49	-0.1	0.40	4.6	06-Aug-07		1995–2007
Polonium-210	D	41/49	-0.1	0.15	0.6	28-Nov-06	NA	1995–2007
	S	40/49	0	0.13	1.6	09-Nov-99		1995–2007
Radium-226	D	45/49	0	0.12	0.6	03-May-06	5 (MCL radium-226/228)	1995–2007
	S	42/47	0	0.06	0.4	09-Nov-99, 28-Nov-06		1995–2007
Thorium-230	D	44/49	-0.1	0.13	0.8	28-Nov-06	NA	1995–2007
	S	41/46	0	0.16	0.9	06-Aug-07		1995–2007

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended

Table 43. Surface water sampling data (chemicals) from the DeWeese Dye Ditch

Chemical	Type	Frequency of Detection	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Date of Maximum	CV (mg/L)	Years Sampled
Aluminum	D	1/4	0.02	0.06*	0.02	14-Jun-95	10 (c-EMEG, child)	1981, 1995
Ammonia	N	0/2	ND	ND	ND	--	30 (LTHA)	1989, 1995
Chloride	N/T**	95/102	2	7	18	08-May-01	250 (Secondary MCL)	1981–1989, 1995–2007
Iron	D	22/50	0.029	0.9	**43**[†]	09-Jun-99	26 (RBC)	1981–1987, 1995–2007
Manganese	D	28/50	0.004	0.05	**1.9**[‡]	09-Jun-99	0.5 (RMEG, child)	1981–1987, 1995–2007
Molybdenum	D	10/120	0.001	0.013[§]	0.013	06-Aug-03	0.035 (SS); 0.05 (RMEG, child)	1981–2007
Nitrate	N/T**	7/26	0.1	0.3	0.8	10-May-00, 02-Aug-06	10 (MCL)	1989, 1995–2007
Selenium	D	4/76	0.005	0.003[††]	0.011	22-Jun-87, 25-Apr-88	0.05 (c-EMEG, child)	1981–1988, 1995
Sulfate	N/T**	102/102	6	31	95	28-Apr-82	250 (Secondary MCL)	1981–1989, 1995–2007
Total Dissolved Solids	N/T**	119/119	12.9	231	**1,647**[‡‡]	10-Sep-90	500 (Secondary MCL)	1981–2007
Uranium	D	86/116	0.0004	0.01	**0.11**[§§]	05-May-83	0.03 (MCL)	1981–2007
	S	0/8	ND	ND	ND	--		1996–1999

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.

* The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.
** For chloride, nitrate, sulfate, and total dissolved solids, pre-1995 data were designated “N” and post-1995 data were designated “T”.
[†] This appears to be an outlier. The next highest concentration is 0.24 mg/L from the same location in 2003. Only the maximum concentration was above the CV.
[‡] Only the maximum concentration was above the CV.
[§] The calculated average is the same as the maximum detected concentration due to including ½ the detection limit in the calculation.

[††] The calculated average is the lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
[‡‡] This appears to be an outlier. The next highest concentration is 870 mg/L. Only three of the 119 samples were above the CV.
[§§] Only three of the samples were above the CV.

c-EMEG – chronic environmental media evaluation guide
CV – comparison value
D – dissolved
LTHA – lifetime health advisory for drinking water
MCL – maximum contaminant level
mg/L – milligrams per liter
N – not defined in the CDPHE database
ND – not detected
RBC – risk based concentration for drinking water
RMEG – reference dose media evaluation guide
S – suspended
SS – Colorado state groundwater standard
T – total

Table 44. Surface water sampling data (radionuclides) from the DeWeese Dye Ditch

Radionuclide	Type	Frequency of Detection	Minimum (pCi/L)	Average (pCi/L)	Maximum (pCi/L)	Date of Maximum	CV (pCi/L)	Years Sampled
Lead-210	D	8/8	0	0.3	1.2	09-May-96	NA	1996–1999
	S	8/8	0	0.09	0.2	12-May-97		1996–1999
Polonium-210	D	8/8	0	0.1	0.2	09-Jun-99, 02-Sep-99	NA	1996–1999
	S	8/8	0	0.05	0.2	09-Jun-99		1996–1999
Radium-226	D	8/8	0	0.04	0.1	09-May-96, 16-Jul-96, 02-Sep-99	5 (MCL radium-226/228)	1996–1999
	S	7/7	0	0.01	0.1	02-Sep-99		1996–1999
Thorium-230	D	8/8	0	0.025	0.2	12-May-97	NA	1996–1999
	S	7/7	0	0.07	0.2	09-Sep-98		1996–1999

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
pCi/L – picocuries per liter
S – suspended

Table 45. Surface water sampling data (chemicals) from the Arkansas River

Chemical	Type		Upstream of Sand Creek at 1st Street (907)	Downstream of Sand Creek at Mackenzie Ave (904)	CV (mg/L)
Chloride	T	Range (mg/L)	3–60	3–14	250 (Secondary MCL)
		Frequency of Detection	127/130	127/130	
		Average (mg/L)	8	8	
Molybdenum	D	Range (mg/L)	0.0029–**0.046**	0.003–0.029	0.035 (SS); 0.05 (RMEG, child)
		Frequency of Detection	32/142	46/142	
		Average (mg/L)	0.025	0.025	
Molybdenum	S	Range (mg/L)	0.0019–0.022	0.0017–0.016	0.035 (SS); 0.05 (RMEG, child)
		Frequency of Detection	8/135	6/135	
		Average (mg/L)	0.025	0.025	
Molybdenum	T	Range (mg/L)	0.006	0.005	0.035 (SS); 0.05 (RMEG, child)
		Frequency of Detection	1/7	1/7	
		Average (mg/L)	0.003*	0.003*	
Sulfate	T	Range (mg/L)	10–1,300**	5–4,200**	250 (Secondary MCL)
		Frequency of Detection	130/130	130/130	
		Average (mg/L)	41	84	
Total Dissolved Solids	T	Range (mg/L)	45–**2,880**†	62–337	500 (Secondary MCL)
		Frequency of Detection	130/130	130/130	
		Average (mg/L)	172	192	
Uranium	D	Range (mg/L)	0.0003– 0.0135	0.0002–0.0155	0.03 (MCL)
		Frequency of Detection	129/130	130/130	
		Average (mg/L)	0.004	0.005	
Uranium	S	Range (mg/L)	0.0002– 0.014	0.0002–0.0043	0.03 (MCL)
		Frequency of Detection	16/121	14/121	
		Average (mg/L)	0.001	0.001	
Uranium	T	Range (mg/L)	0.0033–0.0056	0.0029–0.0054	0.03 (MCL)
		Frequency of Detection	7/7	7/7	
		Average (mg/L)	0.004	0.004	

Source: CDPHE 2007b

Bolded text indicates that the average and/or maximum concentration exceeded the comparison value for that chemical.
Averages were calculated using ½ the reporting detection limit for non-detects.
All samples were collected between 1995 and 2007. The "T" samples for uranium were only collected in 1995.
* The calculated average is lower than the minimum detected concentration due to including ½ the detection limit in the calculation.
** This appears to be an outlier. The next highest concentration is 200 mg/L. Only the maximum concentration was above the CV.
† This appears to be an outlier. The next highest concentration is 405 mg/L. Only the maximum concentration was above the CV.

CV – comparison value
D – dissolved
MCL – maximum contaminant level

mg/L – milligrams per liter
RMEG – reference dose media evaluation guide
S – suspended

SS – Colorado state groundwater standard
T – total

Table 46. Surface water sampling data (radionuclides) from the Arkansas River

Radionuclide	Type		Upstream of Sand Creek at 1st Street (907)	Downstream of Sand Creek at Mackenzie Ave (904)	CV (pCi/L)
Lead-210	D	Range (pCi/L)	ND	3.7	NA
		Frequency of Detection	0/1	1/1	
		Average (pCi/L)	ND	3.7	
Lead-210	S	Range (pCi/L)	ND	0	NA
		Frequency of Detection	0/1	1/2	
		Average (pCi/L)	ND	0.25*	
Polonium-210	D	Range (pCi/L)	ND	ND	NA
		Frequency of Detection	0/1	0/1	
		Average (pCi/L)	ND	ND	
Polonium-210	S	Range (pCi/L)	ND	0.26–3.3	NA
		Frequency of Detection	0/1	2/2	
		Average (pCi/L)	ND	1.8	
Radium-226	D	Range (pCi/L)	0–0.6	0–0.4	5 (MCL radium-226/228)
		Frequency of Detection	119/128	116/127	
		Average (pCi/L)	0.13	0.07	
Radium-226	S	Range (pCi/L)	0–0.8	0–2.3	5 (MCL radium-226/228)
		Frequency of Detection	114/120	112/119	
		Average (pCi/L)	0.08	0.09	
Radium-226	T	Range (pCi/L)	0.1–0.7	0.1–0.7	5 (MCL radium-226/228)
		Frequency of Detection	7/7	7/7	
		Average (pCi/L)	0.3	0.3	
Thorium-230	D	Range (pCi/L)	-0.1–1	-0.1–1.2	NA
		Frequency of Detection	121/127	116/127	
		Average (pCi/L)	0.1	0.1	
Thorium-230	S	Range (pCi/L)	0–2.5	0–2.4	NA
		Frequency of Detection	115/120	113/119	
		Average (pCi/L)	0.2	0.2	
Thorium-230	T	Range (pCi/L)	0.1–0.7	0–0.6	NA
		Frequency of Detection	7/7	7/7	
		Average (pCi/L)	0.3	0.2	

Source: CDPHE 2007b

Averages were calculated using ½ the reporting detection limit for non-detects.
Negative and zero result values were included in the summary statistics.
Radium-226 and thorium-230 "D" and "S" samples were collected between 1995 and 2007. The radium-226 and thorium-230 "T" samples were only collected in 1995. Lead-210 and polonium-210 were sampled upstream (907) in 2005 ("D" and "S") and downstream (904) in 2005 ("D") and 2006 ("D" and "S").

* The calculated average is higher than the detected concentration due to including ½ the detection limit in the calculation.

CV – comparison value
D – dissolved
MCL – maximum contaminant level
NA – not available
ND – not detected
pCi/L – picocuries per liter
S – suspended
T – total

Table 47. Sampling data (chemicals) for local and supermarket foods

Chemical	Food Type	Average (mg/kg)	
		Local	Supermarket
Barium*	Vegetables	4.75	NA
Cadmium*	Vegetables	0.215	NA
Chromium*	Vegetables	0.095	NA
Manganese*	Vegetables	11.25	NA
Molybdenum	Chicken	0.19	0.72
	Fruits	0.079	0.017
	Vegetables	0.667	0.023
Selenium	Chicken	0.31	0.18
	Fruits	0.024	0.017
	Vegetables	0.061	0.020
Strontium*	Vegetables	22	NA
Uranium	Chicken	0.061	0.001
	Fruits	0.0056	0.0013
	Vegetables	0.0043	0.0013
Vanadium*	Vegetables	0.105	NA
Zinc*	Vegetables	7.5	NA

Source: Weston 1996

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.
Vegetables were also tested for arsenic, beryllium, cobalt, lead, mercury, nickel, and silver, but none of these chemicals were detected.

*Chicken and fruits were not analyzed for these chemicals.

NA – not available
mg/kg – milligrams per kilogram

Table 48. Sampling data (radionuclides) for local and supermarket foods

Radionuclide	Food Type	Average (pCi/kg)	
		Local	Supermarket
Lead-210	Chicken	1.26	1.70
	Fruits	1.48	1.18
	Vegetables	0.58	0.60
Polonium-210	Chicken	3.79	21.75
	Fruits	2.26	1.30
	Vegetables	1.13	1.56
Radium-226	Chicken	0.64	2.60
	Fruits	1.34	0.05
	Vegetables	1.37	0.07
Thorium-228	Chicken	0.39	ND
	Fruits	0.33	ND
	Vegetables	0.41	1.42
Thorium-230	Chicken	1.01	0.53
	Fruits	1.85	ND
	Vegetables	0.27	0.29
Uranium-234	Chicken	1.10	1.05
	Fruits	1.53	0.34
	Vegetables	0.55	0.76
Uranium-235	Chicken	ND	0.36
	Fruits	0.13	0.13
	Vegetables	0.13	0.14
Uranium-238	Chicken	1.59	0.53
	Fruits	1.41	0.23
	Vegetables	0.44	0.25

Source: Weston 1996

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.

ND – not detected
pCi/kg – picocuries per kilogram

Table 49. Sampling data (chemicals) for local produce irrigated with contaminated well water

Chemical		Fruits	Vegetables
Arsenic	Frequency of Detection	2/16	14/43
	Average (mg/kg)	0.051	0.077
	Maximum (mg/kg)	0.2	0.4
Barium	Frequency of Detection	7/16	33/43
	Average (mg/kg)	0.44	1.6
	Maximum (mg/kg)	0.9	15
Cadmium	Frequency of Detection	2/16	18/43
	Average (mg/kg)	0.041	0.034
	Maximum (mg/kg)	0.23	0.14
Chromium	Frequency of Detection	12/16	39/43
	Average (mg/kg)	0.052	0.056
	Maximum (mg/kg)	0.1	0.19
Cobalt	Frequency of Detection	0/16	6/43
	Average (mg/kg)	ND	0.02
	Maximum (mg/kg)	ND	0.07
Lead	Frequency of Detection	3/16	26/43
	Average (mg/kg)	0.13	0.2
	Maximum (mg/kg)	1.2	1.9
Manganese	Frequency of Detection	16/16	43/43
	Average (mg/kg)	0.87	2.4
	Maximum (mg/kg)	1.8	11
Molybdenum	Frequency of Detection	6/16	41/43
	Average (mg/kg)	0.11	0.68
	Maximum (mg/kg)	0.3	9.8
Nickel	Frequency of Detection	0/16	2/43
	Average (mg/kg)	ND	0.075
	Maximum (mg/kg)	ND	0.2
Strontium	Frequency of Detection	16/16	43/43
	Average (mg/kg)	1.6	4.9
	Maximum (mg/kg)	8.5	33
Uranium	Frequency of Detection	3/16	14/43
	Average (mg/kg)	0.0074	0.0071
	Maximum (mg/kg)	0.035	0.041
Vanadium	Frequency of Detection	0/16	16/43
	Average (mg/kg)	ND	0.046
	Maximum (mg/kg)	ND	0.21

Chemical		Fruits	Vegetables
Zinc	Frequency of Detection	16/16	43/43
	Average (mg/kg)	1.4	3.1
	Maximum (mg/kg)	4.0	10

Source: Weston 1998

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.

ND – not detected
mg/kg – milligrams per kilogram

Table 50. Sampling data (radionuclides) for local produce irrigated with contaminated well water

Radionuclide		Fruits	Vegetables
Lead-210	Frequency of Detection	3/16	8/43
	Average (pCi/kg)	12	21
	Maximum (pCi/kg)	21	51
Radium-226	Frequency of Detection	1/16	15/43
	Average (pCi/kg)	5.7	6.2
	Maximum (pCi/kg)	18	41
Thorium-230	Frequency of Detection	1/16	8/43
	Average (pCi/kg)	3.9	5.1
	Maximum (pCi/kg)	10	20
Uranium (natural)	Frequency of Detection	3/16	14/43
	Average (pCi/kg)	5.0	4.8
	Maximum (pCi/kg)	23	27

Source: Weston 1998

Averages were calculated using ½ the reporting detection limit for non-detects.
Concentrations are reported on a wet weight basis.
The dates the samples were collected were not specified in the report. It is assumed to be in the 1994–1996 timeframe.
pCi/kg – picocuries per kilogram

Table 51. Characteristics of Cotter Mill's Ambient Air Monitoring Stations

Monitor Code	*Monitor Location*	*Years of Operation*	*Monitor Type*	*Area Description*
AS-202	East Boundary	1979 – present	Perimeter	Eastern perimeter of Cotter Mill facility
AS-203	South Boundary	1979 – present	Perimeter	Southern perimeter of Cotter Mill facility
AS-204	West Boundary	1979 – present	Perimeter	Western perimeter of Cotter Mill facility
AS-206	North Boundary	1981 – present	Perimeter	Northern perimeter of Cotter Mill facility
AS-209	Mill entrance road	1994 – present	Perimeter	Entrance road to Cotter Mill
AS-210	Shadow Hills Estates	1997 – present	Off-site	Near Shadow Hills Golf Club
AS-212	Nearest resident	1999 – present	Off-site	Residential
LP-1/LP-2	Lincoln Park	1980 – present	Off-site	Residential
CC-1/CC-2	Cañon City	1979 – present	Off-site	Residential
OV-3	Oro Verde	1981 – present	Off-site	Remote (1 mile west of AS-204)

Notes: Both the Lincoln Park and Cañon City monitoring stations moved locations in the 1991-1992 time frame. The original station in Lincoln Park (LP-1) operated from 1980 to 1992, and the new station (LP-2) operated from 1991 to the present. The original station in Cañon City (CC-1) operated from 1979 to 1992, and the new station (CC-2) operated from 1991 to the present.

Table 52. Average Annual ^{nat}U Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	6.19E-15	1.50E-15	2.26E-15	--	--	--	--	--	1.00E-15	--
1980	3.71E-15	1.55E-15	2.82E-15	--	--	--	--	8.36E-16	1.40E-15	--
1981	4.07E-15	1.54E-15	5.28E-15	8.30E-15	--	--	--	1.03E-15	1.02E-15	1.37E-15
1982	2.31E-15	1.26E-15	2.48E-14	2.79E-15	--	--	--	5.28E-16	4.79E-16	5.96E-16
1983	1.26E-15	1.43E-15	1.32E-15	1.63E-15	--	--	--	4.77E-16	6.86E-16	5.03E-16
1984	5.50E-16	7.64E-16	8.36E-16	1.52E-15	--	--	--	2.78E-16	3.27E-16	4.01E-16
1985	1.42E-15	1.22E-15	8.96E-16	1.92E-15	--	--	--	4.56E-16	5.77E-16	6.66E-16
1986	6.71E-16	6.56E-16	4.05E-16	9.36E-16	--	--	--	2.95E-16	2.93E-16	4.84E-16
1987	8.08E-16	1.03E-15	1.09E-15	1.05E-15	--	--	--	4.66E-16	5.12E-16	4.60E-16
1988	6.73E-16	6.96E-16	9.03E-16	5.51E-16	--	--	--	1.85E-16	1.95E-16	1.89E-16
1989	9.58E-17	9.95E-17	2.86E-16	3.62E-17	--	--	--	8.37E-17	9.38E-17	6.38E-17
1990	5.59E-17	3.14E-17	1.06E-16	3.10E-17	--	--	--	6.18E-17	1.26E-16	9.09E-17
1991	1.12E-16	9.18E-17	2.65E-16	1.24E-16	--	--	--	1.70E-16	1.73E-16	2.60E-16
1992	6.55E-17	7.84E-17	1.12E-16	6.48E-17	--	--	--	9.71E-17	9.40E-17	8.23E-17
1993	7.13E-17	9.08E-17	1.61E-16	6.30E-17	--	--	--	8.26E-17	1.20E-16	2.55E-16
1994	1.25E-16	4.68E-17	1.00E-16	3.68E-17	1.55E-16	--	--	9.68E-17	8.12E-17	2.54E-16
1995	2.99E-16	5.86E-17	1.53E-16	5.23E-17	2.11E-16	--	--	9.34E-17	1.26E-16	4.83E-16
1996	2.25E-16	1.43E-16	2.26E-16	8.62E-17	2.44E-16	7.89E-17	--	9.73E-17	1.25E-16	5.93E-17
1997	1.23E-16	1.18E-16	2.20E-16	1.19E-16	1.51E-16	1.75E-16	--	1.27E-16	2.00E-16	9.48E-17
1998	1.32E-16	1.02E-16	3.29E-16	1.06E-16	2.27E-15	2.32E-16	--	8.13E-17	7.50E-17	2.43E-16
1999	4.06E-16	1.49E-16	2.91E-16	3.23E-16	1.46E-15	2.82E-16	4.59E-16	1.16E-16	9.41E-17	7.97E-17
2000	4.33E-16	2.04E-16	2.61E-16	1.63E-16	1.49E-15	1.89E-16	4.82E-16	5.39E-17	5.33E-17	5.39E-17
2001	4.96E-16	6.19E-16	4.96E-16	5.29E-16	1.32E-15	2.06E-16	2.88E-16	4.96E-17	3.80E-17	5.18E-17
2002	6.50E-16	4.93E-16	6.21E-16	3.24E-16	9.91E-16	3.69E-16	4.05E-16	2.46E-16	1.59E-16	2.05E-16
2003	3.55E-16	2.19E-16	2.55E-16	2.01E-16	4.91E-16	2.21E-16	2.20E-16	2.11E-16	2.07E-16	2.62E-16
2004	2.51E-16	1.95E-16	2.40E-16	1.99E-16	6.27E-16	1.40E-16	2.30E-16	9.69E-17	9.68E-17	8.61E-17
2005	4.54E-16	2.77E-16	2.87E-16	1.58E-16	3.97E-15	4.85E-16	5.25E-16	1.68E-16	1.29E-16	1.23E-16
2006	5.14E-16	2.68E-16	3.24E-16	2.12E-16	1.72E-15	6.62E-16	3.40E-16	2.20E-16	1.75E-16	1.87E-16
2007	3.56E-16	1.51E-16	2.03E-16	1.39E-16	3.13E-16	1.46E-16	1.33E-16	1.41E-16	1.43E-16	1.27E-16
2008	4.36E-16	8.61E-17	1.72E-16	8.44E-17	2.17E-16	9.77E-17	9.78E-17	9.02E-17	8.97E-17	6.43E-17

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2.
For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2.

Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating.

Table 53. Average Annual ^{230}Th Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	2.33E-15	1.05E-15	8.08E-15	--	--	--	--	--	3.07E-16	--
1980	2.50E-16	8.76E-16	2.81E-16	--	--	--	--	8.17E-17	1.30E-16	--
1981	2.60E-15	3.50E-15	3.00E-14	6.93E-15	--	--	--	1.42E-16	8.17E-17	3.92E-16
1982	2.12E-14	1.94E-14	8.95E-14	1.26E-14	--	--	--	7.49E-16	9.18E-16	3.15E-15
1983	5.86E-15	9.79E-15	5.64E-15	8.26E-15	--	--	--	3.74E-16	3.12E-16	1.07E-15
1984	1.64E-15	2.98E-15	3.82E-15	6.35E-15	--	--	--	2.69E-16	2.00E-16	2.89E-16
1985	1.84E-15	2.15E-15	4.86E-15	3.73E-15	--	--	--	2.60E-16	2.64E-16	2.84E-16
1986	3.70E-15	5.55E-15	3.13E-15	4.68E-15	--	--	--	3.70E-16	3.08E-16	2.41E-16
1987	1.21E-15	1.29E-15	2.28E-15	1.08E-15	--	--	--	2.06E-16	1.77E-16	9.90E-17
1988	2.58E-15	3.51E-15	5.85E-15	2.05E-15	--	--	--	1.41E-16	1.72E-16	1.70E-16
1989	6.33E-16	3.85E-16	9.17E-16	1.08E-16	--	--	--	8.93E-17	9.03E-17	9.24E-17
1990	7.63E-16	4.00E-16	5.86E-16	1.09E-16	--	--	--	7.40E-17	7.04E-17	7.20E-17
1991	7.25E-16	4.59E-16	8.75E-16	2.83E-16	--	--	--	1.91E-16	1.25E-16	1.33E-16
1992	4.57E-16	2.20E-16	4.71E-16	9.46E-17	--	--	--	6.58E-17	5.98E-17	9.56E-17
1993	4.45E-16	3.03E-16	6.42E-16	9.32E-17	--	--	--	1.06E-16	9.17E-17	2.33E-16
1994	1.18E-15	2.96E-16	1.08E-15	1.24E-16	9.20E-16	--	--	1.54E-16	1.16E-16	2.83E-16
1995	1.65E-15	5.33E-16	1.24E-15	1.18E-16	8.88E-16	--	--	9.80E-17	1.12E-16	3.30E-16
1996	2.21E-15	2.95E-16	8.13E-16	8.85E-17	7.67E-16	2.33E-16	--	7.11E-17	5.08E-17	6.39E-17
1997	7.64E-16	1.31E-16	6.17E-16	6.49E-17	1.99E-15	3.82E-16	--	8.37E-17	7.86E-17	3.24E-17
1998	2.88E-15	2.02E-16	9.34E-16	1.15E-16	2.17E-15	3.32E-16	--	7.70E-17	7.99E-17	7.82E-17
1999	3.76E-15	3.24E-16	1.09E-15	1.84E-16	2.19E-15	4.15E-16	3.02E-16	7.37E-17	9.51E-17	1.11E-16
2000	1.22E-15	2.48E-16	1.01E-15	2.02E-16	4.16E-15	4.71E-16	6.69E-16	1.47E-16	1.57E-16	1.27E-16
2001	8.20E-16	5.19E-16	9.67E-16	2.61E-16	4.15E-15	4.04E-16	4.61E-16	1.56E-16	9.95E-17	1.13E-16
2002	5.84E-16	2.76E-16	5.95E-16	2.57E-16	1.25E-15	2.38E-16	3.13E-16	8.15E-17	8.54E-17	8.55E-17
2003	5.19E-16	2.62E-16	4.90E-16	9.73E-17	1.40E-15	4.11E-16	1.77E-16	8.27E-17	8.91E-17	5.30E-17
2004	2.17E-16	8.26E-17	3.87E-16	8.33E-17	6.57E-16	2.26E-16	1.08E-16	5.36E-17	5.62E-17	6.07E-17
2005	3.17E-16	1.97E-16	3.51E-16	2.64E-16	3.41E-15	4.85E-16	4.81E-16	1.04E-16	1.05E-16	1.08E-16
2006	5.17E-16	2.91E-16	4.74E-16	1.77E-16	1.40E-15	4.73E-16	3.27E-16	2.73E-16	2.04E-16	2.85E-16
2007	6.62E-16	1.90E-16	4.32E-16	1.48E-16	1.05E-15	2.77E-16	2.23E-16	1.68E-16	1.57E-16	1.53E-16
2008	7.21E-16	1.87E-16	5.12E-16	1.32E-16	6.21E-16	2.88E-16	2.05E-16	1.11E-16	1.08E-16	1.16E-16

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2. For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2.

Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating; bold cells are concentrations above Cotter Mill's regulatory limit

Table 54. Average Annual ^{232}Th Concentrations 2001-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP #2	CC #2	OV-3
2001	5.78E-17	7.62E-17	6.97E-17	6.37E-17	8.32E-17	4.58E-17	6.67E-17	6.85E-17	8.33E-17	5.68E-17
2002	4.67E-17	3.81E-17	3.09E-17	4.55E-17	4.34E-17	3.17E-17	3.35E-17	5.36E-17	3.51E-17	4.68E-17
2003	4.57E-17	4.14E-17	4.84E-17	2.06E-17	5.72E-17	4.61E-17	3.71E-17	6.21E-17	4.61E-17	3.96E-17
2004	1.39E-17	2.53E-17	2.53E-17	1.40E-17	1.57E-17	1.99E-17	1.65E-17	3.24E-17	2.28E-17	2.39E-17
2005	2.83E-17	2.40E-17	2.86E-17	3.09E-17	3.36E-17	2.53E-17	3.42E-17	3.99E-17	3.57E-17	3.45E-17
2006	4.11E-17	5.18E-17	4.82E-17	4.29E-17	5.54E-17	4.33E-17	4.79E-17	6.25E-17	4.98E-17	3.65E-17
2007	4.07E-17	3.47E-17	4.60E-17	4.14E-17	4.12E-17	3.99E-17	3.51E-17	5.43E-17	4.48E-17	3.92E-17
2008	1.08E-17	1.63E-17	1.15E-17	9.89E-18	1.57E-17	2.30E-17	1.26E-17	3.13E-17	2.25E-17	2.03E-17

Note: Shaded cells are the highest annual averages for the calendar year; “--” indicates that no data are available because the station was not yet operating

Table 55. Average Annual ^{226}Ra Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	1.55E-15	3.75E-16	7.89E-15	--	--	--	--	--	3.07E-16	--
1980	3.61E-15	7.81E-16	1.62E-15	--	--	--	--	2.78E-16	1.58E-15	--
1981	4.19E-15	2.35E-15	2.94E-15	2.96E-15	--	--	--	3.79E-16	4.59E-16	6.30E-16
1982	6.53E-15	6.92E-15	3.81E-15	3.82E-15	--	--	--	6.07E-16	4.02E-16	1.25E-15
1983	2.00E-15	5.08E-15	4.95E-15	2.85E-15	--	--	--	9.42E-17	1.76E-16	5.30E-16
1984	1.11E-15	1.84E-15	3.63E-15	2.20E-15	--	--	--	1.18E-16	1.67E-16	1.87E-16
1985	9.63E-15	1.11E-15	1.78E-15	1.97E-15	--	--	--	1.69E-16	1.88E-16	1.89E-16
1986	1.47E-15	1.98E-15	1.61E-15	2.60E-15	--	--	--	1.43E-16	3.45E-16	2.22E-16
1987	5.91E-16	7.52E-16	1.19E-15	4.74E-16	--	--	--	1.83E-16	1.15E-16	1.89E-16
1988	1.29E-15	2.05E-15	2.53E-15	3.60E-16	--	--	--	1.24E-16	5.09E-17	1.09E-16
1989	2.72E-16	1.81E-16	3.30E-16	4.79E-17	--	--	--	1.02E-16	8.89E-17	7.77E-17
1990	1.75E-16	1.68E-16	1.92E-16	4.36E-17	--	--	--	6.69E-17	8.36E-17	7.82E-17
1991	1.19E-16	1.25E-16	2.68E-16	6.17E-17	--	--	--	6.85E-17	7.16E-17	1.37E-16
1992	8.46E-17	7.30E-17	1.50E-15	3.71E-17	--	--	--	5.10E-17	5.80E-17	1.17E-16
1993	9.11E-17	1.14E-16	2.49E-16	5.99E-17	--	--	--	6.14E-17	6.72E-17	2.20E-16
1994	1.03E-16	7.57E-17	1.69E-16	4.96E-17	1.55E-16	--	--	7.80E-17	8.68E-17	2.64E-16
1995	1.21E-16	1.14E-16	2.07E-16	7.46E-17	2.06E-16	--	--	6.88E-17	1.05E-16	3.99E-16
1996	1.78E-16	1.02E-16	2.08E-16	5.33E-17	2.11E-16	5.82E-17	--	5.22E-17	6.67E-17	3.59E-17
1997	1.29E-16	7.55E-17	2.01E-16	5.66E-17	9.45E-16	1.06E-16	--	5.09E-17	5.40E-17	4.84E-17
1998	2.89E-16	8.22E-17	2.95E-16	9.43E-17	1.34E-15	1.21E-16	--	6.21E-17	6.71E-17	4.24E-17
1999	4.18E-16	1.29E-16	3.81E-16	1.02E-16	1.26E-15	1.46E-16	2.13E-16	8.27E-17	9.21E-17	5.90E-17
2000	3.37E-16	1.53E-16	4.64E-16	1.40E-16	2.38E-15	2.21E-16	4.60E-16	7.41E-17	4.64E-17	5.10E-17
2001	2.15E-16	2.09E-16	4.36E-16	1.38E-16	1.92E-15	1.51E-16	1.99E-16	7.01E-17	6.82E-17	5.16E-17
2002	1.55E-16	1.17E-16	2.34E-16	7.51E-17	3.83E-16	1.05E-16	1.14E-16	8.41E-17	6.07E-17	6.72E-17
2003	1.45E-16	1.10E-16	1.75E-16	8.02E-17	2.96E-16	1.23E-16	9.65E-17	9.70E-17	8.40E-17	8.93E-17
2004	7.81E-17	7.35E-17	1.41E-16	6.14E-17	3.30E-16	9.05E-17	8.14E-17	5.79E-17	6.26E-17	4.95E-17
2005	1.78E-16	1.56E-16	1.75E-16	1.97E-16	2.29E-15	2.49E-16	2.95E-16	1.08E-16	1.22E-16	9.58E-17
2006	4.10E-16	1.40E-16	2.17E-16	1.34E-16	7.52E-16	1.69E-16	1.42E-16	1.20E-16	1.03E-16	1.15E-16
2007	8.67E-16	1.11E-16	2.07E-16	1.00E-16	2.31E-16	1.16E-16	9.11E-17	1.09E-16	9.66E-17	1.11E-16
2008	7.92E-16	7.36E-17	2.00E-16	5.16E-17	1.78E-16	7.33E-17	5.71E-17	6.21E-17	5.91E-17	3.28E-17

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2. For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2. Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating.

Table 56. Average Annual ^{210}Pb Concentrations 1979-2008 (µCi/ml)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	LP-1/2	CC-1/2	OV-3
1979	2.11E-14	1.65E-14	2.08E-14	--	--	--	--	--	2.30E-14	--
1980	1.81E-14	1.69E-14	1.25E-14	--	--	--	--	1.86E-14	1.98E-14	--
1981	2.01E-14	1.72E-14	4.71E-14	2.34E-14	--	--	--	1.57E-14	1.70E-14	2.11E-14
1982	3.87E-14	4.35E-14	9.95E-14	4.07E-14	--	--	--	2.50E-14	3.31E-14	4.05E-14
1983	1.70E-14	1.73E-14	1.82E-14	1.95E-14	--	--	--	1.29E-14	1.79E-14	1.44E-14
1984	1.44E-14	1.46E-14	1.60E-14	1.43E-14	--	--	--	1.26E-14	1.15E-14	1.48E-14
1985	9.12E-15	8.12E-15	8.80E-15	9.30E-15	--	--	--	9.97E-15	1.14E-14	9.90E-15
1986	1.26E-14	1.19E-14	1.12E-14	1.22E-14	--	--	--	1.07E-14	1.22E-14	8.81E-15
1987	1.95E-14	1.92E-14	2.22E-14	2.35E-14	--	--	--	2.17E-14	2.01E-14	1.43E-14
1988	2.15E-14	1.94E-14	2.10E-14	1.93E-14	--	--	--	2.04E-14	2.11E-14	1.76E-14
1989	2.28E-14	2.30E-14	1.98E-14	2.34E-14	--	--	--	2.43E-14	2.35E-14	2.40E-14
1990	2.05E-14	2.10E-14	2.07E-14	2.07E-14	--	--	--	2.24E-14	2.00E-14	1.95E-14
1991	2.40E-14	2.15E-14	2.15E-14	2.13E-14	--	--	--	2.23E-14	2.15E-14	1.07E-14
1992	2.16E-14	2.00E-14	2.20E-14	2.19E-14	--	--	--	1.99E-14	1.61E-14	2.20E-14
1993	2.38E-14	2.35E-14	2.35E-14	2.49E-14	--	--	--	2.22E-14	2.13E-14	2.10E-14
1994	2.21E-14	2.07E-14	2.10E-14	2.24E-14	2.18E-14	--	--	2.33E-14	2.38E-14	2.06E-14
1995	2.07E-14	2.07E-14	2.02E-14	2.01E-14	2.11E-14	--	--	1.97E-14	2.03E-14	1.74E-14
1996	2.02E-14	2.01E-14	2.16E-14	2.21E-14	2.11E-14	--	--	2.08E-14	1.96E-14	1.98E-14
1997	2.21E-14	2.07E-14	2.12E-14	2.20E-14	2.26E-14	2.05E-14	--	2.13E-14	2.00E-14	1.98E-14
1998	2.01E-14	2.07E-14	1.98E-14	2.11E-14	2.01E-14	1.93E-14	--	2.01E-14	2.01E-14	1.93E-14
1999	2.14E-14	1.94E-14	1.83E-14	1.84E-14	2.03E-14	1.94E-14	2.03E-14	2.03E-14	1.94E-14	1.78E-14
2000	2.07E-14	2.05E-14	2.01E-14	2.23E-14	2.37E-14	2.00E-14	2.07E-14	2.16E-14	2.08E-14	2.03E-14
2001	3.10E-14	3.04E-14	2.91E-14	3.11E-14	3.06E-14	2.94E-14	3.12E-14	3.06E-14	2.96E-14	2.79E-14
2002	2.36E-14	2.20E-14	2.28E-14	2.25E-14	2.30E-14	2.37E-14	2.40E-14	2.46E-14	2.33E-14	2.17E-14
2003	2.19E-14	2.11E-14	2.16E-14	2.06E-14	2.28E-14	2.12E-14	2.18E-14	2.11E-14	1.94E-14	2.27E-14
2004	1.72E-14	1.64E-14	1.58E-14	1.60E-14	1.66E-14	1.45E-14	1.79E-14	1.56E-14	1.54E-14	1.59E-14
2005	2.45E-14	2.74E-14	2.82E-14	2.54E-14	3.11E-14	2.91E-14	2.92E-14	3.11E-14	3.15E-14	2.94E-14
2006	2.11E-14	2.31E-14	2.47E-14	2.31E-14	2.09E-14	2.08E-14	1.89E-14	1.98E-14	1.89E-14	2.12E-14
2007	1.88E-14	1.64E-14	1.79E-14	1.82E-14	1.54E-14	1.58E-14	1.49E-14	1.66E-14	1.61E-14	1.72E-14
2008	1.65E-14	1.48E-14	1.64E-14	1.93E-14	1.66E-14	1.73E-14	1.57E-14	1.67E-14	1.61E-14	1.61E-14

Notes: For station LP-1/2, data from 1980-1992 were collected at LP-1, and data from 1993-2008 were collected at LP-2. For station CC-1/2, data from 1979-1992 were collected at CC-1, and data from 1993-2008 were collected at CC-2.

Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating.

Table 57. ^{220}Rn/^{222}Rn Concentrations 2002-2008 (pCi/m^3)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	CC-1	LP-1	OV-3
2002	543	975	1125	693	1475	700	698	875	673	625
2003	700	825	775	900	625	675	700	375	800	567
2004	1500	850	1025	950	1100	850	925	825	875	825
2005	925	1025	850	700	1025	675	775	700	900	800
2006	1250	1275	1275	1450	1400	1125	1275	1075	1375	1200
2007	1000	1100	1175	1100	1250	975	825	925	1175	975
2008	850	900	925	950	1075	950	850	800	925	825

Notes: Data are presented for only those years when measurements quantified combined levels of the two isotopes.
Shaded cells are the highest annual averages for the calendar year.

Table 58. Environmental TLD Measurements, 1979-2008 (µR/hr)

Year	Perimeter Monitoring Stations					Off-Site Monitoring Stations				
	AS-202	AS-203	AS-204	AS-206	AS-209	AS-210	AS-212	CC-1	LP-1	OV-3
1979	14.0	12.6	12.7	--	--	--	--	11.8	11.4	--
1980	13.4	11.7	12.9	--	--	--	--	10.4	11.4	--
1981	14.3	12.8	12.7	--	--	--	--	10.6	12.3	12.3
1982	13.7	12.6	14.7	20.4	--	--	--	9.9	11.2	12.7
1983	13.6	12.6	14.2	15.6	--	--	--	10.6	11.6	12.0
1984	14.5	14.3	14.6	14.8	--	--	--	12.3	11.2	13.2
1985	14.3	13.5	14.5	14.8	--	--	--	10.5	11.2	12.3
1986	13.9	13.7	14.5	14.2	--	--	--	11.0	10.7	11.8
1987	12.9	12.5	12.6	12.6	--	--	--	9.6	9.7	10.4
1988	15.0	13.6	12.8	13.4	--	--	--	9.3	11.6	10.2
1989	14.7	14.9	15.3	15.9	--	--	--	10.6	13.7	11.9
1990	13.2	13.1	14.8	15.2	--	--	--	9.6	11.5	11.7
1991	14.1	13.2	15.7	17.5	--	--	--	10.0	12.9	12.4
1992	13.7	13.2	16.0	18.3	--	--	--	9.6	12.1	11.3
1993	12.5	12.6	14.4	15.6	--	--	--	8.6	10.7	10.9
1994	14.3	13.8	15.9	16.2	27.8	--	--	10.8	12.1	12.3
1995	12.5	13.7	14.0	15.4	23.0	--	--	9.2	10.3	11.3
1996	13.1	13.2	14.5	16.2	27.2	13.0	--	9.7	10.9	11.4
1997	12.6	13.1	13.8	15.7	29.1	12.3	--	9.1	10.2	11.1
1998	12.3	12.0	13.4	15.9	28.0	12.0	--	9.0	10.3	11.5
1999	12.7	12.0	13.8	16.0	29.6	12.2	9.1	9.3	10.6	10.9
2000	12.7	12.6	14.7	16.6	27.7	12.5	9.3	9.5	10.7	11.4
2001	13.7	14.3	15.4	18.6	26.2	13.9	9.7	10.4	12.0	12.2
2002	14.0	14.4	15.9	17.7	30.3	14.3	10.5	10.5	12.3	12.6
2003	12.8	13.3	14.8	15.5	27.7	13.3	10.0	10.0	11.7	11.8
2004	13.6	14.1	15.5	14.7	25.5	14.2	10.9	10.5	12.2	12.5
2005	12.8	13.5	14.8	13.8	22.9	12.9	9.9	10.1	11.5	11.5
2006	12.7	13.4	14.6	14.2	21.5	12.6	9.5	10.1	11.5	11.7
2007	12.9	13.2	14.6	14.1	17.8	12.7	9.5	10.1	11.5	11.6
2008	13.9	13.5	15.5	14.9	18.7	13.3	10.2	10.8	12.2	12.6

Notes: Shaded cells are the highest annual averages for the calendar year; "--" indicates that no data are available because the station was not yet operating.

Table 59. TSP Air Concentrations (μg/m^3) from 1969-1987

Year	Cañon City		Lincoln Park	
	Maximum	Average	Maximum	Average
1969	172	64.2	--	--
1970	200	55.9	--	--
1971	148	58.7	--	--
1972	240	69.9	--	--
1973	229	66.1	--	--
1974	187	58	--	--
1975	419	73.7	--	--
1976	174	56.8	--	--
1977	227	62.7	--	--
1978	313	84.7	--	--
1979	286	72.6	--	--
1980	304	70.4	--	--
1981	180	56.8	61*	8.2*
1982	525	84	228	51.7
1983	187	65.2	106	77.6
1984	571	70.9	--	--
1985	334	64.8	--	--
1986	402	66.3	--	--
1987	385	65.2	--	--

Notes: Data downloaded from EPA's Air Quality System database.
EPA's former annual average National Ambient Air Quality Standard for TSP was 75 μg/m^3.
* The TSP monitoring station in Lincoln Park started operating late in 1981; therefore, the statistics reported are not representative of the entire calendar year.

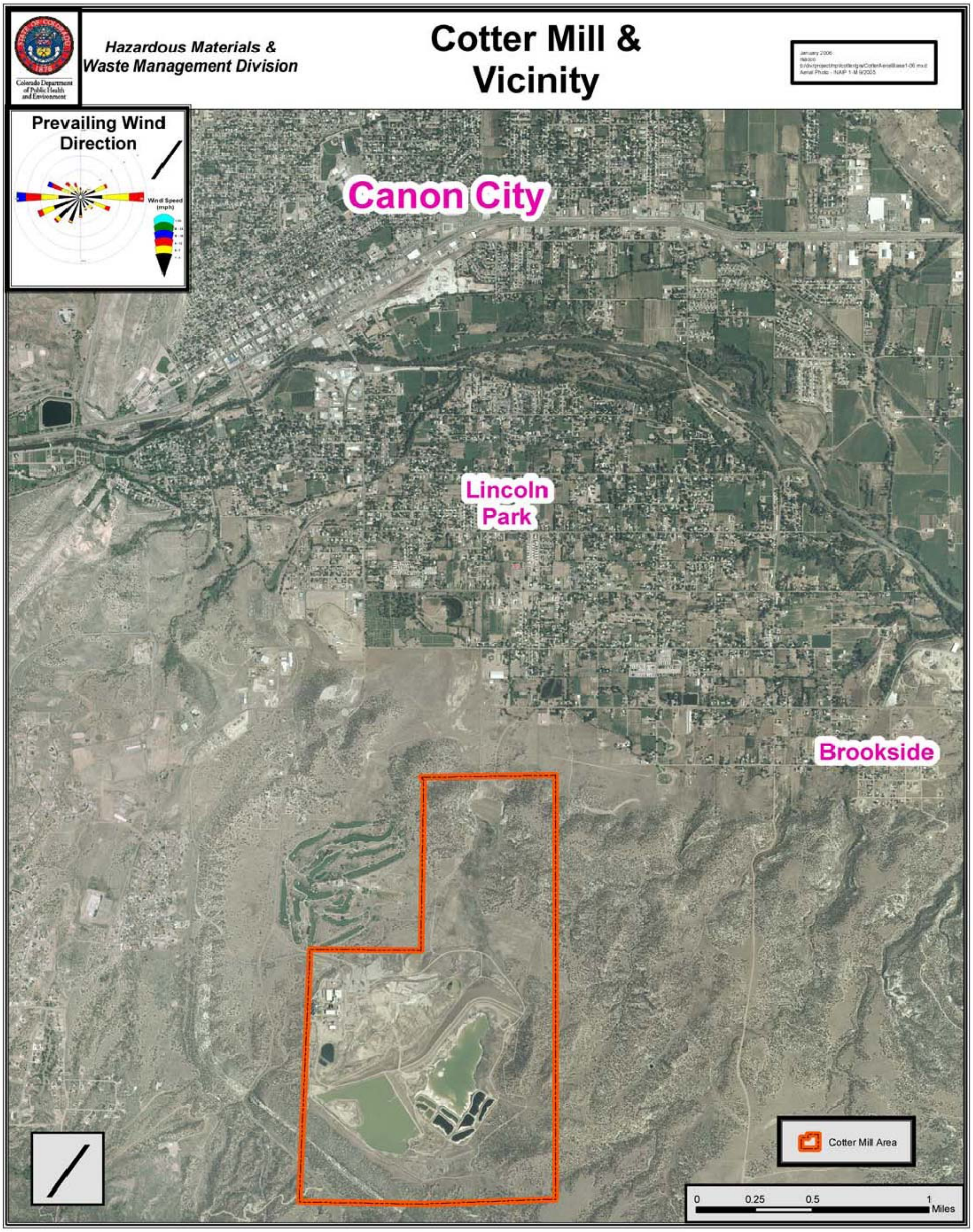
Table 60. Monitoring Data for Constituents in TSP (1978-1987)

Constituent	Location	Years of Data	Concentrations (μg/m^3)	
			Highest 24-Hour Average	Highest Annual Average
Iron	Lincoln Park	1981-1982	1.2	0.8
Lead	Lincoln Park	1981-1982	0.1	0.034
Manganese	Lincoln Park	1981-1982	0.03	0.0185
Nitrate	Cañon City	1978-1987	14.3	2.35
	Lincoln Park	1981-1982	4.7	1.81
Sulfate	Cañon City	1978-1987	18.4	5.99
	Lincoln Park	1981-1982	13	6.48
Zinc	Lincoln Park	1981-1982	0.04	0.0283

Notes Data downloaded from EPA's Air Quality System database.

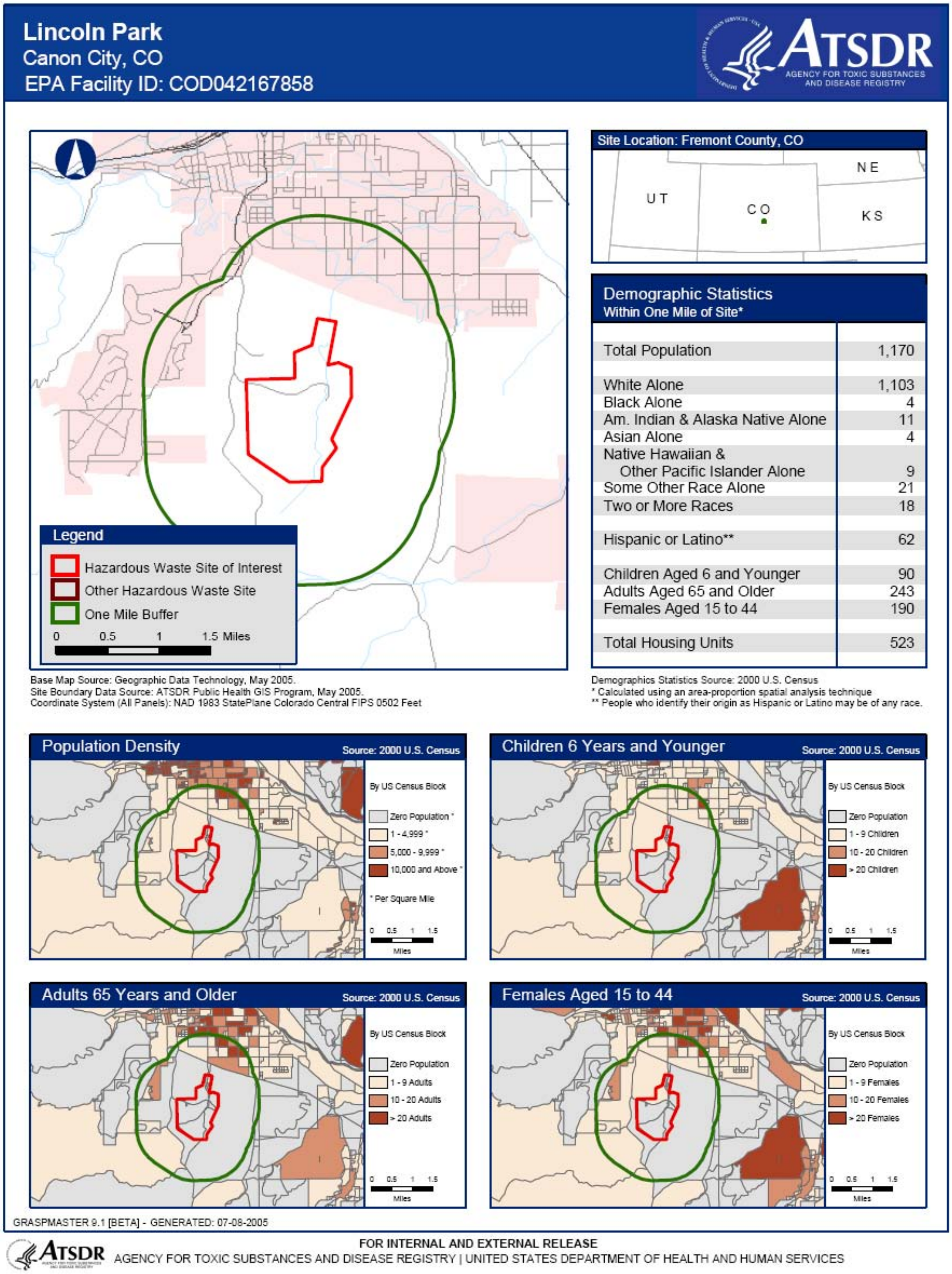
Appendix B - Site Figures

Figure 1. Location of the Cotter Mill, Lincoln Park, and Cañon City



Source: Galant et al. 2007

Figure 2. Demographics within 1 mile of the Cotter Mill property



Demographic Statistics
Within One Mile of Site*

Total Population	1,170
White Alone	1,103
Black Alone	4
Am. Indian & Alaska Native Alone	11
Asian Alone	4
Native Hawaiian & Other Pacific Islander Alone	9
Some Other Race Alone	21
Two or More Races	18
Hispanic or Latino**	62
Children Aged 6 and Younger	90
Adults Aged 65 and Older	243
Females Aged 15 to 44	190
Total Housing Units	523

Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Public Health GIS Program, May 2005.
Coordinate System (All Panels): NAD 1983 StatePlane Colorado Central FIPS 0502 Feet

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.

Figure 3. Wind Rose for Cotter Mill, 2008

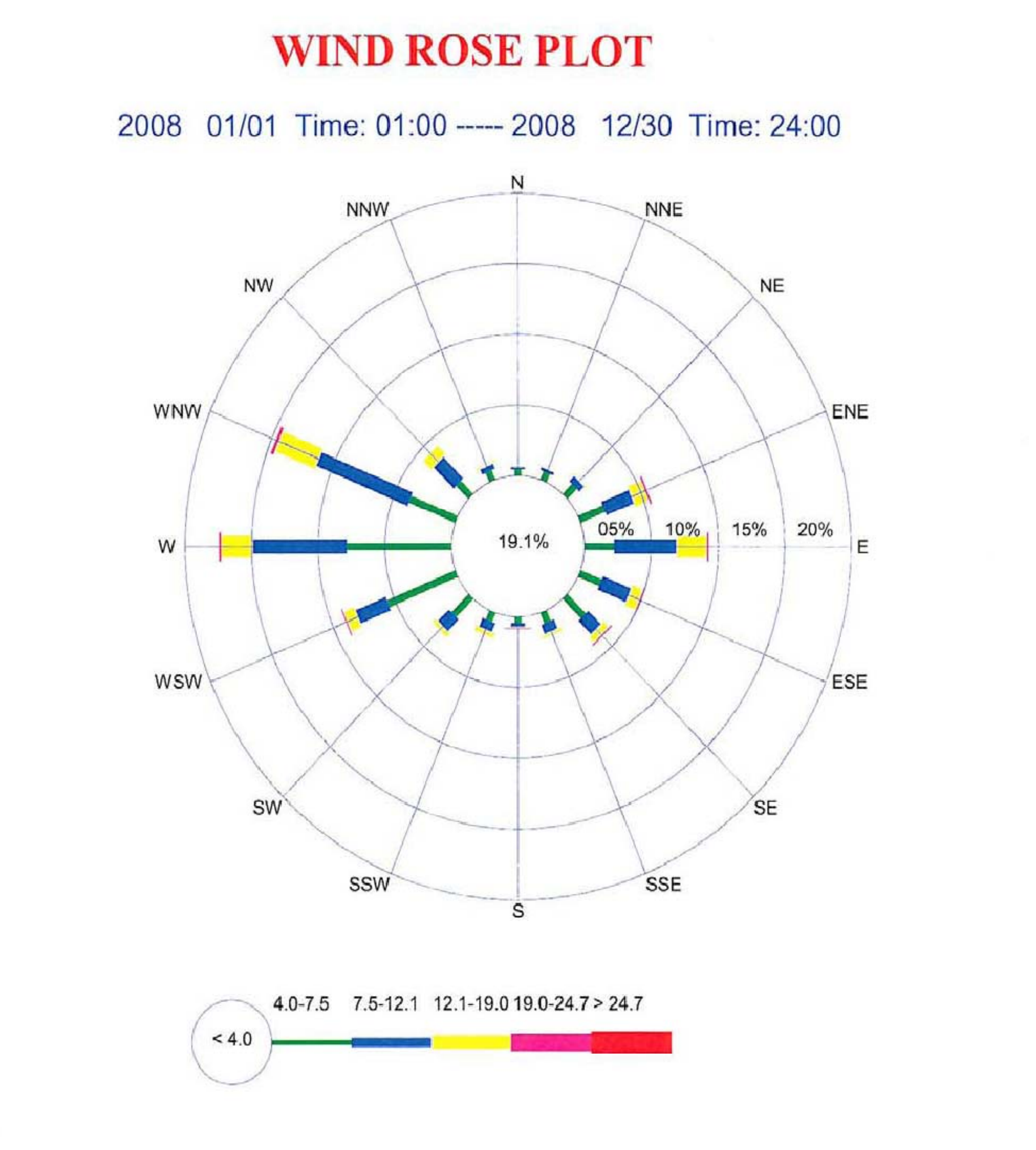
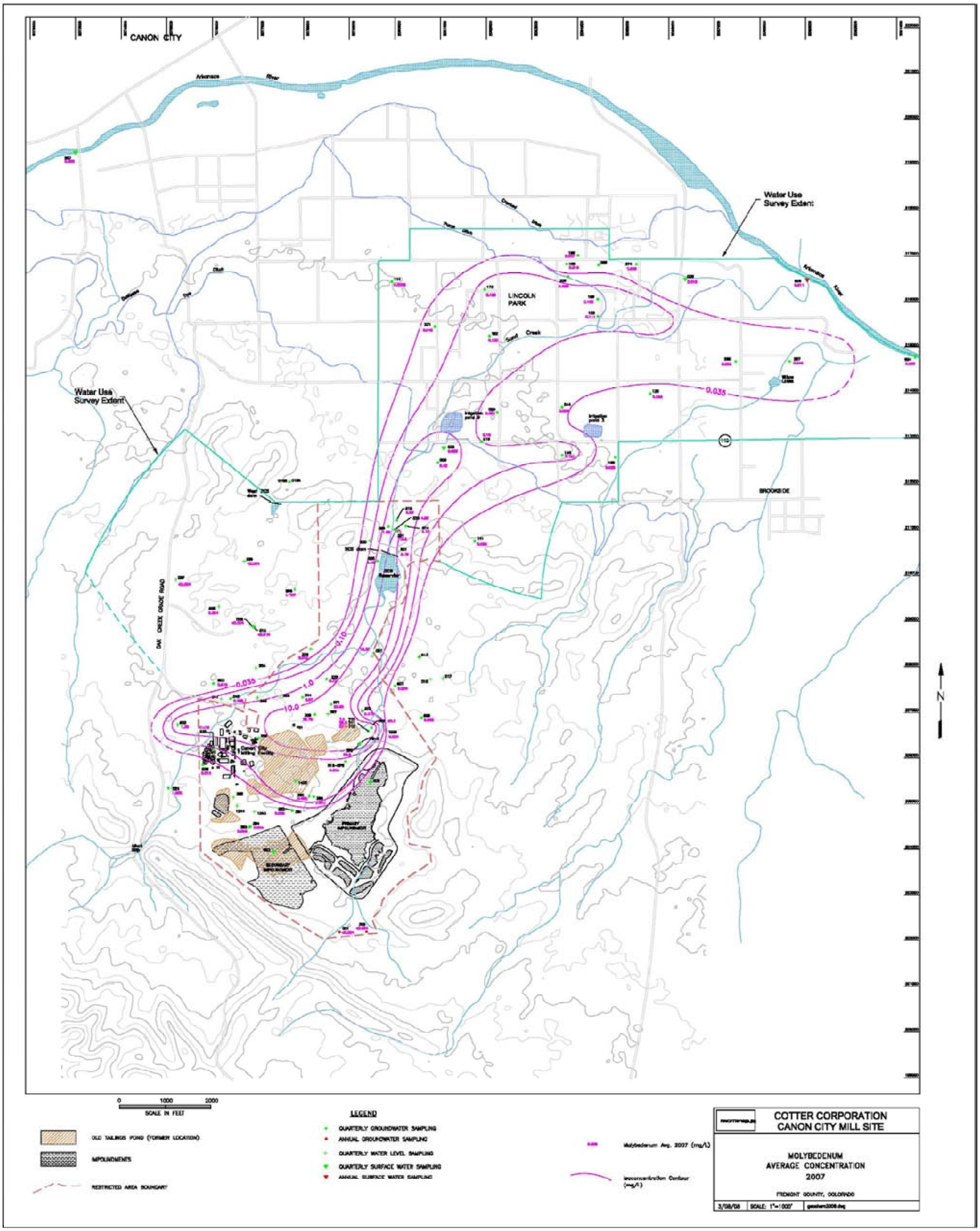
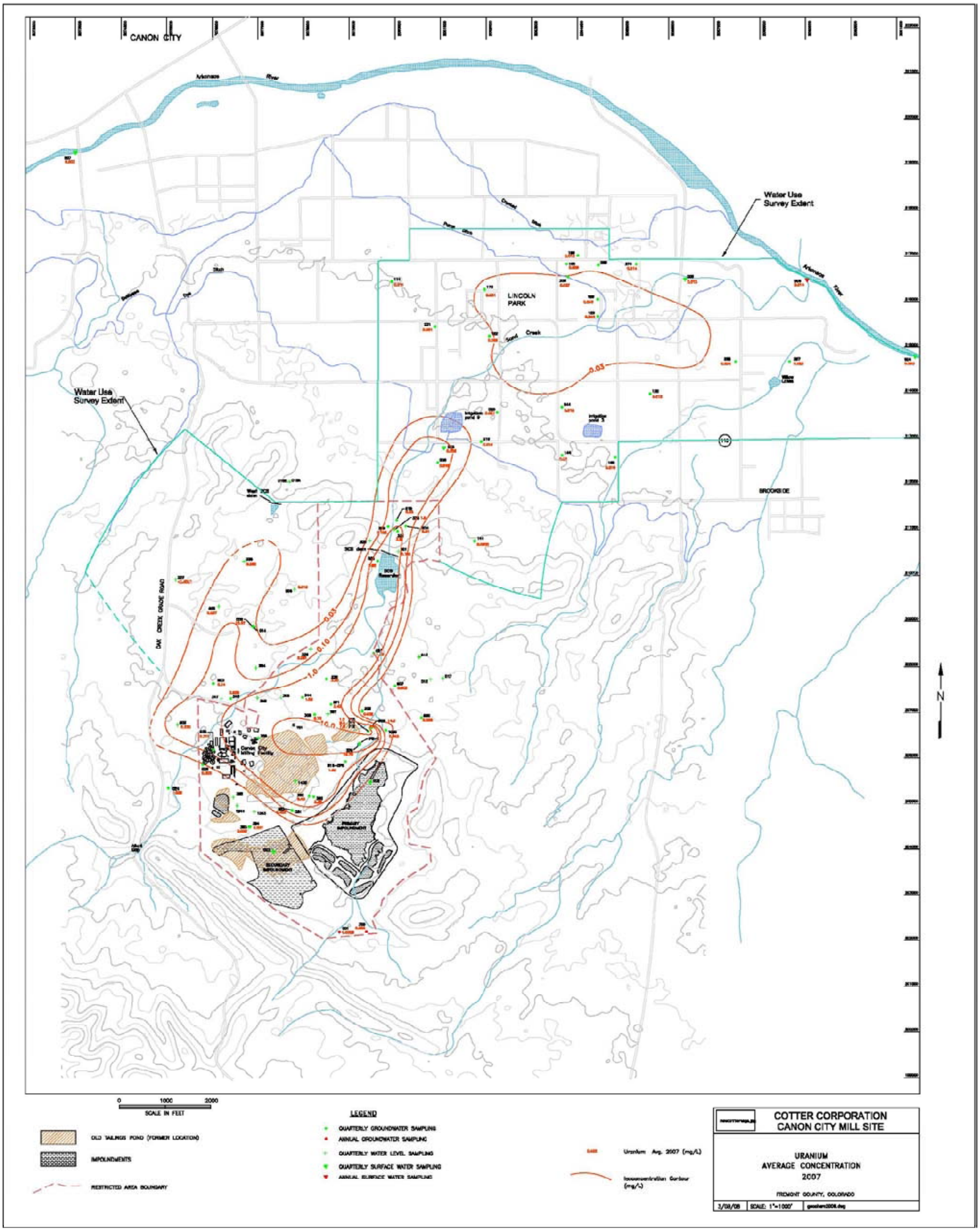


Figure 4. Molybdenum Plume Map



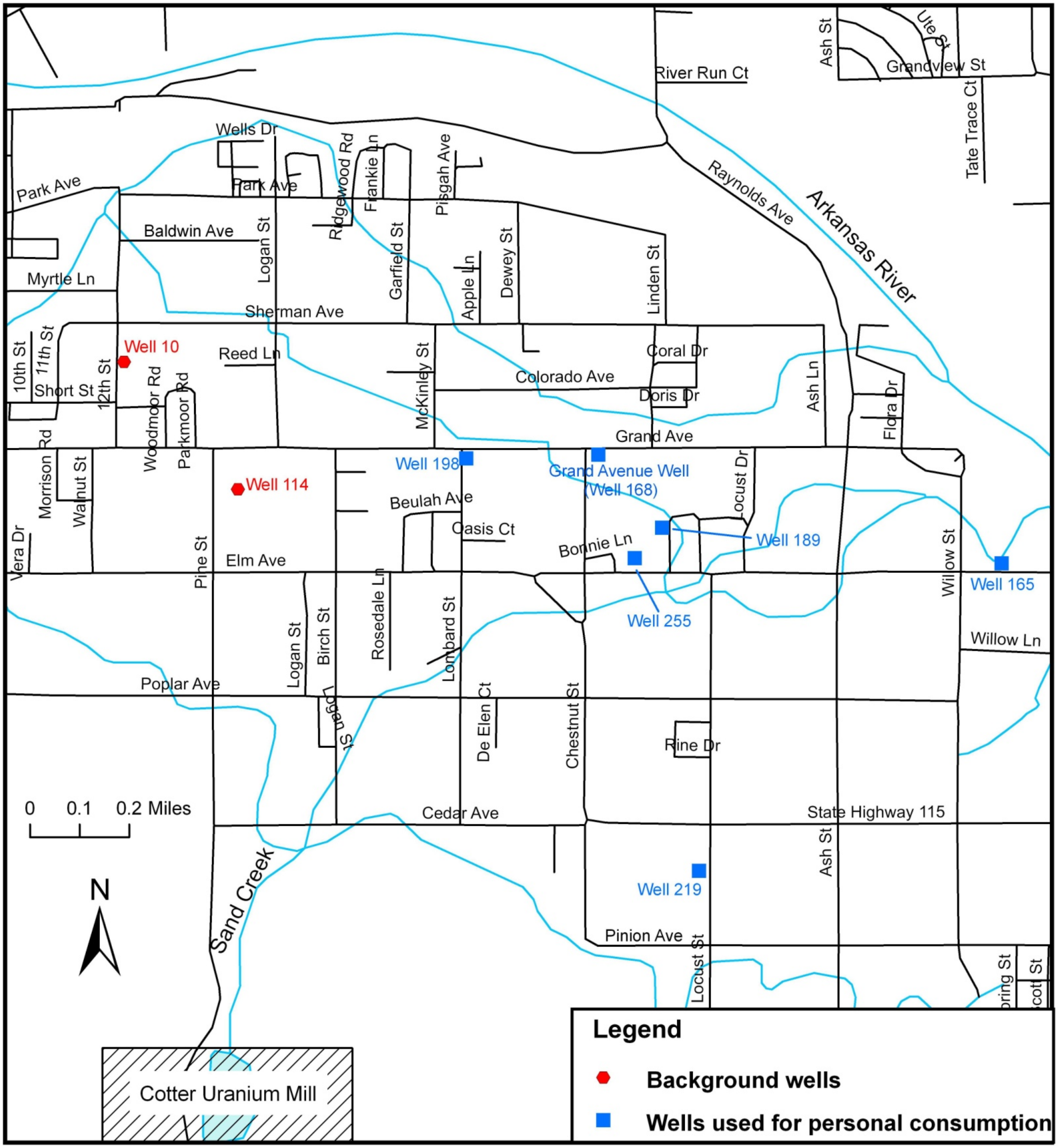
Source: Cotter 2008

Figure 5. Uranium Plume Map



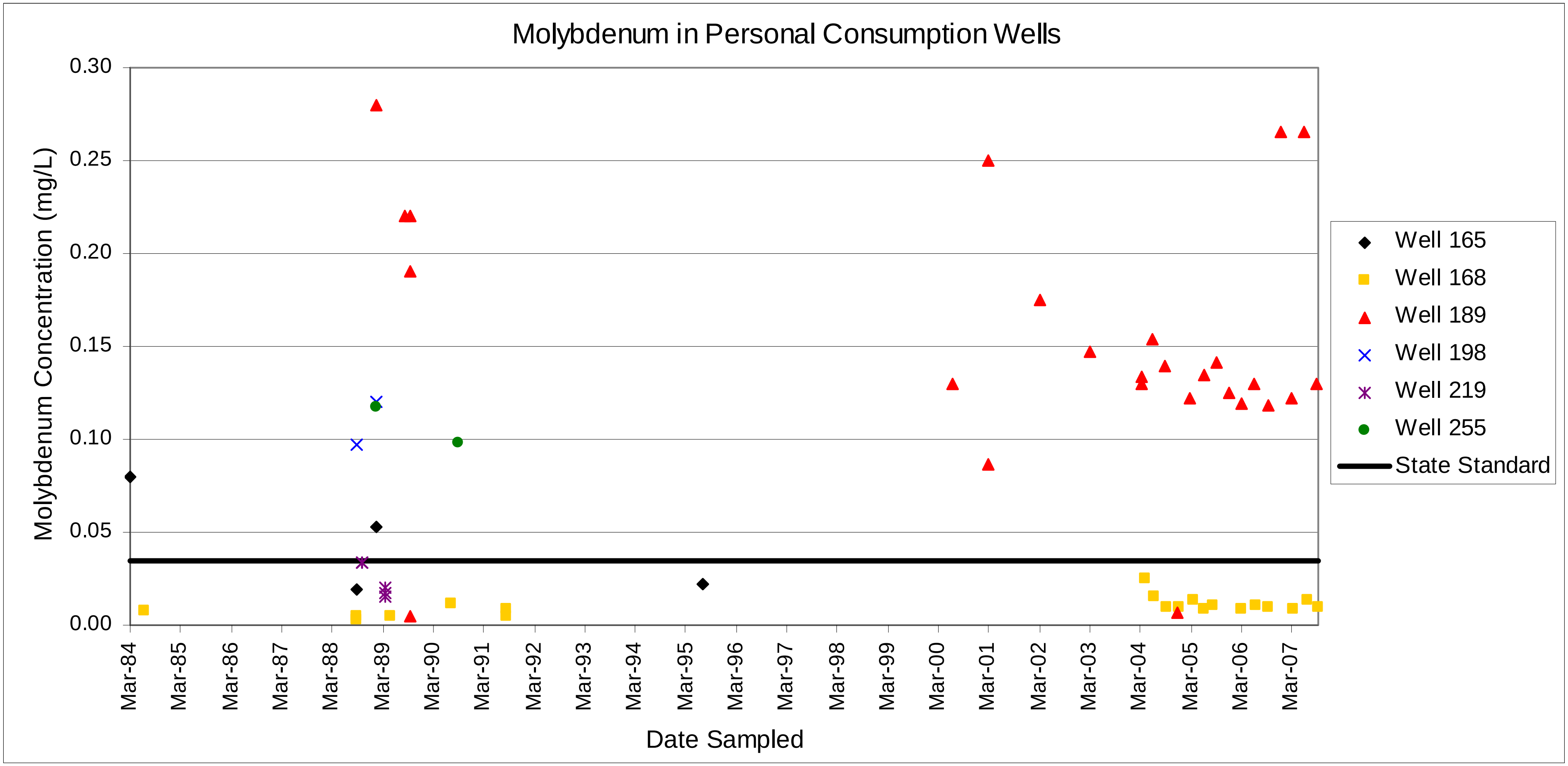
Source: Cotter 2008

Figure 6. Wells in Lincoln Park used for personal consumption



Source: CDPHE 2007b (coordinates)

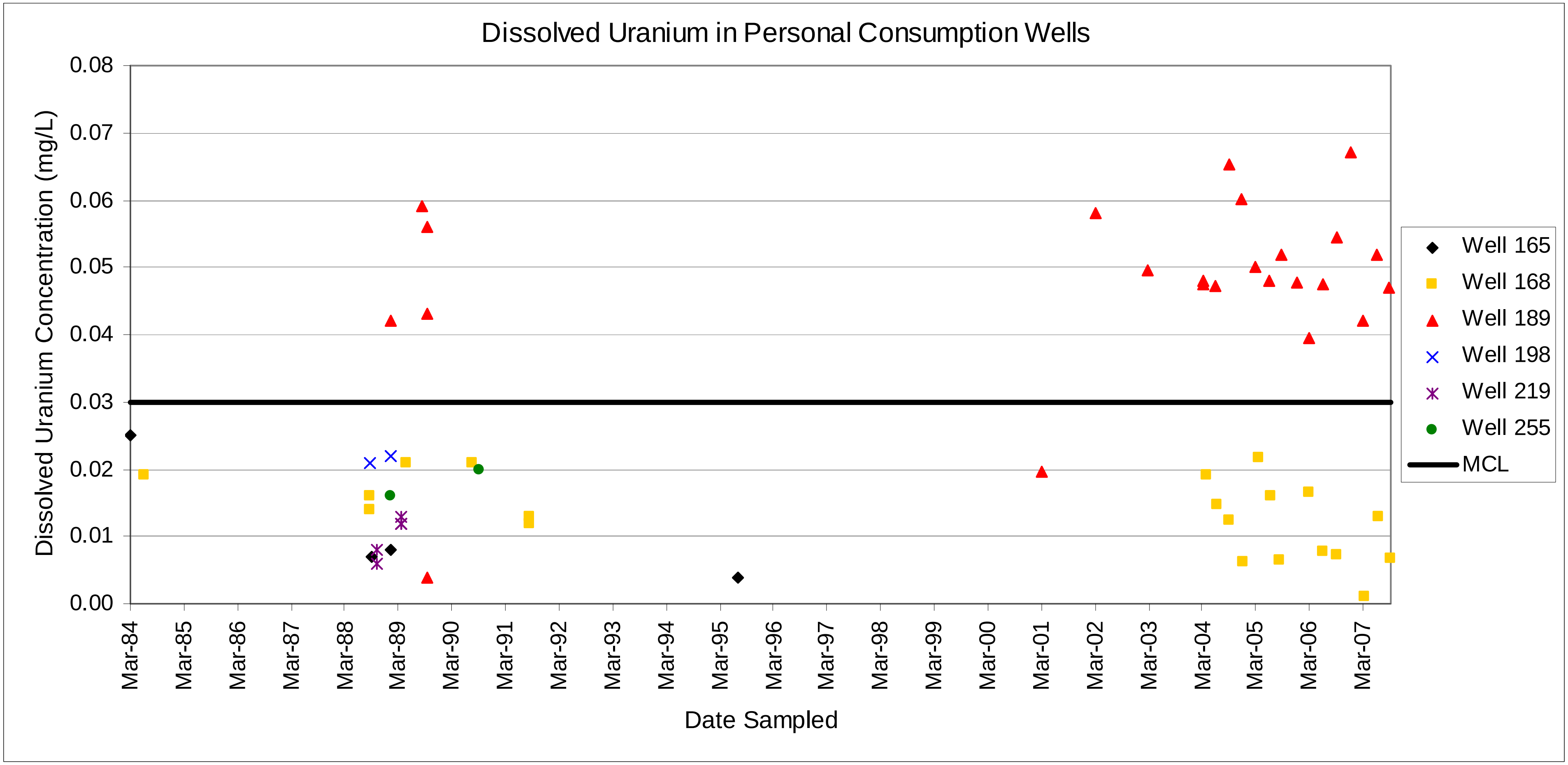
Figure 7. Molybdenum concentrations in wells used for personal consumption



Source: CDPHE 2007b

Non-detected concentrations were plotted as ½ the reporting detection limit.

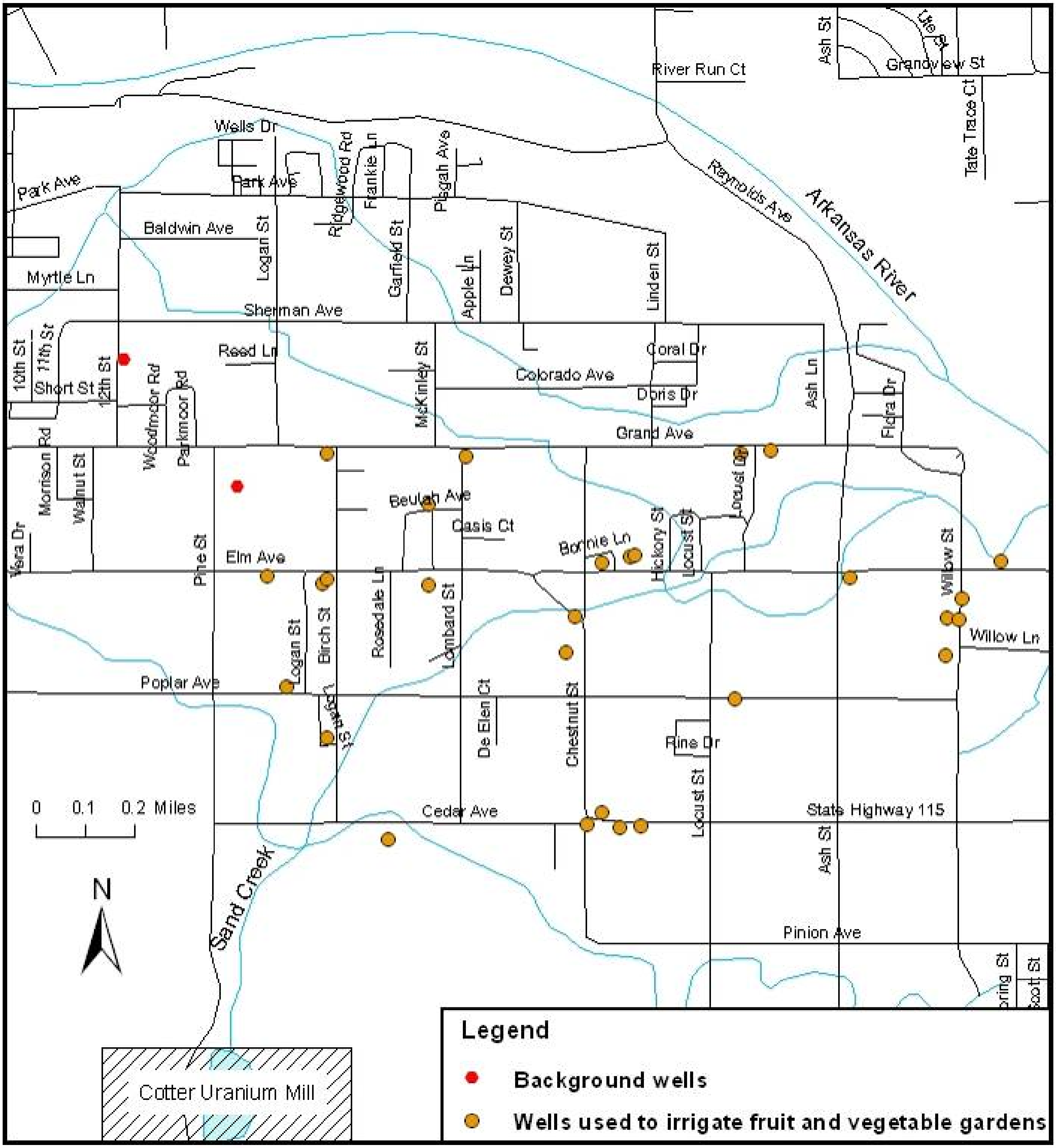
Figure 8. Dissolved uranium concentrations in wells used for personal consumption



Source: CDPHE 2007b

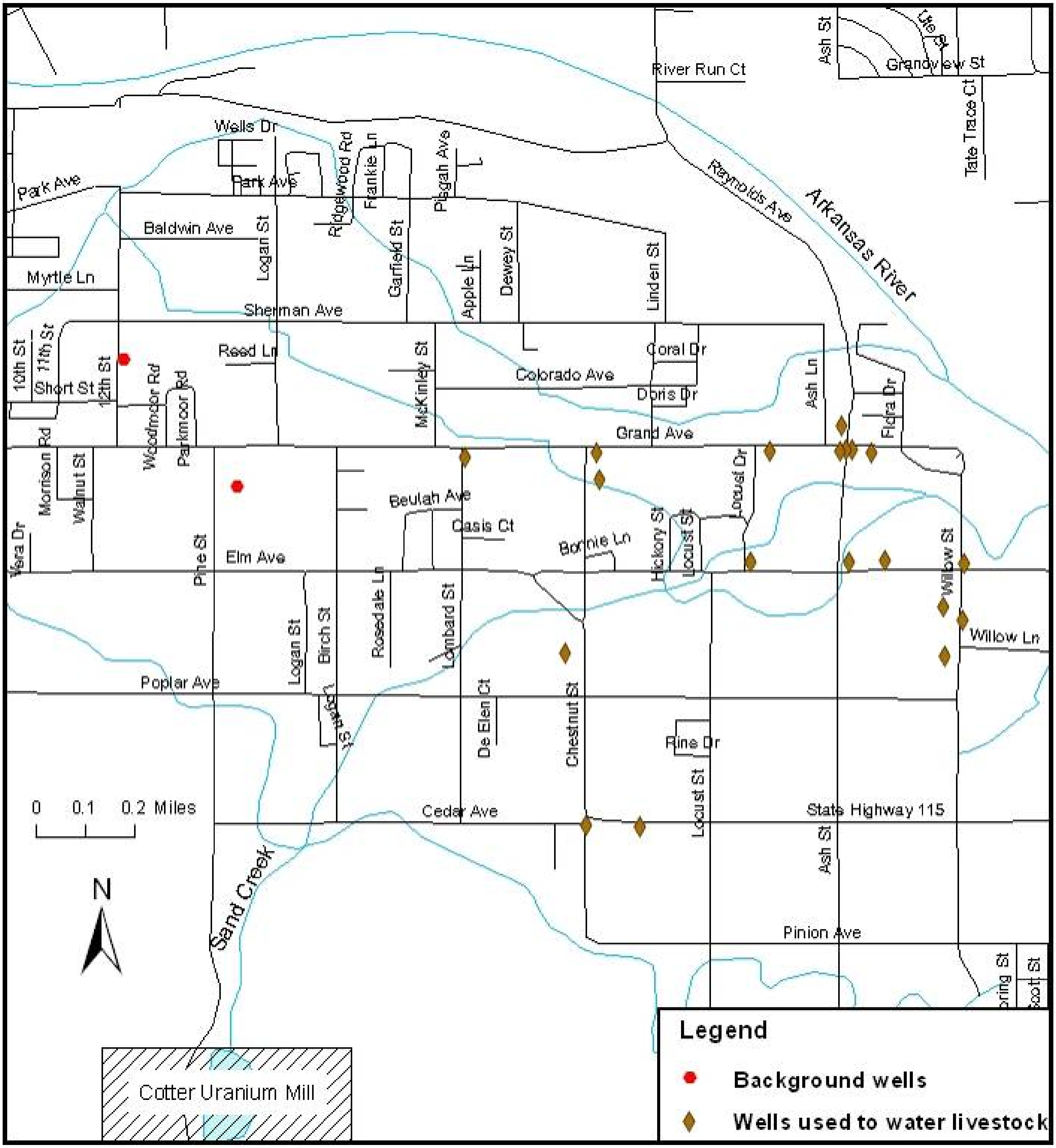
Non-detected concentrations were plotted as ½ the reporting detection limit.

Figure 9. Wells in Lincoln Park used to irrigate fruit and vegetable gardens



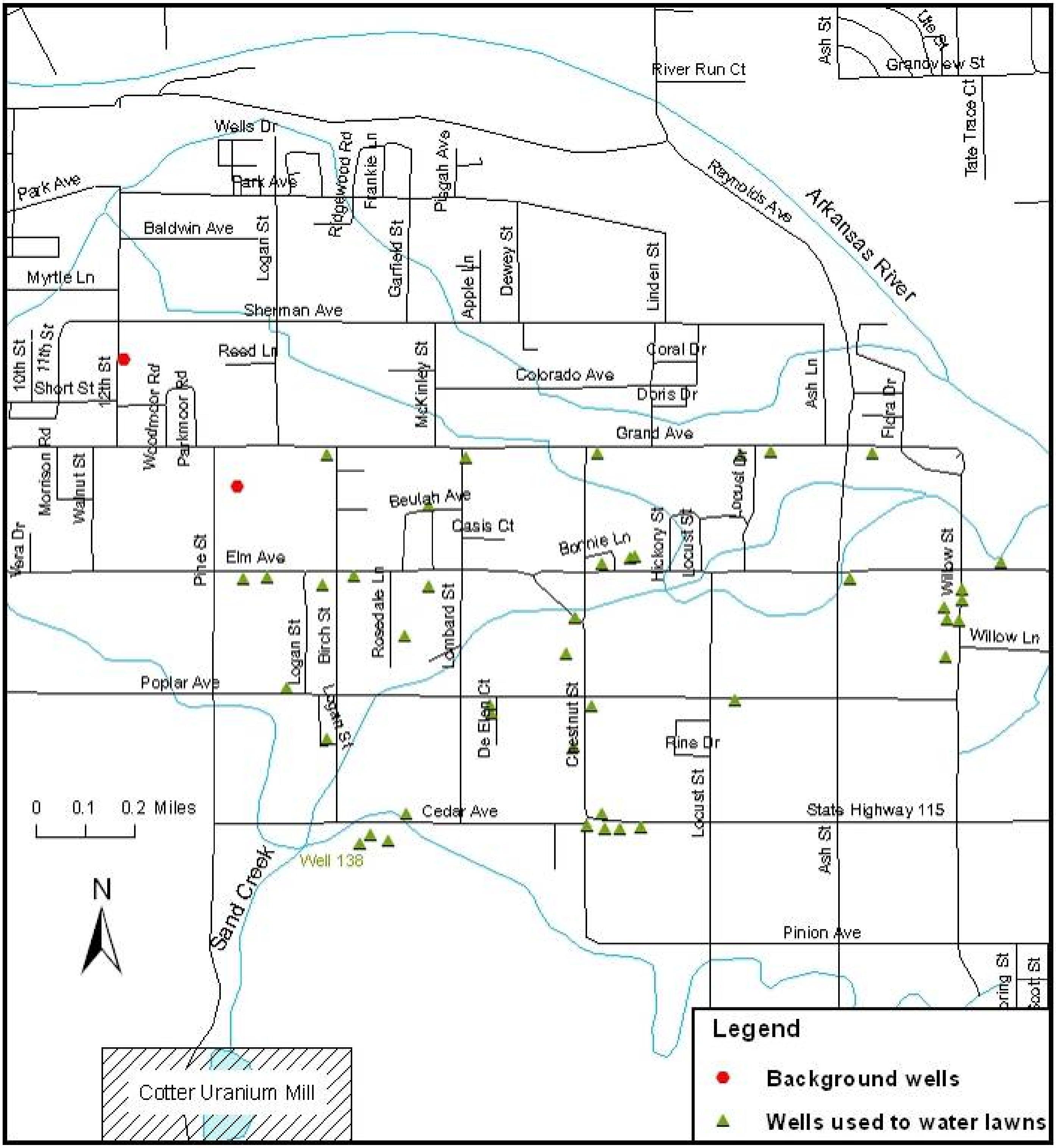
Source: CDPHE 2007b (coordinates)

Figure 10. Wells in Lincoln Park used to water livestock



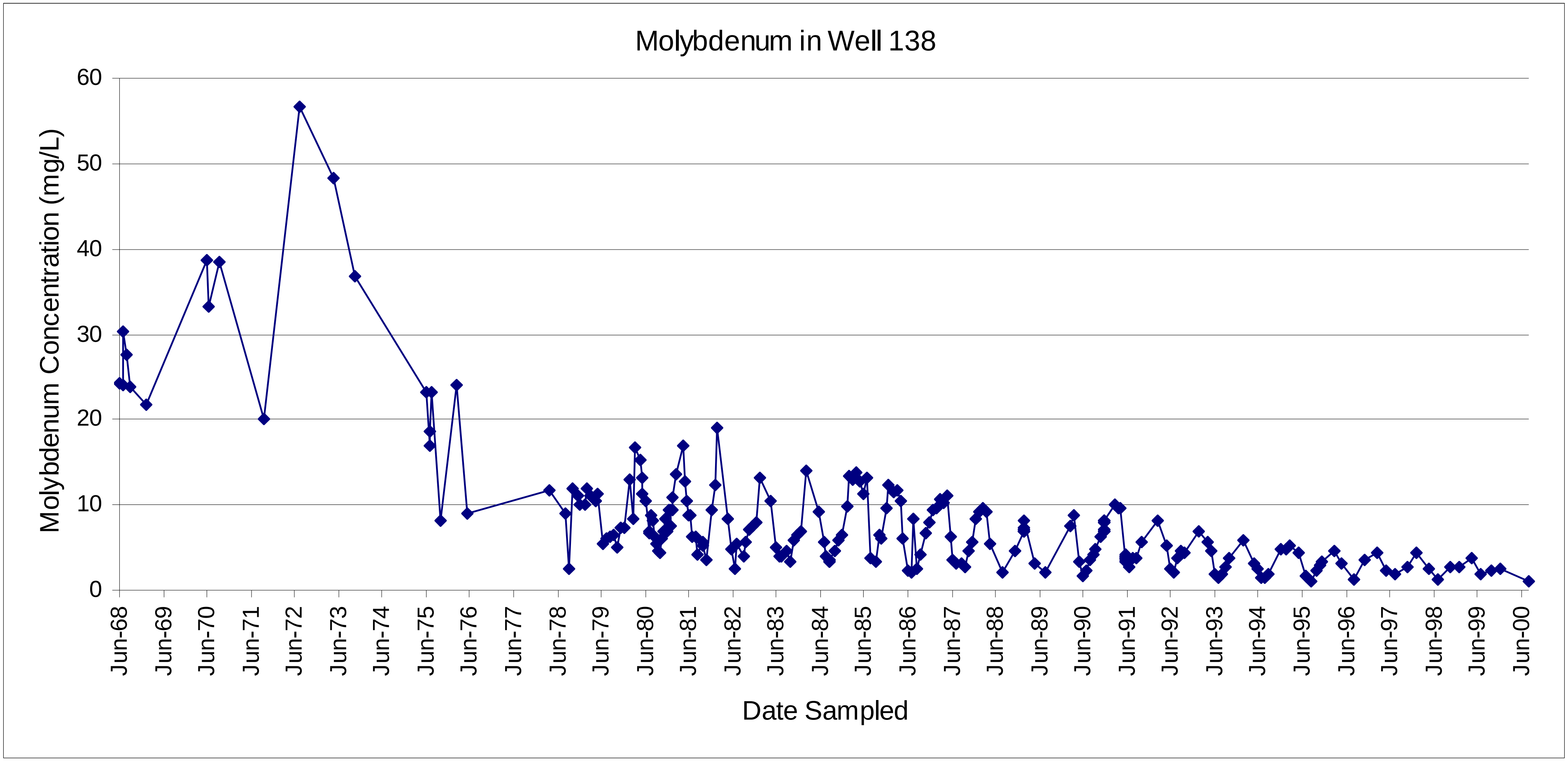
Source: CDPHE 2007b (coordinates)

Figure 11. Wells in Lincoln Park used to water lawns



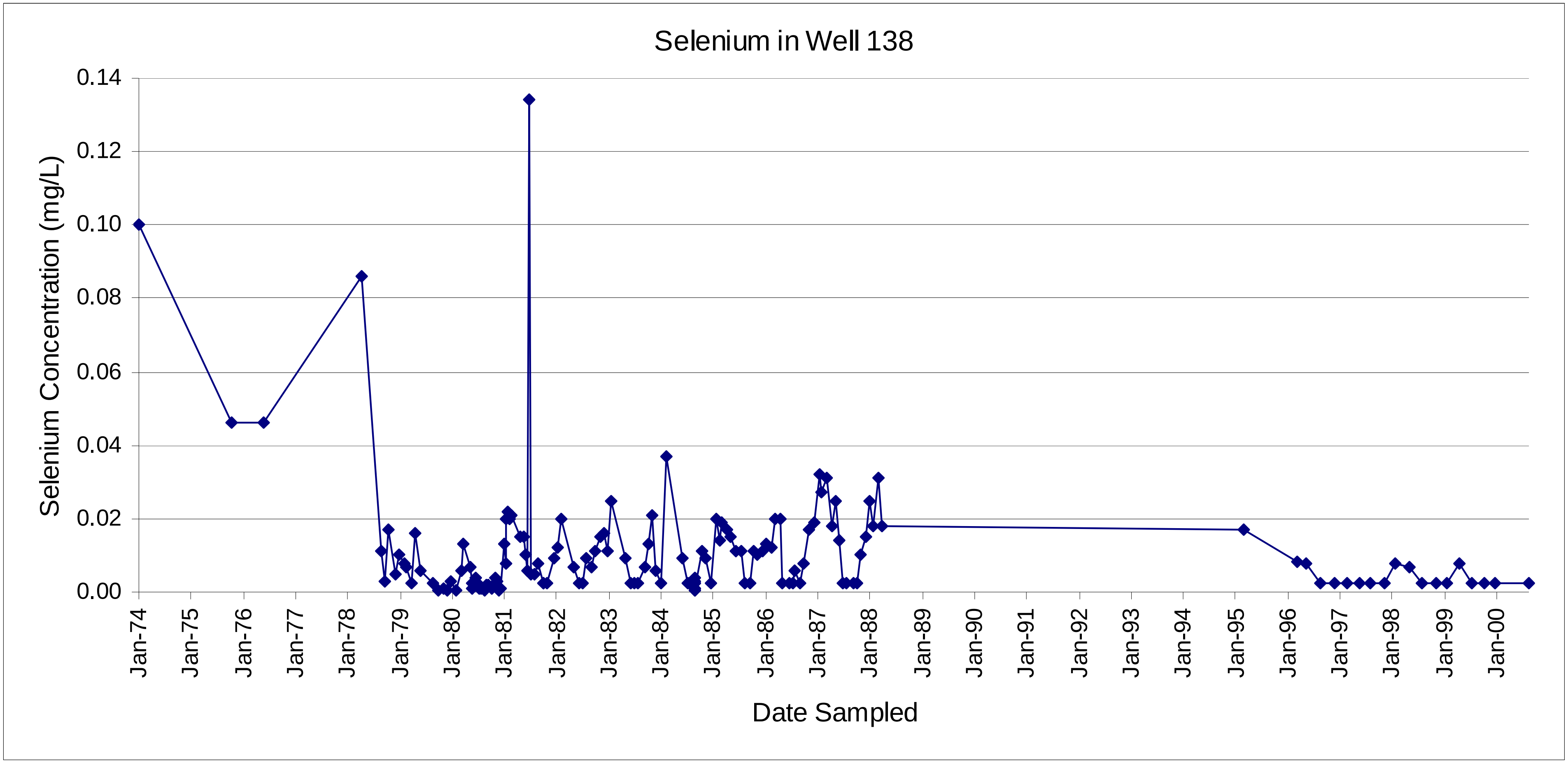
Source: CDPHE 2007b (coordinates)

Figure 12. Molybdenum concentrations in Well 138



Source: CDPHE 2007b

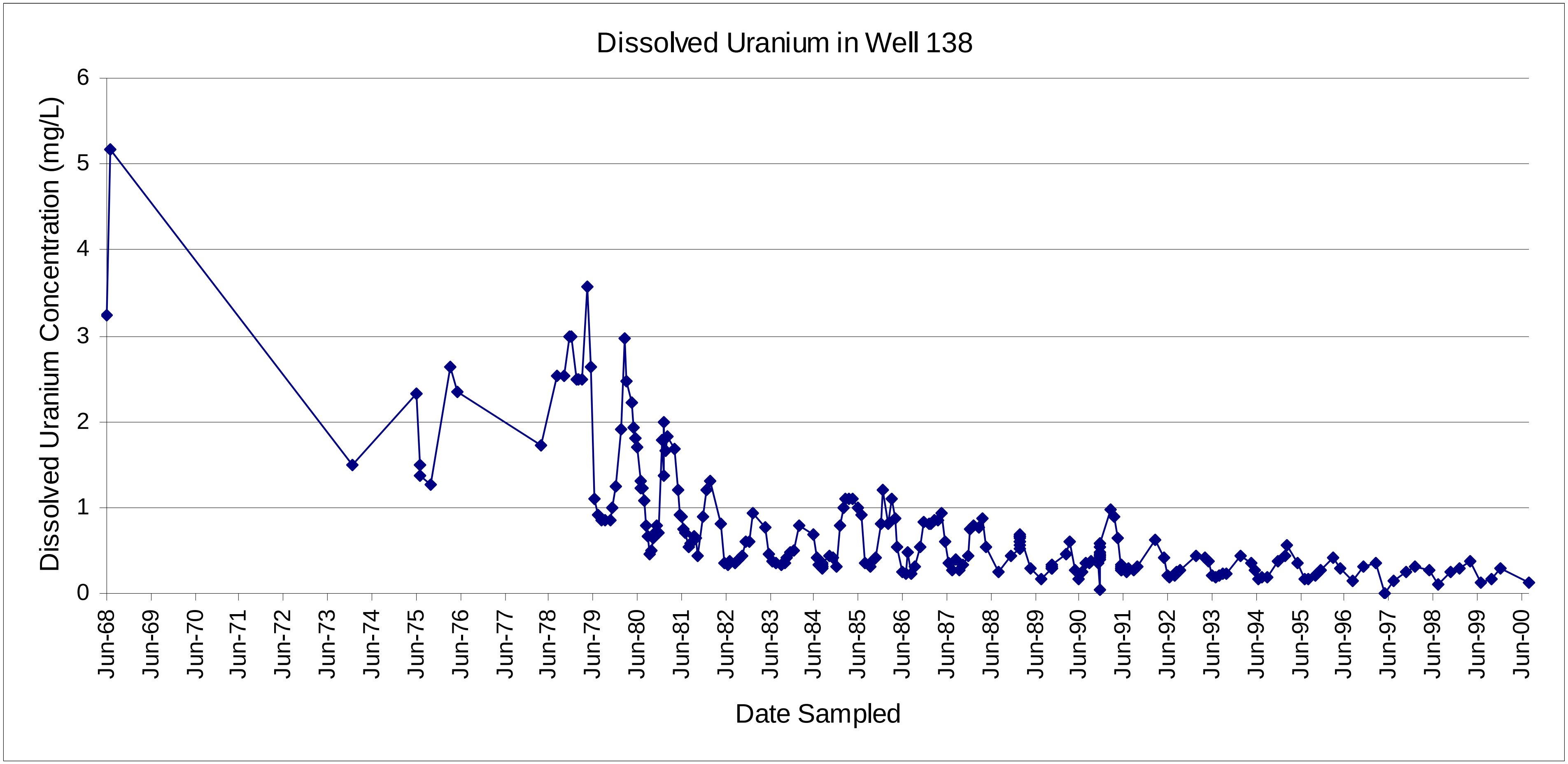
Figure 13. Selenium concentrations in Well 138



Source: CDPHE 2007b

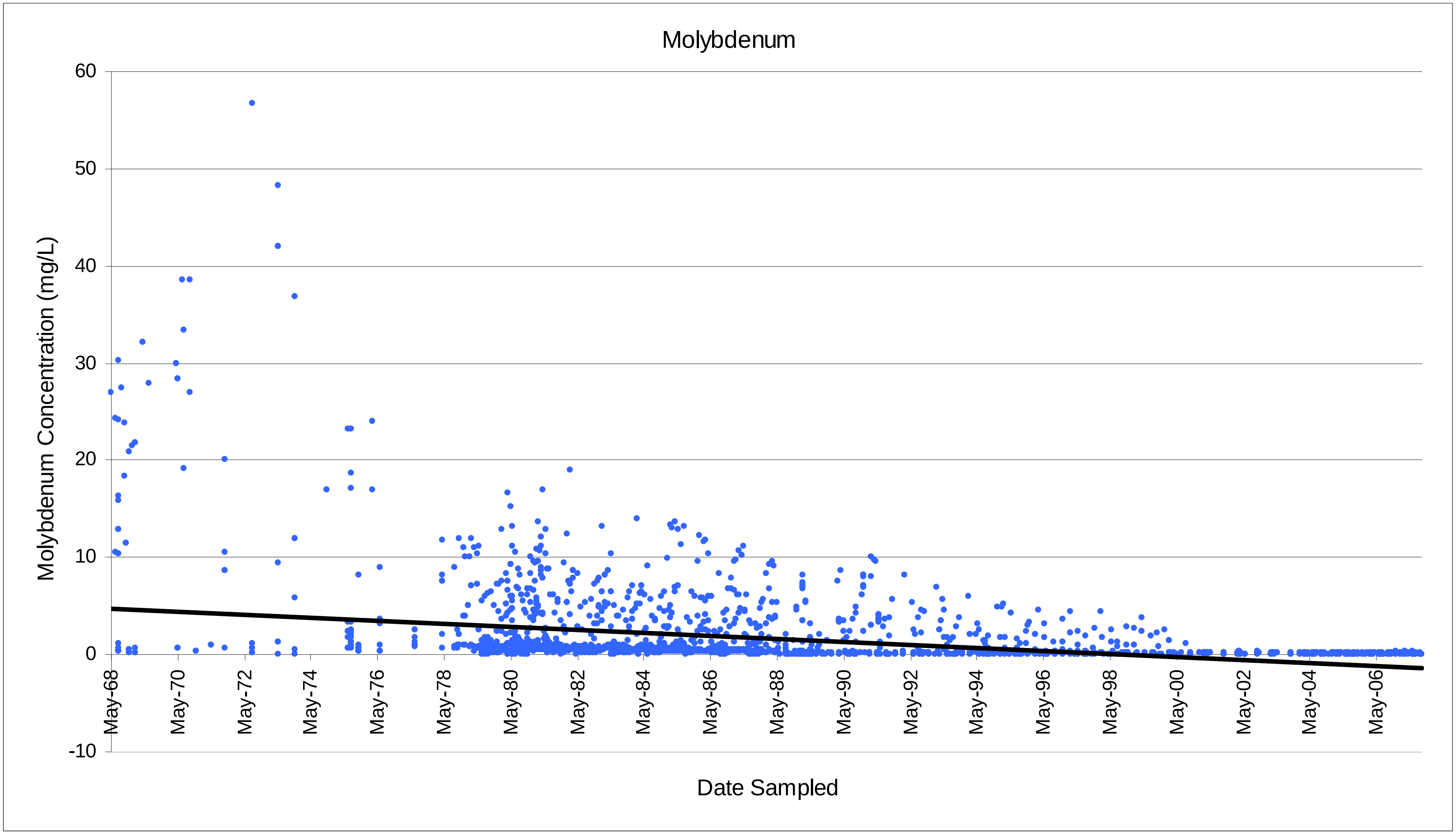
Non-detected concentrations were plotted as ½ the reporting detection limit.

Figure 14. Dissolved uranium concentrations in Well 138



Source: CDPHE 2007b

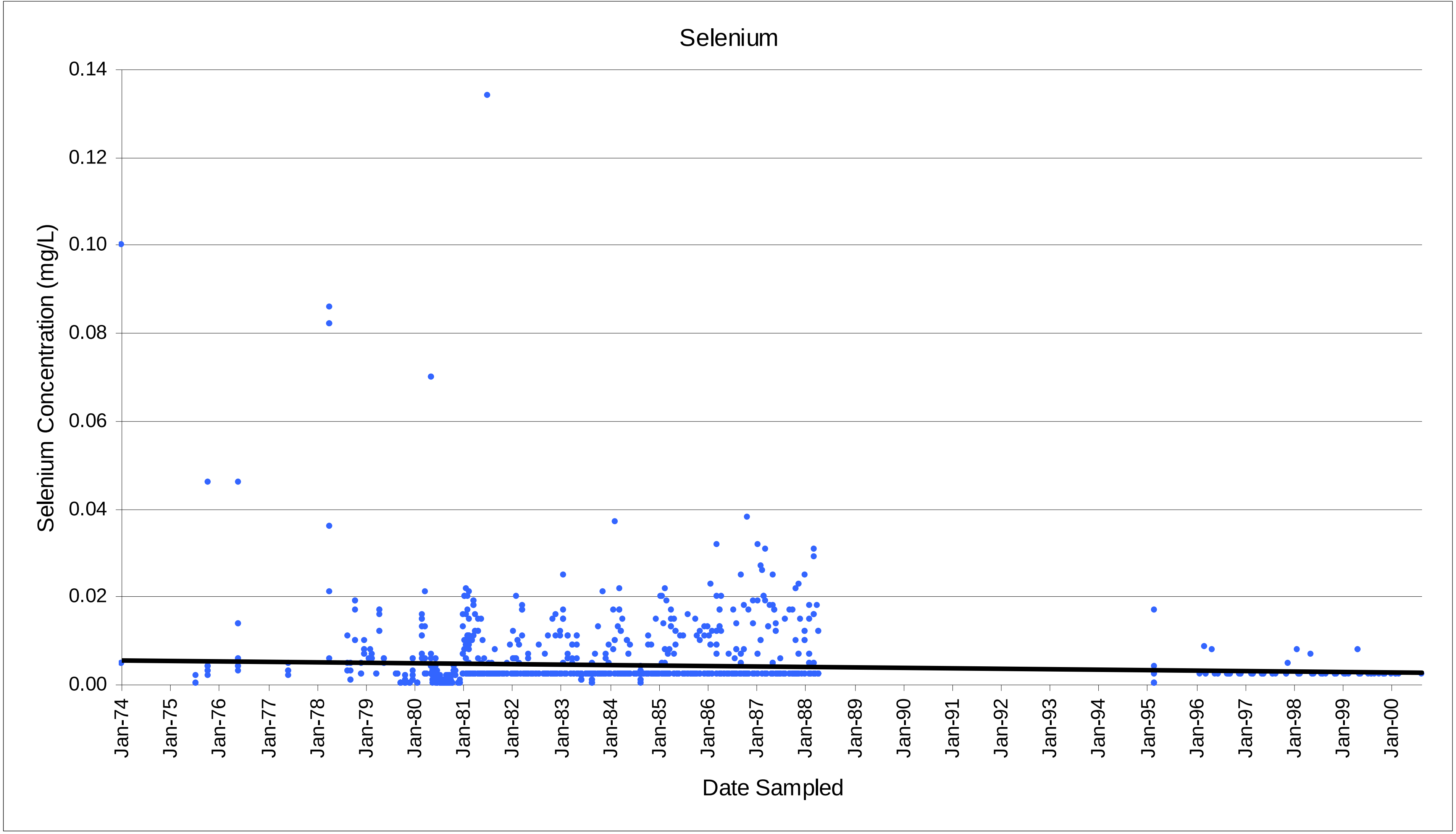
Figure 15. Molybdenum concentrations in all groundwater wells evaluated



Source: CDPHE 2007b

Non-detected concentrations were plotted as ½ the reporting detection limit.

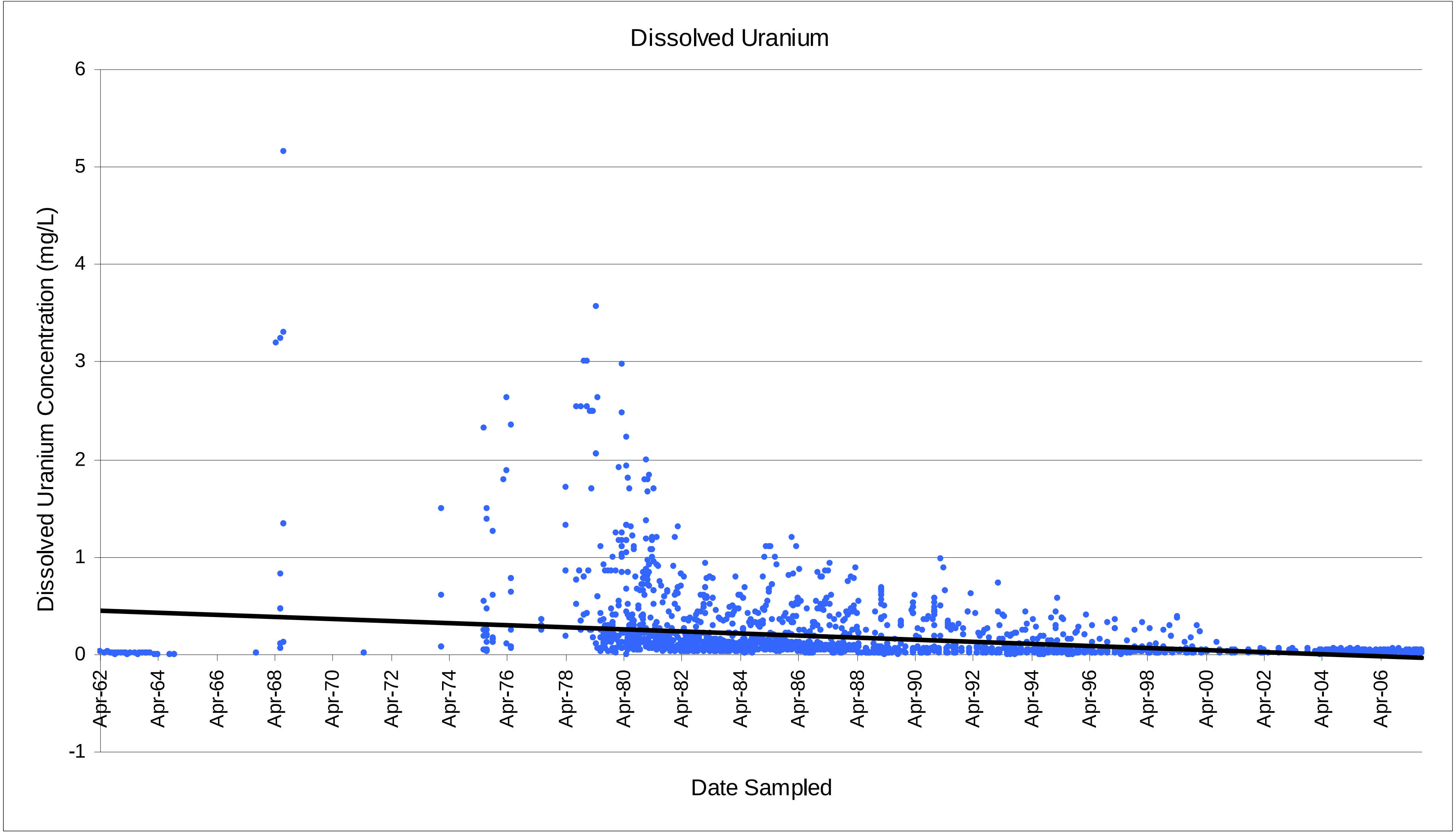
Figure 16. Selenium concentrations in all groundwater wells evaluated



Source: CDPHE 2007b

Non-detected concentrations were plotted as ½ the reporting detection limit.

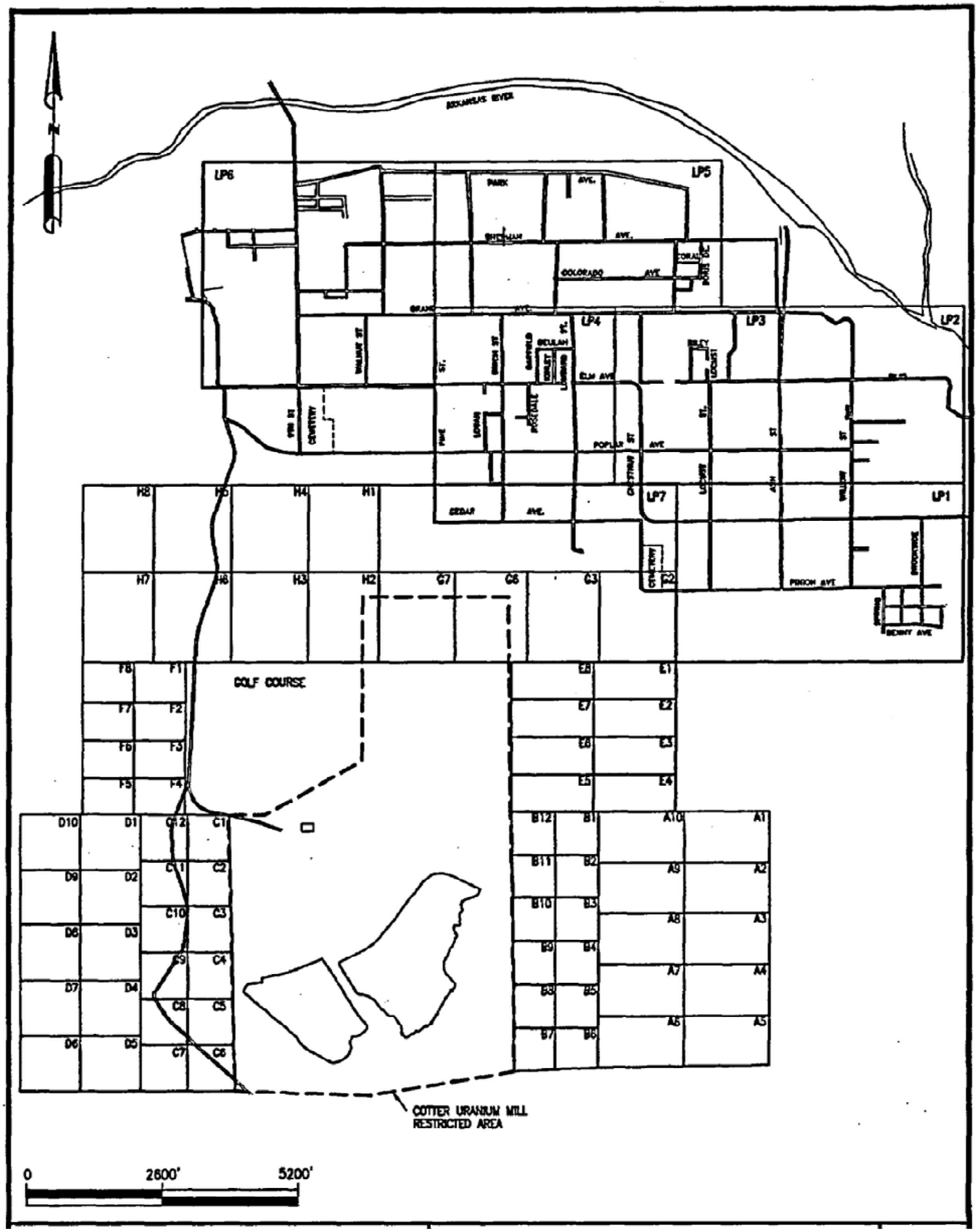
Figure 17. Dissolved uranium concentrations in all groundwater wells evaluated



Source: CDPHE 2007b

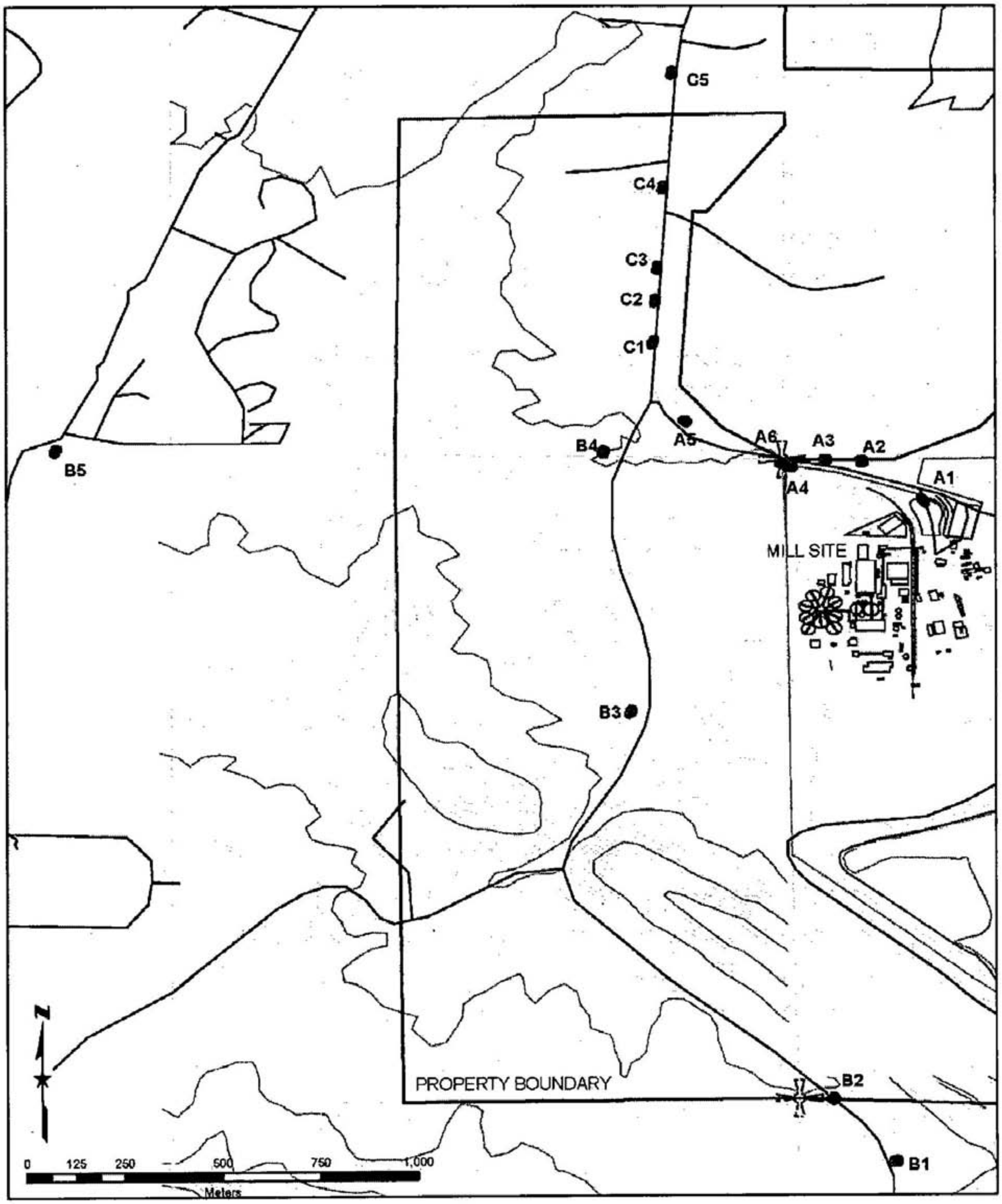
Non-detected concentrations were plotted as ½ the reporting detection limit.

Figure 18. Sampling zones established during the 1998 Supplemental Human Health Risk Assessment



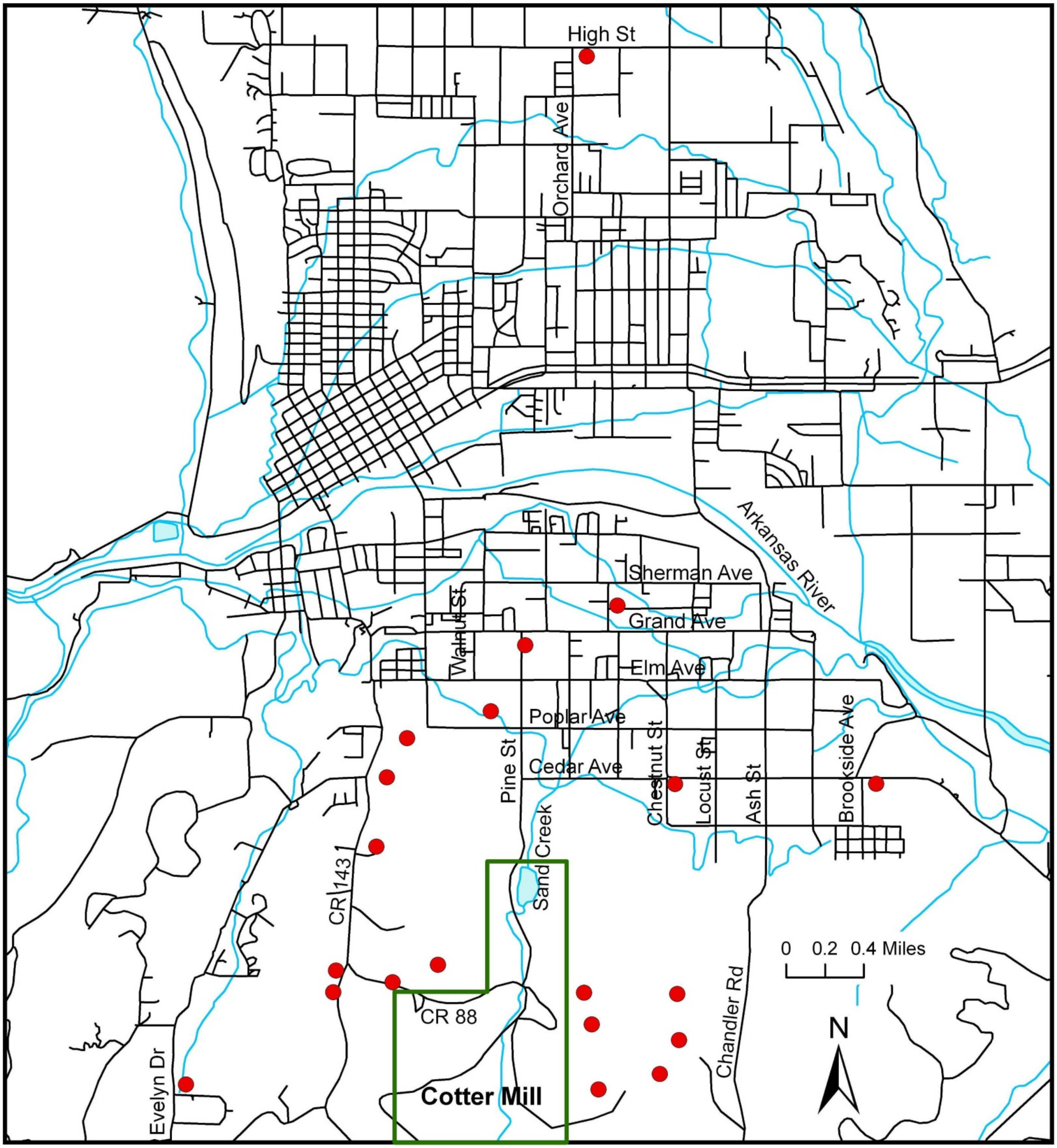
Source: Weston 1998

Figure 19. Locations of soil samples taken along the county road and Cotter Mill's access road



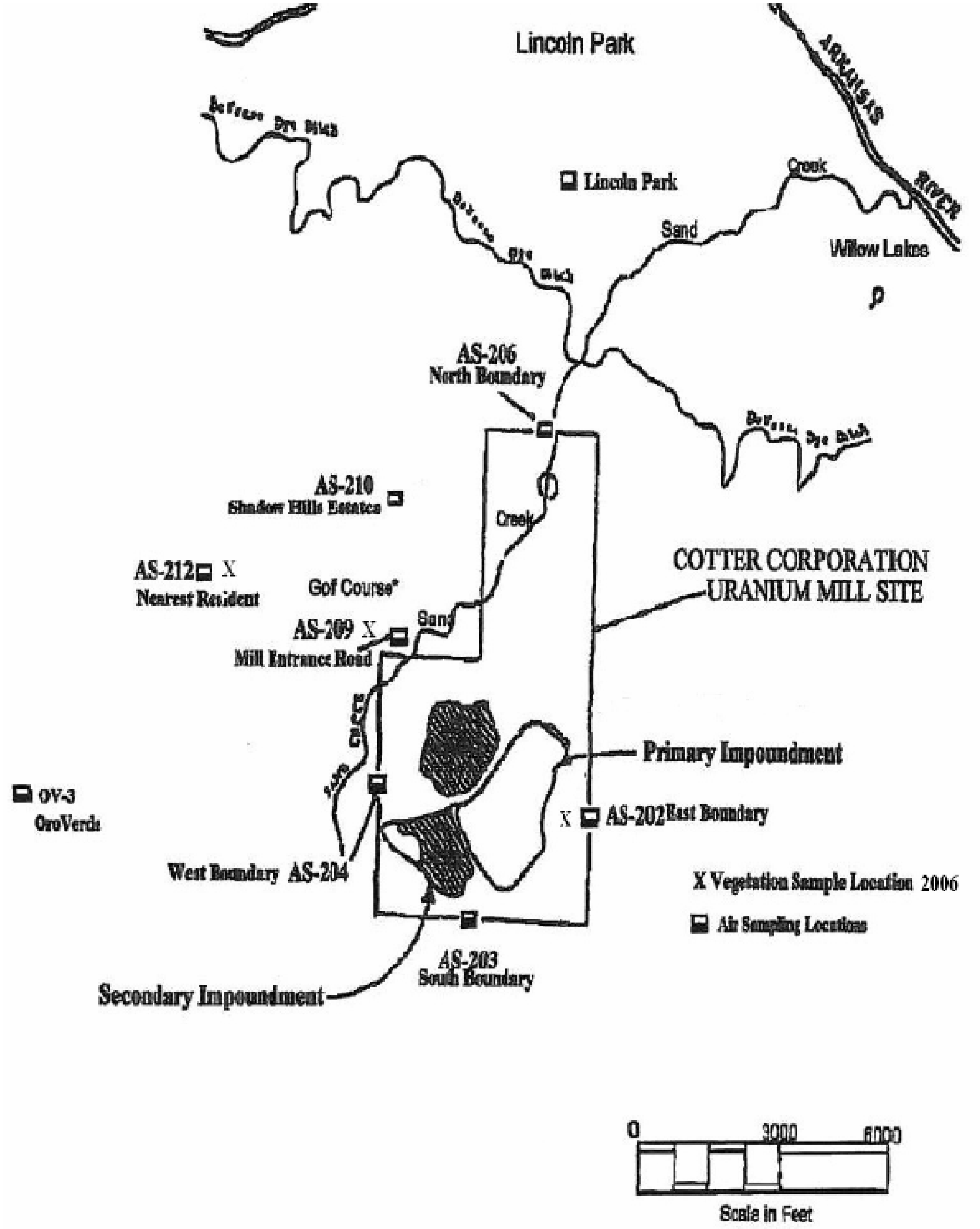
Source: MFG 2005

Figure 20. Locations of soil samples taken by CDPHE in January 2003



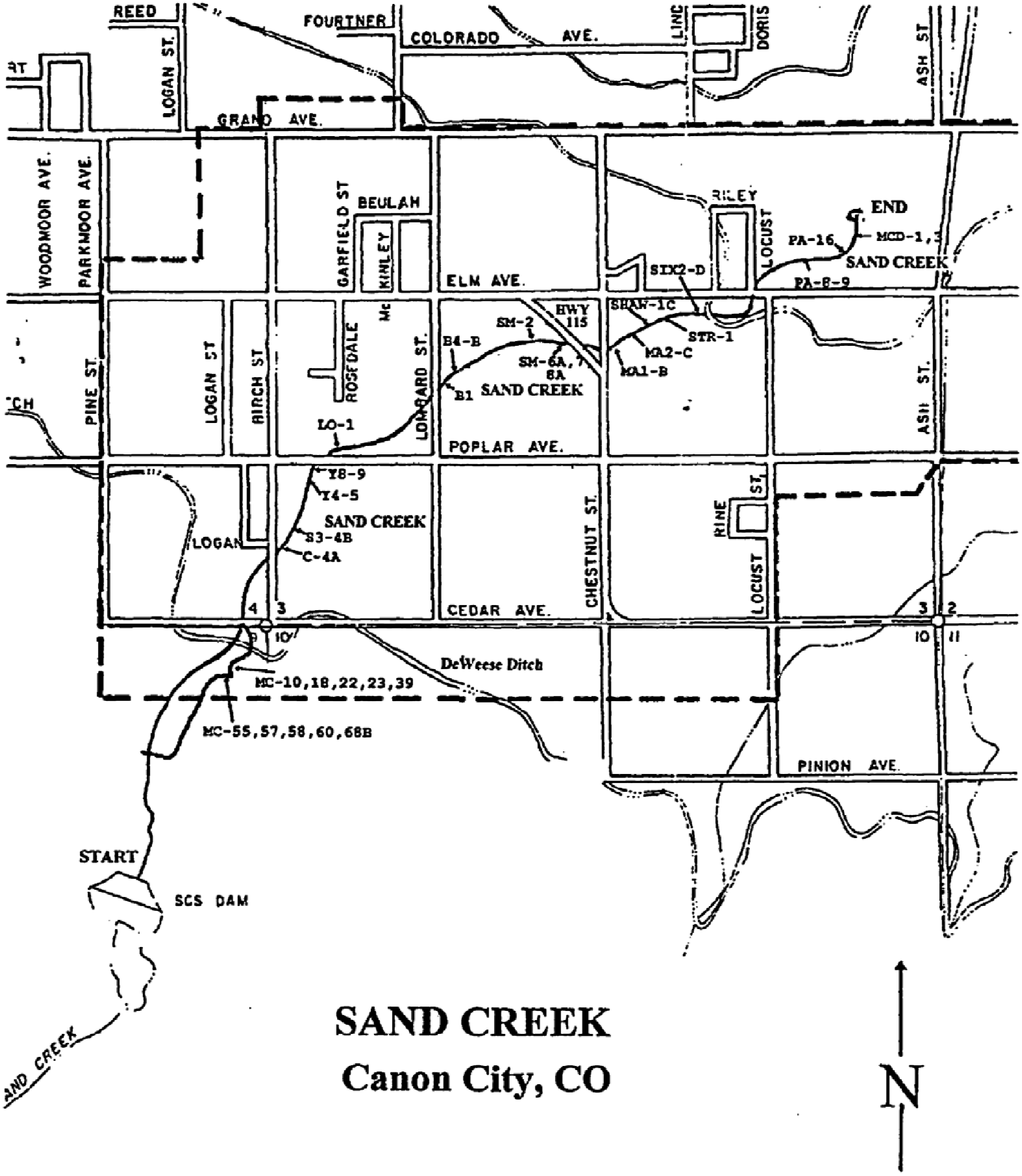
Source: CDPHE 2007b (coordinates)

Figure 21. Location of air sampling locations where soil samples are collected



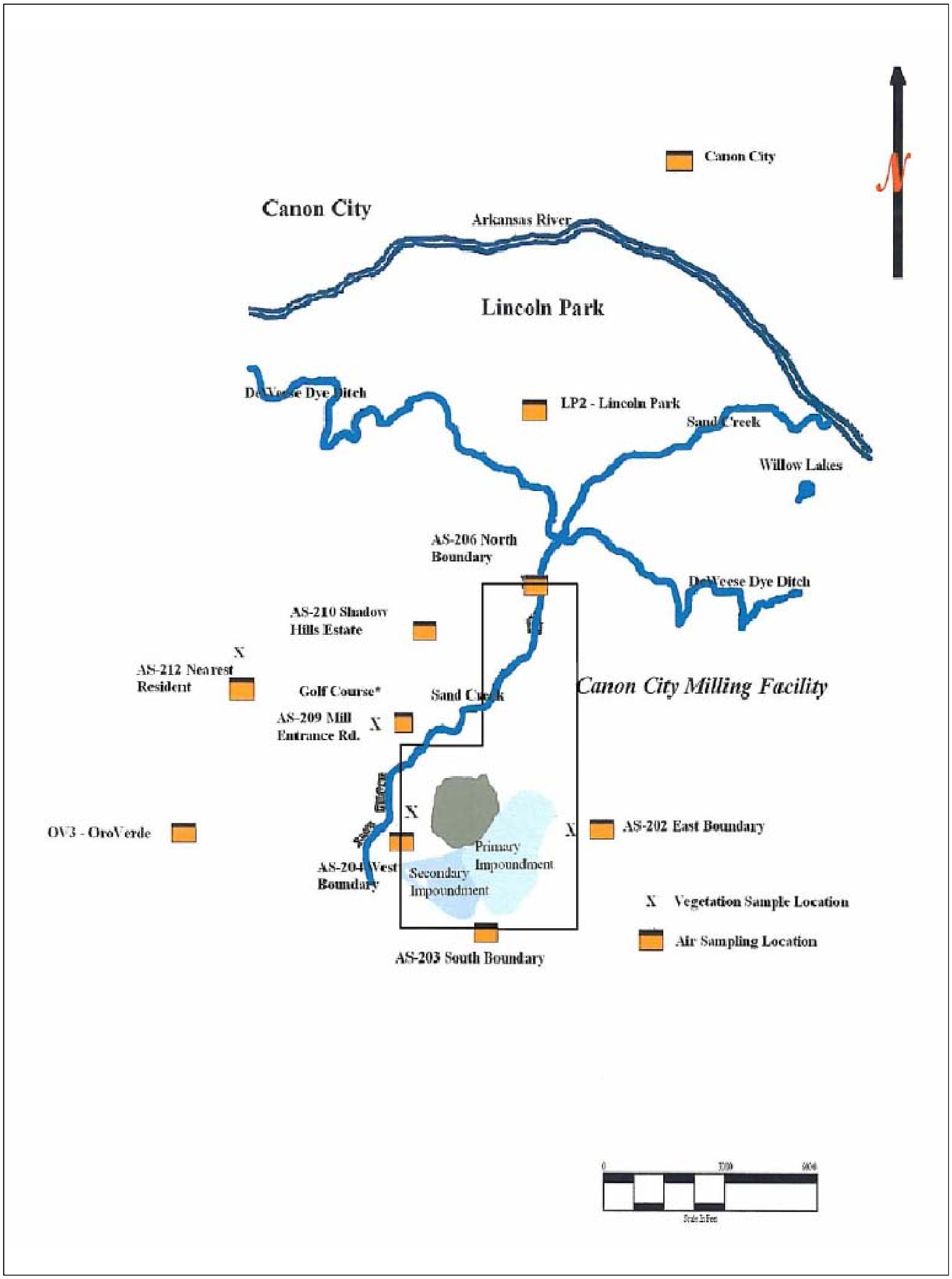
Source: Cotter 2007
Note: An additional air sampling station is located in Cañon City (not depicted on the figure).

Figure 22. Sand Creek Cleanup Project



Source: Cotter 2000

Figure 23. Approximate Locations of Cotter Mill Monitoring Stations



Notes: Figure reproduced from: Cotter 2008

APPENDIX C:
ATSDR's Evaluation Process
And
Exposure Dose Calculations

ATSDR's Evaluation Process

Step 1 – Comparison Values and the Screening Process

To evaluate the available data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are the contaminant concentrations found in a specific media (for example: air, soil, or water) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water, or soil that someone may inhale or ingest each day. CVs are generated to be conservative and non-site specific. These values are used only to screen out chemicals that do not need further evaluation; CVs are not intended as environmental clean-up levels or to indicate that health effects occur at concentrations that exceed these values.

CVs can be based on either carcinogenic (cancer-causing) or non-carcinogenic effects. Cancer-based comparison values are calculated from the U.S. Environmental Protection Agency's (EPA) oral cancer slope factor (CSF) or inhalation risk unit. CVs based on cancerous effects account for a lifetime exposure (70 years) with an unacceptable theoretical excess lifetime cancer risk of 1 new case per 1 million exposed people. Non-cancer values are calculated from ATSDR's Minimal Risk Levels (MRLs), EPA's Reference Doses (RfDs), or EPA's Reference Concentrations (RfCs). When a cancer and non-cancer CV exists for the same chemical, the lower of these values is used in the comparison for conservatism.

Step 2 – Evaluation of Public Health Implications

The next step in the evaluation process is to take those contaminants that are above their respective CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Separate child and adult exposure doses (or the amount of a contaminant that gets into a person's body) are calculated for site-specific exposure scenarios, using assumptions regarding an individual's likelihood of accessing the site and contacting contamination. A brief explanation of the calculation of estimated exposure doses is presented below. Calculated doses are reported in units of milligrams per kilograms per day (mg/kg/day). Separate calculations have been performed to account for non-cancer and cancer health effects, if applicable, for each chemical based on the health impacts reported for each chemical. Some chemicals are associated with non-cancer effects while the scientific literature many indicate that cancer-related health impacts are not expected from exposure.

Exposure Dose Factors and Calculations

When chemical concentrations at the site exceed the established CVs, it is necessary for a more thorough evaluation of the chemical to be conducted. In order to evaluate the potential for human exposure to contaminants present at the site and potential health effects from site-specific activities, ATSDR estimates human exposure to the site contaminant from different environmental media by calculating exposure doses.

A discussion of the calculations and assumptions used in this assessment is presented below. The equations are based on the EPA Risk Assessment Guidance for Superfund, Part A (1989), or ATSDR's Public Health Guidance Manual (2005), unless otherwise specified. Assumptions used were based on default values, EPA's Exposure Assessment Handbook (1997) or Child-Specific Exposure Factors Handbook (2008), or professional (site-specific) judgment. When available, site-specific information is used to estimate exposures.

Ingestion of Chemicals in Well Water:

The exposure dose formula used for the ingestion of chemicals in well water is:

$$\text{Exposure Dose (ED)} = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= concentration of contaminant in water in milligrams per liter (mg/L)*
IR *= ingestion rate in liters per day (L/day)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
BW *= body weight (kg)*
AT *= averaging time, days (equal to ED for non-carcinogens and 70 year lifetime for carcinogens, i.e., 70 years x 365 days/year)*

Note: In the intake equation, averaging time (AT) for exposure to non-carcinogenic compounds is always equal to ED; whereas, for carcinogens a 70 year AT is still used in order to compare to EPA's cancer slope factors typically based on that value.

This pathway assumes that an adult resident drinks 2 liters (L) of water per day for 350 days per year. In terms of exposure duration (ED), the adult resident is assumed to live in the same home and drink the same well water for 30 years. The drinking water ingestion rate for children was assumed to be 1 L per day for 350 days per year for 6 years. For average body weight, 70 kg and 16 kg were used for adults and children, respectively.

ATSDR used the average chemical concentration in Well 186 to represent a high exposure scenario from a single well. Well 186 was selected because it consistently contained the highest chemical concentrations over time. The average concentration for all private wells was used to represent exposures to a typical well user.

Table C1. Summary of Exposure Factors and Exposure Doses for the Drinking Water Pathway for Chemicals at the Cotter Mill Site

Chemical	Chemical Concentration (mg/L)	Daily Ingestion Rate (L/day)	Exposure Frequency (days/yr)	Exposure Duration (yrs)	Body Weight (kg)	Averaging Time (days)	Exposure Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Drinking Water Pathway: Ingestion – ADULT and CHILD								
Molybdenum ADULT	0.16 *WELL 189** HIGH EXPOSURE	2	350	30	70	10950	0.004	0.005 Chronic Oral RfD
Molybdenum CHILD		1	350	6	16	2190	**0.010**	
Molybdenum ADULT	0.082 All wells TYPICAL EXPOSURE	2	350	30	70	10950	0.002	
Molybdenum CHILD		1	350	6	16	2190	0.005	
Uranium ADULT	0.048 Well 189* HIGH EXPOSURE	2	350	30	70	10950	0.001	0.002 Intermediate Oral MRL
Uranium CHILD		1	350	6	16	2190	**0.003**	
Uranium ADULT	0.028 All wells TYPICAL EXPOSURE	2	350	30	70	10950	0.0008	
Uranium CHILD		1	350	6	16	2190	0.002	

Bolded type exceeds a comparison value.
* "Well 189" represents a high exposure scenario. This well contained the highest level of chemicals in the sampled group.
"All wells" is used to represent an average exposure scenario for the average private well drinker.

Accidental Ingestion of Chemicals in Soil

The exposure dose formula for incidental ingestion of chemicals soil and/or sediment is:

$$\text{Exposure Dose (ED)} = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= concentration of contaminant in soil in milligrams per kilogram (mg/kg or ppm)*
IR *= ingestion rate in milligrams per day (mg/day)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
CF *= conversion factor (10^{-6} kg/mg)*
BW *= body weight (kg)*
AT *= averaging time, days (equal to ED for non-carcinogens and 70 year lifetime for carcinogens, i.e., 70 years x 365 days/year)*

This pathway assumes that the average adolescent (11 to 16 years of age) or adult resident accidentally ingests 100 milligrams of soil per day. Because the area is in a primarily vacant "buffer zone" between the Cotter Mill and residential homes, ATSDR assumed that very young children would not access the area. Adolescent and adults would access the site infrequently. Therefore, exposure duration (ED) for an adolescent and adult resident was assumed to be 2 days per week (or 104 days/year) for 30 years. For average body weight, 57 kg was used for an adolescent and70 kg was used for an adult.

In this evaluation, the bioavailability from incidental ingestion of arsenic in soil was assumed to be 80% because it is protective of health. Cadmium was assumed to be 100% bioavailable, which is also conservative but protective of health.

Direct Skin (Dermal) Contact with Chemicals in Soil

Dermal absorption of chemicals from soil depends on the area of contact with exposed skin, the duration of contact, the chemical and physical attraction between the contaminant and soil, the ability of the chemical to penetrate the skin, and other factors.

The exposure dose formula for dermal absorption of chemicals soil and/or sediment is:

$$\text{Exposure Dose (ED)} = \frac{C \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

Where:

ED *= exposure dose in milligrams per kilogram per day (mg/kg/day)*
C *= chemical concentration (mg/kg)*
SA *= surface area exposed (square centimeters/day or cm^2/day)*

AF *= soil to skin adherence factor (milligrams per square centimeters or mg/cm^2)*
ABS *= Absorption factor (unitless)*
EF *= exposure frequency (days/year)*
ED *= exposure duration (years)*
CF *= conversion factor (10^{-6} kg/mg)*
BW *= body weight (kg)*
AT *= averaging time (days)*

Note: Absorption factors (ABS) are used to reflect the desorption of the chemical from soil and the absorption of the chemical across the skin and into the bloodstream.

For the dermal contact pathway, ATSDR assumed that the surface area available in an adolescent for direct skin contact is 4,300 cubic centimeters per day (cm^2/day); the surface area available in an adult is 5,000 cm^2/day. An adherence factor of 0.07 milligrams per cubic centimeter (mg/cm^3) was used. An absorption factor of 0.03 was used for arsenic and 0.01 was used for cadmium. Individuals were assumed to weigh 57 kg as an adolescent and 70 kg as an adult, and to be exposed for 6 and 30 years, respectively.

The total soil oral and dermal non-carcinogenic dose was estimated as follows:

Total Dose (TD) = ***ID + DD***

Where:

TD *= total soil ingestion and dermal non-carcinogenic dose*
ID *= Soil ingestion non-carcinogenic dose (mg/kg/day)*
DD*= Soil dermal non-carcinogenic dose (mg/kg/day)*

Cancer Risk Estimates

EPA classifies arsenic as a Class A known human carcinogen by the oral and inhalation routes. Cadmium is classified by EPA as a probable human carcinogen, but only via the inhalation route of exposure. Therefore, only arsenic is evaluated for its carcinogenic risk.

The Lifetime Estimated Cancer Risk for arsenic is estimated as follows:

LECR = ***TDs x CSF x EF***

Where:

LECR *= lifetime estimated cancer risk*
TDs *= total soil oral and dermal non-carcinogenic dose (mg/kg/day)*
CSF *= cancer slope factor ((mg/kg-day)$^{-1}$)*
EF *= Exposure factor (unitless) = exposure duration / lifetime = (30 years) / (70 years) = 0.4*

The cancer slope factor for arsenic is 1.5 mg/kg-day. Therefore, the LECR is 1.2 x 10^{-5}.

Table C2. Summary of Exposure Factors and Exposure Doses for the Soil Exposure Pathway for Chemicals at the Cotter Mill Site

Chemical	Chemical Concentration (mg/kg)	Daily Intake Rate (mg/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Body Weight (kg)	Averaging Time (days)	Exposure Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Soil Exposure Pathway: Accidental Ingestion and Direct Skin Contact - ADULT and ADOLESCENT								
Arsenic (ingestion)	45	100	104	30	70	10950	0.00002	0.0003 MRL
Arsenic (dermal)		NA	104	30	70	10950	0.000002	
TOTAL DOSE ARSENIC - Adult							0.00002	*Below Guideline*
Cadmium (ingestion)	37	100	104	30	70	10950	0.00002	0.0001 MRL
Cadmium (dermal)		NA	104	30	70	10950	0.0000005	
TOTAL DOSE CADMIUM -Adult							0.00002	*Below Guideline*
Arsenic (ingestion)	45	100	104	6	54	2190	0.00002	0.0003 MRL
Arsenic (dermal)		NA	104	6	54	2190	0.000002	
TOTAL DOSE ARSENIC - Adolescent							0.00002	*Below Guideline*
Cadmium (ingestion)	37	100	104	6	54	2190	0.00002	0.0001 MRL
Cadmium (dermal)		NA	104	6	54	2190	0.0000006	
TOTAL DOSE CADMIUM - Adolescent							0.00002	*Below Guideline*

Incidental Ingestion of Chemicals in Surface Water

The ATSDR exposure dose formula used for the ingestion of chemicals in surface water while wading or swimming is:

$$\text{Exposure Dose (ED)} = \frac{C \times IR \times ET \times EF \times ED}{BW \times AT}$$

Where:

***ED** = exposure dose in milligrams per kilogram per day (mg/kg/day)*
***C** = concentration of contaminant in water in milligrams per liter (mg/L)*
***IR** = ingestion rate in liters per day (L/day); based on contact rate of 50 ml/hr*
***ET** = exposure time (hours/event)*
***EF** = exposure frequency (events/year)*
***ED** = exposure duration (years)*
***BW** = body weight (kg)*
***AT** = averaging time, days (equal to ED for non-carcinogens and 70 year lifetime for carcinogens, i.e., 70 years x 365 days/year)*

This pathway assumes that adult and children residents would accidentally swallow 50 milliliters of water per hour while swimming, wading or recreating in Sand Creek or the DeWeese Dye Ditch. In terms of exposure time and frequency, ATSDR conservatively assumed an adult and child resident would recreate in these waters for 2 hours per day, 2 days per week (or 104 days/year) for 30 years and 6 years, respectively. For average body weight, 70 kg and 16 kg were used for adults and children, respectively.

Direct Skin (Dermal) Contact with Chemicals in Surface Water

ATSDR's exposure dose formula for dermal absorption of chemicals soil and/or sediment is:

$$\text{Exposure Dose (ED)} = \frac{C \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

Where:

***ED** = exposure dose in milligrams per kilogram per day (mg/kg/day)*
***C** = chemical concentration (mg/L)*
***SA** = surface area exposed (cm^2)*
***PC** = chemical-specific dermal permeability constant (cm/hr)*
***ET** = exposure time (hours/day)*
***EF** = exposure frequency (days/year)*
***ED** = exposure duration (years)*
***CF** = volumetric conversion factor for water (1L/1000 cm^3)*
***BW** = body weight (kg)*
***AT** = averaging time (days)*

The dermal contact pathway assumes that the total body surface area available for contact with water is 20,000 cm^2 for adults and 9,300 cm^2 for children. Adults were assumed to weigh 70 kg and to be exposed for 30 years. Children were assumed to weigh 16 kg and to be exposed for 6 years. Adults and children were conservatively assumed to swim in the contaminated water 2 days per week (104 days per year) for 2 hours per recreating event. A dermal permeability constant of 0.001 cm/hr was used for both manganese and molybdenum.

Table C3. Summary of Exposure Factors and Exposure Doses for the Surface Water Pathway for Chemicals at the Cotter Mill Site

Chemical	Chemical Concentration (mg/L)	Daily Ingestion Rate (L/day)	Exposure Frequency (days/yr)	Exposure Duration (yrs)	Body Weight (kg)	Averaging Time (days)	Exposure Dose (mg/kg/day)	Health Guideline (mg/kg/day)
Surface Water Exposure Pathway: Accidental Ingestion and Direct Skin Contact while Wading or Swimming – ADULT and CHILD								
Manganese* Adult Ingestion	1.9	0.1	104	30	70	10950	3.9 x 10^{-4}	0.05 Chronic Oral RfD
Manganese Adult Dermal		NA	104	30	70	10950	3.1 x 10^{-4}	
		TOTAL DOSE MANGANESE – Adult					7 x 10^{-4}	*Below Guideline*
Manganese Child Ingestion		0.1	104	6	16	2190	1.7 x 10^{-3}	0.05 Chronic Oral RfD
Manganese Child Dermal		NA	104	6	16	2190	6.3 x 10^{-4}	
		TOTAL DOSE MANGANESE - Child					2.3 x 10^{-3}	*Below Guideline*
Molybdenum† Adult Ingestion	0.051	0.1	104	30	70	10950	1.0 x 10^{-5}	0.005 Chronic Oral RfD
Molybdenum Adult Dermal		NA	104	30	70	10950	8.3 x 10^{-6}	
		TOTAL DOSE MOLYBDENUM - Adult					1.8 x 10^{-5}	*Below Guideline*
Molybdenum Child Ingestion		0.1	104	6	16	2190	4.5 x 10^{-5}	0.005 Chronic Oral RfD
Molybdenum Child Dermal		NA	104	6	16	2190	1.7 x 10^{-5}	
		TOTAL DOSE MOLYBDENUM - Child					6.2 x 10^{-5}	*Below Guideline*

*Maximum concentration of manganese in surface water detected in DeWeese Dye Ditch

†Maximum concentration of molybdenum in surface water detected in Sand Creek

Consumption of Homegrown Fruits and Vegetables

The following formula presents the method for calculating an exposure dose for a typical consumer of homegrown fruits and vegetables:

$$\text{Exposure Dose (mg/kg/day)} = \mathbf{C \times IR \times CF}$$

Where:

C *= contaminant concentration (mg/kg)*
IR *= intake rate of fruit or vegetable (g/kg/day)*
CF *= conversion factor (*1×10^{-3} *kg/mg)*

Exposure doses for ingestion of garden vegetables were calculated using the average detected concentration of each contaminant measured in fruit and vegetable samples, in mg/kg, multiplied by average consumption rates of homegrown fruits or vegetables in grams per kilogram of body weight per day (g/kg/day). Intake rates were taken from EPA’s Exposure Factors Handbook for adults, and EPA’s Child-Specific Exposure Factors Handbook for children, for the Western United States. The average consumption rate was used to represent a “typical” fruit and vegetable consumer. The 95 percentile consumption rate was used to represent an “above average” consumer of fruits and vegetables. The calculated value was multiplied by a conversion factor of 0.001 kilograms per gram.

Table C4. Summary of Exposure Doses for Local Fruits and Vegetables Irrigated with Contaminated Well Water

Chemical	Chemical Concentration/ Exposure Group	Exposure Dose Fruits (mg/kg/day)	Exposure Dose Vegetables (mg/kg/day)	Health Guideline (mg/kg/day)
Arsenic	Average consumer	0.0001	0.0001	0.0003, Chronic Oral MRL
	Above Average Consumer	0.0006	0.0005	
	Child	0.0002	0.0002	
	Infant	0.0004	0.0004	
Barium	Average consumer	0.001	0.003	0.2 Chronic Oral MRL
	Above Average Consumer	0.005	0.010	
	Child	0.002	0.004	
	Infant	0.004	0.008	
Cadmium	Average consumer	0.0001	0.0001	0.001, RfD
	Above Average Consumer	0.0005	0.0002	
	Child	0.0002	0.0001	
	Infant	0.0004	0.0002	
Chromium	Average consumer	0.0001	0.0001	1.5 RfD
	Above Average Consumer	0.0006	0.0003	
	Child	0.0002	0.0001	
	Infant	0.0005	0.0003	
Cobalt	Average consumer	ND	0.00004	0.01 Intermediate MRL
	Above Average Consumer	ND	0.00012	
	Child	ND	0.00005	
	Infant	ND	0.0001	
Lead	Average consumer	0.0003	0.0004	NA
	Above Average Consumer	0.001	0.001	
	Child	0.0005	0.0005	
	Infant	0.001	0.001	
Manganese	Average consumer	0.002	0.004	0.14 RfD
	Above Average Consumer	0.01	0.02	
	Child	0.004	0.006	
	Infant	0.008	0.01	
Molybdenum	Average consumer	0.0003	0.001	0.005 RfD
	Above Average Consumer	0.001	0.004	

Chemical	Chemical Concentration/ Exposure Group	Exposure Dose Fruits (mg/kg/day)	Exposure Dose Vegetables (mg/kg/day)	Health Guideline (mg/kg/day)
	Child	0.0005	0.002	
	Infant	0.001	0.004	
Nickel	Average consumer	ND	0.0001	0.02 RfD
	Above Average Consumer	ND	0.0005	
	Child	ND	0.0002	
	Infant	ND	0.0004	
Strontium	Average consumer	0.004	0.009	0.6 RfD
	Above Average Consumer	0.02	0.03	
	Child	0.007	0.01	
	Infant	0.01	0.03	
Uranium	Average consumer	0.00002	0.00001	0.002 Intermediate MRL
	Above Average Consumer	0.00008	0.00004	
	Child	0.00003	0.00002	
	Infant	0.00006	0.00004	
Vanadium	Average consumer	ND	0.00008	0.003 Intermediate MRL
	Above Average Consumer	ND	0.0003	
	Child	ND	0.0001	
	Infant	ND	0.0002	
Zinc	Average consumer	0.004	0.006	0.3 Chronic Oral MRL
	Above Average Consumer	0.02	0.02	
	Child	0.006	0.008	
	Infant	0.01	0.02	

Bolded text exceeds a health guideline.
ND = not detected
NA = not available

ATSDR's Evaluation of Cancer and Non-Cancer Health Effects

Non-Cancer Health Effects

The doses calculated for exposure to each individual chemical are compared to an established health guideline, such as a MRL or RfD, in order to assess whether adverse health impacts from exposure are expected. These health guidelines, developed by ATSDR and EPA, are chemical-specific values that are based on the available scientific literature and are considered protective of human health. Non-carcinogenic effects, unlike carcinogenic effects, are believed to have a threshold, that is, a dose below which adverse health effects will not occur. As a result, the current practice for deriving health guidelines is to identify, usually from animal toxicology experiments, a No Observed Adverse Effect Level (or NOAEL), which indicates that no effects are observed at a particular exposure level. This is the experimental exposure level in animals (and sometimes humans) at which no adverse toxic effect is observed. The NOAEL is then modified with an uncertainty (or safety) factor, which reflects the degree of uncertainty that exists when experimental animal data are extrapolated to the general human population. The magnitude of the uncertainty factor considers various factors such as sensitive subpopulations (for example; children, pregnant women, and the elderly), extrapolation from animals to humans, and the completeness of available data. Thus, exposure doses at or below the established health guideline are not expected to result in adverse health effects because these values are much lower (and more human health protective) than doses, which do not cause adverse health effects in laboratory animal studies. For non-cancer health effects, the following health guidelines are described below in more detail. It is important to consider that the methodology used to develop these health guidelines does not provide any information on the presence, absence, or level of cancer risk. Therefore, a separate cancer evaluation is necessary for potentially cancer-causing chemicals detected in samples at this site. A more detailed discussion of the evaluation of cancer risks is presented in the following section.

Minimal Risk Levels (MRLs) – developed by ATSDR

ATSDR has developed MRLs for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily exposure to a contaminant below which non-cancer, adverse health effects are unlikely to occur. MRLs are developed for different routes of exposure, such as inhalation and ingestion, and for lengths of exposure, such as acute (less than 14 days), intermediate (15-364 days), and chronic (365 days or greater). At this time, ATSDR has not developed MRLs for dermal exposure. A complete list of the available MRLs can be found at http://www.atsdr.cdc.gov/mrls.html.

References Doses (RfDs) – developed by EPA

An estimate of the daily, lifetime exposure of human populations to a possible hazard that is not likely to cause non-cancerous health effects. RfDs consider exposures to sensitive sub-populations, such as the elderly, children, and the developing fetus. EPA RfDs have been developed using information from the available scientific literature and have been calculated for oral and inhalation exposures. A complete list of the available RfDs can be found at http://www.epa.gov/iris.

If the estimated exposure dose for a chemical is less than the health guideline value, the exposure is unlikely to result in non-cancer health effects. Non-cancer health effects from dermal exposure were evaluated slightly differently that ingestion and inhalation exposure. Since health guidelines are not available for dermal exposure, the calculated dermal dose was compared with the oral health guideline value (RfD or MRL).

If the calculated exposure dose is greater than the health guideline, the exposure dose is compared to known toxicological values for the particular chemical and is discussed in more detail in the text of the PHA. The known toxicological values are doses derived from human and animal studies that are presented in the ATSDR Toxicological Profiles and EPA's Integrated Information System (IRIS). A direct comparison of site-specific exposure doses to study-derived exposures and doses found to cause adverse health effects is the basis for deciding whether health effects are likely to occur. This in-depth evaluation is performed by comparing calculated exposure doses with known toxicological values, such as the no-observed adverse-effect-level (NOAEL) and the lowest-observed-adverse-effect-level (LOAEL) from studies used to derive the MRL or RfD for a chemical.

Cancer Risks

Exposure to a cancer-causing compound, even at low concentrations, is assumed to be associated with some increased risk for evaluation purposes. The estimated excess risk of developing cancer from exposure to contaminants associated with the site was calculated by multiplying the site-specific adult exposure doses, with a slight modification, by EPA's chemical-specific Cancer Slope Factors (CSFs or cancer potency estimates), which are available at http://www.epa.gov/iris. Calculated dermal doses were compared with the oral CSFs.

An increased excess lifetime cancer risk is not a specific estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime during his or her lifetime following exposure to a particular contaminant. Therefore, the cancer risk calculation incorporates the equations and parameters (including the exposure duration and frequency) used to calculate the dose estimates, but the estimated value is divided by 25,550 days (or the averaging time), which is equal to a lifetime of exposure (70 years) for 365 days/year.

There are varying suggestions among the scientific community regarding an acceptable excess lifetime cancer risk, due to the uncertainties regarding the mechanism of cancer. The recommendations of many scientists and EPA have been in the risk range of 1 in 1 million to 1 in 10,000 (as referred to as 1×10^{-6} to 1×10^{-4}) excess cancer cases. An increased lifetime cancer risk of one in one million or less is generally considered an insignificant increase in cancer risk. Cancer risk less than 1 in 10,000 (or 1×10^{-5}) are not typically considered a health concern. An important consideration when determining cancer risk estimates is that the risk calculations incorporate several very conservative assumptions that are expected to overestimate actual exposure scenarios. For example, the method used to calculate EPA's CSFs assumes that high-dose animal data can be used to estimate the risk for low dose exposures in humans. As previously stated, the method also assumes that there is no safe level for exposure. Lastly, the method computes the 95% upper bound for the risk, rather than the average risk, suggesting that the cancer risk is actually lower, perhaps by several orders of magnitude.

Because of the uncertainties involved with estimating carcinogenic risk, ATSDR employs a weight-of-evidence approach in evaluating all relevant data. Therefore, the carcinogenic risk is also described in words (qualitatively) rather than giving a numerical risk estimate only. The numerical risk estimate must be considered in the context of the variables and assumptions involved in their derivation and in the broader context of biomedical opinion, host factors, and actual exposure conditions. The actual parameters of environmental exposures have been given careful and thorough consideration in evaluating the assumptions and variables relating to both toxicity and exposure. A complete review of the toxicological data regarding the doses associated with the production of cancer and the site-specific doses for the site is an important element in determining the likelihood of exposed individuals being at a greater risk for cancer.

Appendix D. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-800-CDC-INFO (1-800-232-4636).

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems

Aerobic
Requiring oxygen [compare with anaerobic].

Ambient
Surrounding (for example, ambient air).

Anaerobic
Requiring the absence of oxygen [compare with aerobic].

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect
A biologic response to exposure to multiple substances that is less than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study
A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP [see Community Assistance Panel.]

Cancer
Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic
Occurring over a long time [compare with acute].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people from a community and from health and environmental agencies who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause

harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect
A disease or an injury that happens as a result of exposures that might have occurred in the past.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention
Measures used to prevent a disease or reduce its severity.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD
United States Department of Defense.

DOE
United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

EPA
United States Environmental Protection Agency.

Epidemiologic surveillance [see Public health surveillance].

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often

and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Exposure registry
A system of ongoing followup of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Half-life (t½)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to evaluate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR’s public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual’s exposure could negatively affect that person’s health.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period

(acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, a condition, or an injury) is stated.

Mutagen
A substance that causes mutations (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

National Toxicology Program (NTP)
Part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public availability session
An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public health surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD [see reference dose]

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or an environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Substance-specific applied research
A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR’s toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)]

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Surveillance [see public health surveillance]

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen
A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people’s sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Urgent public health hazard
A category used in ATSDR’s public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other glossaries and dictionaries:
Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)
National Library of Medicine (NIH)
(http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

EPA-1846

Reid Rosnick/DC/USEPA/US
10/03/2010 12:43 PM

To Beth Miller, Tom Peake
cc Glenna Shields
bcc
Subject Fw: Postings for Public Subpart W Website

Beth,

I checked the website this morning, and the information (below) I asked you to place on it is still not there. I will not be in the office until Tuesday, but the call is Tuesday morning, and I need this information on the website ASAP. Thanks

Glenna, in case Beth is not in the office on Monday, could you please have someone else on the staff place it on the site? Thanks

Reid

Reid J. Rosnick
Radiation Protection Division (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
202.343.9563
rosnick.reid@epa.gov

-----Forwarded by Reid Rosnick/DC/USEPA/US on 10/03/2010 12:39PM -----

To: Beth Miller/DC/USEPA/US@EPA, Marisa Savoy/DC/USEPA/US@EPA
From: Reid Rosnick/DC/USEPA/US
Date: 09/24/2010 09:39AM
Subject: Postings for Public Subpart W Website

Hi Guys,

I'm sending this to both of you because this way I should catch one of you on Monday. I have a few things that I'd like you to do on the Subpart W public website...

1) Remove the section on Public Information Meetings, and the link on the Tuba City meeting.

2) In the section titled Conference Call Information, please place the following agenda for the 10/5/10 Conference Call:

(See attached file: 10 -5 -2010AGENDA.docx)

3) In the Documents section, under Current Action, please place the following document:

(See attached file: LincolnParkCotterUraniumMillPublicCommentPHA09092010.pdf)

Please call it *ATSDR Public Health Assessment for Lincoln Park/Cotter Uranium Mill.*

Thanks!!

Reid J. Rosnick
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1200 Pennsylvania Ave., NW
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- 10 -5 -2010AGENDA.docx -
LincolnParkCotterUraniumMillPublicCommentPHA09092010.pdf

EPA-2369

Reid Rosnick/DC/USEPA/US

10/07/2010 10:10 AM

To Beth Miller
cc
bcc
Subject Website

Reid J. Rosnick
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1200 Pennsylvania Ave., NW
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rosnick.reid@epa.gov SubWPublicConfCallNotes, 100510.docx 2010 Navajo Uranium Mills.ppt

Rosnick NMA 2010 Presentation.ppt Work_Plan 1-04_Revision_1.pdf

EPA'S
Clean Air Act Requirements: Uranium Mill Tailings Radon Emissions Rulemaking

Reid J. Rosnick
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Washington, DC 20460
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Presentation to
Uranium Contamination
Stakeholders Workshop
September 2010

Overview

- EPA regulatory requirements for operating uranium mill tailings (Subpart W)
- Status update on Subpart W activities
- Outreach/Communications

EPA Regulatory Requirements for Operating Uranium Mill Tailings (Clean Air Act)

- 40 CFR 61 Subpart W requirements apply to facilities licensed to manage uranium byproduct materials during and following the processing of uranium ores
- Limit on number/size of impoundments
  - Phased Disposal – lined impoundments no more than 40 acres, no more than two in operation at any time
  - Continuous Disposal – tailings are dewatered and immediately disposed, no more than 10 acres uncovered at any time

EPA Regulatory Requirements for Uranium Operations (Clean Air Act)

Subpart W Requirements (continued)

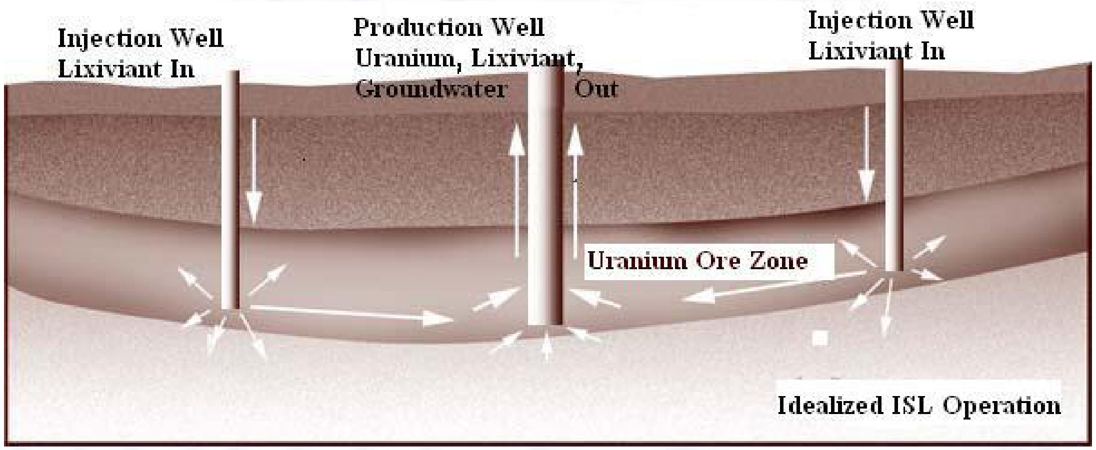
- Radon emission standard of 20 pCi/m^2/sec -- annual reporting requirements, notification in advance of testing
- The radon emission standard is for existing sources only (existing before 12/15/89)
- See http://www.epa.gov/radiation/neshaps/subpartw/index.html for more information

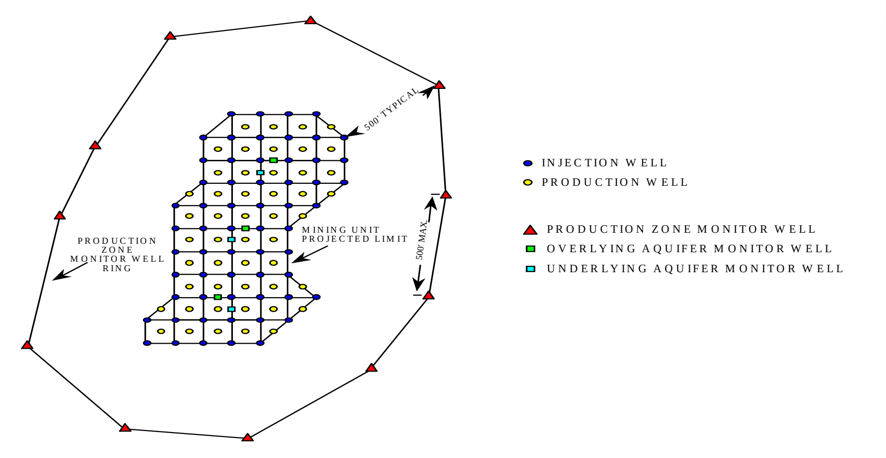
Uranium Recovery Methods

Surface Mill

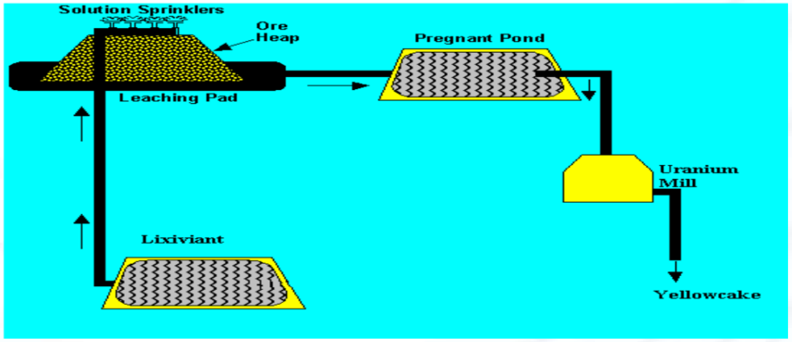
Rio Algom Ambrosia Lake mill, New Mexico, USA (1958-1985)

In Situ Leach (ISL)





Heap Leach



Uranium Mill Tailings In-Situ Leach Impoundments

Status Update on Subpart W Activities

Status of Subpart W Review Activities

- We conducted historical research on the risk assessment work originally done in support of the 1989 standard
- We completed a survey of existing technologies
- We requested that ISL facilities provide radon flux data from their evaporation ponds
- We are now in the process of performing new risk assessments at existing uranium mills and ISL facilities

Communications Plan

- EPA is committed to maintaining an open and transparent rulemaking process
- Objectives:
  - Inform stakeholders of potential changes in EPA's Subpart W requirements
  - Give stakeholders an opportunity to provide feedback
- Audiences:
  - Tribes
  - States
  - Offices/Regions within EPA
  - Other Federal Agencies: NRC, DOE, BLM, others
  - Mining companies

Communications Plan

- Strategies:
  - Develop clear messages and materials to explain the potential amendments to Subpart W
  - Educate stakeholders by using communications tools to provide easy-access to information
  - Work with stakeholder representatives and EPA regional staff to identify additional audiences and methods of dissemination
  - Communicate a timely and consistent message to stakeholders (Industry, Public, Tribes, States, other government agencies)

Outreach

- Holding stakeholder meetings to inform and receive input
  - Cañon City, CO – June 2009
  - Rapid City, SD – October 2009
  - Gallup, NM – November 2009
  - White Mesa, UT – May 2010
  - Denver, CO – May 2010
  - Tuba City, AZ – September 2010

Outreach

- National webinar held June 2010
- Established a dedicated web site to act as an information outlet
- http://www.epa.gov/radiation/neshaps/subpartw/rulemaking-activity.html
- Site contains current and historical rulemaking documents, presentations, contact information, useful links

Outreach

- Quarterly conference calls to answer stakeholder questions
- Next call – October 5, 2010 – 11:00 AM EDT
- Call in number is 1-866-299-3188. You will be prompted for a conference code, which will be 2023439563. After entering the conference code press the # key and you will then be placed into the conference call
- Public participation by e-mail:
  - subpartw@epa.gov

Questions?

Approvals	
Work Assignment Manager	Date
Project Officer	Date

WORK PLAN, REVISION 1

Risk Assessment Revision for 40 CFR Part 61 Subpart W - Radon Emissions from Operating Mill Tailings

Prepared by:

S. Cohen & Associates
1608 Spring Hill Road
Suite 400
Vienna, VA 22182

Under

Contract Number EP-D-10-042
Work Assignment No. 1-04

Prepared for:

U.S. Environmental Protection Agency
Office of Radiation and Indoor Air
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Brian Littleton
Work Assignment Manager

May 4, 2010

1.0 BACKGROUND AND OBJECTIVES

The Office of Radiation and Indoor Air (ORIA) promulgated a National Emission Standard for a Hazardous Air Pollutant (NESHAP) for radon emissions from operating uranium mill tailings impoundments (Subpart W) on 12/15/1989. Subpart W includes two separate standards. First, existing sources must ensure emissions from tailings impoundments not exceed 20 pCi/m2-sec of radon-222. Second, new sources must comply with the requirements for constructing one of two types of impoundment structures. Subpart W requires that existing sources file an annual report of the facility's emissions. Section 112(q) of the Clean Air Act, as amended (CAAA), requires EPA to review, and if appropriate, revise, this standard on a timely basis (10 year interval). The Agency has not reviewed this standard in the period allotted and now desires to do so.

The objective of this Work Assignment is to obtain the support of S. Cohen and Associates (SC&A) for the revision of the risk assessment for the National Emission Standards for Radionuclides from uranium mill tailing facilities. These facilities include mill tailing operations, in situ leach mining facilities, and potentially heap leach facilities. Specifically, SC&A will use its knowledge of these operational sites, and projections on potential future milling, in situ leach, and heap leach mining sites to revise the risks that were conducted in the final environmental impact statements conducted for this portion of the NESHAPs standard only. Risk assessments will be conducted for all existing facilities required to meet the Subpart W provisions, and SC&A will develop risk assessment scenarios for select representative future milling and mining operation sites. The information developed in this Work Assignment will be used by the Agency in the determination of whether the existing standards for Subpart W need revising, and, if so, what may represent reasonable revisions to the standard.

2.0 TASK DESCRIPTIONS AND APPROACH

SC&A will meet the objectives of this Work Plan by performing five distinct tasks, as described below. In meeting the requirements of this work assignment, SC&A will be in a support role, and will not be involved in the development of EPA policy, nor in any other activity that is an "inherently governmental function."

2.1 Task 1 – Prepare work plan and cost proposal

This Work Plan fulfills the deliverable requirements for Task 1. It presents SC&A's approach for accomplishing the Work Assignment, including a schedule of deliverables, staffing plan (with statements of experience), estimated labor hours, and a detailed cost proposal, with relevant ODCs, on a task-by-task basis. In developing the Work Plan, SC&A reviewed the original risk assessment material used to make the risk standard determination, included in the Final Environmental Impact Statement – NESHAPS for Radionuclides, Background Information Document - Volumes 1, 2, and 3 (EPA/520/1-89-005, EPA/520/1-89-006-1 & 2, and EPA/520/1-89-007, September 1989).

SC&A has reviewed the entire three-volume FEIS/BID. Volume 1 contains NESHAPS programmatic information that will not be revised or updated as part of this Work Assignment. SC&A has identified that Volume 2, Section 9 "Licensed Uranium Mill Tailings Facilities" and

Volume 3, Section 4 “Licensed Mill Tailings” are the main portions of the BID that are applicable to Subpart W. Most of the risk assessment information contained in Volume 2, Section 9 is also contained in Volume 3, Section 4. Volume 2, Appendix A contains the risk model data input sheets, which will be revised to reflect the risk model selected for use, as well as the sites to be analyzed. Volume 2, Appendix B contains the generic unit costs for earth cover-based radon control techniques, which will also be updated to reflect current cover designs (if different from the 1989 design) and current unit construction costs. All other sections of Volumes 2 and 3 address facilities other than operating uranium mills, and will not be revised or updated as part of the Work Assignment. Additional specifics on the FEIS revisions and updates are provided below under Task 4.

2.2 Task 2 – Prepare a Quality Assurance Project Plan and a Quality Assurance Report

SC&A’s QA Manager will prepare a brief Quality Assurance Project Plan (QAPP) and a Quality Assurance Report. The QAPP will include:

1. Two reviews of the deliverables listed in Tasks 4 and 5 to determine the reliability of the information provided in the two reports.
2. A QA appendix will be attached to each report from Task 4 and Task 5 which documents the verification activities performed by SC&A’s QA organization

The QAPP will be approved by SC&A’s QA Manager before any work begins on Task 4. The QAPP will be approved by the EPA WAM and EPA QA Coordinator.

The QA Report will include all required reviews to make the product meet Agency QA standards.

2.3 Task 3 – Risk Assessment Model

The FEIS/BID used AIRDOS to calculate dose and risk to the public. SC&A will review the appropriateness of using AIRDOS to calculate individual and population dose and risk. SC&A will also use our knowledge of existing models to determine if other models exist for calculating dose and risk from the management of uranium byproduct materials from the processing of uranium ores. Candidate models that will be evaluated by SC&A include:

- **CAP88**: The CAP88 (which stands for Clean Air Act Assessment Package - 1988) computer model is a set of computer programs, databases, and associated utility programs for estimation of dose and risk from radionuclide emissions to air. CAP88 is composed of modified versions of AIRDOS-EPA and DARTAB. CAP88-PC Version 3 incorporates dose and risk factors from Federal Guidance Report 13. CAP88-PC is an EPA-approved system for demonstrating compliance with 40 CFR 61 Subpart H, the Clean Air Act standard which applies to U.S. Department of Energy (DOE) facilities that emit radionuclides to air. EPA will provide the latest version of CAP88 to SC&A for evaluation; otherwise, SC&A will evaluate Revision 3, currently available from the EPA website: http://www.epa.gov/radiation/assessment/CAP88/.

- **GENII**: The GENII system, developed by the Pacific Northwest National Laboratory, includes the capabilities for calculating radiation doses following chronic and acute releases. Radionuclide transport via air, water, or biological activity may be considered. Air transport options include both puff and plume models. Building wake effects can be included in acute atmospheric release scenarios. The code provides risk estimates for health effects to individuals or populations; these can be obtained using the code by applying appropriate risk factors to the effective dose equivalent or organ dose. In addition, GENII Version 2 uses cancer risk factors from Federal Guidance Report 13 to estimate risk to specific organs or tissues.

- **RESRAD**: RESRAD is a computer model developed by Argonne National Laboratory to estimate radiation doses and risks from RESidual RADioactive materials. Since 1989, RESRAD has been used widely by the U.S. Department of Energy (DOE), its operations and area offices, and its contractors for deriving limits for radionuclides in soil. RESRAD has also been used by the U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers, U.S. Nuclear Regulatory Commission (NRC), industrial firms, universities, and foreign government agencies and institutions.

- **MILDOS-AREA**: The Argonne National Laboratory also developed MILDOS-AREA, a computer code that calculates the radiological dose commitments received by individuals and the general population within an 80-km radius of an operating uranium recovery facility. The transport of radiological emissions from point and different area sources is predicted with a sector-averaged Gaussian plume dispersion model. Mechanisms such as radioactive decay, plume depletion by deposition, in-growth of decay products, and resuspension of deposited radionuclides are included in the transport model. Alterations in operation throughout the facility's lifetime can be accounted for in the input stream. The exposure pathways considered are inhalation; external exposure from groundshine and cloud immersion; and ingestion of vegetables, meat, and milk. Dose commitments are calculated primarily on the basis of the recommendations of the International Commission on Radiological Protection (ICRP). Only airborne releases of radioactive materials are considered in MILDOS-AREA; releases to surface water and to groundwater are not addressed in MILDOS-AREA. MILDOS-AREA is a multi-purpose code that can be used to evaluate population doses for NEPA assessments, maximum individual doses for predictive 40 CFR 190 compliance evaluations, or maximum offsite air concentrations for predictive evaluations of 10 CFR 20 compliance.

- **MEPAS**: Multimedia Environmental Pollutant Assessment System (MEPAS), developed by the Pacific Northwest Laboratory (PNL), is a suite of integrated impact assessment software comprising physics-based fate and environmental transport models of air, soil, and water media. MEPAS simulates the release of contaminants from a source; transport through the air, groundwater, surface water, and/or overland pathways; and transfer through food chains and exposure pathways to the exposed individual or population. For human health impacts, risks are computed for carcinogens and hazard quotients for noncarcinogens.

- **AERMOD**: AERMOD was developed by the AERMIC (American Meteorological Society (AMS)/U.S. Environmental Protection Agency (EPA) Regulatory Model Improvement Committee), as a state-of-the-practice Gaussian plume dispersion model whose formulation is based on planetary boundary layer principles. The AERMOD model utilizes a probability density function and the superposition of several Gaussian plumes to characterize the distinctly non-Gaussian nature of the vertical pollutant distribution for elevated plumes during convective conditions; otherwise, the distribution is Gaussian. Also, nighttime urban boundary layers (and plumes within them) have the turbulence enhanced by AERMOD to simulate the influence of the urban heat island. The AERMOD model is applicable to rural and urban areas, flat and complex terrains, surface and elevated releases, and multiple sources (including, point, area, and volume sources).

Additional programs that may be discussed, but are not expected to make the formal evaluation process, include: GASPAR – used by the NRC to demonstrate compliance with the airborne dose limits of 10 CFR Part 50, Appendix I and GENII-NESHAPS – designed to help site managers plan and improve compliance with 40 CFR 61, Subparts H and I.

Before proceeding with the detailed evaluation a preliminary screening of the codes will be performed. The preliminary screening will eliminate codes that lack a major feature required for the analysis (e.g., the code does not calculate dose), as well as codes which may have the same or similar development histories. Those codes that pass the preliminary screening would be evaluated against a series of criteria, and given a score from 1 to 5. An initial list of the evaluation criteria include:

- **Exposure Pathways Modeled (2)**: Are all of the exposure pathways that are essential to this analysis included in the code? Additionally, does the code allow for exposures to different age groups (i.e., adults, teens, children, infants) and/or sexes to be calculated?
- **Dose Factors Used (1.75)**: Does the code utilize dose conversion factors based on the most recent International Commission on Radiological Protection (ICRP) recommendations?
- **Risk Factors Used (1.75)**: Does the code utilize the most recent risk factors?
- **Processing of Meteorological Data (1.5)**: Can the code process "raw" meteorological data, or does the meteorological data need to be pre-processed prior to being entered into the code? For example, does the code accept "raw" meteorological tower data (e.g., from http://www.epa.gov/scram001/surfacemetdata.htm), or does it accept joint frequency data, or does it only accept dispersion and deposition factors? If a code does not include the capability to process "raw" meteorological data, then a separate code (e.g., STAR from http://www.epa.gov/scram001/metobsdata_procaccprogs.htm) would need to be run to generate the input necessary for the risk assessment model.
- **Source Term Calculation (1.5)**: Can the code calculate radon releases, or must the releases be pre-calculated and entered into the code? If a code does not include the capability to calculate the radon releases, than an additional calculation would be needed to estimate the source term so that it can be entered into the risk assessment model. Alternatively, a code that contains an internal source term calculation would be difficult to modify, should the source term model change.
- **Input Parameter Sensitivity Analysis (1.5)**: Does the code have the capability to perform sensitivity analyses on the input data, or must parameter sensitivity be

determined by multiple runs, each run varying a single parameter? EPA/520/1-89-005, Section 7 describes uncertainty analyses that were performed. Although this Work Assignment does not specify them, EPA may want to perform similar uncertainty analyses for this revision in the future.

- **Verification and Validation (1.25)**: Is there a readily available V&V package that supports the code? Is the V&V package complete? Has there been independent (i.e., by someone other than the code's developer) V&V performed?
- **Ease of Use/User Friendly (1.25)**: Is the code provided with a user interface that is intuitive and easy to understand and use? Alternatively, does the code require the user to manipulate structured input data files? Additionally, does the code have features not required for this analysis, but that might complicate its use?
- **Documentation (1)**: Is the code well documented? Are there User's Manuals readily available? In addition to providing instructions as to how to use the code, are the mathematical models used by the code well documented? It is expected that all of the codes selected for evaluation would have high scores for this criteria.
- **Probabilistic Analysis Capability (1)**: Is there a probabilistic analysis version of the code available? Although the calculations being performed for WA 1-04 are being done deterministically, at some point the EPA may desire to perform a probabilistic analysis, and it would be desirable to use the same code for both analyses.
- **SC&A Familiarity (tie breaker):** If two or more models have identical (or nearly identical [i.e., within 10%]) scores based on the above criteria, then the SC&A recommendation will be based on how familiar SC&A is with the operation of each code.

The above list of evaluation criteria is preliminary, and SC&A will work with the WAM to finalize the code evaluation criteria. As can be seen from the above list, some criteria are of greater importance than other criteria. To account for this, each criterion will be given a weighting factor ranging from 1 to 2; preliminary weighting factors are shown in parenthesis on the above list of evaluation criteria. SC&A will work with the WAM to develop the final weighting factors for each criterion. The final score of the evaluation will be the sum of each criterion's score times its weighting factor.

SC&A will provide a recommendation to the WAM on the best model for use in presenting findings on individual and population dose and risk. This task will be completed prior to proceeding with the detailed risk estimates in Task 4.

2.4 Task 4 – Detailed Risk Estimates

SC&A will develop detailed risk estimates for each currently operating source of emission regulated by Subpart W from the management of uranium byproduct materials from the processing of uranium ores. These estimates were presented on a facility-by-facility basis in the 1989 EIS, and SC&A will conduct them in the same format for this analysis for all currently operating uranium mills (i.e., permanently shut-down mills and mills in DOE's long-term care will not be analyzed). Tables 1 and 2 present a preliminary list of operating conventional and in situ uranium mills, respectively.

Table 1. Tailings Impoundments at Conventional Uranium Mills

Mill	Total Acres	Ponded	Wet	Dry	Radium Content (pCi/g)
Sweetwater	37	30	0	2	280
White Mesa	130	55	70	5	961
Canon City	130	128	2	0	400

Source: SC&A Report to EPA WA 4-11, Task 5, July 18, 2008, Table 1

Table 2. Operating ISL Facilities

Company	Site	State
Cameco	Smith Ranch – Highland	WY
Cameco	Crow Butte	NE
Hydro Resources	Crown Point	NM
Cogema*	Christenson/Irigaray	WY
Hydro Resources	Church Rock	NM
Mestena	Alta Mesa 1,2,3	TX
Uranium Resources	Kingsville Dome 1,3	TX
Uranium Resources	Vaquez 1,2	TX

Source: SC&A Report to EPA WA 4-11, Task 5, July 18, 2008, Table 4
* Provided by B. Littleton, EPA, April 28, 2010

The Tables 1 and 2 lists of sites to be evaluated are preliminary, but have been used to provide a cost estimate for this Work Assignment. SC&A will work with the WAM to finalize the list of currently operating uranium mills to be included in the analysis.

In addition to currently operating facilities, SC&A will identify two or three representative facilities that will be used to approximate conditions of new facilities. This will be done to accommodate the recognition that several new processing facilities are expected to apply for licenses in the near future.

SC&A will develop a report that may be used to revise the specific text, tables, and figures of the FEIS – NESHAPS for Radionuclides, Background Information Document. Specifically, as specified by the Work Assignment, SC&A will address the following four topics:

(1) The source category, the processes that result in the releases of radionuclides into the environment, and existing controls.

For each of the uranium mills identified in Tables 1 and 2, SC&A will perform a literature search to obtain information relevant to the characterization of the facility. As stated above, the characterization will begin with the source category (e.g., operating in situ, standby conventional, etc.), a description of the processes involved, a description of the site layout (including a plot plan, if possible), and a description of existing radon control devices.

Sources contacted by SC&A will include the Nuclear Regulatory Commission, Agreement State regulatory agencies, the Department of Energy, and the owner/operator of the mill. Types of documents consulted will include license applications, responses to requests for additional information (RAIs), safety evaluation reports, environmental assessments, radiological and environmental monitoring reports, inspection reports, etc. For example, the NRC's Agency Document Access and Management System (ADAMS) contains 577 documents the contain Crow Butte in their title.

Due to our previous work with ORIA, SC&A is already in possession of many of the documents that are needed to complete this portion of the Work Assignment.

If necessary, visits to one or more of the facilities by SC&A may be necessary to obtain additional necessary information.

SC&A will present the facility-specific information obtained in a summary table, similar to EPA/520/1-89-007, Table 4-25.

(2) The bases for the risk estimate, including reported emissions, source terms used, and other site parameters relevant to the dose assessment.

The second Task 4 subtask is also a data collection task. Specifically, the data collected in this subtask will be used as the input for the exposure and risk assessment models. First of all, radon release, or source term, data are necessary. It may be possible to reconstruct the source term from the semi-annual radiological effluent and environmental monitoring reports that are required from each facility (e.g., there are 23 such reports in the NRC's ADAMS for the Crow Butte facility). For example, Appendix E of the 2009 Third and Fourth Quarter Crow Butte effluent report indicated the following radon releases:

Second Half 2009 Startup:	7 Ci
3rd Quarter 2009 Leaching Operations (26,445 liters processed)	1,772 Ci
4th Quarter 2009 Leaching Operations (26,358 liters processed)	1,745 Ci
Restoration – Wellfield Loss	87 Ci
Restoration – Ion Exchange Loss	26 Ci
Restoration – Reverse Osmosis Loss	105 Ci
Startup of New Restoration	1 Ci
Total Estimated Radon Release, Second Half 2009	3,744 Ci

Similar reports exist for the other operating uranium facilities, and each facility's reports will be obtained, reviewed, and the data utilized, as appropriate.

As an alternative and/or supplement to the data from the semiannual effluent reports, SC&A will calculate the source term. For tailing areas that have been covered, SC&A will use the methodology documented in NRC's Regulatory Guide 3.64, "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers", Appendix B "The RADON Program".

Alternatively, the World Information Service on Energy (WISE) Uranium Project websites contain: (1) a Uranium Mill Tailings Radon Flux Calculator (http://www.wise-uranium.org/ctb.html) to determine the radon flux from a bare and/or water-covered uranium mill tailings pile, and (2) a Uranium Mill Tailings Cover Calculator (http://www.wise-uranium.org/ctc.html) to determine the radon flux through a multi-layer soil cover of an uranium mill tailings pile and/or optimize the cover for a given flux. SC&A may use either or both of the WISE calculators to determine the radon flux. The radon emission from evaporation ponds scenario developed under Task 5 of this Work Assignment may be used by SC&A to model the source term from evaporation ponds.

For tailing areas that have not been covered, SC&A will estimate the source term from: the radon flux per unit area, the fluxing area of the tailings pile, and the duration, in years. To calculate the radon flux from bare tailings, SC&A may use either a radon flux per unit area of 1 pCi/m^2/s radon-222 is emitted per pCi/g radium-226 (consistent with EPA/520/1-89-007) and/or the WISE calculator, described in the preceding paragraph.

The semiannual effluent reports may also provide information on the ambient radon (and U-natural and Pb-210) concentration at off-site air monitoring locations. These radon air concentration data may be used to directly calculate the exposure/risk to an individual assumed to be living at the air monitoring location. This type of calculation will be used by SC&A to either check or supplement the individual exposure/risk results obtained from the risk assessment model.

SC&A will present the facility-specific source term in a summary table, similar to EPA/520/1-89-007, Table 4-26.

In addition to developing source term data (either from effluent reports or calculated), SC&A will need to collect demographic and meteorological data for the area surrounding each of the Tables 1 and 2 facilities. Information on the reasonable maximum exposed individual (RMEI) (i.e., the nearest resident) will be obtained from available facility documentation [see subtask (1), above]. In the unlikely event that no information can be located to define the nearest resident, SC&A would estimate the RMEI exposure/risk at the facility's site boundary in the most frequent downwind direction.

SC&A will obtain regional (i.e., within 80 kilometers) population data from the 2000 U.S. census. SC&A is aware that for the years between censuses, the U.S. Census Bureau provides estimates of the population. SC&A will work with the WAM to determine whether to use the data from the 2000 census directly or to use a Census Bureau estimate for a later year, i.e., 2009. The SECPOP code may be used to convert the census data into sector- and distant-dependent data for each site.

SC&A will present the facility-specific population data in a summary table, similar to EPA/520/1-89-007, Table 4-27.

For each facility SC&A will obtain meteorological data from the nearest National Weather Service (NWS) station. NWS data are available from the EPA website (http://www.epa.gov/ scram001/surfacemetdata.htm) in the form of "raw" meteorological data (e.g., ceiling height, wind direction, wind speed, dry bulb temperature, and cloud cover). Alternatively, NWS data may be taken from CAP88 (even if CAP88 is not selected as the risk assessment model). The CAP88 weather data library provides data in the form of joint frequency tables (i.e., wind speed, wind direction, and stability class). Depending on the risk assessment model used, either source of meteorological data may need pre-processing prior to its use.

The Work Assignment has requested that two or three representative facilities be used to approximate conditions of new facilities. Like the facilities in Tables 1 and 2, these representative facilities would be defined by their source term, demographics, meteorology, and nearest resident. For the representative facility source term, SC&A would select a specified percentile source term that was developed for the Tables 1 and 2 facilities. SC&A will work with the WAM to decide whether to select the 50th, 90th, or some other percentile, and whether one or more source terms are necessary.

There are a couple of possible ways to specify the demographics and meteorology for the reference facility. First, a specific location within the country could be selected (possibly a location that has shown an interest in developing a uranium mill). Once the location is selected, the demographics and meteorology data would be obtained from the U.S. Census Bureau and National Weather Service, just as it was for the Tables 1 and 2 facilities. Alternatively, all of the U.S. Census Bureau and National Weather Service national data could be used to calculate a national distribution of the relevant parameters (e.g., population density, atmospheric dispersion); then the representative facility's values could be selected at the 50th, 90th, or some other percentile level (the exact percentile would be decided in consultation with the WAM).

The reference facility's nearest resident, or RMEI, would be located at a specified distance in the most frequent downwind direction. The distance could be based on the distance to the nearest resident at the Tables 1 and 2 facilities, or it could be simply a nominal distance (e.g., a half-mile, a half-kilometer). SC&A will work with the WAM to select the nearest resident distance for the reference facility. (Note, although this discussion refers to a reference facility, SC&A would actually evaluate two or three reference facilities, as per the Work Assignment.)

(3) The results of the dose and risk calculation, along with an extrapolation to the entire category.

This section would present the results of the dose and risk facility-by-facility risk assessment model results. An extrapolation of the doses and risks to the entire source category will also be provided. SC&A will present the facility-specific estimated exposures and risk in a summary table, similar to EPA/520/1-89-007, Table 4-29. Estimated total cancers per year will be presented in a table similar to EPA/520/1-89-007, Table 4-30, while the estimated distribution of the fatal cancer risk will be presented in a table similar to EPA/520/1-89-007, Table 4-31.

Additionally, the risk assessment model data input sheets will be provided in a manner similar to the input sheets in EPA/520/1-89-006-2, Appendix A. SC&A will work with the WAM to determine the exact form of the input data sheets, i.e., whether they are to be data summaries (similar to what is currently in Appendix A), or whether they are the exact files used as input to the risk assessment model. The advantage of the latter is that it allows for the risk assessment model to be easily run; its disadvantage is that it may be difficult to understand by anyone not intimately familiar with the operation of the risk assessment model.

Note: EPA/520/1-89-006-1 and EPA/520/1-89-007 presented individual and population exposures in units of working-level (WL) and person-working level month (person-WLM), respectively. SC&A proposes to present individual and population exposures in the more conventional units of millirem and person-rem, respectively.

(4) A description of supplementary emissions controls and their cost and effectiveness in reducing dose and risk.

EPA/520/1-89-006-1, Section 8.4 evaluated the effectiveness of eight emission control technologies: Earth Cover, Water Covers, Synthetic Covers and Chemical Sprays, Thermal Stabilization, Chemical Processing, Soil Cement Covers, Deep-Mine Disposal, and Caliche Cover. For various reasons, Section 8.4 found that (with the exception of the earth cover) none of the technologies were effective at controlling radon emissions. SC&A will review the currently available literature to determine whether sufficient progress has been made in any of the technologies since 1989 to modify the EPA/520/1-89-006-1 conclusion. SC&A will also review the literature to determine whether there are any additional technologies that have been developed since 1989, which could be used to control radon emissions. The information gathered by SC&A during this effort will be presented in a manner similar to that used in EPA/520/1-89-006-1, Section 8.4.

EPA/520/1-89-006-2, Appendix B presents a generic cost estimate for the installation of an earth cover to control radon emissions. Because EPA/520/1-89-006-1, Section 8.4 identified the earth cover as the only effective emission control technology, the earth cover was the only technology that had an Appendix B generic cost estimate. The Appendix B costs were based on five basic steps or operations required to place earthen covers on inactive tailings piles: (1) regrading the slopes of the pile to achieve long-term stability; (2) procurement and placing of the dirt cover; (3) placing gravel on the pile tops; (4) placing of riprap on the pile sides; and (5) reclamation of the borrow pits.

To arrive at the earth cover generic cost, Appendix B is divided into three sections: Section B.2 – the formulas used to calculate the depth of cover required to meet specified emission rates; Section B.3 – a summary of the geometry required to estimate the pile volumes and surface area; and Section B.4 – the development and documentation of the generic units costs. SC&A will review the formulas and geometry used in Appendix B to insure that they remain valid. If it is discovered that the current earth cover design differs significantly from the 1989 design, SC&A will update and revise Sections B.2 and B.3 accordingly.

However, at this time SC&A believes that most of the effort of this subtask will be for updating the unit costs contained in Section B.4. As done in the 1989 Appendix B, construction cost data will be taken from the cost compendiums published by the RS Means Company (e.g., Heavy Construction Cost Data 2010 Book, Site Work & Landscape Cost Data 2010 Book, Environmental Remediation Estimating Methods).

Even though most of Sections B.1 through B.3 will not be changed by this update, in order to keep all of the unit cost information together, SC&A proposes to re-issue EPA/520/1-89-006-2, Appendix B in its entirety. As in the current Appendix B, the report will include the inputs, the calculation, the basis of all parameters, and the methodology used to calculate the costs and effectiveness of earthen covers to control radon emissions from area sources. The revised earth cover unit costs will be provided in two tables – the first in units of dollars per square yard or cubic yard, and the second in units of dollars per square meter or cubic meter, similar to current Tables B-9 and B-10.

Because EPA/520/1-89-006-1, Section 8.4 identified the earth cover as the only effective emission control technology, the earth cover was the only technology that had an Appendix B generic cost estimate. Should SC&A's literature review reveal that there are additional effective emission control technologies, SC&A will provide generic cost estimates for implementing those technologies using a similar approach as was used to develop the earth cover generic cost estimate.

2.5 Task 5 – Radon Emissions from Evaporation Ponds

SC&A will develop a scenario to bound radon emissions from evaporation/settling ponds in a worst-case scenario. This bounding emission calculation will be based on the highest concentrations of contaminants in the ponds and will model upset conditions which include reasonable time periods for turbulent flow conditions. The results will be included in a report, along with a detailed explanation of the scenario and the basis of all parameters included in the analysis.

Estimates of radon from water-covered tailings were presented in the ORNL-TM-4903[1] review of the uranium extraction industry. The ORNL report used a "stirred pond model" which assumed all radon from the decay of radium is dissolved in the pond water and all radon which diffuses to the solid liquid interface is released to the atmosphere. Subsequently, radon from the surface of tailings ponds was ignored, as diffusion calculations indicated radon would travel no more than a few centimeters due to its very low diffusion coefficient in water (of the order of 10^{-5} cm^2/sec or so. Nielson and Rogers[2] noted that the tailings ponds were not motionless, but had considerable water motion. They considered the advective transport of radon from the surface of tailings ponds. The World Information Service on Energy (WISE) Uranium Project website contains a Uranium Mill Tailings Radon Flux Calculator (http://www.wise-uranium.org/ ctb.html) that uses Nielson and Rogers' methodology to determine the radon flux from a bare and/or water-covered uranium mill tailings pile.

Mudd[3] has used the Nielson and Rogers studies to show estimates of radon from Australian uranium tailings ponds are problematic. Other authors used one-dimensional vertical advection-diffusion models to estimate radon exchange from sediments and fluxes to the atmosphere. These models are particularly important in oceanographic studies where radon is used as a natural tracer. For example, a 2000 study by Burnett, et al.[4] Also, in an anticipated paper[5], Simonds, Schierman, and Baker describe a method for predicting the radon flux from a water body, which incorporates Fick's laws of diffusion and the stagnant-layer theory of gas-water exchange. Good agreement was found between the model predictions and measurements obtained from floating adsorption canisters on an evaporation pond containing elevated Ra-226 concentrations.

Evaporation ponds are used to retain process-related liquid effluents that cannot be discharged directly to the environment. These effluents are considered byproduct material, as defined in Section 11e.(2) of the Atomic Energy Act of 1954. The residual solid waste materials normally

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[1] ORNL (Oak Ridge National Laboratory) 1975. "Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing 'as Low as Practicable' Guides-Milling of Uranium Ore," ORNL-TM-4903 Volume 1, Sears, M.B., R.E. Blanco, R.C. Dahiman, G.S. Hill, A.D. Ryan, and J.P. Witherspoon. May 1975.

[2] Nielson K. K., V.C. Rogers, "Surface water hydrology considerations in predicting radon releases from water-covered areas of uranium tailings ponds", Geotechnical & Geohydrological Aspects of Waste Management / Fort Collins 1986, 215-222.

[3] Mudd G.M. (2002). Uranium Mining in Australia: Environmental impact, radiation releases and rehabilitation. *Protection of the Environment from Ionising Radiation-Proceedings of the Third International Symposium,* Darwin, Australia, 22-26 July 2002, Vienna, International Atomic Energy Agency.

[4] Burnett, W.C., J. Chanton, D.R. Corbett and K Dillon, "The Role of Groundwater in the Nutrient Budget of Florida Bay". Part I Final Report, NOAA Project # NA96OP0234, July 14, 2000.

[5] Simonds, M.H., M.J. Schierman, and K.R. Baker, "Radon Flux from Evaporation Ponds Containing Elevated Concentrations of Radium-226," Environmental Restoration Group, 55th Annual Meeting of the Health Physics Society, 27 June - 1 July 2010, Salt Lake City, Utah.

remain in ponds until the ponds are decommissioned, when sludges are disposed of as 11e.(2) material at a licensed disposal facility. A typical facility may have three evaporation ponds, with each pond having a surface area of up to 6.2 acres and a depth of about 17 feet[6].

Finally, SC&A understands that the EPA has requested that ISL facilities provide radon flux data from their evaporation ponds[7]. SC&A will utilize any data that are provided as a result of that request in the development of an evaporation pond radon emission model.

Based on the above discussion, SC&A will review the various models and parameters, select an appropriate model, and develop a set of parameters to use for predicting evaporation pond radon emissions, including an upper bound, worst-case scenario.

2.6 Communication

Principal communications will be between the WAM and the SC&A Task Manager. As warranted, some communications will also include the SC&A Project Manager and other SC&A technical staff assigned to work on specific aspects of the WA. SC&A will file a written monthly report with the WAM that summarizes the work accomplishments during the previous month, discusses any issues that have arisen and actions taken or underway to resolve those issues, and estimates the level of effort that will be accomplished in the upcoming month. At least monthly, SC&A will participate in a teleconference with the WAM.

3.0 STAFFING PLAN

The staffing plan for this Work Assignment will focus mainly on SC&A personnel who have experience in NEPA compliance and preparation of NEPA documentation, with specific expertise in the area of radiological impacts to the environment and health and safety of the public from the construction and operation of nuclear facilities.

Personnel on the proposed SC&A team are described below, along with an indication of the role we anticipate each will play. SC&A may elect to change the assignments to accommodate schedule changes, shifts in workload, or a need for a specific unforeseeable expertise.

3.1 Specific Staffing

Dr. Abe Zeitoun is the SC&A Project Manager for this contract. Dr. Zeitoun is a Senior Vice President with SC&A and will have full authority to direct all services of the SC&A team. This will also provide Dr. Zeitoun ready access to the full resources of the company. He has more than 35 years of experience as a technical manager, with a proven track record in the management and oversight of multitask projects and programs. He holds a Ph.D. in Environmental Sciences, an M.S. in Fisheries, a Higher Diploma in Oceanography, and a B.S. in Chemistry and Zoology. Dr. Zeitoun has supported multidisciplinary programs and projects in waste management, energy, transportation, NEPA, and regulatory compliance for U.S.

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[6] Crow Butte Resources, SUA-1534 License Renewal Application, p 4-4, November 2007.

[7] R. Rosnick, Navajo Uranium Contamination Stakeholder Workshop, November 3, 2009.

Department of Energy (DOE), the U.S. Nuclear Regulatory Commission (NRC), EPA, the National Aeronautics and Space Administration (NASA), international entities, and electric utilities. He is currently the Project Manager of a multitask contract supporting the regulatory mission of EPA Office of Indoor Radiation and Air.

Mr. Stephen Marschke is the proposed Task Manager for this WA, and will also function as the SC&A principal point of contact and senior technical analyst for all the deliverables. Mr. Marschke has over 35 years of experience in nuclear engineering and radiological assessment. He provided on-site assistance to the West Valley Demonstration Project (WVDP) site closure and long-term management NEPA evaluations for the finalization of DOE/EIS-0226. He was directly responsible for estimating greenhouse gas emissions (utilizing EPA's AP-42 emission factors), radiological effluents, radiological waste volumes, etc. for the various proposed remedial actions, including in-place closure and exhumation of the underground storage tanks. Mr. Marschke was an author of the AIF/NESP-032 study on the environmental consequences of higher nuclear fuel burn-up, which updated the 10 CFR Part 51, Table S-3 nuclear fuel cycle impacts. In addition, Mr. Marschke has performed the analyses of the radiological impact sections in support of the preparation of the licensing of various pressurized and boiling water reactors, including Seabrook, Shearon Harris, St. Lucie, and Waterford. Finally, Mr. Marschke has successfully managed numerous multi-discipline technical NRC, EPA, DOE, NIOSH, and private client projects, including as the Task Manager for EPA ORIA's WA 5-13, "Technical Support for Review of Nuclear Power Plant Environmental Impact Statements – 2; WA 5-16, "Use of Integrated Environmental Decision-Making to combine GHG and Radiological Hazards on Energy Alternatives using Life Cycle Analyses;" and WA 5-19, "Gap Analysis for 40 CFR Part 190 Environmental Protection Radiation Standards for Nuclear Power Operations."

Dr. Stephen Ostrow, SC&A's Senior Vice President of Advanced Technology, is a proposed quality assurance specialist for this WA. In addition to his duties at SC&A, Dr. Ostrow is an Adjunct Professor at Columbia University, teaching graduate-level Nuclear Physics in the Applied Physics & Applied Math Department and a member of the Medical Physics faculty. His current course includes a unit on nuclear power and, in previous semesters at Columbia, he has taught courses on alternative energy, including wind, solar (photovoltaic and thermal), and geothermal. Dr. Ostrow has over 30 years of experience with nuclear projects, including different power and research reactor types, fuel and radioactive waste storage facilities and repositories, and fuel cycle facilities, and served as Manager and Chief Engineer of Nuclear Engineering of a major architect-engineering firm, where he was responsible for all radiation-related tasks. He has led and participated in environmental impact and cost analysis studies for different facilities. In addition, Dr. Ostrow has participated as Task Manager, Technical Analyst, and QA Manager in several work assignments under the previous SC&A EPA contract.

Dr. Les Skoski is proposed as a technical analyst for this task. Dr. Skoski has over 35 years of experience in managing projects or tasks dealing with uranium and thorium from mining to remediation of commercial and industrial sites contaminated with NORM materials. These include primary uranium producers in the U.S. and abroad, secondary uranium/thorium metal and non-metal miners and millers (e.g. phosphates), and NORM contaminated Superfund, FUSRAP and SDMP sites. He prepared regulatory compliance programs for over twenty domestic and foreign primary and secondary uranium producers, including conventional mill, heap-leach and in-situ facilities, and phosphate, copper, beryllium, other mineral processing facilities with uranium extraction circuits. Under the previous contract, Dr. Skoski has provided support to the ORIA Uranium Recovery Program, including WAs 5-03, 5-04, and 5-17.

Mr. Gary Konwinski has more than 35 years of relevant experience, including 11 years as a senior license reviewer and senior environmental and safety inspector for the NRC. He was responsible for reviewing license renewals and terminations for a variety of uranium recovery facilities. Additionally, Mr. Konwinski was the Decommissioning Program Manager for the 800-Area at Rocky Flats (uranium and beryllium processing facilities). In this capacity he was responsible for operational and decommissioning work, while assuring that plant emissions in the work areas were ALARA. Under the preceding contract, Mr. Konwinski supported multiple tasks for the EPA Uranium Recovery Program. He was the senior lead on the review of environmental monitoring and all effluent control systems and technologies proposed for use in uranium recovery facilities. He is an expert in hydrology, operational systems, and decommissioning.

Mr. Robert Barton is proposed as a technical analyst for this task. Mr. Barton has three years experience in nuclear engineering and radiological assessment. He has provided technical support to the Advisory Board on Radiation Worker Health in evaluating the radiation dose reconstruction program developed by the National Institute for Occupational Safety and Health (NIOSH), including (but not limited to): development and analysis of databases containing worker exposure histories, technical review of Excel-based calculation workbooks used in dose reconstruction procedures, and review of historical documentation to determine Department of Energy site-specific practices in the context of radiological exposure scenarios. Mr. Barton updated decommissioning and remediation estimates for the West Valley Demonstration Project, including occupational exposures, resource requirements, effluent releases (both radiological and non-radiological), generated wastes, and schedule implementation. Mr. Barton performed a key role in determining the radiological doses and risks for the EPA report: *Technologically Enhanced Naturally Occurring Radioactive Materials From Uranium Mining Volume 2: Investigation of Potential Health, Geographic, and Environmental Issues of Abandoned Uranium Mines,* as well as in WA 5-18, “Low Activity Mixed Waste: 40 CFR Part 193 Support.”

Ms. Karene Riley is proposed to conduct research and data collection for the task. She holds a BS in Environmental System Engineering and has more than ten years of progressive engineering experience providing environmental and safety analysis, facilities planning, and regulatory and program support for several commercial nuclear power plants and various federal agencies including the U.S. Navy, U.S. Army, U.S. Environmental Protection Agency (EPA) and U.S. Federal Aviation Administration (FAA). She currently provides technical and project management support in the development of Combined Operating Licensing (COL) Applications for new and existing commercial nuclear power plants in the U.S. and supports the DOE NEPA office in reviewing EISs and conducting data searches and evaluations.

Ms. Laurie Loomis will be responsible for financial reporting and for producing the monthly progress reports.

A breakdown of the proposed hours per task is presented in Table 3.

Table 3. Proposed Work-Hour Allocation by Task

Staff	Role	P-Level	Task 1	Task 2	Task 3	Task 4	Task 5	Total
A. Zeitoun	Project Manager	4	8	4	4	16	8	**40**
S. Marschke	Task Manager	4	24	8	20	92	24	**168**
S. Ostrow	QA/QC Manager	4	0	28	2	8	2	**40**
L. Skoski	Physicist	4	8	0	0	57	72	**137**
R. Barton	Nuclear Engineer	2	2	0	54	57	8	**121**
G. Konwinski	Environmental Scientist	4	0	0	0	36	0	**36**
K. Riley	Environmental Engineer	3	0	0	0	114	4	**118**
L. Loomis	Contracts Manager	3	4	2	2	2	2	**12**
Clerical			*2*	*2*	*16*	*16*	*16*	*52*
Total Technical Hours (LOE)			**46**	**42**	**82**	**382**	**120**	**672**

4.0 COST ESTIMATE

The detailed cost estimate to complete all work is contained in Attachment 1 to this Work Plan. We have estimated the labor costs using the proposed staffing mix from Section 3, Table 3. ODCs are estimated based on what we anticipate our actual requirements will be, using both historical data for similar work and projections.

As described in Section 2.4, the Task 4 work hours shown in Table 3 and the associated cost given in Attachment 1 are based on evaluating the 11 operating facilities shown in Tables 1 & 2, plus three reference facilities. Should the total number of facilities to be evaluated differ from the 13 assumed, the Task 4 work hours and cost estimates would be adjusted accordingly. Also, as stated in Section 2.4, SC&A may need to visit one or more of the operating facilities to collect data. For the purpose of the cost estimate, two trips were assumed: one via plane and the other via automobile. If one or both of these assumed trips proves to be unnecessary, then the cost would be accordingly adjusted.

5.0 SCHEDULE OF DELIVERABLES

- Task 1 – Work Plan and Cost Estimate
  - This WA began on March 27, 2009, and the Work Plan and Cost Estimate are due on April 16, 2009

- Task 2 – Prepare a Quality Assurance Project Plan and a Quality Assurance Report
  - QAPP – To be delivered within 10 days after Work Plan approval
  - QA Report – To be delivered no later than February 28, 2011

- Task 3 – Draft Risk Assessment Model Report
  - To be delivered no later than 30 days after Work Plan approval

- Task 4 – Draft Report on Detailed Risk Estimates
  - To be delivered no later than 120 days after Work Plan approval

- Task 5 – Draft Report on Radon Emissions from Evaporation Ponds
  - To be delivered no later than 30 days after Work Plan approval

- Communication
  - Monthly teleconference, after Work Plan approval
  - Monthly progress reports

SC&A will provide an electronic copy in Microsoft Word and PDF Formats to the Work Assignment Manager (WAM).

The WAM is authorized to provide technical direction which clarifies the statement of work as set forth in this work assignment. Technical direction will be issued in writing or confirmed in writing, by the WAM, within five (5) calendar days after verbal issuance.

The WAM will forward a copy of the technical direction memorandum to the Contracting Officer and a copy to the Project Officer. Technical direction must be within the contract and the Work Assignment statement of work. Technical direction includes (1) direction to SC&A which assists SC&A in accomplishing the Statement of Work, and (2) comments on and approval of reports and other deliverables.

6.0 CONFLICT OF INTEREST

To the best of our knowledge, no facts exist relevant to any past, present, or currently planned interest or activity (financial, contractual, personal, organizational, or otherwise), which relate to the proposed work, and suggest that SC&A has a possible conflict of interest with respect to (1) being able to render impartial, technically sound, and objective assistance or advice, or (2) being given an unfair competitive advantage. Should this situation change, appropriate steps will be taken as prescribed by the contract, and the EPA WAM and Project Officer will be notified.

7.0 MANAGEMENT APPROACH

The SC&A Project Manager and Task Manager will exercise appropriate control over the assigned tasks. In addition, the management team will advise the EPA Contracting Officer, the Project Officer, and the WAM as soon as it is known if any aspect or requirement of the WA cannot be met.

SC&A will follow the approved Work Plan for the duration of the WA. SC&A will use its best efforts not to exceed the total level of effort (labor hours) specified in the approved WA, or the total estimated cost presented in the Work Plan. SC&A will submit a revised Work Plan to the EPA Contracting Officer, the Project Officer, and the WAM for approval, as necessary, whenever SC&A becomes aware that the total level of effort or total estimated cost will be exceeded.

ATTACHMENT 1
Contract No. EPD10042
CRAE0/104; Work Assignment 1-04
Rev. 1 to Work Plan, May 4, 2010

Direct Labor

		Task 1		Task 2		Task 3		Task 4		Task 5		Total	
Name	P-level	Hours	$	Hours	$	Hours	$	Hours	$	Hours	$	Hours	$
A. Zeitoun	4	8		4		4		16		8		40	
S. Marschke	4	24		8		20		92		24		168	
Employee P-4		*32*	*2,134*	*12*	*817*	*24*	*1,565*	*108*	*7,007*	*32*	*2,134*	*208*	*13,657*
S. Ostrow	4	0		28		2		8		2		40	
Employee 2 P-4	4	0		0		0		0		0		0	
Employee 2 P-4		*0*	*0*	*28*	*2,294*	*2*	*164*	*8*	*655*	*2*	*164*	*40*	*3,277*
L. Skoski	4	8		0		0		57		72		137	
G. Konwinski	4	0		0		0		36		0		36	
Associate P-4		*8*	*650*	*0*	*0*	*0*	*0*	*93*	*7,917*	*72*	*5,846*	*173*	*14,413*
L. Loomis	3	4		2		2		2		2		12	
K. Riley	3	0		0		0		114		4		118	
Employee P-3		*4*	*181*	*2*	*90*	*2*	*90*	*116*	*4,750*	*6*	*253*	*130*	*5,364*
R. Barton	2	2		0		54		57		8		121	
Employee P-2	2	0		0		0		0		0		0	
Employee P-2		*2*	*60*	*0*	*0*	*54*	*1,627*	*57*	*1,717*	*8*	*241*	*121*	*3,645*
Clerical		2		2		16		16		16		52	
Employee Clerical		*2*	*60*	*2*	*60*	*16*	*480*	*16*	*480*	*16*	*480*	*52*	*1,560*
Subtotal		46	3,085	42	3,261	82	3,926	382	22,526	120	9,118	672	41,916
Fringe1 (FR) on Empl 1 Labor @	45.26%		1,102		437		1,702		6,315		1,407		10,963
Fringe2 (FR) on Empl.2 Labor @	15.27%		0		350		25		100		25	0	500
OH on Empl. Labor + FR @	25.66%		906		1,039		1,450		5,396		1,207		9,998
Other Direct Costs (ODCs)													
Subcontract (None)		0	0	0	0	0	0	0	0	0	0	0	0
Travel			0		0		0		1,410		0		1,410
Misc. ODCs (see attached detail)			14		26		59		295		59		453
Total ODCs		0	14	0	26	0	59	0	1,705	0	59	0	1,863
Subcontractor Handling @	3.97%		0		0		0		0		0		0
G & A Expense @ (app. to Total Labor + FR + OH + Non-Subcontract ODCs + Sub. Handling)	13.69%		700		701		980		4,934		1,618		8,933
Total Costs before Fee			5,807		5,814		8,142		40,976		13,434		74,173
Fixed Fee @	$6.00	/hour	276		252		492		2,292		720		4,032
GRAND TOTAL		46	6,083	42	6,066	82	8,634	382	43,268	120	14,154	672	78,205

Avg. $/hr: $116.38

ATTACHMENT 1
Contract No. EPD10042
CRAE0/104; Work Assignment 1-04
Rev. 1 to Work Plan, May 4, 2010

Detail for ODC Estimates

Task 1:

Reproduction:	100	copies @	$0.04	each	4
Telephone/Fax:	0	hours @	$7.20	/hour	0
Postage/Delivery:	1	Fed-Ex @	$10.00	each	10
Total ODCs					14

Task 2:

Reproduction:	100	copies @	$0.04	each	4
Telephone/Fax:	1	hours @	$7.20	/hour	7
Postage/Delivery:	1	Fed-Ex @	$15.00	each	15
Total ODCs					26

Task 3:

Reproduction:	200	copies @	$0.04	each	8
Telephone/Fax:	5	hours @	$7.20	/hour	36
Postage/Delivery:	1	Fed-Ex @	$15.00	each	15
Total ODCs					59

Task 4:

Publications (Data):	1	estimated @	$200.00	each	200
Reproduction:	200	copies @	$0.04	each	8
Telephone/Fax:	10	hours @	$7.20	/hour	72
Postage/Delivery:	1	Fed-Ex @	$15.00	each	15
Total ODCs					295

Travel:

Denver/Corpus Christi	Qty	Price	Total
RT Airfare	1	300.00	300
M&IE	2	51	102
Lodging	1	90	90
Rental Car	1	70	70
Ground Transp/Parking	1	40	40
Misc.	1	40	40
Trip Total			642

ATTACHMENT 1
Contract No. EPD10042
CRAE0/104; Work Assignment 1-04
Rev. 1 to Work Plan, May 4, 2010

Detail for ODC Estimates

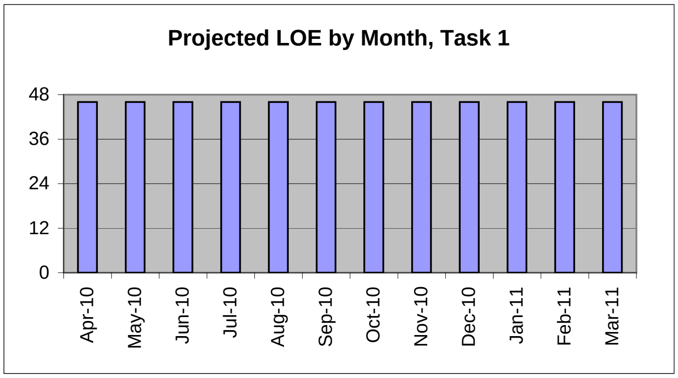
Denver/White Mesa, UT	Qty	Price	Total
RT Mileage	900	0.50	450
M&IE	3	46	138
Lodging	2	70	140
Misc.	1	40	40
Trip Total			768

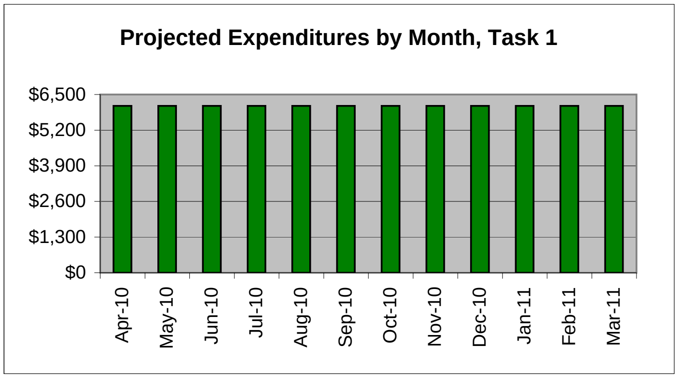
GRAND TOTAL TRAVEL THIS TASK 1410

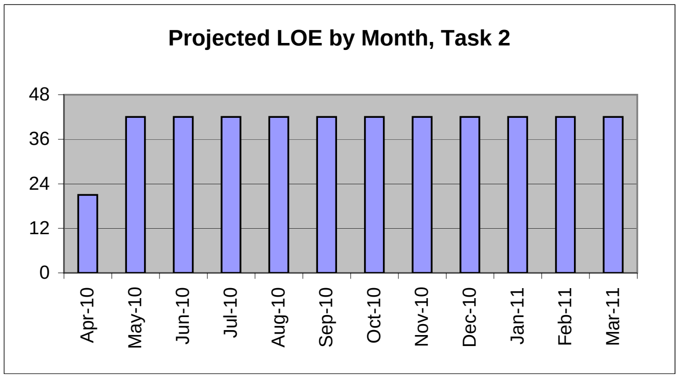
Task 5:

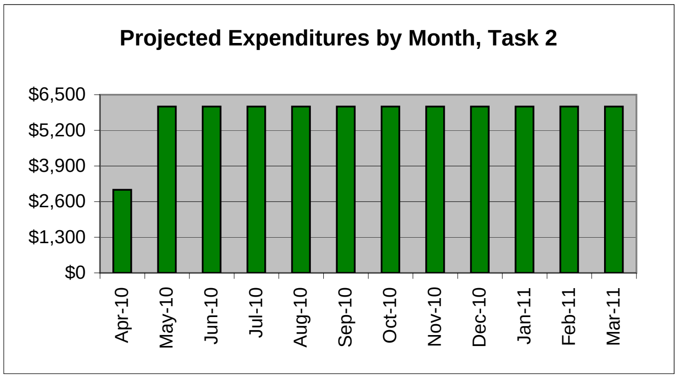
Reproduction:	200	copies @	$0.04	each	8
Telephone/Fax:	5	hours @	$7.20	/hour	36
Postage/Delivery:	1	Fed-Ex @	$15.00	each	15
Total ODCs					59

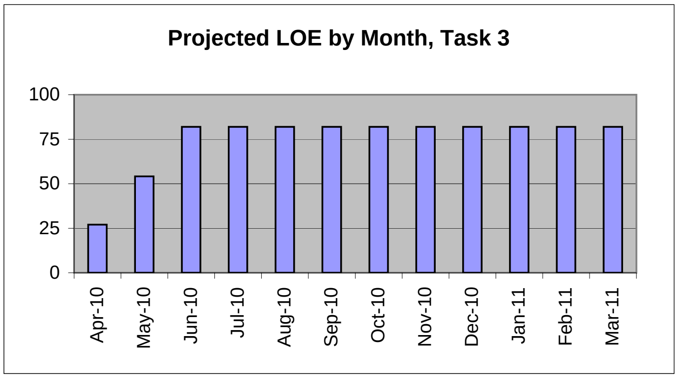
Projected LOE and Expenditures, by Month

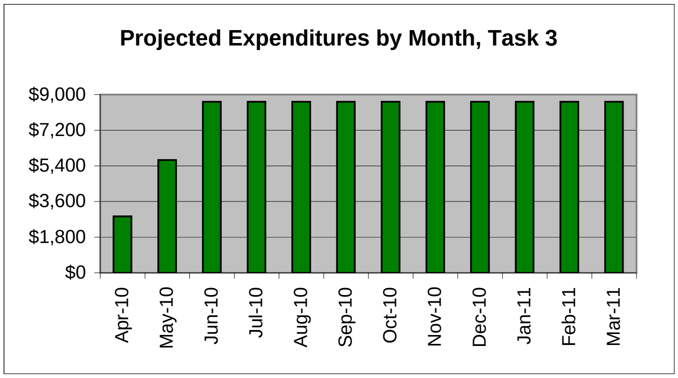


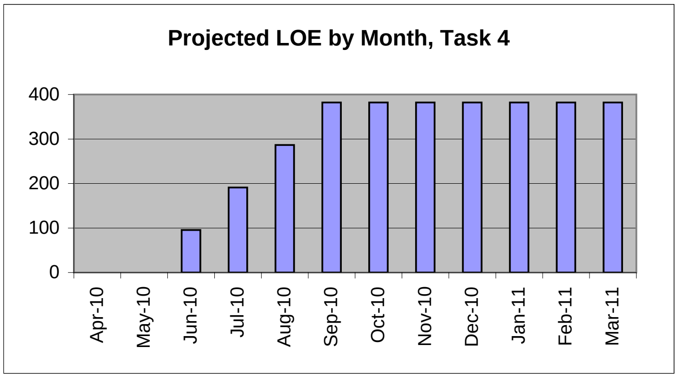


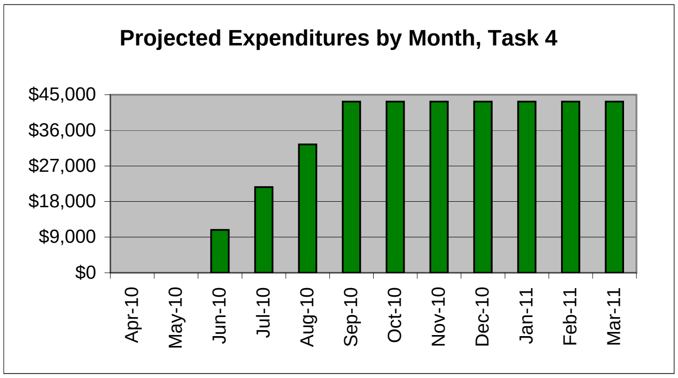




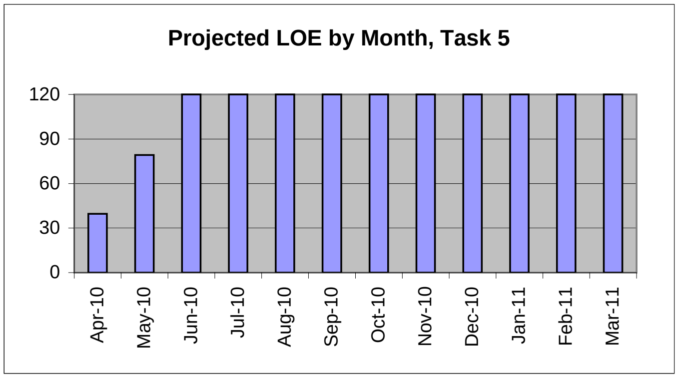


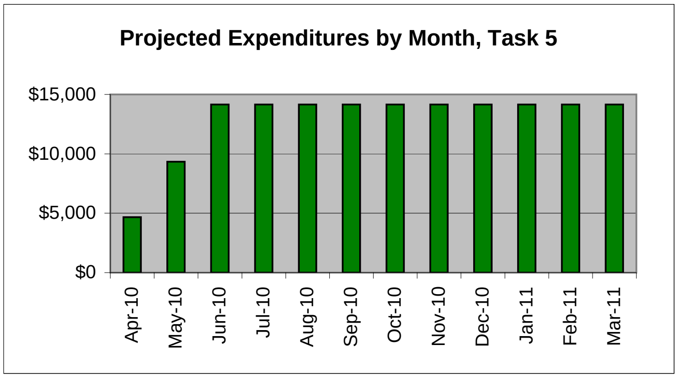


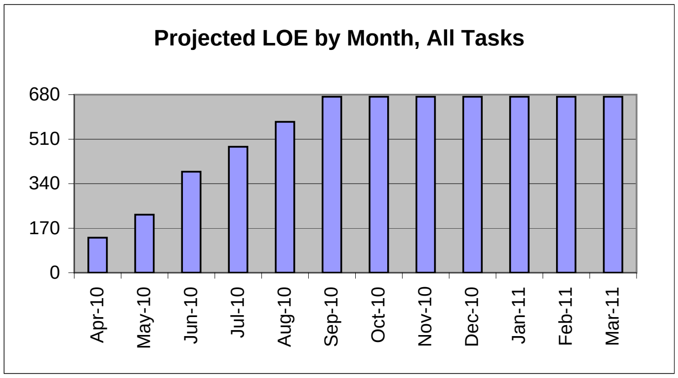


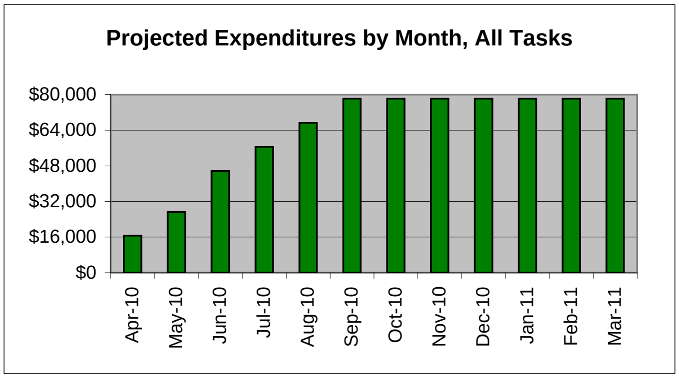


Projected LOE and Expenditures, by Month


Projected LOE by Month, Task 5


Projected Expenditures by Month, Task 5


Projected LOE by Month, All Tasks


Projected Expenditures by Month, All Tasks

Subpart W Public Conference Call

October 5, 2010

EPA: Reid Rosnick (ORIA), Angelique Diaz (R8)
CCAT: Sharyn Cunningham, Lynn Manassy?
Cotter: Jim Cain
Oscar Paulson – Kennecott
Zach Rogers – Energy Fuels
Katie Sweeney – NMA
Mike Newman – Neutron Energy
Bill Brister – Cameco
John Cash – Ur Energy
Horst Leftwich(?) – Cameco
Steve Brown - SENES

Updates and Questions

- Attended Uranium Stakeholder conference in Tuba City, AZ the week of 9/13 and gave presentations on Subpart W status, both at the conference and at a public meeting held during the week. Loren Setlow also presented on Part 192 update. Last public mtg for a while so workgroup can get some work done
- Two things in progress: 1. Contract work assignment for risk assessment work. Contractor performing site-specific risk assessment and determining which model to use to predict radon flux from impoundments. Should have data in next 2-3 months to determine if 20 pCi/m2-s still protective. 2. Contractor for economic impact analysis. Tribal, EJ, and children's health included in the analysis. The analysis will support efforts on Subpart W. Will share information with Part 192 workgroup.
- Katie asked if we are getting public input on models. Reid explained how the contractor is working in reviewing the various codes/models. We have solicited feedback on models from public.
- Oscar: will contractors be contacting licensees for site specific data and will they will evaluating existing 115 data and downwind data? Reid – to the best of his knowledge, yes. S. Cohen and Associates is the contractor
- Steve Brown: what information does EPA have that 20 pCi/m2-s is not protective? What is missing and what is driving the need? Reid – Last time a risk assessment performed was in the mid 1980s and science and application of risk assessment models has improved and changed over the past 20 years. Reid told him that we are following statutory requirements to review.
- Sharyn: will data gathered from contractor be put on website? Reid –yes, eventually, but not in the draft/unreviewed form so we are confident in the data before it goes up
- Sharyn requested an explanation of what the contractor is doing and updates on the website. Reid – will put the approved workplan on the website.
- Sharyn: has EPA had any messages coming in; she didn't see them on the website. Reid – policy that everything needs to be screened prior to posting.

Have received 2 e-mails during June 17th webinar (1 from Oscar Paulson and 1 from Jim Cain related to the webinar). We have received no others.

- Reid: on the website under “current actions” there is a draft document developed by ATSDR for Lincoln Park. Comment period ends 11/9/2010.
- Oscar: will Tuba City PowerPoint presentation be available? Reid – Yes, it will be placed on the website within the week
- Oscar: an FYI – in August 2010 Kennecott performed a test on fluid retention ponds. Constructed floating detectors and intend to publish the data. Still waiting for emanation coefficients and radium in sediments. 0.8 pCi/m2-s is the highest result they received from a lined impoundment. 1750 pCi/L Rn-222 in the pond water. Compared to Dr. Baker’s NRC/NMA results. Data will be submitted as part of comments on Subpart W rulemaking.
- Steve Brown: measurements indicate that radon flux is essentially background. Keep in context the numbers we have compared to background when performing risk assessments.
- Sharyn: asked Reid if he presented at NMA/NRC U recovery workshop? Request to place on the website. Reid will make sure it’s placed on the website
- Oscar: Industry interest in ATSDR report was that no public health hazard to radon or daughters from Cañon City was found.

Next Call: January 5, 2011 11:00am EST

EPA'S
NESHAP Subpart W Activities

Reid J. Rosnick
Environmental Protection Agency
Office of Radiation and Indoor Air
Radiation Protection Division (6608J)
Washington, DC 20460
rosnick.reid@epa.gov
May 27, 2010
Uranium Recovery Workshop 2010

Overview

- EPA regulatory requirements for operating uranium mill tailings (Subpart W)
- General requirements applicable to Subpart W
- Status Update on Subpart W Activities
- Communications

EPA Regulatory Requirements for Operating Uranium Mill Tailings (Clean Air Act)

- 40 CFR 61 Subpart W requirements apply to facilities licensed to manage uranium byproduct materials during and following the processing of uranium ores
  - Preconstruction approval, 40 CFR 61.07
  - Impoundment construction and operation requirements in 40 CFR 192 cross referenced in Subpart W
  - Limit on number/size of impoundments
    - Phased Disposal – lined impoundments no more than 40 acres, no more than two in operation at any time
    - Continuous Disposal – tailings are dewatered and immediately disposed, no more than 10 acres uncovered at any time

EPA Regulatory Requirements for Uranium Operations (Clean Air Act)

Subpart W Requirements (continued)

- Radon emission standard of 20 pCi/m^2/sec -- annual reporting requirements, notification in advance of testing
- The radon emission standard is for existing sources only (existing before 12/15/89)
- All operators must comply with 40 CFR 192.32(a) See http://www.epa.gov/radiation/neshaps/subpartw/rulemaking-activity.html for more information

EPA Regulatory Requirements for Underground Uranium Mining (Clean Air Act)

- 40 CFR 61.20, Subpart B regulations limiting radon emissions from underground uranium mines include:
  - Applies to 10,000 tons/yr ore production, or 100,000 tons/mine lifetime
  - Ambient air radon standard not to exceed 10 mrem/yr to any member of the public-compliance determined with COMPLY-R, or equivalent, approved code
  - Annual reporting requirements – by 3/31 each year, emissions calculations for the year, monthly if not in compliance
  - Record keeping requirements: Five years

General Requirements Applicable to Subpart W

- Subpart W and B facilities are subject to the general requirements of 40 CFR 61.01 - .19
  - Application for construction and modification
  - Notification of startup
  - Compliance with monitoring/maintenance requirements

- Subpart W facilities are subject to the design and ground-water requirements of 40 CFR 192.32(a)
  - Ground-water protection standards
  - Impoundment design requirements similar to hazardous waste facilities

Status Update on Subpart W Activities

Status of Subpart W Review Activities

- Major emphasis on risk assessments
- Purpose is to update risk numbers used in 1989 rulemaking to reflect state of the science
  - Evaluate impacts to the public
  - Also focus on Tribes, EJ communities, children’s health
- All operating tailings piles and ISL’s
- Stylized scenarios will also be developed for representative future sites
- Scenarios would include varied climate, heap leach

Status of Subpart W Review Activities

Choosing a Risk Assessment Model

- 1989 rule used AIRDOS to calculate dose and risk
- Determination which model is appropriate
- Candidate models include CAP88, GENII, RESRAD, MILDOS-AREA, MEPAS, GASPAR
- We welcome any other candidates you may know about

Status of Subpart W Review Activities

- Preliminary screening of candidate codes
- Once defined, the code will be used to determine individual and population dose and risk
- Some evaluation criteria include:
  - Exposure pathways modeled
  - Dose factors used
  - Risk factors used
  - Source term calculation
  - Input parameter sensitivity analysis
  - Verification/validation/documentation
  - Ease of use/user friendly

Status of Subpart W Activities

- Risk estimates will be developed for each Subpart W facility
- Estimates will be presented on a facility-by-facility basis, the same format used in the 1989 rulemaking
  - Source category, radionuclides released, existing controls
  - Bases for the risk estimate
  - Results of the dose and risk calculations
  - Description of supplementary emissions controls and cost effectiveness in reducing dose and risk

Communications

Communications

- We have developed a website dedicated to Subpart W which provides internet access to background information already compiled by EPA
- Provides public access to all non-privileged records, especially technical documents, as well as useful links to sites relevant to Subpart W
- http://www.epa.gov/radiation/neshaps/subpartw/rulemaking-activity.html

Communications

- We are conducting quarterly conference calls to brief stakeholders on the review of Subpart W

- Next Call is scheduled for Tuesday, July 6, 2010 at 11:00 AM EDT

- Phone-in number – 1-866-299-3188
- Conference Code 2023439563

Communications

- In addition to in-person regional presentations such as this, we are also holding an internet seminar (webinar)
- Thursday, June 17, 2010 at 11:00 AM, EDT
- Please see the Subpart W website for details on how to access the webinar

Questions?

EPA-5638

Tony Nesky

To

cc

bcc

Subject UPLOAD C:\Users\ANesky\Desktop\June14search\tubacitypresentation.pdf

- tubacitypresentation.pdf

EPA'S Clean Air Act Requirements: Uranium Mill Tailings Radon Emissions Rulemaking

Reid J. Rosnick
Environmental Protection Agency
Radiation Protection Division (6608J)
Washington, DC 20460
rosnick.reid@epa.gov

Presentation to
Uranium Contamination
Stakeholders Workshop
September 2010

Overview

- EPA regulatory requirements for operating uranium mill tailings (Subpart W)
- Status update on Subpart W activities
- Outreach/Communications

EPA Regulatory Requirements for Operating Uranium Mill Tailings (Clean Air Act)

- 40 CFR 61 Subpart W requirements apply to facilities licensed to manage uranium byproduct materials during and following the processing of uranium ores
- Limit on number/size of impoundments
    - Phased Disposal – lined impoundments no more than 40 acres, no more than two in operation at any time
    - Continuous Disposal – tailings are dewatered and immediately disposed, no more than 10 acres uncovered at any time

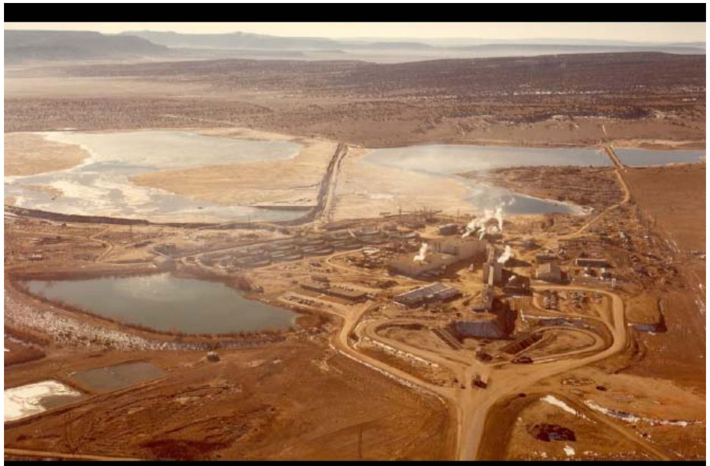
EPA Regulatory Requirements for Uranium Operations (Clean Air Act)

Subpart W Requirements (continued)

- Radon emission standard of 20 pCi/m^2/sec -- annual reporting requirements, notification in advance of testing
- The radon emission standard is for existing sources only (existing before 12/15/89)
- See http://www.epa.gov/radiation/neshaps/subpartw/index.html for more information

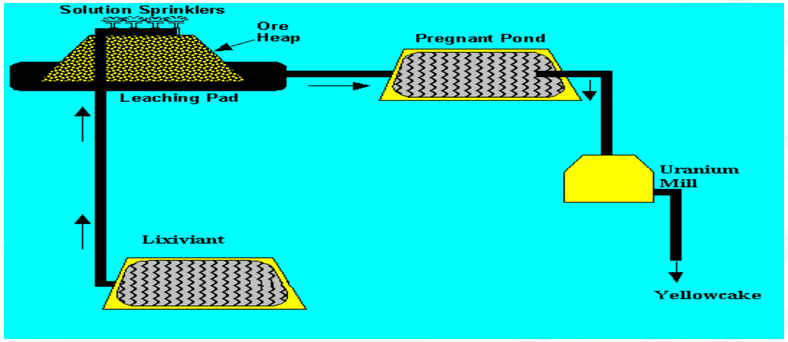
Uranium Recovery Methods

Surface Mill

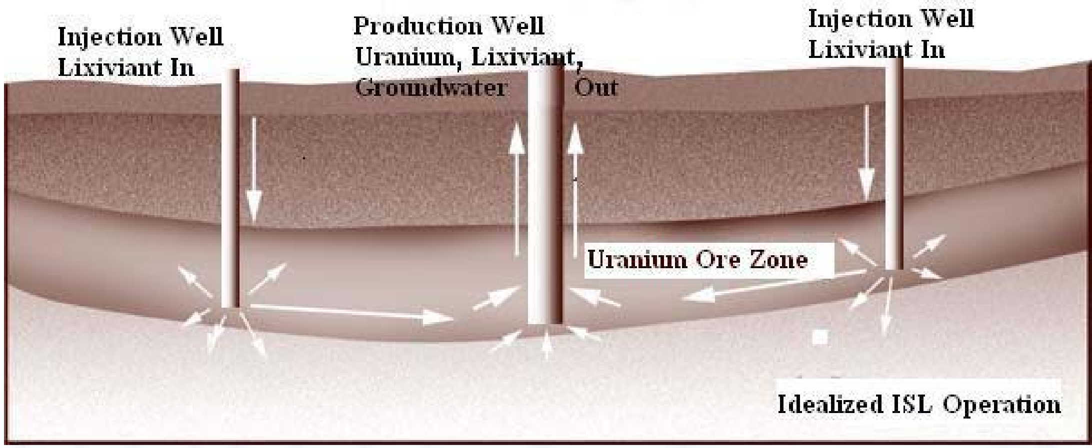


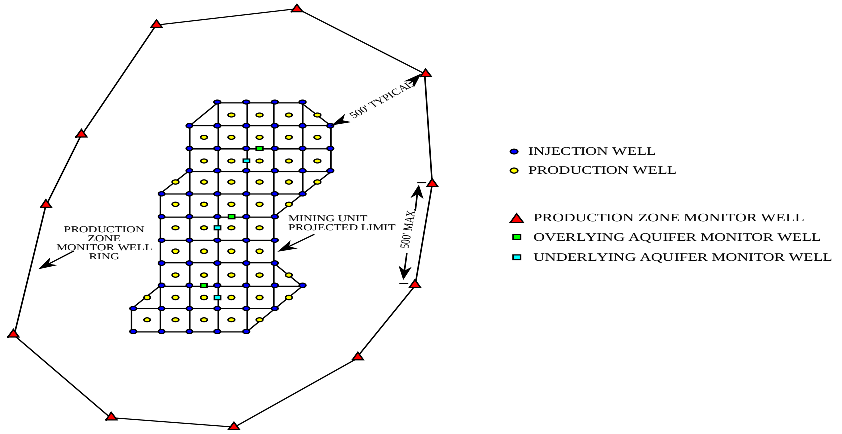
Rio Algom Ambrosia Lake mill, New Mexico, USA (1958-1985)

Heap Leach



In Situ Leach (ISL)





Uranium Mill Tailings Impoundments In-Situ Leach

Status Update on Subpart W Activities

Status of Subpart W Review Activities

- We conducted historical research on the risk assessment work originally done in support of the 1989 standard
- We completed a survey of existing technologies
- We requested that ISL facilities provide radon flux data from their evaporation ponds
- We are now in the process of performing new risk assessments at existing uranium mills and ISL facilities

Communications Plan

- EPA is committed to maintaining an open and transparent rulemaking process
- Objectives:
  - Inform stakeholders of potential changes in EPA's Subpart W requirements
  - Give stakeholders an opportunity to provide feedback
- Audiences:
  - Tribes
  - States
  - Offices/Regions within EPA
  - Other Federal Agencies: NRC, DOE, BLM, others
  - Mining companies

Communications Plan

- Strategies:
  - Develop clear messages and materials to explain the potential amendments to Subpart W
  - Educate stakeholders by using communications tools to provide easy-access to information
  - Work with stakeholder representatives and EPA regional staff to identify additional audiences and methods of dissemination
  - Communicate a timely and consistent message to stakeholders (Industry, Public, Tribes, States, other government agencies)

Outreach

- Holding stakeholder meetings to inform and receive input
  - on City, CO – June 2009
  - Rapid City, SD – October 2009
  - Gallup, NM – November 2009
  - White Mesa, UT – May 2010
  - Denver, CO – May 2010
  - Tuba City, AZ – September 2010

Outreach

- National webinar held June 2010
- Established a dedicated web site to act as an information outlet
- http://www.epa.gov/radiation/neshaps/subpartw/rulemaking-activity.html
- Site contains current and historical rulemaking documents, presentations, contact information, useful links

Outreach

- Quarterly conference calls to answer stakeholder questions
- Next call – October 5, 2010 – 11:00 AM EDT
- Call in number is 1-866-299-3188. You will be prompted for a conference code, which will be 2023439563. After entering the conference code press the # key and you will then be placed into the conference call
- Public participation by e-mail:
  - subpartw@epa.gov

Questions?

EPA-5639

Tony Nesky

To

cc

bcc

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- TubaCityreport.doc

	15 people
	Facilitator asked everyone up to the front of the room.
	Linda Reeves facilitated and introduced herself
	We will start of off with a background statement, then will have questions, and invited people to make statements.
	Loren Setlow introduced himself. He is a geologist for RPD in Washington DC, 35 years experiences. Expert in abandoned.
	Reid Rosnick introduced himself as a hydrologist for RPD in Washington DC. He has been with the Agency since the 80;s and worked in the state government as well as Federal. Welcomed
	Bridged, Val, tone
	Policy
	In audience 5 miles-3 20- 50 100-4 More than 100--25
	Navajo-7 Hope-1 Government-3 Mining company-1
	Question for Linda: Lillie Lane? Is this an informational meeting, where you yare just telling us what you are doing. L: Yes. But we also want to hear what is on your minds, and we are looking at standards for tailings, radon, and cleanup I don't want you to sneak up on Tuba City, and say we had a public hearing and that everyone agreed. No. This is an informational meeting only. We have a note taker, but we are not recording or using a court recorder. Reid noted that is not a public hearing. We have not written a rule, we're not at that point yet. We want to collect as much information as we can from people who are affected by uranium mills, and find out their concerns. Loren reminded the group that people could sign up to speak at any time, and that they can submit questions at any time.

	Loren's Presentation EPA is reviewing and possibility revising uranium and thorium rules. There are two rules—40 CFR Part 192 and 40 CFR Part 61 (Subpart W). The regulations are used by the NRC and their agreement states and the DOE. The rules apply to extraction facilities, operations, sites, and wastes The other rules apply to byproduct material from convention mill, In-Situ Leach, Recovery facilities, and heap leach Facilities.
	Background It has been 20 years since the regulations were issues. The meeting is to provide the public to learn what we're doing in the review, and get your input on what we need to consider when we review it. You live close to the facilities and know what is going on. When there is a draft rule, there will be opportunities to submit comments and have a public hearing.
	Loren explained that the most common way of extracting uranium is In-situ Leaching. He explained how the process worked. The liquid is then taken to a processing mill. The well field monitors the ground water to ensure that
	UMTRCA EPA's authority is very limited. We issue health safety and environ for FRNC and its Agreement Sates, DOE We have a concurrence role over NRC regulations s to implement EPA standards. The facilities licences are overseen by NRD or its Agreement States Reclamation of closed conventional mills and cleanup is over seen b DOE
	EPA does have other regulatory authorities over uranium mills, ISL, Clean Air Acts, Subparts W and A Clean Water Act—there is a provision that pertains, for stormwater permits SDWA—issues of injection well, issuance of Aquifer Exemptions NEPA—review EIS done by other agencies for facilities CERCLA—authority RCRA authority
	40 CFR 192
	It has been 23 years since originally used, 15 years since last update for groundwater protection

	Standards for lining of the impoundment and groundwater excursion. Cross-references RCRA regulatory requirements
	Radon emission standards- Contacts to be effective for 1000 yours where reasonable achieve
	Readings of radon 222 not to exceed 20 picocuries per square meter per second
	Limits on groundwater concentrations of hazardous substances, have to b e kept at background or MCLs, whichever is higher. After reasonable attempts to remediate groundwater to background, they can apply for alternative concentration limits that are as low s reasonably achieved. This comes into play a lot with discussions of ISL. Remediation standards for contaminated soils/buildings
	Requirements for
	Idea; diagrams. What can EPA do, video of a Geiger counter
	Provide environmental protection standards for operating thorium mills. Thorium can be used in nuclear power in a reactor, and produces less waste. There is great interesting in the US, in other parts of the world use of thorium is much more common, so we cant to make sure that the rule is protective for thorium's will.
	He went over maps of mills.
	Proposed ISL—the price of uranium has gone up significantly, so there are more proposals for ISL mills. He showed some of the license requirements.
	ISL/ISR facilities None in AZ, but here is talk of them in NEW Mexico. Our standards provide for groundwater protection during production and aquifer restoration following production. The rule was written for convention. The NRC interprets the rule for ISL/ISR licensees for undergournd mining unit and aquifers above, below, and adjacent. The NRC applies to surface and subsurface facilities. As interpreted by NRC: Restoraiton standards to abackgournd or MCLs.
	UNDER SDWA, EPA issues underground injection control well permits for uranium ISL/ISLR. They have to get it from EPA; they cannot operate the facility with out it, even if they have an NRC license. EPA issues aquifer exemptions for or portions form SDWA protection if the aquifer will not be used for drinking water, and for salty aquifers, and for potions of an aquifer, a small portion of the aquifer. It
	It cannot be used for drinking water, but it could be used for livestock or industrial It does not prevent people from drilling a well in that aquifer.
	See aquifer exemption diagram—re do
	REID
	Reid said that he will talk about the CLEAN AIR ACT These rules were promulgated in 1989—these ones are specifically about air. This is a NESAHAP-National Emission Standard for Hazardous Air Pollutant. The original flux

	rate was 20, and applies to facilities existing before DEC 1989. The flux standard is protective of the environment. After 12/15/89, new impoundments must meet one of two new work practices—phased disposal –40 acres of left. Continuous disposal=-de
	Review We reviewed after receiving Notice of Intent to Sue by two Colorado environmental groups. They filed based on allegation that we failed to review after 10 years, as required by the CAA. We entered in negotiation and reached agreement by consent. Added as lot more communications and meetings.
	Also realized that there were a lot of ISL and heap leach, and determined that they would have to meet Subpart W, because they are impoundments of by product materials.
	We are reviewed to determine is still appropriate because of dominant use of ISL/ISR, . The languate in the rule is not very specific—how to make regulatory requirements easier for owners to understand. They want to add test methods for evaporation pounds, when you don't have a solid surface like a tailings pile. We have requested that ISL/ISR facilities provide radon flux data from their evaporation ponds. We are also looking at technology and design of mill tailing facilities. Loren
	Are the standards still appropriate in risk and dose actors for radiation from radon? Principal scenarios for exposure Substance and cultural lifestyles of affected communities including Tribal, EJ and c Free release of some facility sites after decommissioning—implications for 40 CFR 192 Changes in EPA protective standards for hazardous substances in groundwater and drinking water. Some of the values of changed Chanes in extraction and site remediation Potential for uranium extraction in new areas.
	EPA is coordinating with other Agencies, making presentations at State association and other conferences EPA Region Offices in coordination with EPA HQ to provide lead role for outreach to public, industry
	We're holding a series of public information

	We have some websites Interactive Internet Sites-Discussion Forum And address
	Several people asked about web address
	Contact Information for Subpart W Quarterly conference call is October 5, 11 AM EDT 1-866-299-
	Radiation
	Need cards with web address:

	PUBLIBC PARTICIPATION
	QUESTIONS
	Jason Kaufman What are the methods to protect surface soils? L: The only protection standards we have are for uranium, so currently the only protection standard in the rule is for radium. The rule is silent on other heavy metals.
	Can RCRA be changed to include radioactive materials as hazardous, either specific properties like flammable corrosive items, or numerical levels? L: We are not part of the RCRA program. We are obligated to revise the rule under UMTRCA authority. R: I spent a number of years in RCRA. Radionuclides are specifically not included; radionuclides have been historically regulated under the AEA. All the rules are frankly convoluted. Radionuclides are covered under various statues under AEA, CAA. We borrowed RCRA standards for surface impounds because they were the best designs at the time. We borrow from the best practices from the various statues. To do that it would take a reauthorization of RCRA from Congress to include radionuclides in the scope. L; It was looked at years ago, but the determination was not to include it under RCRA/
	Q: What about airborne dust? What about the constituent attached to dust blowing in the wind? R: At operating mill facilities, the NRC converts the levels that can be emitted in dust. They are covered in NRC licenses L: They are part of the consideration of 192 and the impacts to surrounding communities, but were not determined to be a sufficient hazard to require regulations We will look at it again.
	O YOU LOOK AT Other countries rules, such as EU
	We do look at those
	Can you explain standards applicable to u recovery and the role of the EPA, the NRC, and the Tribal Environmental Protection agencies?
	L: It comes down to who has the permits. For example, let’s look at n ISL facility in WY. The NRC grants the license, the state of WY gives a mining permit. Each under their own authority inspects the facility, and check for leaks and excursion. Each can independent c an make an enforcement action to make them cleanup the facility EPA has an agreement with NRC under the Superfund, and EPA has the authority under the UIC permitting We try to work with our sister agencies to provide oversight. We do have anything form NRC.

	What about the tribal role? In cases of facilities that has excursion or contamination event—it depends on whether operating or close. If operating, it's NRC. If on tribal land or excursion on tribal land, the tribe has authority. IF it issued by the NRC, they have agreements with the tribes to If it is a closed facilities, DOE is the regulator, the DOE will work with the tribes, and EPA will step in to provide the tribe with assistance
	15 more questions
	Why does the US continue to extract on indigenous lands. What are the negative truths on how native land will be affected.
	L: I'll try to address the first. The US uranium for its nuclear power plants and weapons. Currently the US is an importer of uranium from Canada, Australia, and Kazakhstan. The demand for uranium is growing with China and India. It is a matter of national security. The Minerals Policy act of 1980 requires us to increase extraction of minerals domestically as a matter of national security. EPA's role in uranium milling is somewhat limited. We have a real responsibility to work with tribes, as government to government. Every agency has an agreement with Tribes. We are trying to work with tribes and work on the important. The NRC has opened up lines of communication on these complicated issues. EPA takes tribal issues into consideration when reviewing EIS. Many areas on the land are considered sacred. R> The questioner talked about the negative truths. We don't have to look very far from the negative truths. Right here the negative truth is a mile and half up the road. We don't want to put you in that position. We will try our best to prevent effects. L: As a matter of policy of EPA, we have a policy for protection of Native Americans from the 1980 and there is an Executive order that. We did a review of all the areas of the uranium mills, 75% of the sites were federal and tribal, so we recognize the disproportionate impacts.
	What is your timeline for issuing the draft regulations
	For UMTRCA, we will complete our review early next year, if we were to revise it would be early 2012.
	R: I'm further along. We have completed risk assessments on all facilities to determine if the flux standard is still protective. I'm hoping that we can propose a rule within 13 months.
	Q: Will these rules affect new AISL facilities that have permits approved, but are not producing uranium?
	L" The facilities will be bound by the conditions in the existing regulations
	Q: Would current UMTRCA sites, including the 4 on the Navajo Nation, have to abide by these revised regulations?
	L: It depends on how extensively the rule is revised. For example, if an old facilities are

	not lined to dig up and rebuild Comment from the audience: Activist: It will cost $1 billion to do that as a result of the failure of the existing Part 191 regulations. (Sarah Fields?)
	Q: Subpart W affects only ISR, right? Is there a proposal to affect conventional, too.
	No. Subpart W applies to conventional, ISL, and heap leach facilities. Any revision would apply to all three types.
	Q: What is the process to override an aquifer exemption, and why doesn't that decision go public?
	L: I'll do the best to answer that question, but will refer to Region 9 Three is no provision to override it in the existing regulation. IF it was granted by a state agency, as is the case in Crown Point, where EPA disapproved but was overturned by the circuit courts. IF the state has provided it, EPA can ask them to reconsider, but it is hypothetical and I don't know. Please see me after the meeting t
	What the financial requirements of milling companies to protect the taxpayers form bankruptcies and fly by night operations: L: There are not many fly by night milling facilities as these are extensive facilities. NRC has its own regulations for bonding and assurity.. States also have them in their permits. For ISL, EPA's UIC also has a bonding requirement The strongest are the NRC's. Many of the permits The expenses would be great for the federal government, so the Superfund is reviewing them to determine if they are adequate. Who is taking a hard look?
	Does EPA have any compensation program like those under DOJ that are affected by mining operations. :L The only ones I know are here at the Navajo Nation for the rebuilding and relocation of homes. T
	How are background levels set? Examples of radius, depth, and number of samples.
	MARSSIM Manual, which has been agreed to by EPA and NRC. It sets forward a set of principles about the surveys that have to be taken and how to determine background statistically. It can also look outside the boundaries of the contaminated sites. The manual is available on our website. Go to epa.gov/radiation
	What are the penalties for violation and how much wiggle room in the Law is there. L: The regulatory agencies, ie the states and NRC issue the penalties. If it is closed, and Supefund applies, there are forumulas. Are you reviewing? Under UMTRCA, we don't' have authority for boneding requirements. So its sounds like you don't have power to penalize except Superfund? : IF its stormwater, its CEAS, if it is excursion, it is CWA.

	R;; The Office of Enforcement handles this. Each region has their office, and enforcement is usually done at the Regional level.
	Comment on Superfund from Andy Bain, Region 9 Region 9 was able to use CERCLA authority to clean up houses from mines. There is an exclusion to use monies to address Uranium Mills. There is no sunset provision to address soil contamination from after 1978,
	What is the time frame to protect drinking water and adjacent LL IF NRC facilities it is up to 6 months from the time of the excursion. Please give me you After milling has stopped, under UMTRCA requirements they have up to 18 months. Under conventional mills, the monitoring requirement is annual (change this sentence). It is possible that an excursion could be missed
	What are the methods for the public to monitor the testing and monitoring data? Will the data be kept back by corporate secrecy. The monitoring is provided to the NRC. They will include it in their ATOMS systems, which is accessible by the Internet.
	Can the Navajo Nation request a workshop to be better understand. The ISL Can your office set this up. L: We'd love to, and will work with the Navajo Nation to setup
	What is EPA doing NOW to address health hazards of the present population including vegetation. Be specific. The EPA in region 6 is looking at groundwater studies. In Wyoming, where the DOE wanted to allow an alternative concentration limit at milling facilities, we recognized that ranchers watered livestock just off the, we asked state and DOE to consider these impacts, and the operators purchased the land so that livestock would be used?
	Why doesn't Thorium have a drinking water MCL? Linda: I honestly don't know. Can I get back to you?
	Can you gather information about the operations at the Rare Metals sites in the 1970s? L: There is data available about the site that was published in the EIS. The data is on our website Other information on the Rare metals site is available at the DOE. In terms of the operations, it is a Tile1, abandoned and closed facilities, records may exist at the old AEC, but I don't know how to retrieve them. Please give me your contact information.
	Follow-up: We have a lot of people who are sick in the area south of rare metals. Three is no vegetation, livestock are deformed from uranium contamination, and there are high rates of disease in our population; cleft palate, cancer, Bells Palsy, and no one ever talks about it. L: That's handled by our regional office. I'll have to take your name

	Follow-on: That was 50 years ago, an we are still feeling the effects Because all this is going on, and continues to go on, just leave us alone, we're
	Can the people who live nearby Rare Metals be compensated because they were relocated there to build a f I cant' answer
	I'm confused by everyone's roles. Could I get a list of everyone's authorities and activities? L There is a five-year plan that lists what the agencies are doing. There is also information on Region 9's websites.
	Does your current risk assessment address restoration to baseline after U is extracted, and if so, how?
	L; That risk assessment has not been done yet. It will included impacts to those adjacent and all exposure pathways, groundwater use, housing on or adjacent, length of exposure by ingestion versus inhalation, scenarios for operating versus non-operating. Your sugesstions are welcome.
	Follow-up : what is baseline? The exact concentration of anions cations. Will they be the same after BLANK is removed? L: We'll look at that. We'll look at exposure scenarios for operating versus non-opearting, and look at the risk to determined a remediation point.
	Follow-on: Companies are saying hat they are restoring to baseline, but how can you achieve the same equilibrium after u is removed. L: The U can be bound up to other things. We need to look at impacts to subsistence farmer drinking water every day. We have not yet developed the scenarios. The requirement is that they go to background or the MCL. Most facilities have one or two hazardous substances—not necessarily u—that require ACL
	What are issues related to thorium? L: How will it be milled, what are the emissions, the natural decay of thoron, we don't have a model facility for thorium, so we will model on thoron outgassing, from there look at risk assessment for radon gas impacts.
	Comment: Radon from thorium has a shorter half life, and its' decay products have a short half life and are more active. I don't think it's an improvement on uranium.
	Does EPA of 2005 cover uranium extraction on tribal lands under the tribal energy agreements? ; A: We don't know and will have to get back to you
	What process would one person need to do to get an :L: We will defer to Water Resources Board
	Is there a timeframe for Subpart W under Consent Decree
	It was a consort agreement, not decree. The consent agreement is on our website. There is no court ordered deadline. I want it in place within 13 moths. It terms of your question on baseline, are you asking about the exact amount of bi carbonate.

	L: The companies in their restoration use a variant of pump and treat. They will inject things to stop the leading of fur, e.g. sulfide, to change ph to neutral. There are so many other minerals in the ground; the process may not work for every mineral. They will replace certain volume of waters several times and evaporate the sludge, or pump into ground. They may do these four and five times, but some time up to 10 times the volume of the aquifer. So you will never get back to baseline. You will for some constituents, but not for all...

	7 speakers.
	Sarah Fields, Moab Utah Se Utah IS THE center of
	Se UTAH is the center of conventional milling. I have problem with Part 61 Subpart W. You heed to take a look at Subpart a, general requirements. They were promulgated in and have a Utah is the only state I see a total breakdown in application approval process. IT is basecially a rubberstamp, I have sent hat with Supbart b. IT needs to be more than a rubber stamp, that provides a great deal of information and chance of public Mine owners are not complying, I suspect that mill are not A new tailings cell under subpart A should be for a set period of time, not for decades. The biggest problem is Subpart W and 192; there is a gap for radon release during operation and the time when they put in a final barrier. Tailings blow around, there is a lot of radioactive particulate matters, and you haven't resolved the There is supposed to be a tailings closure plan, and reclamation milestones with public notice. There was none at Cotter. The tailings impoundment closed in 2005, and there were not miles tones or notices. CO doesn't think it needs to measure the radon flux at the Cotter pile; Apparently EPA gave them a pass. Everything looks good on paper, but you don't have the enforcement.
	Allison Gibbon of the Sierra Club Sierra Club will stand behind the toughest regulations possible to protect our environmental, people and wildlife. It is great that you are here to talk to the people who have suffered the travesties of the past. There are many permits in the Grand Canyon areas, there are now mines proposed on the North Rim that affect to halavpi suluapi, it is

	hard for them to travel to Tuba City. The Arizona 1 mine was approved in the 80s, sat idle for year, and reopened without needing reconsideration. They are on public lands, and when the mine opens they are fenced up and not longer public. There is no way to completely cleanup the tailings. There should be total cost accounting on the cleanup. A Canadian company is running the mine and selling the U to Korea and Japan, so there are not national security issues. You should consider this in the rule. Thank you for listening. L: I want to clarify. We are authorized under UMTRCA to regulate mills not mine. Only heap; leach? (AKS) I fully understand your concerns and used to work with mines in the past. There were instances. Waste used by campers is not The issue is that for the Bureau of Land Management. EPA regulates the mines stormwater permits under NPDES, and if underground has approval process under Subpart A under NESHAP Are the regulations on conventional mines being updated. R: No. But I am aware of the Arizona One Issues, and am working with Region 9 on this. Region 9 has the lead and is working on the issues.
	Michelle Dinuyache SeLF as community member, Fort Defiance, AZ. I have a comment on risk assessment. I recommend that you obtain information on inputs to models from tribal representatives to ensure they are fully representative of lifestyles. My next comment is on dose and risk factor scenarios. For 192 I think that currently levels I would recommend at risk-based approach at the low end of the range as opposed to continue (inaudible) LL: The regional offices will be approaching the tribes for the tribal specific input to reflect lifestyles. That should be happening soon
	David L Neztsosie, self and family, Shadow Mountain, AZ I'm here at this is the only opportunity I have to attend a workshop. I liked the question that somebody asked. What has happened. For 30 years, mining went on, mills developed next to streams, near communities, and abandoned overnight. So it has spread by wind and other seasonal weather. It has been determined that this is a good location for wind farm. So how much of a down winder are we? There are sicknesses related to uranium in my hometown, respiratory and nervous disease, it is troubling my mom and dad,. Two of my youngest sisters have died for it, aged 30 years. I can see that in the community. What authorities and the people's government do not seem to agree how U can be related to health problems. Somebody's windmill was taken down because of its' high concentration of uranium (SEE ABOVE). Abandoned mines collect water, sheep drink the water. You can go miles before you reach another water resource. Although mines have been remediated, this is only a band-aid solution. Horse and livestock would step into holes and fall, The only thing you can do is hoot people east of me have a high content of U in their only drinking water and give it to their live stock.

L: A good piece of the meeting today dealt with water problems. We realize that this is a very large problem, and that when a well is posted and shut down, (SEE WINDMILL COMMENT—means that well was posted) it is a very large problem to find a replacement. We are doing the best we can to identify other water sources for these communities. We know that the Navajo Nation has forbidden mining on its lands again.

Cassandra Bloedel, Navajo Nation EPA

I was going to request EPA HQ continue to look at all the data for Tuba City Dump, HWY 160 because there is thorium in the GW, and BLA is ignoring that fact. It is important that EPA determined MCLs for all radionuclides. We have copper and arsenic in the groundwater. The former RARE METALS site had arsenic products, and we found them at HWY 160, and these facts are being pushed to the side. In any new development process, you have to recognize that it will generate radionuclides.

We had to go to the forensic analysis of the U isotopes to related HWY 160 to the Mill. You may have to establish MCLs for isotopes.

I missed the fact that water was being reinjected into the Navajo Aquifer. It is the main source of potablae water. They are only publishing reports on certain consitutrents. What about the others—aresenci mollydenum We need to make sure that we have the correct technology to

Crown Point is within a quarter mile of the community, and it is upgradient. The aquifer is fractured, and shallow GW contaminated will contaminate deeper groundwater.

Look at data that have been released. Look at the Navajo reports presented to Congress. Thank you for y our time and being here.

:L: I appreciate the discussion of thorium. Our existing standards issued in 1995 did include a few substances that are not primarily MCLs, such as silver and molybdenum, these metals are typically found
We will look at thorium and vanadium

Carl Holliday, Navajo Nation, Monument Valley, AZ

I appreciate what Sandra said. Our concerns seem to fall on deaf

My concern on 191 A, limits of uranium shall apply to thorium
Under 192 DS, dose equivalents to any member of the public—aren’t dose equivalents high compared to Uranium or gamma radiation/ Could someone clarify for me?

The other thing is exposure rates. If you have 600 or 700 lbs of uranium in a pond, how does not show up somewhere else?

L: The history of the radon dose to the public. It looks at dose form all part

	25 to public, 75 to any organ. We're looking a hard look in thee revision We are looking to see if we can make it more protective. It is an upper limit, and we could make it more protective In terms of the ISL pounds, we are looking at thither constituent.
	Esther Honeyestewa, self and family, Hotevilla, AZ Thanks for people coming form the US government. We have a lot of issues on the reservation. We have a lot of issues concerning our water here. We have an issue on the Peaks, and not one member came out, so it is not that important, but springs are being contaminated. You came out. I'm from HOPI, and I am concerned about water. Our water is sacred here, and we do not waste water. It looks like this is another project to take water away. The uranium a mile away has really affected our land. If our water goes away, we will go away. Our pure water is becoming contaminated. Our people are dying from all the things the government is doing to the land. We cannot mess wiuth Mother Earth. Our farmers work hard for the families. My family was one of the ones shipped to Rare Metals when the hospital was being built. My Dad planted right outside the Mill tailing, we ate it, and a lot of people in my family have caners. Think about that when you write your rule. We don't have it easy—this is dry desert, and people want to take our water. All the water underneath is one body of water, and we need to respect that water. Why do we want to make bombs? That is not right We are here to help each other, not hurt each other. We are a spiritual people we have prayers for everything Our plants are not what they used to be. I'm a farmer and I'm proud of it, and I want my grandkids to Water is sacred. Do your mining somewhere else.
	Harrilene Yazcie, self and family, Greasewood, AZ A lot of what we are discussing. I can understand the Federal government's position where you have to take our comments and balance them against If you drive to Flagstaff you can see energy leaving the Navajo Nation. With all the contamination, as well as the water, it leaves little room for development—not just economic development, but also subsistence development. You need to find the balance between what is right from the nation, as well has what is respectful for the indigenous peoples. There is no wiggle room. You are forced to make decisions that keep you up at night. The fundamental reasons we are facing these issues

	are due to violence—it was all for greed or gain. There are a few things. I've learned that you listen to numbers. The use of water on Navajo is 10 t 15 gallons, per person, but we pay more per capita. In Phoenix. Arizona has more boats per capita than the states of Minnesota. The mindset is to do $5 for 7400 gallons ofaa170 per day per person. So when you re-inject thorium into the Navajo Aquiger, and children die in infancy. When a child laughs, we Navajo have a celebration, because the child is a person. That will be denied someone, because you can't determine background, because you can't determine MCLs? We are so far behind under
	Open floor:
	Same gentlemen David Assisi I wish all the agencies involve could learn how to work as a team. Is it in the 5 year plan? It seems that everyone is pursuing this individual. The aquifer could be a precious source. In 1996 we had the worst drought, springs weren't putting out, but some other ones did. The Navajo EPA was surprised—50 to 100 gallons per minute. The lower xxx—anything we can do to save it, that's what I'm interested in. Thank you for the
	L: Congratulations for your stamina. Thank your for refereeing each others. We will pay attention The comments on usage of water have been loudly heard. We could address water quantity, we address additional elements for which MCLs have not been determined. R:Thanks you for sharing parts of your lives.
	Ettstitty: Workshops:--across Navhajo nation Explain the rules in greater detail Explain the jargon Purshpose—residents and citzens can provide relevant comments when we propose the rules.

Tony Nesky

To

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EPA Review of Standards for Uranium and Thorium Milling Facilities

PUBLIC INFORMATION MEETING
Tuba City Arizona
September 15, 2010

On September 15, 2010 EPA held a public information meeting in Tuba City, Arizona to provide the public an overview of the regulatory review and existing standards and to seek public input on the review of 40 CFR Part 192 and the revision of 40 CFR Part 61 (Subpart W).

MEETING STRUCTURE

The meeting began with opening remarks and introductions. Loren Setlow and Reid Rosnick of EPA's Radiation Protection Division (RPD) opened the meeting by giving a presentation on the EPA's review of 40 CFR Part 192 and 40 CFR Part 61 (Subpart W). The presentation was followed by a question and answer session. Participants were invited to submit their questions on an index card so that they could be read aloud for the benefit of all. After the question and answer session, the public was invited to provide input by signing up for five-minute presentations. In the remaining time, the floor was opened up for additional audience questions and input. Linda Reeves of EPA Region 9 served as facilitator. Tony Nesky of RPD took notes. Loren Setlow, Reid Rosnick and Linda Reeves closed the meeting by thanking the group for their participation, and sharing parts of their lives. Loren noted that the many comments on water usage had been loudly heard, and that EPA's review of the rule will examine water usage and constituents for which MCLs have not been determined.

There was one question about the purpose of the meeting. Lillie Lane of the Navajo EPA asked if this meeting was informational only or a hearing as part of a rulemaking. She expressed concern that the U.S. EPA could go back to Washington saying that they held a hearing in Tuba City and that everyone agreed. Loren Setlow replied that the purpose of the meeting was informational and that the U.S. EPA wanted to know what was on everyone's mind as it reviewed the uranium and thorium rules. Loren reminded participants that they could sign up to speak or sign up for questions at any time.

ATTENDANCE

Thirty people signed up to attend the meeting, though attendance was probably higher as people continued to join the meeting after the registration desk closed. Facilitator Linda Reeves asked participants about their affiliations. Seven people indicated affiliation with the Navajo Nation, and one person indicated affiliation with the Hopi Nation. Three persons indicated that they were attending for a government agency, and one person was attending for a mining company. Linda also asked participants to indicate how far they had travelled to attend the meeting. Three people only had to travel a short distance—5 miles or less. Four persons travelled up to 100 miles to reach the meeting, and the rest—25 people—had to travel more than 500 miles. Appendix A contains the list of registered participants.

AUDIENCE QUESTIONS TO EPA

QUESTION	EPA RESPONSE
What are the methods to protect surface soils?	Loren answered that the only protection standards currently in the rule are for uranium and radium. The rule is silent on other heavy metals.
Can RCRA be changed to include radioactive materials as hazardous, either specific properties like flammable corrosive items, or numerical levels?	Loren noted that the rule review is not part of the RCRA program, and any revision of the rule would under UMTRCA authority. Reid noted that RCRA does not specifically include radionuclides, which have historically been regulated under the Atomic Energy Act. He acknowledged that the regulatory scheme can be complicated, and that radionuclides are covered under various statues under AEA, CAA. RCRA standards for surface impoundment were used in Subpart W because they were the best designs at the time. When regulating radionuclides, EPA "borrows" from the best practices from the various statues. Reid completed his answer by noting that addition of radionuclides in RCRA would require reauthorization of RCRA. Loren added that the addition of radionuclides to RCRA had been considered years ago, but the determination was made not to include it.
What about airborne dust? What about the constituents attached to dust blowing in the wind?	At operating mill facilities, the NRC converts the levels that can be emitted in dust. They are covered in NRC licenses. Loren added that constituents in dusts part of the consideration the impacts to surrounding communities in 40 CFR Part 192, but were not determined to be a sufficient hazard to require regulations He said that EPA will examine this issue again.
Do you look at other countries' rules, such as those of the European Union?	Yes, EPA does look at the rules of other countries.
Can you explain the standards applicable to Uranium Recovery and the role of the EPA, the NRC, and the Tribal Environmental Protection Agencies?	Loren answered that authority depends on who has the permits. He cited a hypothetical example of an ISL facility in Wyoming. In this case, the NRC grants the license, the State of Wyoming gives a mining permit. Each under their own authority inspects the facility, and checks for leaks and excursion. Each can independently undertake an enforcement action to make them clean up the facility. He

QUESTION	EPA RESPONSE
	continued that EPA has an agreement with NRC under the Superfund, and that EPA has the authority permits for Underground Injection Controls. He added that EPA tries to work with its sister agencies to provide oversight.
What about the tribal role?	Loren answered that if it facility has an excursion or contamination event—the roles depend on whether the facilities are operating or closed. The NRC has authority for operating facilities. If the facilities are on tribal land or there is an excursion on tribal land, the tribe has authority. The NRC also has some agreements with tribes. DOE is the regulator of closed facilities. The DOE will work with the tribes, and EPA will step in to provide the tribe with assistance.
Why does the U.S. continue to extract on indigenous lands? What are the negative truths on how native land will be affected?	Loren said that he would try to address the first question. He began by noting that the U.S. needs uranium for its nuclear power plants and weapons. Currently the U.S. is an importer of uranium from Canada, Australia, and Kazakhstan. The demand for uranium is growing in China and India. Uranium mining has thus become a matter of national security. The Minerals Policy Act of 1980 requires the U.S. to increase extraction of minerals domestically as a matter of national security. EPA's role in uranium milling is somewhat limited. We have a real responsibility to work with tribes, as government to government. Every agency has an agreement with Tribes. We are trying to work with tribes and work on the important. The NRC has opened up lines of communication on these complicated issues. EPA takes tribal issues into consideration when reviewing Environmental Impact Statements, which note when areas of the land are considered sacred. Loren added that EPA has had a policy for protection of Native Americans since the 1980s and there is an Executive Order as well. EPA did a review of the locations of uranium mills, and found that 75% of the sites were on federal and tribal lands. EPA recognizes the disproportionate impacts. Reid referred to the question about "negative truths," noting that there is a "negative truth" one mile and a half up the road, and that EPA will try its best to prevent effects.
What is your timeline for	Loren answered that EPA will complete its UMTRCA

QUESTION	EPA RESPONSE
issuing the draft regulations?	review early next year, and that any revision would be issued in early 2012. Reid answered that the review of Subpart W is further along. EPA has completed risk assessments on all facilities to determine if the flux standard is still protective. Reid hopes that EPA can propose a rule within 13 months.
Will these rules affect new ISL facilities that have permits approved, but are not producing uranium?	Loren answered that the facilities will be bound by the conditions in the existing regulations.
Would current UMTRCA sites, including the four on the Navajo Nation, have to abide by these revised regulations?	Loren answered that it depends on how extensively the rule is revised. For example, if an old facility is not lined, they would have to dig up tailings and rebuild the impoundment. *Comment from the audience (Sarah Fields)*: It will cost $1 billion to do that as a result of the failure of the existing Part 191 regulations.
Subpart W affects only ISR, right? Is there a proposal to regulate conventional mines, too?	Reid answered that Subpart W applies to conventional, ISL, and heap leach facilities and that any revision would apply to all three types.
What is the process to override an aquifer exemption, and why doesn't that decision go public?	Loren said that he would do his best to answer this question, but will refer the question to Region 9. He said that there is no provision to override it in the existing regulation. He cited the example of Crown Point, where the exemption was granted by a state agency. EPA disapproved but was overturned by the circuit courts. Loren brought up a hypothetical situation where EPA could ask a state to reconsider an aquifer exemption, but he asked the questioner to see him in person after the meeting.
What are the financial requirements of milling companies to protect the taxpayers form bankruptcies and fly by night operations?	Loren observed that there were not many fly-by-night milling facilities as these are extensive operations. NRC has its own regulations for bonding and surety. States also have financial requirements in their permits. EPA's UIC program also has a bonding requirement for ISL facilities. NRC has the strongest requirements. The expenses [of a bankrupt facility] would be great for the federal government, so the

QUESTION	EPA RESPONSE
	Superfund is reviewing them to determine if they are adequate.
Does EPA have any compensation program like those under DOJ that are affected by mining operations?	Loren answered that the only ones he knew were here at the Navajo Nation for the rebuilding and relocation of homes.
How are background levels set? Give examples of radius, depth, and number of samples.	Loren and Reid answered that background levels are set using the MARSSIM Manual, which has been agreed to by EPA and NRC. It sets forward a set of principles about the surveys that have to be taken and how to determine background statistically. It can also look outside the boundaries of the contaminated sites The manual is available on our website at epa.gov/radiation.
What are the penalties for violation and how much wiggle room is there in the law?	Loren answered that the regulatory agencies--the states and NRC issue the penalties. The Superfund applies if the facility is closed and has formulas for penalties.
Are you reviewing them?	Loren replied that EPA does not have authority to issue bonding requirements under UMTRCA.
So its sounds like you don't have power to penalize except Superfund?	Loren explained that there are penalties for stormwater violations under the Safe Water Drinking Act and penalties for excursions under the Clean Water Act. Reid added that EPA's Office of Enforcement handles penalties. Each region has their office, and enforcement is usually done at the Regional level. Andy Bain of Region 9 answered that Region 9 was able to use CERCLA authority to clean up houses contaminated with mine wastes. He added that there is an exclusion to use monies to address Uranium Mills. There is no sunset provision to address soil contamination from after 1978.
What is the time frame to protect drinking water and adjacent areas?	Loren answered that that NRC-regulated facilities have up to up to six months to clean up the facility from the time of the excursion. Under UMTRCA requirements they have up to 18 months to clean up the facilities after milling has stopped. At conventional mills the monitoring is done on an annual basis, so that it is possible that an excursion could be missed.

QUESTION	EPA RESPONSE
What are the methods for the public to monitor the testing and monitoring data? Will the data be kept back by corporate secrecy?	Loren replied that monitoring data is provided to the NRC. NRC includes it in their ATOMS system, which is accessible by the Internet.
Can the Navajo Nation request a workshop to be better understand the rulemaking and ISL implications? Can your office set this up?	Loren replied that EPA would be happy to help, and will work with the Navajo Nation to set up a workshop.
What is EPA doing now to address health hazards of the present population including vegetation? Be specific.	Loren replied that the EPA in Region 6 is looking at groundwater studies. In Wyoming, where the DOE wanted to allow an alternative concentration limit at milling facilities, EPA recognized that ranchers watered livestock just off the site so it asked the state and DOE to consider these impacts.
Why doesn't thorium have a drinking water MCL?	No one from EPA could answer this question, so EPA offered to get back to the questioner.
Can you gather information about the operations at the Rare Metals site in the 1970s?	Loren noted that there is data available about the site that was published in the Environmental Impact Statement. The data is on our website. Other information is available on the Rare Metals site is available at the DOE. Records may exist at the old AEC for abandoned and closed facilities. Loren didn't know how to retrieve these records so he asked the questioner to provide contact information.
We have a lot of people who are sick in the area south of rare metals. Three is no vegetation, livestock are deformed from uranium contamination, and there are high rates of disease in our population; cleft palate, cancer, Bells Palsy, and no one ever talks about it.	Loren replied that the Regional Office would handle this complaint, and asked the questioner to provide contact information. *The questioner replied*: "That was 50 years ago, and we are still feeling the effects. All this is going on, and continues to go on--just leave us alone."

QUESTION	EPA RESPONSE
Can the people who live nearby Rare Metals facility be compensated because they were relocated there to make way for a mine?	No one from EPA could answer this question.
I'm confused by everyone's roles. Could I get a list of everyone's authorities and activities?	Loren referred the questioner to a five-year plan that lists what the agencies are doing and noted that there is also information on Region 9's websites.
What are issues related to thorium?	Loren answered that the issues are how thorium will be milled, what the emissions are, and the natural decay of thoron. EPA does not have a model facility for thorium, so we will model on thoron outgassing, and from there look at risk assessment for radon gas impacts. *Comment from the floor:* Radon from thorium has a shorter half life, and its decay products have a short half-life and are more active. I don't think it's an improvement on uranium.
Does your current risk assessment address restoration to baseline after uranium is extracted, and if so, how?	Loren replied that this risk assessment has not been done yet. It will include impacts to those adjacent and all exposure pathways, groundwater use, housing on or adjacent to the facility, the length of exposure by ingestion versus inhalation, scenarios for operating versus non-operating. He replied that EPA will look at exposure scenarios for operating versus non-operating, and look at the risk to determine a remediation point. He invited suggestions from the public.
Follow-on question: What is baseline? What is the exact concentration of anions, cations? Will they be the same after the uranium is removed?	Loren explained that the companies in their restoration use a variant of pump and treat. They will inject things like sulfide to stop the leaching of uranium to change pH to neutral. There are so many other minerals in the ground; the process may not work for every mineral. They will replace certain volume of waters several times and evaporate the sludge, or pump into ground. They may do these four and five times, but some time up to 10 times the volume of the aquifer. The original baseline may be the same for some

QUESTION	EPA RESPONSE
	constituents, but not for all.
Does the Energy Policy Act of 2005 cover uranium extraction on tribal lands under the tribal energy agreements?	No one knew. EPA offered to get back to the questioner.
What process would one person need to do to get a well re-opened?	EPA will defer that question to the Water Resources Board.
Is there a timeframe for Subpart W under Consent Decree?	Reid answered that it was a Consent Agreement, not a decree. The consent agreement is on our website. There is no court ordered deadline, but I want it in place within 13 months.

PUBLIC PRESENTATIONS

Members of the public were invited to provide five-minute presentations on the following topics:

- Changes in uranium industry technologies (such as utilization of the In-Situ Leaching recovery process as the principal current technology for extracting uranium) and their potential environmental impacts
- Revisions in EPA drinking and groundwater protection standards
- Judicial decisions concerning the existing regulations
- Issues relating to children's health, Tribal impacts, and environmental justice
- Dose and risk factors and scenarios for assessing radiological and non-radiological risk
- Facilities proposed in states outside existing uranium mining and milling areas
- Costs and benefits of possible revisions.

Presentations are summarized as follows--

Sarah Fields

Uranium Watch, Moab Utah

Ms. Fields has problem with 40 CFR Part 61Subpart A, General Requirements. She sees a total breakdown in application approval process, believing it to a “rubberstamp” process in Utah. Ms.

Fields wants the process to be more than a rubberstamp; it should provide a great deal of information and the chance for public participation.

Ms. Fields believes that mine owners are not complying with requirements and suspects that mills are not either. Ms Fields thinks that approval of a new tailings cell under 40 CFR Part Subpart A should be for a set period of time, not for decades.

She said that the biggest problem in Subpart W and 192 is the time gap for radon release between operations and installation of a final barrier. Tailings blow around, and there is a lot of radioactive particulate matter.

Ms. Fields commented that there is supposed to be a tailings closure plan, and reclamation milestones with public notice, but there was none at Cotter. The tailings impoundment closed in 2005, and there were not miles tones or notices.

Ms. Fields said that Colorado doesn't think it needs to measure the radon flux at the Cotter pile and that "apparently EPA gave them a pass. Everything looks good on paper, but you don't have the enforcement."

Allison Gibbon
Sierra Club

Ms. Gibbon said that the Sierra Club will stand behind the toughest regulations possible to protect our environmental, people and wildlife. She commented "It is great that you are here to talk to the people who have suffered the travesties of the past. There are many permits in the Grand Canyon areas, there are now mines proposed on the North Rim that affect the Hualapai and Havasupai, but it is hard for them to travel to Tuba City for this meeting. The Arizona One mine was approved in the eighties, sat idle for year, and reopened without needing reconsideration. They are on public lands, and when the mine opens they are fenced up and not longer public. There is no way to completely cleanup the tailings. There should be total cost accounting on the cleanup. A Canadian company is running the mine and selling the uranium to Korea and Japan, so there are not national security issues. You should consider this in the rule. Thank you for listening."

EPA Response and Discussion:

Loren clarified the EPA is authorized under UMTRCA to regulate mills not mines, and regulates stormwater discharges, groundwater quality, and air emissions.

There was a follow-on question to this clarification: "Are the regulations on conventional mines being updated?" Reid answered that they were not, but that he was aware of the Arizona One Issues, and was working with Region 9, who has the lead on these issues.

Michelle Dinuyache
Community Member, Fort Defiance, Arizona

Ms. Dinuyache commented on risk assessment and recommended that EPA obtain information on inputs to models from tribal representatives to ensure the assessments were fully representative of lifestyles.

She also commented on dose and risk factor scenarios. For 40 CFR Part 192, she recommended a risk-based approach that based standards on the low end of the range.

EPA Response and Discussion:

Loren replied that the regional offices will be soon approaching the tribes for the tribal specific input to reflect lifestyles.

David L Neztsosie
Shadow Mountain, AZ

"For 30 years, mining went on, mills were developed next to streams, near communities, and abandoned overnight. So it has spread by wind and other seasonal weather. It has been determined that this is a good location for wind farms. So how much of a down winder are we? There are sicknesses related to uranium in my hometown, respiratory and nervous disease, it is troubling my mom and dad. Two of my youngest sisters have died for it, aged 30 years. I can see that in the community. Authorities and the people's government do not seem to agree how uranium can be related to health problems. Somebody's windmill was taken down because of its high concentration of uranium [in the well water]. Abandoned mines collect water, sheep drink the water. You can go miles before you reach another water resource.

Although mines have been remediated, this is only a "band-aid" solution. Horses and livestock would step into holes and fall. People east of me have a high content of uranium in their only drinking water and give it to their live stock. "

EPA Response and Discussion:

Loren Setlow of EPA replied: A good piece of the meeting today dealt with water problems. EPA realizes that this is a very large problem, and that when a well is posted and shut down, it is a very large problem to find a replacement when a well is shut down. EPA is doing the best it can to identify other water sources for these communities, and knows that the Navajo Nation has forbidden further mining on its lands.

Cassandra Bloedel
Navajo Nation EPA

"I was going to request EPA HQ continue to look at all the data for Tuba City Dump, Highway 160 because there is thorium in the groundwater, and BLA [the Bureau of Land Management] is ignoring that fact. It is important that EPA determine MCLs for all radionuclides. We have copper and arsenic in the groundwater. The former Rare Metals site had arsenic products, and we found them at Highway 160, and these facts are being pushed to the side. In any new development process, you have to recognize that it will generate radionuclides.

We had to go to the forensic analysis of the uranium isotopes to relate Highway 160 to the mill. You may have to establish MCLs for isotopes.

I missed the fact that water was being reinjected into the Navajo Aquifer. It is the main source of potable water. They are only publishing reports on certain constituents. What about the others—arsenic, molybdenum?

Crown Point is within a quarter mile of the community, and it is upgradient. The aquifer is fractured, and shallow groundwater contamination will contaminate deeper groundwater.

Look at data that have been released. Look at the Navajo reports presented to Congress. Thank you for your time and being here."

EPA Response and Discussion:

Loren Setlow of EPA thanked Ms. Bloedel for the discussion of thorium and mentioned noted that the existing standards issued in 1995 did include a few substances that did not have drinking water MCLs, particularly silver and molybdenum, which are typically found with uranium. Loren said that EPA will look at thorium and vanadium in its review of 40 CFR 192.

Carl Holliday
Navajo Nation, Monument Valley, AZ

Mr. Holliday expressed appreciation what Sandra said, commenting "Our concerns seem to fall on deaf ears." He expressed concern about the application of uranium limits to thorium, questioning whether the dose equivalents were high compared to uranium or gamma radiation. He asked for clarification.

He also had a question about exposure rates: "If you have 600 or 700 lbs of uranium in a pond, how does it not show up somewhere else?"

Loren Setlow replied by giving a history of the radon dose to the public. The dose looks at dose from all parts, 25% to whole organism, and the 75% to any organ (Not sure I got it right--Tony). EPA is giving the radon dose a hard look in this review; it is an upper limit, and we could be made more protective. He also said that EPA was looking at thorium in ISL ponds.

Esther Honyestewa
Hotevilla, AZ

Thanks to the people coming from the U.S government. We have a lot of issues on the reservation. We have a lot of issues concerning our water here. We have an issue on the Peaks, and not one member came out, so it is not that important, but springs are being contaminated. You came out.

I'm from Hopi, and I am concerned about water. Our water is sacred here, and we do not waste water. It looks like this is another project to take water away. The uranium a mile away has really affected our land. If our water goes away, we will go away. Our pure water is becoming contaminated. Our people are dying from all the things the government is doing to the land. We cannot mess with Mother Earth.

Our farmers work hard for the families. My family was one of the ones shipped to Rare Metals when the hospital was being built. My Dad planted right outside the Mill tailing, we ate it, and a lot of people in my family have cancers. Think about that when you write your rule. We don't have it easy—this is dry desert, and people want to take our water. All the water underneath is one body of water, and we need to respect that water.

Why do we want to make bombs? That is not right We are here to help each other, not hurt each other. We are a spiritual people--we have prayers for everything. Our plants are not what they used to be. I'm a farmer and I'm proud of it, and I want my grandkids to be proud of it. Water is sacred. Do your mining somewhere else."

Harrilene Yazcie
Greasewood, AZ

Ms. Yazcie said she understood the Federal government's position where it had to balance public comments with national needs. She commented, "With all the contamination, as well as the water, it leaves little room for development—not just economic development, but also subsistence development. You need to find the balance between what is right from the nation, as well has what is respectful for the indigenous peoples. There is no wiggle room. You are forced to make decisions that keep you up at night. The fundamental reasons we are facing these issues are due to violence—it was all for greed or gain. There are a few things. I've learned when you listen to numbers. The use of water on Navajo is 10 to 15 gallons per person per day, but we pay more per capita. Phoenix, Arizona has more boats per capita than the state of Minnesota. The mindset is to pay $5 for 7400 gallons, 170 gallons per day per person.

So when you re-inject thorium into the Navajo Aquifer, children die in infancy. When a child laughs, we Navajo have a celebration, because it means that the child is a person. That will be denied someone, because you can't determine background, because you can't determine MCLs?"

David Assisi

"I wish all the agencies involved could learn how to work as a team. Is it in the 5 year plan? It seems that everyone is pursuing this individually. The aquifer could be a precious resource. In 1996 we had the worst drought, springs weren't putting out, but some other ones did. The Navajo EPA was surprised—50 to 100 gallons per minute. The water—anything we can do to save it, that's what I'm interested in. Thank you for the chance to speak."

FOLLOW-UP ACTIONS

EPA committed to the following actions during the meeting—

- Provide Mr. Holliday of the Navajo Nation with information on thorium dose equivalents.
- Examine the following during the review of 40 CFR 192—
  - Water usage in In-Situ Leaching
  - MCLs for thorium
  - Pathways associated with Native American lifestyles
  - Pathways from radionuclides in dust.
- Set up a rulemaking and/or ISL workshop with the Navajo Nation. The workshop should address rules in greater detail, explain jargon, and enable citizens to provide relevant comments to a proposed rule.
- Respond to Ms. Cassandra Bloedel of the Navajo EPA on why there is no drinking water MCL for thorium.
- Respond to Ms. Esther Honyestewa on where to get operations information for old AEC rare metals sites.
- Refer Mr. Alden Seweyestewa to the Regional Office for information on illness from possible uranium contamination.
- Reply to Ms. Michelle Dinuyache’s question on the process required to override an aquifer exemption.
- Get back to the person who asked if the Energy Policy Act of 2005 covers uranium extraction on tribal lands.

APPENDIX A: ATTENDANCE LIST

Attendance--EPA Public Information Meeting, Tuba City, AZ, September 15, 2010				
Name	**Representing**	**Address**	**Phone No.**	**Email**
John Acothley				
Melvin Acothley	self	P.O. Box 2526 Tuba City, AZ	928-206-4143	macothley@hotmail.com
Rudy Acothley				
Andrew Bain	EPA	Region 9, San Francisco, CA		bain.andrew@epa.gov
Denise Begaye	RECA	P.O. Box 3072, Ktown, AZ	928-255-3477	
Jerry Bigun	Navajo Nation EPA-NSP			
Vianu Blackhorn	student			
C. Bloedel	Navajo Nation EPA	P.O. Box 339, Window Rock, AZ		
Alex Brock		P.O. Box 1225, Tuba City, AZ 86045	928-600-6428	alexbrock@tlhealth.org
Lydia Chang	NRC			
Emerson D.				
Michele Dinuyache	Navajo Nation EPA	Window Rock, AZ		
Stephen B. Etstty	Navajo Nation EPA	P.O. Box 339, Window Rock, AZ,86515		
Sarah Fields	Uranium Watch	P.0 Box 344, Moab Utah, 84532	435-210-0166	sarah@uraniumwatch.org
Pamela Hill	Uranium Industry	28 N 100 E, Kanab, UT 84741	303-335-6425	phill2647@msn.com
Julie Holiday	RECA	P.O. Box 1553, Kayenta, UT 84741	303-335-6425	

Attendance--EPA Public Information Meeting, Tuba City, AZ, September 15, 2010				
Name	**Representing**	**Address**	**Phone No.**	**Email**
Esther K. Honyestwa	self	P.O. Box 256, Hotevilla, AXZ 86030	928-401-6542	
Yvonne Hoosava	UVM Community Member	P.O. Box 595, Tuba City, AZ		yhoosava@yahoo.com
Lilli Lane	Navajo Nation EPA	Window Rock, AZ		
Cardis Mayweather	ATSDR	4771 Buford Hwy NE Atlanta, GA 30341		heb8@cdc.gov
Chandra Manadhar	Navajo Nation EPA-RCRA			
David L. Neztsosie	Cameron Chapter Community	P.O. Box 741, Tuba City, AZ		dlneztsosie@yahoo.com
Vernon Nez	Navajo Nation EPA-Superfund	Box 339, Window Rock, AZ 86515		vfnneparcra@yahoo.com
Billy Orman	self	P.O. Box 989, Tuba City, AZ 86049	928-283-4640	
Tere Orman	self	P.O. Box 989, Tuba City, AZ 86048	928-283-4639	
Angela Ragin-Wilson	ATSDR	4770 Buford Hwy NE Atlanta, GA 30341		aragin@cdc.gov
Alden Seweyestewa	self	Box 1605 Tuba City, AZ 86045	928-550-0192	
Beverly Smith	RECA	5303 E. Cortland Blvd, Flagstaff, AZ 86004		Beverly.Smith@nau.edu
Libby Vianu	ATSDR			vianu.libby@epa.gov
Beatrice Watson			928-863-9190	
Freida S. White	Navajo Nation EPA-Superfund		928-401-0953	
Harrilene Yazcie	BIA - NRO	P.O. Box 301, Gallup, NM 87301		

EPA-5404

Loren Setlow/DC/USEPA/US	To	Tom Peake, Tony Nesky, George Brozowski
11/01/2010 03:24 PM	cc	
	bcc	
	Subject	PowerPoint Slides for Thursday

All,
Attached are slides for the Corpus Christi public meetings on Thursday.

TX mtg 112010.ppt

Tom, you should sit at the table with me in front for the presentation. You will need to speak to slides 22-24, plus help out on answering questions we may get. Also, could you provide a short bio for George to talk to in the intro of the meeting? Mine is provided here: Loren Setlow bio.doc

In case you haven't had a chance to check on weather, some showers are being predicted for Corpus this week, temps from 50s to mid 70s.

See you all tomorrow.

--Loren

U.S. EPA URANIUM AND THORIUM MILL TAILINGS REGULATIONS REVIEW

Public Information Meeting

Corpus Christi, Texas
November 4, 2010

UraniumReview@epa.gov

Meeting Agenda

1:00 PM	Welcoming Statements and Introductions
1:10 PM	EPA Presentation: Overview of EPA Regulatory Review and Existing Standards
1:40 PM	Audience Questions – Round 1 Public Input (5 minutes each) Audience Questions – Round 2
3:00 PM	Wrap-up Adjourn

Meeting Agenda

6:30 PM	Welcoming Statements and Introductions
6:40 PM	EPA Presentation: Overview of EPA Regulatory Review and Existing Standards
7:10 PM	Audience Questions – Round 1 Public Input (5 minutes each) Audience Questions – Round 2
9:30 PM	Wrap-up Adjourn

Meeting Process

Meeting Presentations

- Sign up to provide input
- Limit your presentations to 5 minutes

Questions for EPA

- EPA will address the questions you write on the index cards
- If you have additional questions during the meeting, write them on the provided index cards
- Raise your hand and we will come and collect them

Introductions

Loren Setlow

- *EPA Office of Radiation and Indoor Air*

Washington, DC

George Brozowski

- *EPA Region 6, Office of Air Toxics*

Dallas, TX

Tom Peake

- *EPA Office of Radiation and Indoor Air*

Washington, DC

Background

The Environmental Protection Agency (EPA) is reviewing and potentially revising its regulations for uranium and thorium milling:

- 40 CFR Part 192 issued under authority of Uranium Mill Tailings Radiation Control Act (UMTRCA)
  - Establishes health, safety and environmental protection standards utilized by U.S. Nuclear Regulatory Commission (NRC) and its Agreement States, and U.S. Department of Energy (DOE) for their oversight of uranium and thorium extraction facility licensing, operations, sites, and wastes

- 40 CFR Part 61, Subpart W, issued under authority of the Clean Air Act (CAA)
  - Provides standards for radon emissions from active uranium mill tailings impoundments

- These regulations apply to byproduct material from conventional mills, In Situ Leach/Recovery (ISL/ISR) facilities, and heap leach facilities, <u>but not conventional mines (open pit or underground)</u>

Background

- Over 20 years since regulations were originally issued

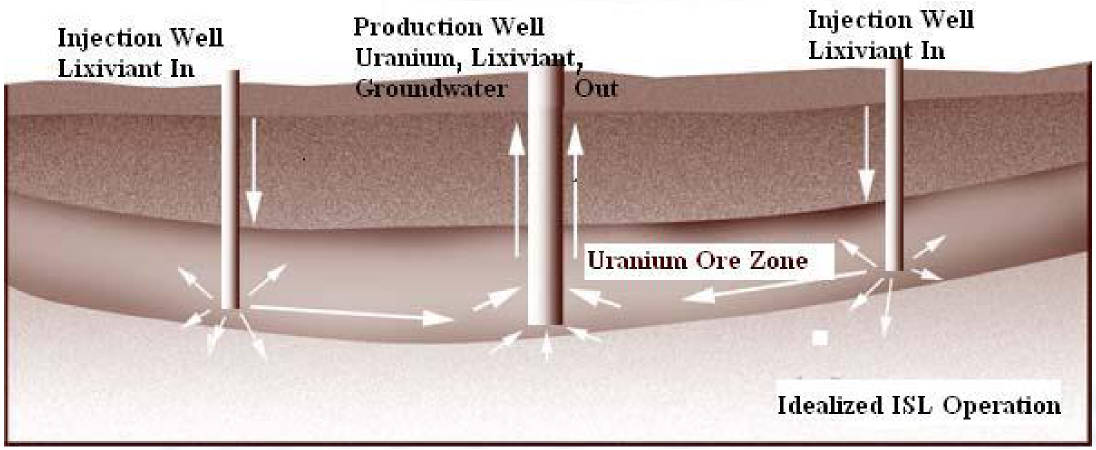
- This meeting is intended to provide the public with an opportunity to learn what EPA is doing in its current regulations review

- Provide the public with an opportunity to offer input to the reviews at an early stage

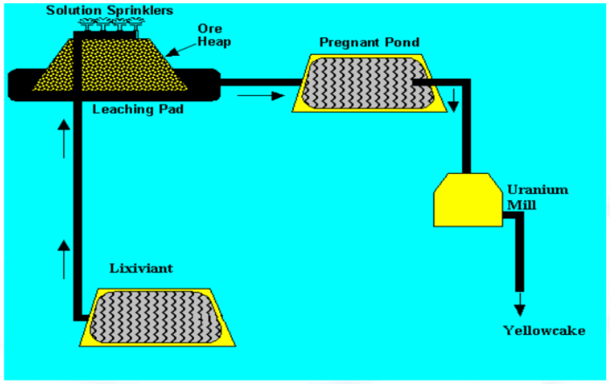
- This review is being conducted before any decision has been made to formally propose any new draft rules for public comment

Background

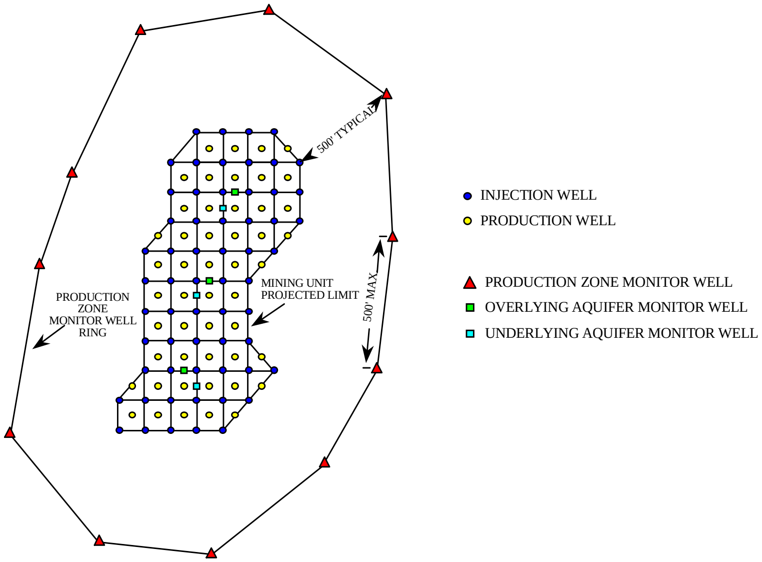
Rio Algom Ambrosia Lake mill, New Mexico, USA (1958-1985)



Conventional Surface mill



Heap leaching



Background

Under UMTRCA, EPA authority limited:

- Issue health, safety, environmental protection standards for use by NRC and its Agreement States, DOE
- Concurrence role over NRC regulations to implement EPA standards
- Facility licensing/operations (mills in operation 1978 or later) overseen by NRC or its Agreement States
- Reclamation of closed conventional mills and cleanup of lands/buildings contaminated by mill tailings overseen by DOE with NRC concurrence

Background

EPA does have other regulatory authorities over uranium mills, ISL, heap leach facilities

- CAA--40 CFR Part 61, Subparts W (and A)
- Clean Water Act—40 CFR Part 440, Subpart C
  - Issuance of NPDES permits
- Safe Drinking Water Act—40 CFR Parts 144-146
  - Issuance of injection well (UIC) permits
  - Issuance of Aquifer Exemptions
- National Environmental Policy Act review authority
- CERCLA (Superfund) authority
- RCRA authority

40 CFR Part 192

- Over 25 years since originally issued, ~15 years since last update for groundwater protection
- Standards include:
  - Construction standards for mill tailings impoundments
  - Cross-reference RCRA regulatory requirements

  - Radon emission standards—
    - Controls to be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years
    - Releases of radon-222 not to exceed 20 picocuries per square meter per second

40 CFR Part 192

- Limits on groundwater concentrations of hazardous substances including radionuclides—concentration limits must not exceed whichever is higher:
  - Background level of that constituent, or
  - MCLs listed in 40 CFR Part 192, or
  - Alternate Concentration Limits (ACLs)

- Remediation standards for contaminated soils/buildings
  - Concentration of radium-226 not to exceed background level by more than—
    - 5 pCi/g, averaged over the first 15 cm of soil below the surface, and
    - 15 pCi/g, averaged over 15 cm thick in layers of soil more than 15 cm below the surface
  - Gamma radiation ≤ 20 microRoentgens (mR) per hour above background

40 CFR Part 192

- Requirements for:
    - monitoring,
    - corrective action,
    - post-closure monitoring

- Provides for acceptance of alternate feed at operating mills

- Provides environmental protection standards for operating thorium mills

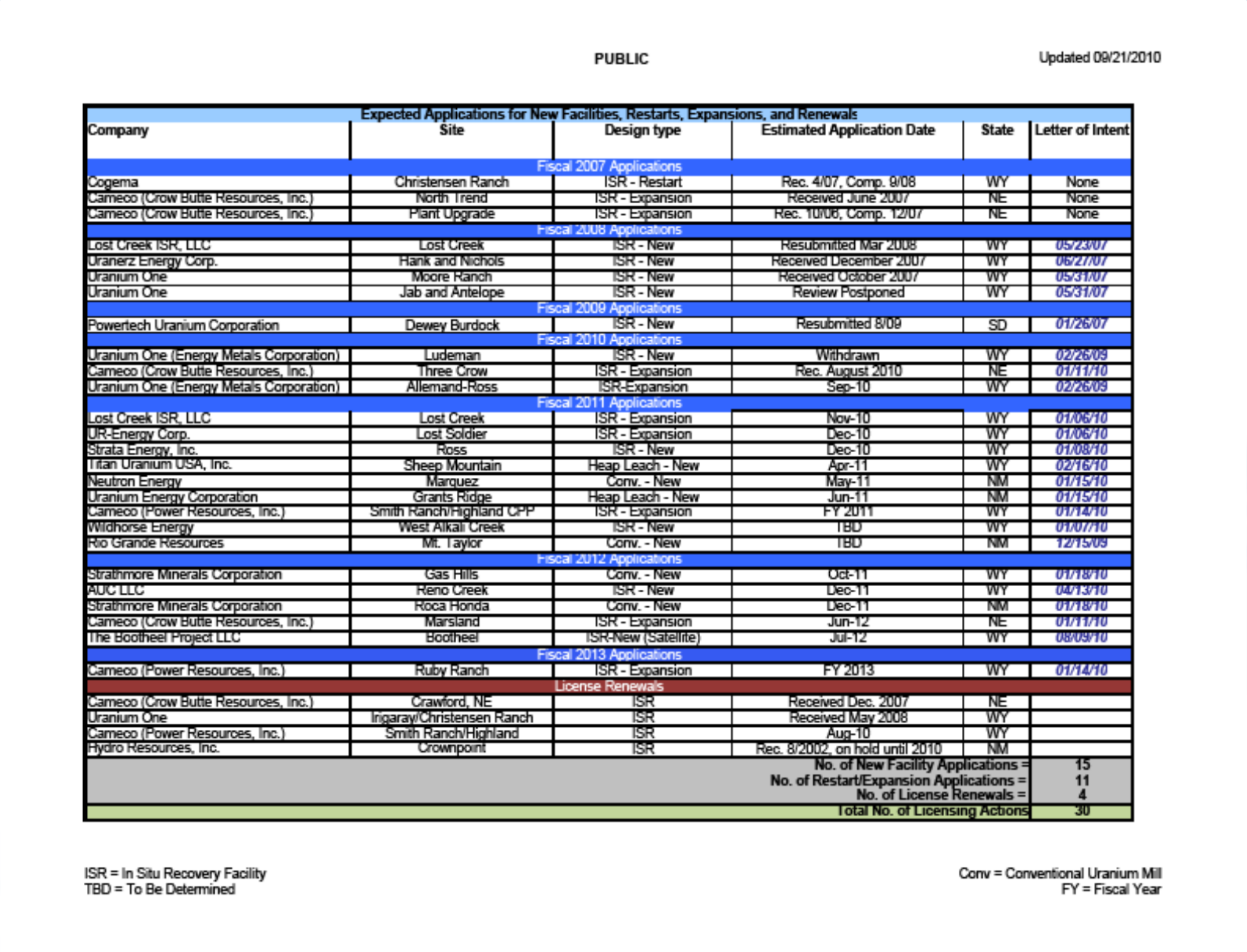
Title I Closed Mills

Title II Mills (Excluding ISL/ISRs)

ISL/ISRs (Closed, Active, Standby)

Proposed ISL/ISRs, Mills, Heap Leach Facilities

NRC license applications



PUBLIC

Updated 09/21/2010

Expected Applications for New Facilities, Restarts, Expansions, and Renewals					
Company	**Site**	**Design type**	**Estimated Application Date**	**State**	**Letter of Intent**
Fiscal 2007 Applications					
Cogema	Christensen Ranch	ISR - Restart	Rec. 4/07, Comp. 9/08	WY	None
Cameco (Crow Butte Resources, Inc.)	North Trend	ISR - Expansion	Received June 2007	NE	None
Cameco (Crow Butte Resources, Inc.)	Plant Upgrade	ISR - Expansion	Rec. 10/06, Comp. 12/07	NE	None
Fiscal 2008 Applications					
Lost Creek ISR, LLC	Lost Creek	ISR - New	Resubmitted Mar 2008	WY	05/23/07
Uranerz Energy Corp.	Hank and Nichols	ISR - New	Received December 2007	WY	06/27/07
Uranium One	Moore Ranch	ISR - New	Received October 2007	WY	05/31/07
Uranium One	Jab and Antelope	ISR - New	Review Postponed	WY	05/31/07
Fiscal 2009 Applications					
Powertech Uranium Corporation	Dewey Burdock	ISR - New	Resubmitted 8/09	SD	01/26/07
Fiscal 2010 Applications					
Uranium One (Energy Metals Corporation)	Ludeman	ISR - New	Withdrawn	WY	02/26/09
Cameco (Crow Butte Resources, Inc.)	Three Crow	ISR - Expansion	Rec. August 2010	NE	01/11/10
Uranium One (Energy Metals Corporation)	Allemand-Ross	ISR-Expansion	Sep-10	WY	02/26/09
Fiscal 2011 Applications					
Lost Creek ISR, LLC	Lost Creek	ISR - Expansion	Nov-10	WY	01/06/10
UR-Energy Corp.	Lost Soldier	ISR - Expansion	Dec-10	WY	01/06/10
Strata Energy, Inc.	Ross	ISR - New	Dec-10	WY	01/08/10
Titan Uranium USA, Inc.	Sheep Mountain	Heap Leach - New	Apr-11	WY	02/16/10
Neutron Energy	Marquez	Conv. - New	May-11	NM	01/15/10
Uranium Energy Corporation	Grants Ridge	Heap Leach - New	Jun-11	NM	01/15/10
Cameco (Power Resources, Inc.)	Smith Ranch/Highland CPP	ISR - Expansion	FY 2011	WY	01/14/10
Wildhorse Energy	West Alkali Creek	ISR - New	TBD	WY	01/07/10
Rio Grande Resources	Mt. Taylor	Conv. - New	TBD	NM	12/15/09
Fiscal 2012 Applications					
Strathmore Minerals Corporation	Gas Hills	Conv. - New	Oct-11	WY	01/18/10
AUC LLC	Reno Creek	ISR - New	Dec-11	WY	04/13/10
Strathmore Minerals Corporation	Roca Honda	Conv. - New	Dec-11	NM	01/18/10
Cameco (Crow Butte Resources, Inc.)	Marsland	ISR - Expansion	Jun-12	NE	01/11/10
The Bootheel Project LLC	Bootheel	ISR-New (Satellite)	Jul-12	WY	08/09/10
Fiscal 2013 Applications					
Cameco (Power Resources, Inc.)	Ruby Ranch	ISR - Expansion	FY 2013	WY	01/14/10
License Renewals					
Cameco (Crow Butte Resources, Inc.)	Crawford, NE	ISR	Received Dec. 2007	NE	
Uranium One	Irigaray/Christensen Ranch	ISR	Received May 2008	WY	
Cameco (Power Resources, Inc.)	Smith Ranch/Highland	ISR	Aug-10	WY	
Hydro Resources, Inc.	Crownpoint	ISR	Rec. 8/2002, on hold until 2010	NM	
				No. of New Facility Applications =	**15**
				No. of Restart/Expansion Applications =	**11**
				No. of License Renewals =	**4**
				Total No. of Licensing Actions	**30**

ISR = In Situ Recovery Facility
TBD = To Be Determined

Conv = Conventional Uranium Mill
FY = Fiscal Year

Relationship Between EPA and NRC Requirements for ISL/ISR Facilities

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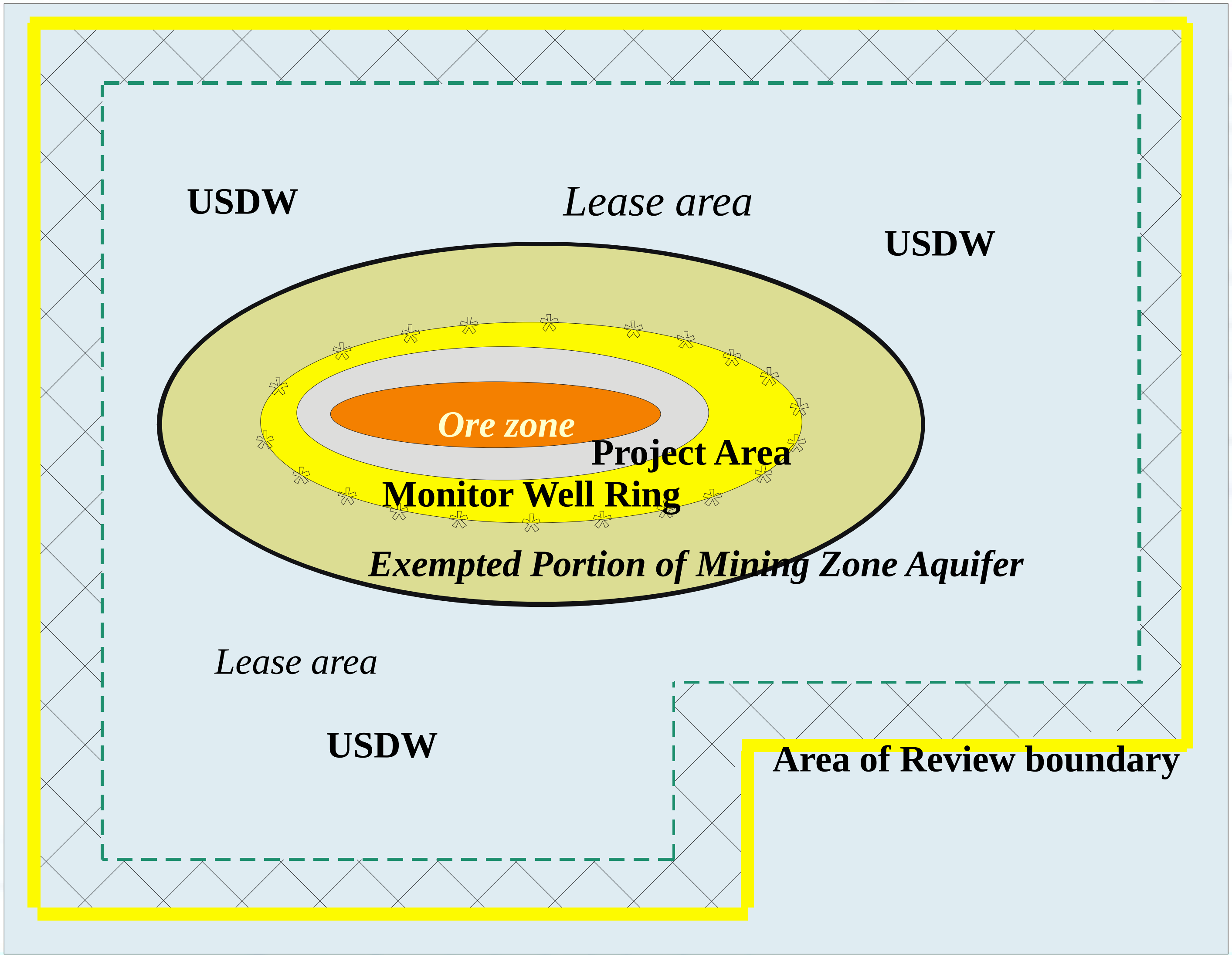

USDW

Lease area

USDW

Ore zone

Project Area

Monitor Well Ring

Exempted Portion of Mining Zone Aquifer

Lease area

USDW

Area of Review boundary

40 CFR Part 61, Subpart W

- Promulgated on 12/15/1989 -- Applies to radon emissions from operating uranium mill tailings -- flux standard: 20 pCi/m^{2-}sec

- After 12/15/1989, new impoundments must meet one of two new work practices to achieve at least equivalent emissions reductions
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40 CFR Part 61, Subpart W

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  - Based on EPA's alleged failure to review & revise regulation within ten years after enactment of Clean Air Act Amendments of 1990 (11/15/2000)
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  - Settlement agreement reached November 2009

40 CFR Part 61, Subpart W

- While performing early research for the NOI, EPA determined uranium ISL/ISR and heap leach impoundments are subject to Subpart W:
  - Preconstruction approval, impoundment construction and operation requirements in 40 CFR Part 192 cross referenced in Subpart W
  - Annual reporting requirements, notification in advance of testing

Regulatory Review Process (1)

Existing regulations and standards are being reviewed to determine if they are still appropriate in light of:

- Dominant use of ISL/ISR, now principal means of uranium recovery in U.S., and for heap leach facilities
  - Lack of provisions in current regulations
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- Technology and design, historical performance of mill tailings impoundments and ISL/ISRs

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- Free release of some facility sites after decommissioning -- implications for 40 CFR Part 192

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- Changes in economics of extraction & site remediation
- Potential for uranium/thorium extraction in different geographic locations
- Court cases

Coordination and Stakeholder Input

Federal Agency Coordination

- NRC and DOE
- Other involved agencies (Interior, Agriculture…)
- ISCORS—Interagency Steering Committee on Radiation Standards

- EPA Intra-agency Workgroups
  - Regional offices
  - HQ – Office of Water, Office of Research and Development, Office of Solid Waste and Emergency Response, Office of General Counsel, Office of Policy

Coordination and Stakeholder Input

- Presentations at State association and other conferences:
    - CRCPD, ASTSWMO
    - National Mining Association Uranium Recovery Workshop
    - National Tribal Science Forum, National Tribal Water Council
    - Uranium Contamination Workshop
    - Engineered Barriers and Uranium Mill Tailings Workshop
- EPA Regional Offices in coordination with EPA HQ to provide lead role for outreach to:
    - Public
    - Industry
    - States
    - Tribes and EJ populations
    - Environmental and other NGO's

Coordination and Stakeholder Input

Holding of Public Information Meetings (40 CFR Part 192):

- Casper WY—May 2010
- Denver, CO—May 2010
- Tuba City, AZ—September 2010
- Corpus Christi, TX—November 2010

Coordination and Stakeholder Input

Public Stakeholder Meetings (Subpart W)

- Cañon City, CO – June 2009
- Rapid City, SD – October 2009
- Gallup, NM – November 2009
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Coordination and Stakeholder Input

40 CFR Part 192

Interactive Internet Site – Discussion Forum

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Email address for additional public input:
UraniumReview@epa.gov

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For further information on 40 CFR Part 61, Subpart W review

http://www.epa.gov/radiation/neshaps/subpartw/rulemaking-activity.html

Site contains current and historical rulemaking documents, presentations, contact information, useful links

Email address for additional public input:

Subpartw@epa.gov

Contact Information

Loren Setlow and Reid Rosnick
Office of Radiation and Indoor Air (6608J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., N.W.
Washington, DC 20460

E-mails:
UraniumReview@epa.gov
Subpartw@epa.gov

Discussion Topics Today

- Changes in uranium industry technologies
- Revisions in EPA drinking and groundwater protection standards
- Radon emission standards
- Issues relating to Tribal communities, children's health and environmental justice (e.g., impact on minorities and low-income communities)
- Dose and risk factors and scenarios for assessing radiological and non-radiological risk
- Facilities proposed in states outside existing production locations
- Costs and benefits of possible revisions

Thank You !

Loren Setlow –

Mr. Setlow is the program lead for EPA's review of its regulations issued under the Uranium Mill Tailings Radiation Control Act. He is a geologist in EPA's Center for Waste Management and Regulation, Radiation Protection Division in Washington, DC, and has been working on uranium related issues at the Agency since 1997. He is also currently serving as an expert consultant on projects for the International Atomic Energy Agency and the International Commission on Radiological Protection. Prior to joining EPA, Mr. Setlow served in capacities as a Board Director at the National Academy of Sciences, Senior Geologist at Congress' General Accountability Office, and Supervisory Geologist at the U.S. Department of the Interior. He has a B.S. in geology from Tulane University, an M.S. in geology from Florida State University, and is a Certified Professional Geologist in Virginia with nearly 40 years experience.

EPA-5641

Tony Nesky	To	
	cc	
	bcc	
	Subject	UPLOAD C:\Users\ANesky\Desktop\June14search\TX mtg 112010.ppt

- TX mtg 112010.ppt

U.S. EPA URANIUM AND THORIUM MILL TAILINGS REGULATIONS REVIEW

Public Information Meeting

Corpus Christi, Texas
November 4, 2010

UraniumReview@epa.gov

Meeting Agenda

1:00 PM	Welcoming Statements and Introductions
1:10 PM	EPA Presentation: Overview of EPA Regulatory Review and Existing Standards
1:40 PM	Audience Questions – Round 1 Public Input (5 minutes each) Audience Questions – Round 2
3:00 PM	Wrap-up Adjourn

Meeting Agenda

6:30 PM	Welcoming Statements and Introductions
6:40 PM	EPA Presentation: Overview of EPA Regulatory Review and Existing Standards
7:10 PM	Audience Questions – Round 1 Public Input (5 minutes each) Audience Questions – Round 2
9:30 PM	Wrap-up Adjourn

Meeting Process

Meeting Presentations

- Sign up to provide input
- Limit your presentations to 5 minutes

Questions for EPA

- EPA will address the questions you write on the index cards
- If you have additional questions during the meeting, write them on the provided index cards
- Raise your hand and we will come and collect them

Introductions

Loren Setlow

- EPA Office of Radiation and Indoor Air

Washington, DC

George Brozowski

- EPA Region 6, Office of Air Toxics

Dallas, TX

Tom Peake

- EPA Office of Radiation and Indoor Air

Washington, DC

Background

The Environmental Protection Agency (EPA) is reviewing and potentially revising its regulations for uranium and thorium milling:

- 40 CFR Part 192 issued under authority of Uranium Mill Tailings Radiation Control Act (UMTRCA)
  - Establishes health, safety and environmental protection standards utilized by U.S. Nuclear Regulatory Commission (NRC) and its Agreement States, and U.S. Department of Energy (DOE) for their oversight of uranium and thorium extraction facility licensing, operations, sites, and wastes

- 40 CFR Part 61, Subpart W, issued under authority of the Clean Air Act (CAA)
  - Provides standards for radon emissions from active uranium mill tailings impoundments

- These regulations apply to byproduct material from conventional mills, In Situ Leach/Recovery (ISL/ISR) facilities, and heap leach facilities, <u>but not conventional mines (open pit or underground)</u>

Background

- Over 20 years since regulations were originally issued

- This meeting is intended to provide the public with an opportunity to learn what EPA is doing in its current regulations review

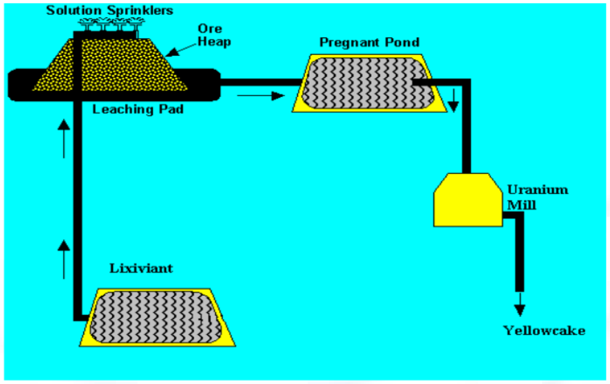
- Provide the public with an opportunity to offer input to the reviews at an early stage

- This review is being conducted before any decision has been made to formally propose any new draft rules for public comment

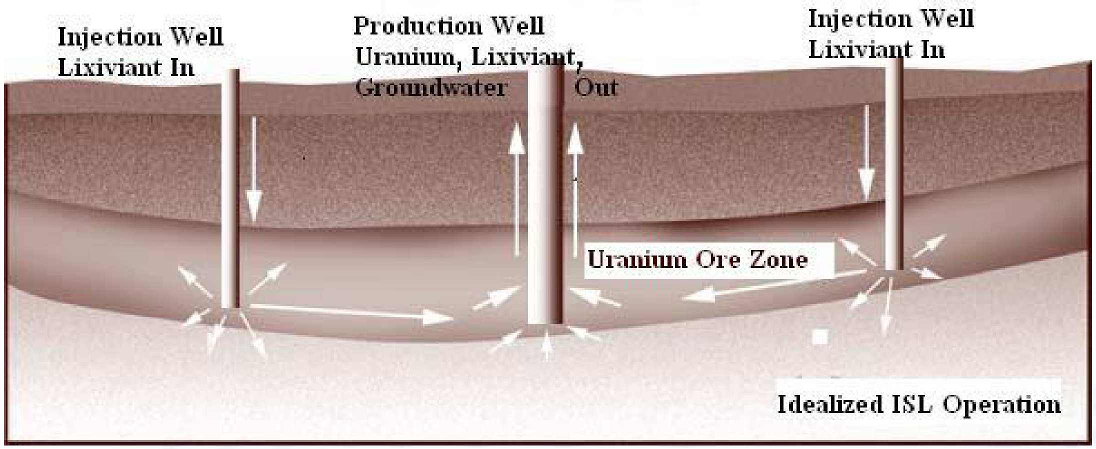
Background

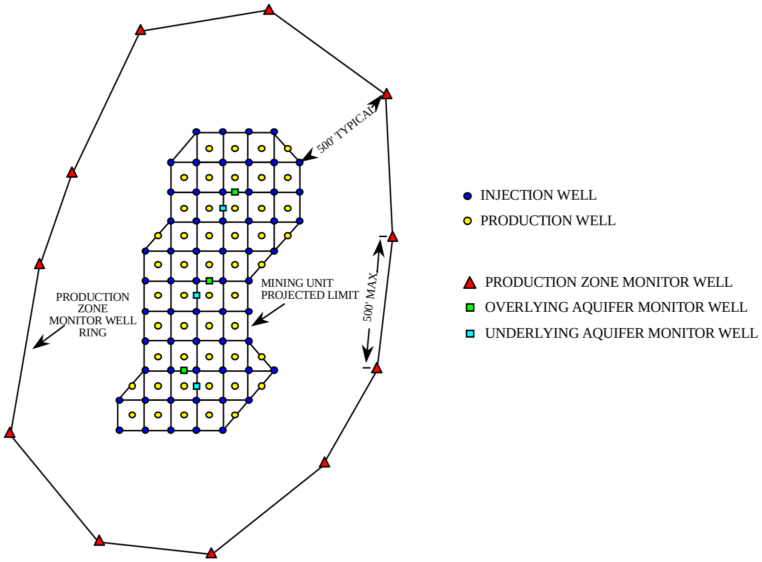
Rio Algom Ambrosia Lake mill, New Mexico, USA (1958-1985)

Conventional Surface mill



Heap leaching





Background

Under UMTRCA, EPA authority limited:

- Issue health, safety, environmental protection standards for use by NRC and its Agreement States, DOE
- Concurrence role over NRC regulations to implement EPA standards
- Facility licensing/operations (mills in operation 1978 or later) overseen by NRC or its Agreement States
- Reclamation of closed conventional mills and cleanup of lands/buildings contaminated by mill tailings overseen by DOE with NRC concurrence

Background

EPA does have other regulatory authorities over uranium mills, ISL, heap leach facilities

- CAA--40 CFR Part 61, Subparts W (and A)
- Clean Water Act—40 CFR Part 440, Subpart C
  - Issuance of NPDES permits
- Safe Drinking Water Act—40 CFR Parts 144-146
  - Issuance of injection well (UIC) permits
  - Issuance of Aquifer Exemptions
- National Environmental Policy Act review authority
- CERCLA (Superfund) authority
- RCRA authority

40 CFR Part 192

- Over 25 years since originally issued, ~15 years since last update for groundwater protection
- Standards include:
  - Construction standards for mill tailings impoundments
  - Cross-reference RCRA regulatory requirements
  - Radon emission standards—
    - Controls to be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years
    - Releases of radon-222 not to exceed 20 picocuries per square meter per second

40 CFR Part 192

- Limits on groundwater concentrations of hazardous substances including radionuclides—concentration limits must not exceed whichever is higher:
  - Background level of that constituent, or
  - MCLs listed in 40 CFR Part 192, or
  - Alternate Concentration Limits (ACLs)

- Remediation standards for contaminated soils/buildings
  - Concentration of radium-226 not to exceed background level by more than—
    - 5 pCi/g, averaged over the first 15 cm of soil below the surface, and
    - 15 pCi/g, averaged over 15 cm thick in layers of soil more than 15 cm below the surface
  - Gamma radiation ≤ 20 microRoentgens (mR) per hour above background

40 CFR Part 192

- Requirements for:
    - monitoring,
    - corrective action,
    - post-closure monitoring

- Provides for acceptance of alternate feed at operating mills

- Provides environmental protection standards for operating thorium mills

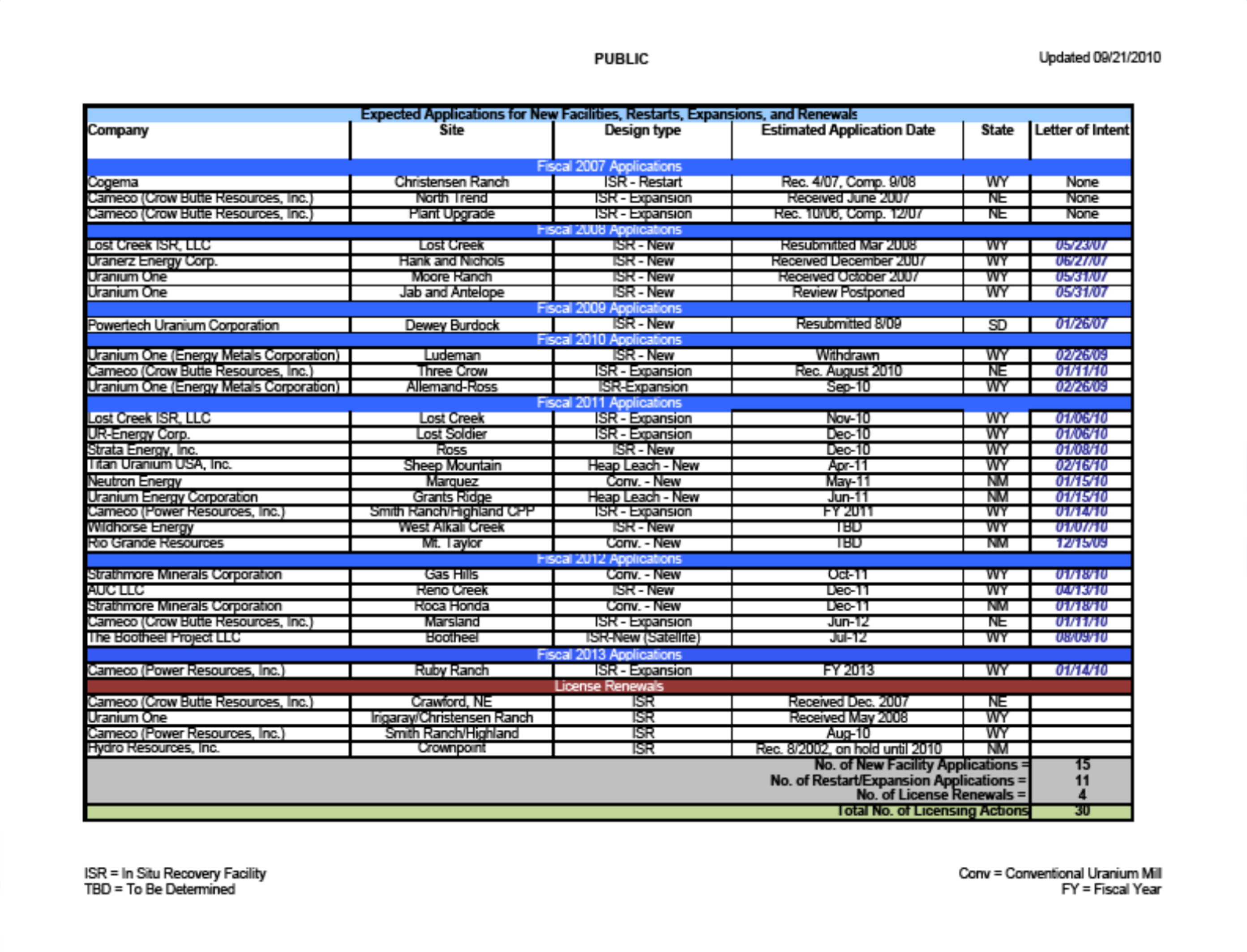
Title I Closed Mills

Title II Mills (Excluding ISL/ISRs)

ISL/ISRs (Closed, Active, Standby)

Proposed ISL/ISRs, Mills, Heap Leach Facilities

NRC license applications



PUBLIC

Updated 09/21/2010

Expected Applications for New Facilities, Restarts, Expansions, and Renewals

Company	Site	Design type	Estimated Application Date	State	Letter of Intent
Fiscal 2007 Applications					
Cogema	Christensen Ranch	ISR - Restart	Rec. 4/07, Comp. 9/08	WY	None
Cameco (Crow Butte Resources, Inc.)	North Trend	ISR - Expansion	Received June 2007	NE	None
Cameco (Crow Butte Resources, Inc.)	Plant Upgrade	ISR - Expansion	Rec. 10/06, Comp. 12/07	NE	None
Fiscal 2008 Applications					
Lost Creek ISR, LLC	Lost Creek	ISR - New	Resubmitted Mar 2008	WY	05/23/07
Uranerz Energy Corp.	Hank and Nichols	ISR - New	Received December 2007	WY	06/27/07
Uranium One	Moore Ranch	ISR - New	Received October 2007	WY	05/31/07
Uranium One	Jab and Antelope	ISR - New	Review Postponed	WY	05/31/07
Fiscal 2009 Applications					
Powertech Uranium Corporation	Dewey Burdock	ISR - New	Resubmitted 8/09	SD	01/26/07
Fiscal 2010 Applications					
Uranium One (Energy Metals Corporation)	Ludeman	ISR - New	Withdrawn	WY	02/26/09
Cameco (Crow Butte Resources, Inc.)	Three Crow	ISR - Expansion	Rec. August 2010	NE	01/11/10
Uranium One (Energy Metals Corporation)	Allemand-Ross	ISR-Expansion	Sep-10	WY	02/26/09
Fiscal 2011 Applications					
Lost Creek ISR, LLC	Lost Creek	ISR - Expansion	Nov-10	WY	01/06/10
UR-Energy Corp.	Lost Soldier	ISR - Expansion	Dec-10	WY	01/06/10
Strata Energy, Inc.	Ross	ISR - New	Dec-10	WY	01/08/10
Titan Uranium USA, Inc.	Sheep Mountain	Heap Leach - New	Apr-11	WY	02/16/10
Neutron Energy	Marquez	Conv. - New	May-11	NM	01/15/10
Uranium Energy Corporation	Grants Ridge	Heap Leach - New	Jun-11	NM	01/15/10
Cameco (Power Resources, Inc.)	Smith Ranch/Highland CPP	ISR - Expansion	FY 2011	WY	01/14/10
Wildhorse Energy	West Alkali Creek	ISR - New	TBD	WY	01/07/10
Rio Grande Resources	Mt. Taylor	Conv. - New	TBD	NM	12/15/09
Fiscal 2012 Applications					
Strathmore Minerals Corporation	Gas Hills	Conv. - New	Oct-11	WY	01/18/10
AUC LLC	Reno Creek	ISR - New	Dec-11	WY	04/13/10
Strathmore Minerals Corporation	Roca Honda	Conv. - New	Dec-11	NM	01/18/10
Cameco (Crow Butte Resources, Inc.)	Marsland	ISR - Expansion	Jun-12	NE	01/11/10
The Bootheel Project LLC	Bootheel	ISR-New (Satellite)	Jul-12	WY	08/09/10
Fiscal 2013 Applications					
Cameco (Power Resources, Inc.)	Ruby Ranch	ISR - Expansion	FY 2013	WY	01/14/10
License Renewals					
Cameco (Crow Butte Resources, Inc.)	Crawford, NE	ISR	Received Dec. 2007	NE	
Uranium One	Irigaray/Christensen Ranch	ISR	Received May 2008	WY	
Cameco (Power Resources, Inc.)	Smith Ranch/Highland	ISR	Aug-10	WY	
Hydro Resources, Inc.	Crownpoint	ISR	Rec. 8/2002, on hold until 2010	NM	
				No. of New Facility Applications =	15
				No. of Restart/Expansion Applications =	11
				No. of License Renewals =	4
				Total No. of Licensing Actions	30

ISR = In Situ Recovery Facility
TBD = To Be Determined

Conv = Conventional Uranium Mill
FY = Fiscal Year

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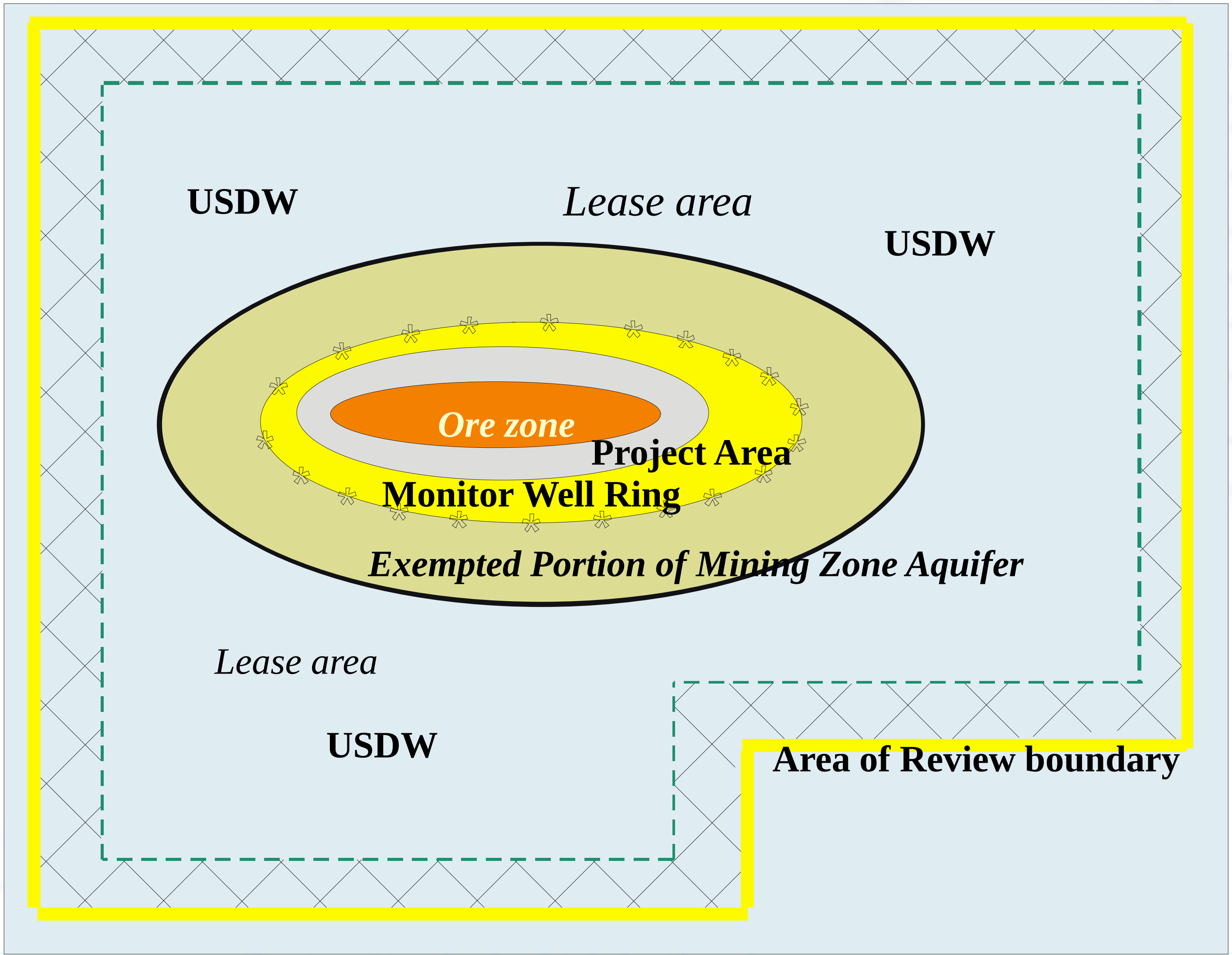

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1200 Pennsylvania Ave., N.W.
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- Facilities proposed in states outside existing production locations
- Costs and benefits of possible revisions

Thank You !

EPA-5405

Loren Setlow/DC/USEPA/US	To	"Steven Brown"
11/17/2010 09:02 AM	cc	Reid Rosnick, Tony Nesky
	bcc	
	Subject	Re: Comments to EPA Regarding Review of 40 CFR Parts 61 and 192

Steve,
It was good to see you in Corpus Christi as well, and appreciate your taking the time to provide your views on these issues. I am forwarding these materials to Tony Nesky of our outreach program who is compiling the notes of the session.

As you have seen, we have been making a strong effort to provide both information on our process as well obtain stakeholder views on the existing regulations which we hope will assist us in our review. We hope you will continue to voice your suggestions to us as we proceed.

Best regards,
Loren

"Steven Brown"	Loren - good seeing you again last week and tha...	11/08/2010 03:00:04 PM

From: "Steven Brown" <sbrown@senes.ca>
To: Loren Setlow/DC/USEPA/US@EPA
Cc: Reid Rosnick/DC/USEPA/US@EPA, SubpartW@EPA, Doug Chambers <dchambers@senes.ca>
Date: 11/08/2010 03:00 PM
Subject: Comments to EPA Regarding Review of 40 CFR Parts 61 and 192

Loren - good seeing you again last week and thanks for opportunity to provide input at the EPA's public meeting on this subject in Corpus Christi on Nov 4. You might remember that at the meeting, I had provided to you some written comments. However, having had the opportunity in the course of the meeting to hear more detail from EPA regards to concerns and issues, I have revised and expanded them. Please replace those previously submitted with the comments attached. Feel free to call anytime to discuss if it is your pleasure. Again, most appreciative of EPA for providing the opportunity for input to this nationally important regulatory review process - regards and cheers - steve

Steven H Brown, CHP
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8310 South Valley Highway
Suite 3016
Englewood, Colorado, USA
80112
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SHB Comments_EPA CFR 40 Sub W_REVISED_Nov 7 2010.pdf

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E-mail: senescolorado@senes.ca
Web Site: http://www.senes.ca

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EPA Review of Standards for Uranium and Thorium Milling Facilities @ 40 CFR Parts 61 and 192.

Comments by Steven H Brown, CHP
Revised November 7, 2010

I am Steven Brown from Centennial Colorado. I appreciate the opportunity to provide these comments for EPA's consideration regards to review of EPA standards for Uranium and Thorium Milling Facilities @ 40 CFR Parts 61 and 192.

I have been a practicing health physicist for over 40 years. I am certified by the American Board of Health Physics and a Diplomat of the American Academy of Health Physics. I am a past president of Central Rocky Mountain Chapter of the Health Physics Society.

The Health Physics Society, formed in 1956, is a scientific organization of professionals who specialize in radiation safety. Its mission is to support its members in the practice of their profession and to promote excellence in the science and practice of radiation safety. Today its nearly 6,000 members represent all scientific and technical areas related to radiation safety including academia, government, medicine, research and development, analytical services, consulting, and industry in all 50 states and the District of Columbia.

I would like to provide EPA with some broad scientific perspectives related to the adequacy of existing public exposure standards for uranium mills and in situ recovery facilities that are promulgated in 40 CFR Parts 61, 190 and 192. Specifically, these are the 20 picocuries per meter squared per second (pCi / m2-sec) radon flux criteria for uranium mill tailings impoundments specified in Part 61 Subpart W and Part 192, Subpart D as well as the 25 mrem /year public exposure standard in Part 190 as referenced in Part 192.

My remarks will address the following seven questions:

1. Are the existing radiation dose limits in the regulations (Federal and Agreement States) for uranium milling facilities (including in situ recovery plants) adequate to protect the public from additional radiation exposure above our natural background exposure?
2. Is the existing 20 picocuries per meter squared per second (pCi/meter^2 – sec) radon flux (emission) standard in 40 CFR Parts 61, Subpart W and 192, Subpart D adequate to protect the public from additional radiation exposure above our natural background exposure?
3. What do we know about radon releases from water impoundments?
4. What do we know about radon emissions from ISRs?
5. What are current practices and results in estimating doses to the public from uranium recovery facilities?
6. What is known about the potential health effects to populations living in the vicinity of uranium mines and mills?
7. What is known about the health impacts (e.g., lung cancer) to many uranium miners who worked underground in the 1950s and 1960s?

1. Are the existing regulations (Federal or USNRC Agreement States) for uranium milling facilities (including in situ recovery plants) adequate to protect the public from additional radiation exposure above our natural background exposure?

Our lifestyles, where we choose to live, what we eat and drink, has a much larger impact on our radiation exposure than exposure at current regulatory limits. The basic regulatory limits that operating uranium mills and ISRs must comply with are 100 millirem* per year from all sources including radon and 25 millirem / year excluding radon** (US Nuclear Regulatory Commission: 10 CFR 20 and 10 CFR 40 Appendix A; US Environmental Protection Agency: 40 CFR 190; Texas Department of State Health Services, Title 30 of the Texas Administrative Code, Chapter 336; Colorado Department Health of Public and Environment, 6 CCR 1007 - 1, Part 4)

*NOTE: a millirem is a unit of effective radiation dose. It is related to the amount of energy absorbed by human tissue and other factors. 1,000 millirem = one rem.

** Radon is a naturally occurring radioactive gas, which is released into the atmosphere at the Earth's surface from the decay of radium. Both radium and radon are daughter products of uranium.

Now lets compare these numbers to the annual radiation doses we receive as citizens of planet Earth. Figure 1 below depicts the typical components of human exposure in the US to ionizing radiation.

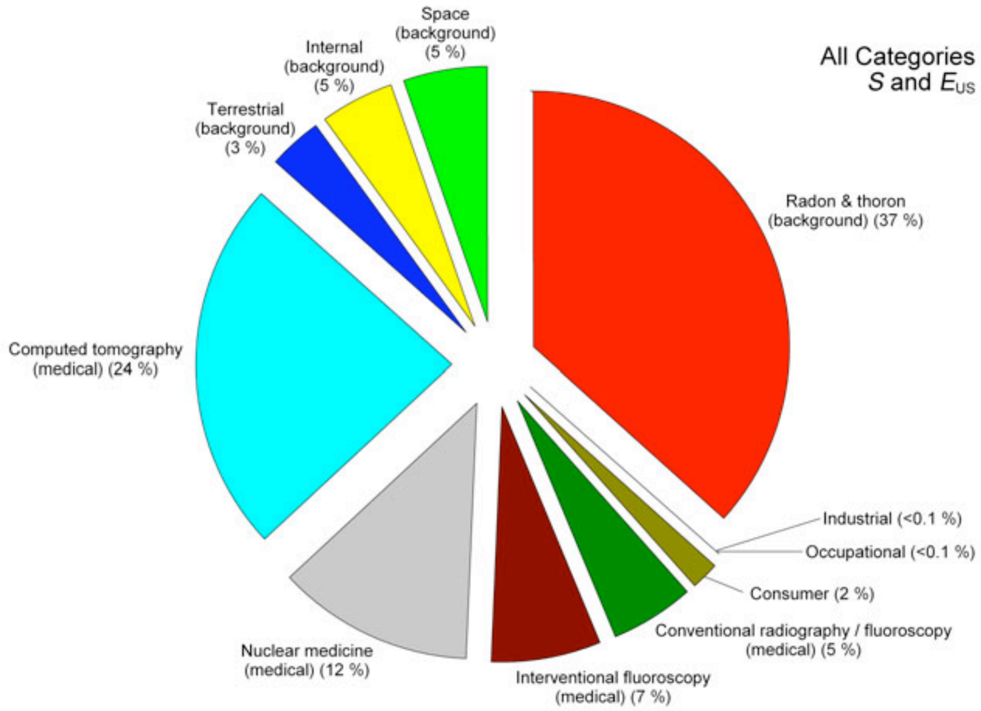

Figure 1: Percent contribution of various sources of exposure to the total radiation dose of a typical resident in the US. Reproduced from National Council on Radiation Protection and Measurements. Report No. 160*, Ionizing Radiation Exposure of the Population in the United States.* 2009.

As can be seen from figure 1, background radiation exposure is about 50% of the total exposure; the other 50% is primarily from medical exposures. Consumer products we use everyday that contain radioactive materials (e.g., smoke detectors, luminous watches, etc) contribute about 2 % of our dose. Other man made sources of radiation, including the nuclear industry, contribute < 0.1% of our annual dose.

Natural background can vary considerable from place to place across the United States or over relatively small areas within a region. This is due to effects of elevation (higher cosmic radiation exposure at higher elevations), greater levels of naturally occurring radioactive elements in soil and water in mineralized areas (e.g., igneous formations in Rocky Mountains) and other factors like local geology and chemistry. This is depicted in Table 1, which compares average annual background radiation exposure for the US, all of Colorado and Leadville, CO. (high elevation and in mineralized area) as contrasted to coastal areas like Virginia and Oregon. This table shows the major components of natural background radiation including terrestrial radiation (uranium, radium, thorium and a naturally radioactive form of potassium in soil, rocks and water), cosmic radiation (high energy particles and rays from space) and internal radiation (from food, water and radon gas from natural uranium decaying in the ground).

The data in Table 1 demonstrates that the differences in annual background exposure based on where one chooses to live, what one chooses to eat and drink have a much greater impact on public exposure than the regulatory dose limits we discussed above.

Source	US Avg.[1]	Colorado [2]	Leadville, CO. [2]	Virginia [3]	Oregon [3]
Cosmic Radiation	31	50	85	28	28
Terrestrial Radiation	19	49	97	20	27
Radon and Other Internal	260	301	344	182	102
Totals	310	400	526	230	157

TABLE 1: Comparison of average radiation backgrounds in US (units of millirem / yr)

[1] National Council on Radiation Protection and Measurements. Report No. 160*, Ionizing Radiation Exposure of the Population in the United States.* 2009.
[2] Moeller D, Sun LSC*. Comparison of Natural Background Dose Rates for Residents of the Amargosa Valley, NV, to those in Leadville, CO, and the States of Colorado and Nevada.* Health Physics 91:338-353; 2006
[3] USEPA. Assessment of Variations in Radiation Exposure in the United States. Contract Number EP-D-05-002 (Revision 1). Washington, DC. 2006

Because background radiation varies significantly across the U.S., it follows that population exposure varies accordingly. As indicated in Table 1, if for example, one chooses to live in Colorado vs. Oregon, the difference in his or her annual radiation dose is more than 240 mrem /yr which is more than twice the Federal public exposure limit for uranium mills of 100 mrem /yr. In other words, if you are a resident of Colorado and leave to visit your sister for a month in Oregon, you could “save” 20 – 30 mrem of exposure, which is about equal to the EPA 40 CFR 190 limit of 25 mrem /year excluding radon.

2. Is the existing 20 picocurie/meter^2 – second (pCi/m2-sec) radon flux /emission standard in 40 CFR Parts 61, Subpart W and 192, Subpart D adequate to protect the public from additional radiation exposure above our natural background exposure ?

Specifically regarding natural background exposure to radon, note that Figure 1 and Table 1 demonstrate that radon can contribute much more than 50 % of our total background exposure and almost 300 mrem / yr in the Rocky Mountain States (due to higher levels of natural uranium and radium in the soil and rocks than, e.g., the coastal plains of the US).

It is recognized that EPA’s public exposure criteria for radon in 40 CFR 61, Subpart W and Part 192, Subpart D is expressed as a “flux” (emission rate from a surface) of 20 pCi/m2-

sec. This limit however includes natural background, which is typically 1-2 pCi/m^2-sec almost anywhere on the earth's surface and can be several times higher than this in mineralized areas. So in some places, the EPA radon flux limit could be just a few times the existing background rate.

It is also recognized that 40 CFR Subpart W also imposes work practice requirements @ 61.252(b)(1) limiting the operator to two tailings impoundments of no more than 40 acres each. Accordingly, if it is assumed that the entire 80- acres are emitting radon at the limit of 20pCi/m2 -sec, the annual "source term" can be directly calculated to be about 200 Curies. This is approximately equal to the "source term" from 2-3 square miles of the earth, almost anywhere, at a typical planet wide background flux of 1 - 2 pCi/m2- sec.

However, the quantity or emission rate of a radionuclide from a source within the restricted area of a licensed facility is not the primary criteria for public radiation protection. This is routinely achieved by demonstrating compliance with the fundamental public dose limit of 100 mrem /year including radon (e.g., @ 10 CFR 20.1301 and commensurate sections of Agreement State regulations) and in demonstrating compliance to concentrations of radionuclides permitted to be released to unrestricted areas (e.g., at the site boundary) specified in 10 CFR 20, Appendix B, Table 2 (for radon = 1 X 10^{-8} uCi/ml w/o progeny; 1 X 10^{-10} with progeny).

It is at the site boundary and/or locations where people actually live, not at a somewhat arbitrary* location within the restricted area inaccessible to the public, that public radiation protection criteria should be applied. Although the historical need is understood for establishment of the radon flux criteria to limit radiological impact to a future public who may have access to formerly decommissioned uranium tailings sites, for licensed operating facilities, other mature regulatory controls as referenced here provide much greater assurances that exposure of the public is maintained ALARA in support of optimizing the risk vs. benefit relationship.

* "Arbitrary" relative to the most likely pathways of exposure to a member of the pubic including considerations of local meteorology and demography

3. What Do We Know About Radon Releases from Water Impoundments?

In response to concerns regards to radon releases from the decay of its radium parent contained in water impoundments (e.g., evaporation ponds) associated with uranium recovery facilities, two recent reports provide some valuable insight:

(1) SENES Consultants Ltd, *Evaporation Pond Radon Flux Analysis, Piñon Ridge Mill Project, Montrose County, Colorado*. August 2010 for Energy Fuels Resources Corporation; included as Appendix D of Energy Fuels' *Application for Approval for Construction, Pinon Ridge Mill, Montrose County,* Colorado as submitted to US EPA Region VIII, Denver, Colorado August 31 2010. This report is posted along with the complete application on the EPA Subpart W web

site under "Applications", *Pinon Ridge Mill: Application for Approval of Construction of Tailings Facility.*

This study provided estimates of radon flux from and concentrations above proposed water impoundments (evaporation ponds containing raffinate solution) with a specified radium concentration and compared results to other existing models. Conservative estimates of radon flux indicates that the emissions are low and less than or similar to the pre-operational average background radon flux of 1.7 pCi m^{-2} s^{-1} observed at various locations within the proposed tailings areas on the site. The estimated radon flux levels from the evaporation ponds is also a small fraction (less than 10%) of the 20 pCi m^{-2} s^{-1} limit for pre-1989 uranium tailings that has been assumed here for context. This conservative estimate was based on the Nielson and Rogers model *.

* Nielson, K.K. and V.C. Rogers 1986. *Surface Water Hydrology Considerations in Predicting Radon Releases from Water-Covered Areas of Uranium Tailings Ponds.* Proc. Eighth Annual Symposium on Geotechnical & Hydrological Aspects of Waste Management, Geotechnical Engineering Program, Colorado State University & A.A. Balkema, Fort Collins, CO, USA, February 507, PP:215-222.

The model assumes that the emission rates are enhanced by the turbulence at the top layer of the water column where all the radon in the top one-meter of water is assumed to be released to air instantaneously. For comparison purposes, the same parameters were used to estimate the radon emissions using an on-line program that is available on the World Information Services on Energy (WISE) website. The on-line model, which is attributed to the Rogers and Nielson model, produced identical results.

The results of this assessment also indicated that the radon emissions associated with the evaporation of the raffinate solution and the emissions due to the operation of sprinkler systems are extremely low and insignificant compared to the radon flux from the ponds due to diffusional and turbulence processes.

Finally, the calculations indicated that the incremental air concentration due to the emission of radon from the evaporation ponds is very small (on the order of 3%) relative to the assumed background radon concentration.

(2) K.R. Baker and A.D. Cox 2010. *Radon Flux from Evaporation Ponds*. Presented at National Mining Association (NMA) / Nuclear Regulatory Commission (NRC) Uranium Recovery Workshop 2010, Denver, CO, May 26-27.

A presentation by Baker and Cox at the most recent NMA/NRC workshop in Denver (May 2010) and subsequently at the National Health Physics Society Annual Meeting in Salt Lake City (June 2010) considers the situation where appreciable concentrations of radon are present in the ponded water, as may arise for example from elevated levels of Ra-226 dissolved in the pond water. Baker and Cox, reporting on a stagnant film model and some measurement data*, suggest a radon flux of the order of 1 pCi m^{-2} s^{-1} per 100 pCi/L of dissolved radon in the ponded water.

* A modified version of EPA Method 115 was used to measure radon flux from the pond surface

4. What do we know About Radon Emissions from ISRs?

Regarding radon evolution from in situ uranium recovery facilities, the majority of radon, which is released at the surface is not (as at a conventional mill) a result of on-surface decay of radium over time in tailings impoundments since ISRs do not generated conventional tailings as a radon source. At ISRs, the radon is brought to the surface dynamically, dissolved in the lixiviant returning from underground. Just as dynamically, that portion of the total dissolved radon that is above the solution's saturation value is released when encountering atmospheric pressures and temperatures.

Modern ISR uranium recovery processes are operated under “closed loop’ conditions. The circulating lixiviant goes directly from well field header houses thru the ion exchange process and is then reconstituted and returned directly to the well field as an essentially closed system. Atmospheric conditions are initially encountered during resin transfer at the shaker screens. Accordingly, the vast majority of the “radon source term” for these facilities is associated with small releases from the well heads and header houses in the well fields and from the IX - resin – elution system interface where the process is first opened to atmospheric pressure. For facilities that have water retention ponds at the back end of the process (barren lixiviant bleeds, restoration wastes, etc), only a small percentage of the radon originally dissolved in the pregnant lixiviant initially returning from the well fields would be expected to remain. ISRs in Texas are currently operating without these “surge ponds” and send liquid wastes directly to a permitted deep disposal well.*

* For general discussions of the radiological characteristics of ISRs, including mechanisms of radon evolution, see: National Mining Association. *Generic Environmental Report in Support of the Nuclear Regulatory Commission’s Generic Environmental Impact Statement for In Situ Uranium Recovery Facilities,* K Sweeney, NMA to L Camper, USNRC November 30, 2007; Brown, S. *The New Generation of Uranium In Situ Recovery Facilities: Design Improvements Should Reduce Radiological Impacts Relative to First Generation Uranium Solution Mining Plants*. Proceedings of the 2008 Waste Management Symposium, Phoenix. ASME Press, New York, NY, ISBN # 978160560422. 2008.

For more on mechanisms of ISR radon source terms see: Brown**,** S. and Smith, R., 1982. *A Model for Determining the Radon Loss (Source) Term for a Commercial In Situ Leach Uranium Facility.* In: M. Gomez (Editor), Radiation Hazards in Mining-Control, Measurement, and Medical Aspects. Soc. Min. Eng., pp. 794—800; Marple, M.L and Dziuk, T, Texas Department of Health, Bureau of Radiation Control. *Radon Source Terms at In Situ Uranium Extraction Facilities in Texas.* Proceedings of the Sixth Annual Uranium Seminar, South Texas Minerals Section of AIME. Corpus Christi. September 11-14, 1982

5. What are Current Practices and Results in Estimating Doses to the Public from Uranium Recovery Facilities?

Calculations performed in accordance with existing NRC guidance are used to estimate source terms and calculate off-site dose to the public. For example, USNRC Regulatory Guide 3.59, Section 2.6 provides methods acceptable to NRC for estimating the radon source term during ISR operations. Additionally, USNRC NUREG 1569, Appendix D, provides the MILDOS – AREA computer code methodology acceptable to the NRC, which includes expressions for calculating the annual Rn-222 source terms from various aspects of ISR operations which is then used by MILDOS to calculate off-site public dose and demonstrate compliance with dose limits of 10 CFR 20.1301.

See e.g.: U.S. Nuclear Regulatory Commission, NUREG-1569, *Standard Review Plan for In Situ Leach Uranium Extraction License Applications*, June 2003. Yuan, Y.C., J.H.C. Wang and A. Zielen. 1989. *MILDOS-AREA: An Enhanced Version of MILDOS for Large-area Sources.* Argonne National Laboratory (ANL) report ANL/ES-161. June 1989; U.S. Nuclear Regulatory Commission (NRC), 1987*. Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations*. Regulatory Guide 3.59.

Regards to historical estimates of offsite radon concentrations and public dose from ISRs as reported by its licensees, the U.S. Nuclear Regulatory Commission, in NUREG-1910, *Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities (*2009), Chapter 4.2 indicates:

- Quarterly and biannual measurements of downwind concentrations of radon at an operational ISR facility boundary from 1991 to early 2007 were below 74 Bq/m3 [2.0 pCi/liter] with a majority of measurements below 37 Bq/m3 [1 pCi/liter]. For comparison, these measured values are well below the NRC effluent limit for radon at 10 CFR Part 20, Appendix B of 370 Bq/m3 [10 pCi/liter] and in fact, are probably just background values.

- Argonne National Laboratory's MILDOS-AREA computer code (Argonne National Laboratory, 1989 – see above) is typically used to calculate radiation doses to individuals and populations from releases occurring at operating uranium recovery facilities. The code is capable of modeling airborne radiological effluent releases applicable to both conventional mills and ISR facilities (including radon gas from well fields and processing facilities and yellowcake particulates from thermal drying operations)

- All reported doses have been well within the 10 CFR Part 20 annual radiation dose limit for the public of 1 mSv [100 mrem/yr] including dose from radon and its progeny and within the EPA fuel cycle annual limit (40 CFR 190) of 0.25 mSv [25 mrem], which does not include dose due to radon and its progeny.

6. What is known about the potential health effects to populations living in the vicinity of uranium mines and mills?

Uranium is a heavy metal and acts similarly to other heavy metals in the body (like molybdenum, lead, mercury). Accordingly, for natural uranium, national and international human exposure standards are based on the possible *chemical toxicity* of uranium (e.g., effect on kidney—nephrotoxicity), not on radiation and possible "cancer effects" (radiotoxicity). However, there has never been a death or permanent injury to a human from uranium poisoning*.

* See e.g.: (1) U.S. Nuclear Regulatory Commission. *Standards for Protection Against Radiation*; 10 CFR 20, Appendix B., Table 1. 1992. (2) International Commission on Radiological Protection. *Limits for Intakes of Radionuclides by Workers*. ICRP Publication 30, 1979. (3) US Dept. of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. *Toxicological Profile for Uranium.* 1999. *(4) Acute Chemical Toxicity of Uranium.* Kathryn, RL and Burkin, RK. Health Physics, 94(2), pp 170-179, February 2008)

Regarding ionizing radiation in general, the health effects are well understood. No health effects have been observed in human populations at the exposure levels within the range and variability of natural background exposures in the US. An official position of the National Health Physics Society is that below 5,000 – 10,000 millirem (which includes the range of both occupational and environmental exposures), risks of health effects are either to small to be observed or non- existent (see *Radiation Risks in Perspective* @hps.org/hpspublications/positionstatements). International and national authorities that establish exposure standards for workers and the public rely on the work of scientific committees of the highest professional standing for their evaluations of the scientific information on the health effects of ionizing radiation. These scientific committees include the United Nations Scientific Committee on the Effects of Ionizing Radiation (UNSCEAR); the International Commission on Radiological Protection (ICRP); the National Academy of Science's Biological Effects of Ionizing Radiation (BEIR) Committee, the National Council on Radiation Protection and Measurements (NCRP) and others.

But what about the specific concerns regarding health effects to populations living close to uranium recovery facilities? Despite much confusion and misunderstanding, possible health effects in populations living near uranium mines and mills have been well studied. No additional effects have been observed when compared to the health status of other similar populations not living nearby. A few sources providing the scientific evidence that supports this conclusion include:

- US Department of Health and Human Services, Public Health Services, Agency for Toxic Substance and Disease Registry, *Toxicological Profile for Uranium*, 1999. Chapter 1: Public Health Statement for Uranium, Section 1.5: How Can Uranium Effect My Health? – " No human cancer of any type has ever been seen as a result of exposure to natural or depleted uranium" (Available at:

http://www.atsdr.cdc.gov/toxprofiles/tp150.html)

- *Cancer and Noncancer Mortality in Populations Living Near Uranium and Vanadium Mining and Milling Operations in Montrose County, Colorado, 1950 -2000*. Boice, JD, Mumma, MT et al. International Epidemiology Institute, Rockville, MD and Vanderbilt University, Vanderbilt-Ingram Cancer Center, Nashville, TN. Journal of Radiation Research, 167:711-726; 2007: " The absence of elevated mortality rates of cancer in Montrose County over a period of 51 years suggests that the historical milling and mining operations did not adversely affect the health of Montrose County residents"

- *Cancer Mortality in a Texas County with Prior Uranium Mining and Milling Activities, 1950 – 2001.* Boice, JD, Mumma, M et al. International Epidemiology Institute, Rockville, MD and Vanderbilt University, Vanderbilt-Ingram Cancer Center, Nashville, TN Journal of Radiological Protection, 23:247 – 262; 2003 – "No unusual patterns of cancer mortality could be seen in Karnes County over a period of 50 years suggesting that the uranium mining and milling operations had not increased cancer rates among residents".

- *Cancer Incidence and Mortality in Populations Living Near Uranium Milling and Mining Operations in Grants, New Mexico, 1950–2004.* Boice, JD, Mumma, M et al. International Epidemiology Institute, Rockville, MD and Vanderbilt University, Vanderbilt-Ingram Cancer Center, Nashville, TN. Journal of Radiation Research, 174, 624–636. 2010 – "With the exception of male lung cancer (*in former underground miners*), this study provides no clear or consistent evidence that the operation of uranium mills and mines adversely affected cancer incidence or mortality of county residents".

7. But what about the known health impacts (e.g., lung cancer) to many uranium miners who worked underground in the 1950s and 1960s?

These miners worked in conditions that by today's standards we would consider unacceptable. They were exposed to very high levels of radon progeny (which are decay products of uranium) in poorly ventilated underground mines. Many of these miners also had severe smoking habits, which enhanced the ability of the radon daughters to deliver radiation dose to the lung. Follow up of 68,000 former miners over many years indicated the occurrence of about 2700 lung cancers in this population; much higher than the expected incidence. This is an incidence rate of about 4%. As a point of comparison, the baseline incident rate of lung cancer in non-smoker, Caucasian males today is about 0.4 % (Dr. John Boice, International Epidemiology Institute, Vanderbilt University – personal communication)

These conditions existed before we had Federal Agencies (Occupational Safety and Health

Administration - OSHA, Mine Safety and Health Administration - MSHA, US Nuclear Regulatory Commission - NRC) and laws to better protect workers throughout American industry (construction, manufacturing, farming, mining, etc). Based on the best scientific information available, we consider as safe the occupational exposure standards we have today as enforced by these agencies. The level of exposure of some of these early uranium miners was 100 – 1000 times higher than our current Federal standards.

As just one of many possible historical comparisons regards to working conditions in American industry decades ago, it is of note that almost 100 men died from construction and related accidents in the building of the Hoover Dam in the 1920s, long before Federal regulations were in place to protect workers. These circumstances would of course also be unacceptable today

Conclusions:

(1) The existing public radiation exposure criteria for uranium mills and in situ recovery facilities in 40 CFR Parts 61, 190 and 192 are adequately protective since they represent small fractions of the natural radiation background variation across the US. Our lifestyles, where we choose to live, what we eat and drink, has a much larger impact on our radiation exposure than exposure at these very low regulatory limits.

(2) Regarding ionizing radiation in general, the health effects are well understood. No health effects have been observed in human populations at the exposure levels within the range and variability of natural background exposures in the US.

(3) Radon emission rates (flux) from water impoundments (evaporation ponds) at licensed conventional mills and ISRs are not expected to be significantly different than that from typical background radon emission associated with land surfaces almost anywhere due to the very poor diffusion of radon through water.

(4) Historical environmental measurements made in the vicinity of uranium recovery facilities and public dose assessment performed and reported to the USNRC indicate radon concentrations at site boundary locations and doses to the public are consistently well below Federal limits.

(5) The possibility of health effects in populations living near uranium mines and mills over 50 years have been well studied by national scientific bodies of the highest professional standing. No additional effects have been observed when compared to the health status of other similar populations not living nearby.

(6) However, given that 40 CFR 192 was released in 1983, changes and updates have been made in the basic dosimetry models and science we use today to estimate radiological doses and risks. Accordingly, EPA should consider reassessing exposure terminology and criteria (e.g., as used in 40 CFR 190) to be consistent with current national and international methods and models, e.g., (1) International Commission on Radiological

Protection, 2008. “Publication 103 Recommendations of the ICRP, Annals of the ICRP.” 2008 and (2) National Research Council, 2006. “Health Risks for Exposure to Low Levels of Ionizing Radiation; BEIR VII, Phase II.”

EPA-1637

Tom Peake/DC/USEPA/US
12/22/2010 01:35 PM

To Setlow.Loren, Reid Rosnick
cc
bcc
Subject 192 and Subpart W dates--let me know if you have edits. Thx

Tier 1 Deliverable Dates 192 and Subpart W.docx

Tom Peake
Director
Center for Waste Management and Regulations
US EPA (6608J)
1200 Pennsylvania Ave, NW
Washington, DC 20460
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Washington, DC 20005

40 CFR 192 and Subpart W Deliverable Dates

Draft December 21, 2010

40 CFR 192*	Revised Schedule
Risk Assessment/Peer Review Complete	Fall 2011
Economics Analysis	Summer 2011
SAB Advisory (important, but not critical path)	November 2011
Summary info	November 2011
Opt selection pkg prior to opt selection	December 2011
Option selection	*February 2012*
FAR Agency Reg Rev	June 2012
To OMB	September 2012
Proposal in FR	*1st quarter 2013*

*Assumptions: We have Loren’s replacement hired as a TENORM subject matter expert and someone else to manage the regulatory process; and we don’t have continued poor performance issues with the contracts office. We also realize that the Fall of 2012 puts us in dicey territory with the election. *Italicized* items are the ones listed in the ORIA Priority Tiering.

Subpart W	Revised Schedule
Risk Assessment	Winter 2010
Peer Review Complete	Summer 2011
Economics Analysis	Summer 2011
Opt selection pkg 2 months prior to opt selection	September 2011
Option selection	November 2011
FAR Agency Reg Rev	3rd quarter 2012
To OMB	June 2012
Proposal in FR	December 2012

EPA-5403

Tony Nesky/DC/USEPA/US
10/27/2010 04:46 PM

To tim.andruss
cc Jose Torres, Loren Setlow
bcc Glenna Shields
Subject Re: Fw: Re: Fw: Re: Fw: Re: Fw: Details on EPA Public Information Meeting on Uranium and Thorium Rules, 11-4-10, Corpus Christi, TX

1 attachment

publicinfomeetings11-4-10.pdf

Dear Mr. Adruss::

I got your email address from my colleague José Torres, who thought you might be interested in our upcoming Public Information Meeting on our review of rules covering Uranium and Thorium milling.

The U.S. Environmental Protection Agency is holding public information meetings on November 4, 2010 to discuss its review of regulations on uranium and thorium milling and to solicit public input. The meetings are free and open to the public. All are welcome to participate. Two sessions will be offered for your convenience: one in the afternoon, and one in the evening. Advance registration is not required. Anyone who wants to speak may sign-up at the event. Public presentations will be time-limited to 5 minutes each.

Location:
Omni Corpus Christi Hotel – Marina
Riviera 1–2 Room
707 North Shoreline Blvd.
Corpus Christi, Texas 78401

Meeting Times :
Afternoon Session: 1:00-3:00 PM
Evening Session: 6:30-9:30 PM

An information flyer is attached. Please distribute this information to anyone who you think would be interested in it.
Please feel free to contact me if you would like additional information.Thanks!

Tony Nesky
Center for Radiation Information and Outreach
Tel: 202-343-9597
nesky.tony@epa.gov

EPA REVIEW OF STANDARDS FOR URANIUM AND THORIUM MILLING FACILITIES

Public Information Meetings – Corpus Christi, TX
November 4, 2010

Location

Omni Corpus Christi Hotel – Marina
Riveria 1–2 Room
707 North Shoreline Blvd.
Corpus Christi, Texas 78401

Meeting Times

Afternoon Session: 1:00-3:00 PM
Evening Session: 6:30-9:30 PM

The U.S. Environmental Protection Agency (EPA) is reviewing and potentially revising its regulations for uranium and thorium milling to bring them up-to-date, and welcomes your input. Two public information meetings will be offered for your convenience—one in the afternoon and one in the evening.

About the Regulations

The regulations under review are—

- 40 CFR Part 61, Subpart W, *National Emission Standards for Radon Emission Standards from Operating Mill Tailings*
- 40 CFR Part 192*, Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*

These regulations currently in effect, and establish standards for protection of the public health, safety, and environment from radiological and nonradiological hazards associated with uranium and thorium ore processing, and their associated wastes.

The radon emission standards at 40 CFR Part 61 apply to tailings at operating mills.

The cross-media standards at 40 CFR Part 192 apply to pollution emissions and site restoration. The U.S. Nuclear Regulatory Commission (NRC) and their Agreement States use these cross-media standards in their oversight of uranium and thorium facility operations and in issuing licenses for source material. The U.S. Department of Energy (DOE) uses them in their management of closed uranium mills and in the cleanup of contaminated soil and buildings.

Topics for Public Input

Members of the public are invited to provide five-minute presentations and submit questions to EPA on the following topics:

- Changes in uranium industry technologies (such as utilization of the In-Situ Leaching recovery process as the principal current technology for extracting uranium) and their potential environmental impacts
- Revisions in EPA drinking and groundwater protection standards
- Judicial decisions concerning the existing regulations
- Issues relating to children’s health, Tribal impacts, and environmental justice
- Dose and risk factors and scenarios for assessing radiological and non-radiological risk
- Facilities proposed in states outside existing uranium mining and milling areas
- Costs and benefits of possible revisions.

Interested parties may sign up to speak at the meeting location. Advance reservations are not required.