July 30, 1997

Uranium Recovery Licensees and
State Officials on Attached list

Subject: MINUTES FROM THE JOINT NUCLEAR REGULATORY COMMISSION - NATIONAL MINING ASSOCIATION URANIUM RECOVERY WORKSHOP ON JUNE 3-5, 1997.

Dear Ladies and Gentlemen:

On June 3-5, 1997, the Nuclear Regulatory Commission, Uranium Recovery Branch staff held a public meeting with representatives of the uranium recovery industry in Denver, Colorado. The purpose of the regularly scheduled meeting was to provide a forum for all participants to discuss relevant issues within the uranium recovery industry. Enclosed is a summary of the meeting minutes, with its attached attendance list and presentation materials from the workshop.

If you have any questions, please contact Jane Marshall of my staff. She can be reached at (301) 415-6390.

Sincerely,

(original signed by Daniel M. Gillen for)

Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material
Safety and Safeguards

Enclosure: As stated

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DATE	7/11/97		7/21/97	H	7/24/97	H				

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MINUTES FROM THE JOINT NUCLEAR REGULATORY COMMISSION - NATIONAL MINING ASSOCIATION URANIUM RECOVERY WORKSHOP, JUNE 3-5, 1997

On June 3-5, 1997, Uranium Recovery Branch staff from the U.S. Nuclear Regulatory Commission and National Mining Association (NMA) staff and members conducted a uranium recovery workshop in Denver, Colorado. The purpose of the meeting was to provide a forum for these organizations to discuss pertinent issues within the uranium industry.

Enclosed as attachment 1 is a list of all meeting attendees. Attachment 2 is the final meeting notes for the workshop.

On June 3, NRC and NMA staff presented items of interest to the uranium recovery industry including: the status of the final decommissioning rule, an overview of the recent US Nuclear Energy and Regulatory Conference, a summary of the Commission briefing by Industry representatives, communication with the NRC staff, the linear non-threshold model of radiation exposure, the NRC contracting process, strategic issues, and the procedures of the NRC Headquarters Operations Center. On June 4, 1997, presentations included research activities related the uranium recovery industry, performance based license conditions, the status and accomplishments of the NRC uranium recovery program for the current year, and an overview of MILDOS. The two days of presentations ended with an open regulatory forum for discussion of regulatory issues and questions not already discussed during the earlier presentations.

On June 5, 1997, a groundwater mini-workshop was held, which covered various groundwater issues of interest in the industry. These included: industry experience in groundwater cleanup, DOE experience from the Title I groundwater cleanup program, and the NRC staff discussion on As Low As Reasonably Achievable demonstrations. Agreement and non-agreement states discussed their experiences with groundwater aspects of the uranium industry, and the Center for Nuclear Waste Regulatory Analysis gave a presentation on the current state of the ISL standard review plan documentation they are developing for the NRC.

In the open regulatory forum, the NRC announced that future meetings will be annual instead of semi-annual due to budget resource limitations.

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rec'd with letter dtd 7/30/97

U.S. Nuclear Regulatory Commission
National Mining Association

Uranium Recovery Meeting
June 3-5, 1997
Denver Colorado
Final Meeting Notes

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United States
Nuclear Regulatory Commission

NRC/NMA
Uranium Recovery Workshop

June 3-5, 1997
Denver, Colorado

NRC / NMA Workshop
Tuesday, June 3

8:00 - 8:30	REGISTRATION
8:30 - 9:00	Introduction - Joseph J. Holonich (NRC) - Katie Sweeney (NMA)
9:00 - 9:30	Industry Report Katie Sweeney (NMA)
9:30 - 10:30	Non Linear Threshold Theory - Douglas B. Chambers (NMA)
10:30 - 10:50	Coffee Break
10:50 - 11:45	NRC Contracting Process - Ronald D. Thompson (NRC)
11:45 - 1:15	LUNCH
1:15 - 2:15	Strategic Issues Tony Thompson (NMA)
2:15 - 3:15	NRC Response - Joseph J. Holonich (NRC)
3:15 - 3:40	Coffee Break
3:40 - 4:40	NRC Operations Center - Melanie Galloway (NRC)

NRC/NMA Workshop
Wednesday, June 4

8:00 - 8:30	Late Registration
8:30 - 9:00	Research Activities - William H. Ford (NRC) - Katie Sweeney (NMA)
9:00 - 9:45	Report on CNWRA - Patrick C. Mackin (CNWRA)
9:45 - 10:10	Other Federal Agencies Part in FEIS - Joseph J. Holonich (NRC)
10:10 - 10:30	Coffee Break
10:30 - 11:00	Uranium Recovery Inspection Program - Charles L. Cain (NRC)
11:00 - 11:45	General Uranium Recovery Issues Surety Transmittals, NRC Contacts, Groundwater Monitoring for License Termination, and Status of NRC Uranium Recovery Program. - Joseph J. Holonich (NRC)
11:45 - 1:15	LUNCH
1:15 - 2:00	Performance Based License Conditions - Joseph J. Holonich(NRC)
2:00 - 2:45	DOE Title II experience - Joe Virgona (DOE)
2:45 - 3:05	Coffee Break
3:05 - 3:35	DOE Title I experience (DOE)
3:35 - 4:00	Overview of MILDOS - Duane W. Schmidt (NRC)
4:00 - 4:30	Open Regulatory Forum led by Joseph J. Holonich (NRC)
4:30	Adjourn

United States
Nuclear Regulatory Commission

Industry Report

Katie Sweeney
National Mining Association

UNITED NUCLEAR -- CHURCH ROCK

• Anticipated Completion of Groundwater Corrective Action	• December 31, 1998
• Anticipated Completion of Reclamation	• December 31, 1998
• Anticipated License Termination	• December 31, 1998

UMETCO -- GAS HILLS

- Anticipated Completion of Groundwater Corrective Action
  - December 31, 2000
- Anticipated Completion of Reclamation
  - December 31, 2000
- Anticipated License Termination
  - December 31, 2002

ATLAS MINERALS

• Anticipated Completion of Groundwater Corrective Action	• December 2005
• Anticipated Completion of Reclamation	• December 2000
• Anticipated License Termination	• December 2005

US ENERGY -- SHOOTARING CANYON

- Anticipated Completion of Groundwater Corrective Action
  - ?
- Anticipated Completion of Reclamation
  - > 10 - 20 years *
- Anticipated License Termination
  - > 10 - 20 years *

* Plan to return to operation

SOHIO-WESTERN L-BAR

• Anticipated Completion of Groundwater Corrective Action	• 1997-1998
• Anticipated Correction of Degradation Items	• 1998
• Anticipated License Termination	• 1998-2000

PETROTOMICS -- SHIRLEY BASIN

• Anticipated Date for Radon Barrier	• October 1997
• Anticipated Completion of Reclamation	• December 1999
• Anticipated License Termination	• 2001 >

PATHFINDER -- SHIRLEY BASIN

- Anticipated Completion of Groundwater Corrective Action
  - 2005
- Anticipated Completion of Reclamation
  - December 2000
- Anticipated License Termination
  - 2006

PATHFINDER -- LUCKY MC

- Anticipated Completion of Groundwater Corrective Action
  - 2004
- Anticipated Completion of Reclamation
  - September 1999
- Anticipated license Termination
  - 2005

EXXON -- HIGHLAND

- Anticipated Completion of Groundwater Corrective Action
  - 1997
- Anticipated Completion of Reclamation
  - 1999
- Anticipated License Termination
  - 2002

HOMESTAKE - GRANTS

- Anticipated Completion of Groundwater Corrective Action
  - 2010
- Anticipated Completion of Reclamation
  - 2014
- Anticipated License Termination
  - 2015

KENNECOTT -- SWEETWATER

• Anticipated Completion of Groundwater Corrective Action	• ?
• Anticipated Completion of Reclamation	• > 20 years *
• Anticipated License Termination	• > 20 years *

* Plan to return to operation

RIO ALGOM -- AMBROSIA LAKE

- Anticipated Completion of Groundwater Corrective Action
  - 2001
- Anticipated Completion of Reclamation (Existing tailings impoundment)
  - 1998
- Anticipated License Termination
  - Not Forecast

RIO ALGOM -- LISBON

- Anticipated Completion of Groundwater Corrective Action
  - 2005
- Anticipated Completion of Reclamation
  - 2008
- Anticipated License Termination
  - 2010

WESTERN NUCLEAR -- SPLIT ROCK

• Anticipated Completion of Groundwater Corrective Action	• December 1998
• Anticipated Completion of Reclamation	• December 1997
• Anticipated License Termination	• December 2000

WESTERN NUCLEAR -- SHERWOOD

• Anticipated Completion of Groundwater Corrective Action	• N/A
• Anticipated Completion of Reclamation	• Completed (in stability period)
• Anticipated License Termination	• December 1997

RECLAMATION PROJECTIONS

CAVEAT

MEETING THESE DATES IS IN MANY CASES DEPENDENT UPON:

- Timely action by NRC
- Granting of Alternate Concentration Limits or Other Alternative

TOP TEN INDUSTRY ISSUES

DRUG TESTING

- VERY COMPANY SPECIFIC
- WIDE RANGE OF ACTIVITIES

INDUSTRY REPORT

- REPORT ON U.S. NUCLEAR ENERGY AND URANIUM CONFERENCE
- PERSPECTIVE ON COMMISSION BRIEFING
- RECLAMATION PROJECTIONS
- TOP TEN INDUSTRY ISSUES
- DRUG TESTING

FINAL RULE ON RADIOLOGICAL CRITERIA FOR DECOMMISSIONING

- FINAL RULE DOES NOT ADDRESS DECOMMISSIONING AT URANIUM RECOVERY FACILITIES
- EXPEDITED RULEMAKING FOR DECOMMISSIONING OF URANIUM RECOVERY FACILITIES
- COMMISSIONER MCGAFFIGAN'S COMMENTS ON DECISION TO OMIT URANIUM RECOVERY FACILITIES

COMMISSIONER MCGAFFIGAN'S COMMENTS

- DECISION TO REMOVE LANGUAGE ON URANIUM RECOVERY FACILITIES WAS **WITHOUT PREJUDICE**
- STAFF MADE STRONG CASE FOR ITS POSITION
- ISSUE CAN STILL BE RESOLVED SATISFACTORILY

COMMISSION'S SPECIFIC COMMENTS

The scope of the final rule should be revised to exclude facilities that are currently subject to Appendix A to 10 CFR Part 40. The Commission has considered the difficulties associated with the decommissioning of these unique facilities, some of which are also subject to EPA standards under UMTRCA, and is concerned that the complexities of this issue may have been overshadowed by other provisions of this rule. Therefore, the Commission believes that this aspect of the rule warrants additional consideration by the NRC and the affected parties. Without prejudice to the approach described in SECY 97-046A and on an expedited basis, the staff should develop a rule which addresses license termination for these facilities. In the interim, the staff should continue its current practice for decommissioning uranium and thorium mills and in situ leach facilities.

U.S. NUCLEAR ENERGY AND URANIUM CONFERENCE

- MARCH 20-21 IN RIVERTON, WY
- SPONSORED BY RIVERTON RANGER AND OTHERS
- FUTURE OF URANIUM RECOVERY INDUSTRY

PERSPECTIVE ON COMMISSION BRIEFING

- MAY 13, 1997
- National Mining Association, Wyoming Mining Association and the Uranium Producers of America
- Purpose: Introduction of Organizations, Licensees, Uranium Recovery Methodologies, Technical and Regulatory Issues
- Regulatory Issues Raised: ISL Jurisdiction, Effluent Disposal Guidance, Non11(e)2 Disposal Policy, Concurrent Jurisdiction over Nonradiological Components of 11(e)2 Byproduct Material

United States
Nuclear Regulatory Commission

Linear Non-Threshold Model

Douglas B. Chambers, Ph.D.
National Mining Association

Low Dose Linearity:

A Practitioner's Review of the Science and Applications

Dr. Douglas B. Chambers

NRC / NMA Joint Meeting
Denver, Colorado
June 2, 1997

SENES Consultants Limited

SCIENCE
HEALTH PHYSICS

Atomic Split: Data Recharge Debate on Low-Level Radiation Risk

By Joby Warrick
Washington Post Staff Writer

The statistics seem clear and compelling, and completely at odds with common sense: In Japan, site of the world's only nuclear attacks, radiation victims are *outliving* their peers.

It's one of the stranger twists in 50 years of scientific monitoring of atom bomb survivors. As expected, the people closest to ground zero have died in high numbers of cancers that began in a white-hot flash of nuclear radiation. But as one moves farther from the blast site, the death rate plunges until it actually dips below the baseline.

And so, oddly, people with limited radiation exposure appear to live longer than neighbors who had none at all.

The discrepancy has several possible explanations, but none of them have quelled the growing debate over what the data seem to suggest: Could low-level radiation—regulated in this country and elsewhere as a powerful carcinogen—be less dangerous than commonly believed?

The question, which has divided scientists and academicians for years, has flared again because of a number of provocative new studies that seem to refute prevailing views about low-level radiation—the relatively low-grade sort found in some kinds of medical waste or in the natural radon gas found in many homes.

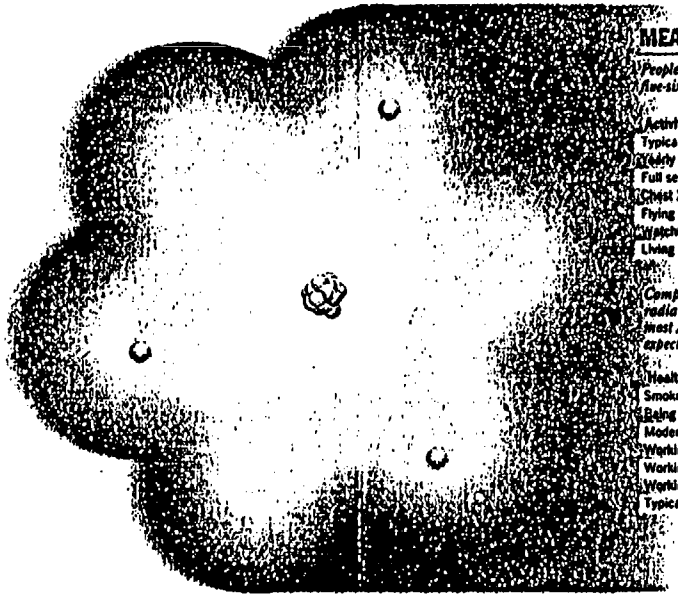
"It's like a religious dispute," said Steven Galson, the Energy Department's chief medical officer. "It's very, very intense."

The issue has broad implications, not just for nuclear workers but for ordinary consumers and taxpayers. If the government relaxed radiation exposure standards, by even a small degree, it could result in enormous savings for utilities, hospitals and other businesses that use radioactive materials. Taxpayers could save billions of dollars if cleanup standards were eased for the dozens of lightly contaminated sites around the country.

There's no sign that such a change is imminent. Some long-term epidemiological studies continue to suggest risks from even the most minute quantities of radiation. But others are challenging the conventional wisdom in ways that are becoming harder to ignore. Here are a few of the recent findings:

- Tens of thousands of Navy shipyard workers were exposed to radiation in the 1960s and 1970s. Yet, in carefully controlled epidemiological studies by Johns Hopkins University, the radiated workers appear to have suffered no ill effects. In fact, they have fewer cancers than non-exposed workers.
- Thousands of soldiers took part in nuclear weapons tests in the early years of the Cold War. But in a pair of recent analyses, researchers found no sign of unusual illnesses or higher death rates among these "atomic veterans."
- A University of Pittsburgh researcher tracked cancer rates in American counties with the highest levels of radon, the naturally radioactive gas. His finding: Lung cancers are lower in the areas where exposure is the highest.

Each case has been met with criticism over possible flaws that may have skewed the results. One problem is that epidemiological studies, which track human illness and deaths over time, can be relatively crude instruments for measuring health effects. "It's like hitting an ant with a hammer," said the Energy Department's Galson.



MEASURING RADIATION'S EFFECTS

People are exposed to radiation in many ways, and about five-sixths of the exposure comes from natural sources.

Activity	Millirems
Typical yearly exposure, all sources	360.00
Yearly exposure from natural sources	300.00
Full set of dental X-rays	40.00
Chest X-ray	8.00
Flying round-trip from D.C. to Los Angeles	5.00
Watching TV for one hour	0.15
Living outside nuclear power plant for a year	0.10

Compared with other health risks, radiation poses little risk for most Americans, reducing life expectancy about 18 days.

Health risk	Expected life lost
Smoking a pack of cigarettes a day	6 years
Being 15 percent overweight	2 years
Moderate alcohol consumption	1 year
Working in agriculture	320 days
Working in construction	227 days
Working in nuclear plant (1,000 mrem/yr)	51 days
Typical annual radiation dose (360 mrem/yr)	18 days

SOURCE: Department of Energy, Nuclear Regulatory Commission

THE WASHINGTON POST

To help resolve the dispute, a committee of the National Academy of Sciences gathered in Washington recently to launch a months-long project to decide whether the latest evidence on low-level radiation and health should be formally reviewed. A similar review is underway at the National Council on Radiation Protection and Measurements, the congressionally chartered board that helps advise the government on radiation safety.

It's too early to predict the outcome, but already prominent scientific groups are taking sides. Last year, the Health Physics Society, a professional association of scientists who study the health effects of radiation, surprised many observers when it effectively rejected the government's existing guidelines as too conservative.

Others take a more cautious view. Some, like the Environmental Protection Agency's Jerry Puskin, have observed that many of the most vocal advocates for change have their own reasons for wanting to see nuclear-based technologies succeed. "If you already have an agenda, you tend to grab on to these things," Puskin said.

At the core of the debate is a simple but powerful theorem, born amid the uncertainty and anxiety of the atomic era. It states that all radiation is harmful—and the more radiation, the greater the harm. Known among scientists as the "linear no-threshold" model, it holds that there is no truly "safe" level of exposure because even a single radioactive particle could cause damage to cells that could lead to cancer.

This model guided U.S. regulators in setting exposure limits for radiation in the 1950s, and it continues to do so today. The government's exposure limit for most Americans is 0.1 rems a year, a level lower than the average person's exposure from natural radiation sources (The average American receives 300 millirems of radiation from natural sources each year.)

Radiation is simply energy in movement and can take the form of high-speed particles or electromagnetic waves. The weaker, or "nonionizing," forms of radiation include visible light and radio and television waves. Considerably more powerful is "ionizing" radiation, so named because it packs enough energy to strip electrons from atoms.

At high levels, ionizing radiation can do serious damage to the genetic material within cells. Damage can also occur at small doses, but it is "indistinguishable, at the cellular level, from the damage routinely experienced from metabolism," argues Theodore Rockwell, of Radiation, Science and Health Inc., a pro-nuclear group.

In the March edition of the journal The Scientist, Rockwell notes that living cells have adapted over billions of years to natural radiation that is present in virtually every rock, and which bombards Earth daily from space. He dismisses as "silly" government standards that attempt to control radiation at levels smaller than a typical tourist encounters by walking through naturally radioactive granite halls in the U.S. Capitol.

"Even sleeping with another person or moving to a hill or up 10 floors of a building increases one's radiation dose beyond the permissible minimum," he wrote.

At the very least, Rockwell and others who share his views hope the debate will result in a better public understanding about radiation. In the United States, in contrast to other Western countries, fear of radiation has led to public rejection of nuclear power as an energy source. It also fuels public suspicion about such potentially beneficial technologies as food irradiation, which can kill deadly pathogens and reduce the waste of food through spoilage, they say.

"In the United States we have taken the position that radiation is so dangerous we don't want anything to do with it," said David P. Hickman of the federal Lawrence Livermore National Laboratory. "There's a real question of whether we may be hurting our future."

HPS Position Statement
(March, 1996)

- Below these doses (ie. 5 rem in one year or 10 rem lifetime above background)

" ... estimates should not be used; expressions of risk should only be qualitative emphasizing the inability to detect any increased health detriment (i.e. zero health effects is the most likely outcome)."

We Must Accept That Zero Risk is Unattainable and That it is Necessary to Weigh Benefits Against Costs

Background

- 2 - 3 mSv/y (200 - 300 mrem/y)
- Risk ~ 3 mSv/y
  x 70 y
  x 5 x 10^{-5} / mSv
  ~ 1%
- Natural Risk of Death From Cancer > 25%
- Radiation ~ 4% of Total Natural

Excess Relative Risk Estimates (and 90% Confidence Intervals)

Study population	All cancers excluding leukemia	Leukemia
High background area* in China	-0.06 (-0.16 to 0.05)	-0.08 (-0.40 to 0.39)
Bomb survivors **	0.027 (0.018 to 0.036)	0.26 (0.14 to 0.33)
Bomb survivors with ICRP DDREF† of 2	0.014	0.13

* Lifetime Dose: 60 mSv (bone marrow)
** Atomic Bomb Survivors: 60 mSv (whole body)
† Dose and Dose-Rate Effectiveness Factor

Source: UNSCEAR, 1994 (ANNEX A,B)

"We Need to be Cautious About Predictions of Risk not Distinguishable From Background Dose ..."

UNSCEAR

"Relative risks of this magnitude (i.e. background) are very difficult to detect epidemiologically, so even if observation is extended over a lifetime, it will be difficult to obtain a definitive result. Similar considerations apply to many of the smaller occupational studies, although some of these low-dose studies can be expected to provide an upper limit to the risk and therefore make a useful contribution to radiation-induced cancer risk evaluation."

$$\text{TOTAL RISK} = R_o + \Delta R$$

BACKGROUND

EXCESS

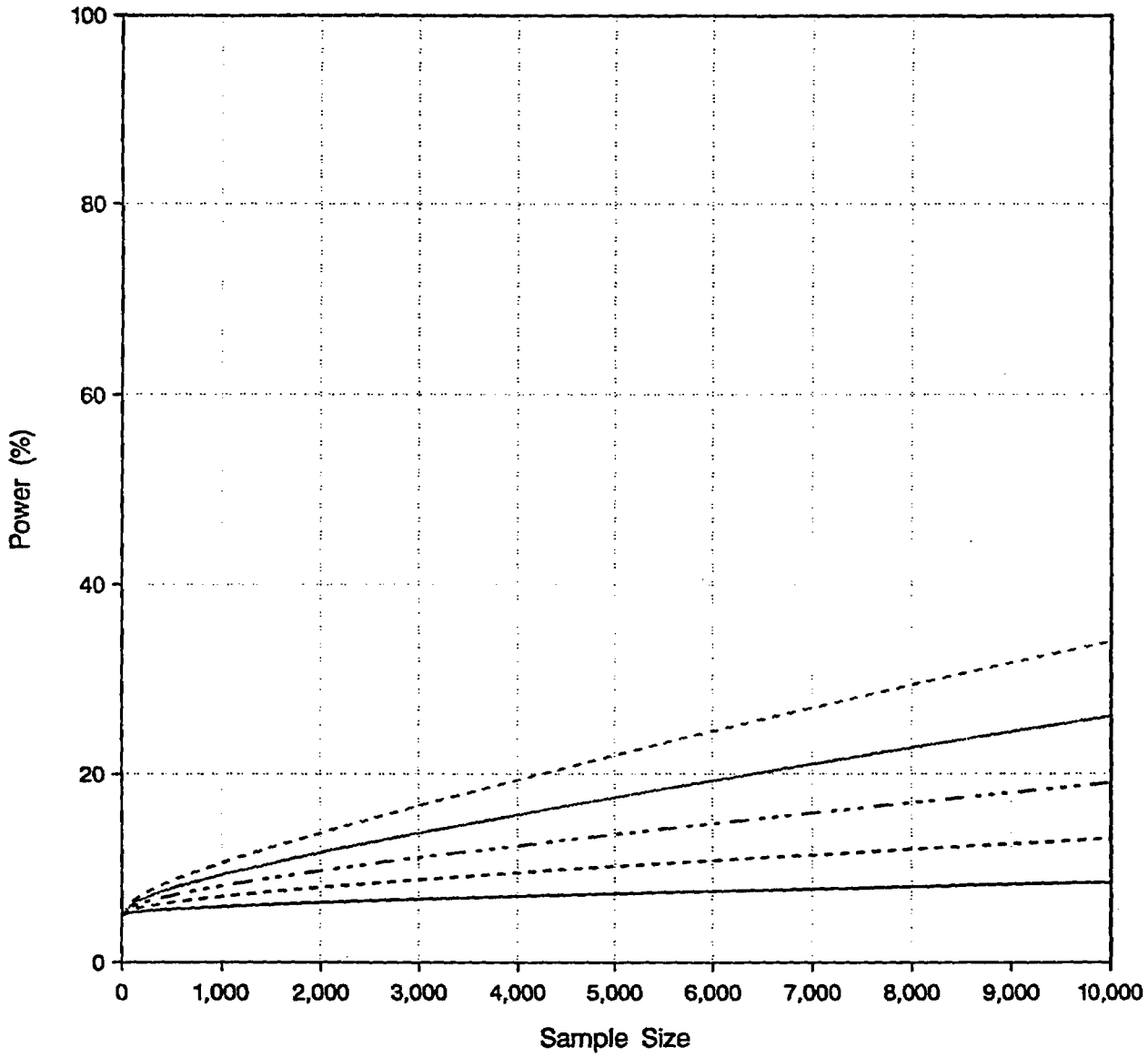
$$\text{RELATIVE RISK} = \frac{\text{“OBSERVED”}}{\text{“EXPECTED”}}$$

$$RR = \frac{R_o + \Delta R}{R_o}$$

$$= 1 + \frac{\Delta R}{R_o}$$

$$ERR = \frac{\Delta R}{R_o}$$

Approximate Power Curves for Various Assumed Relative Risks

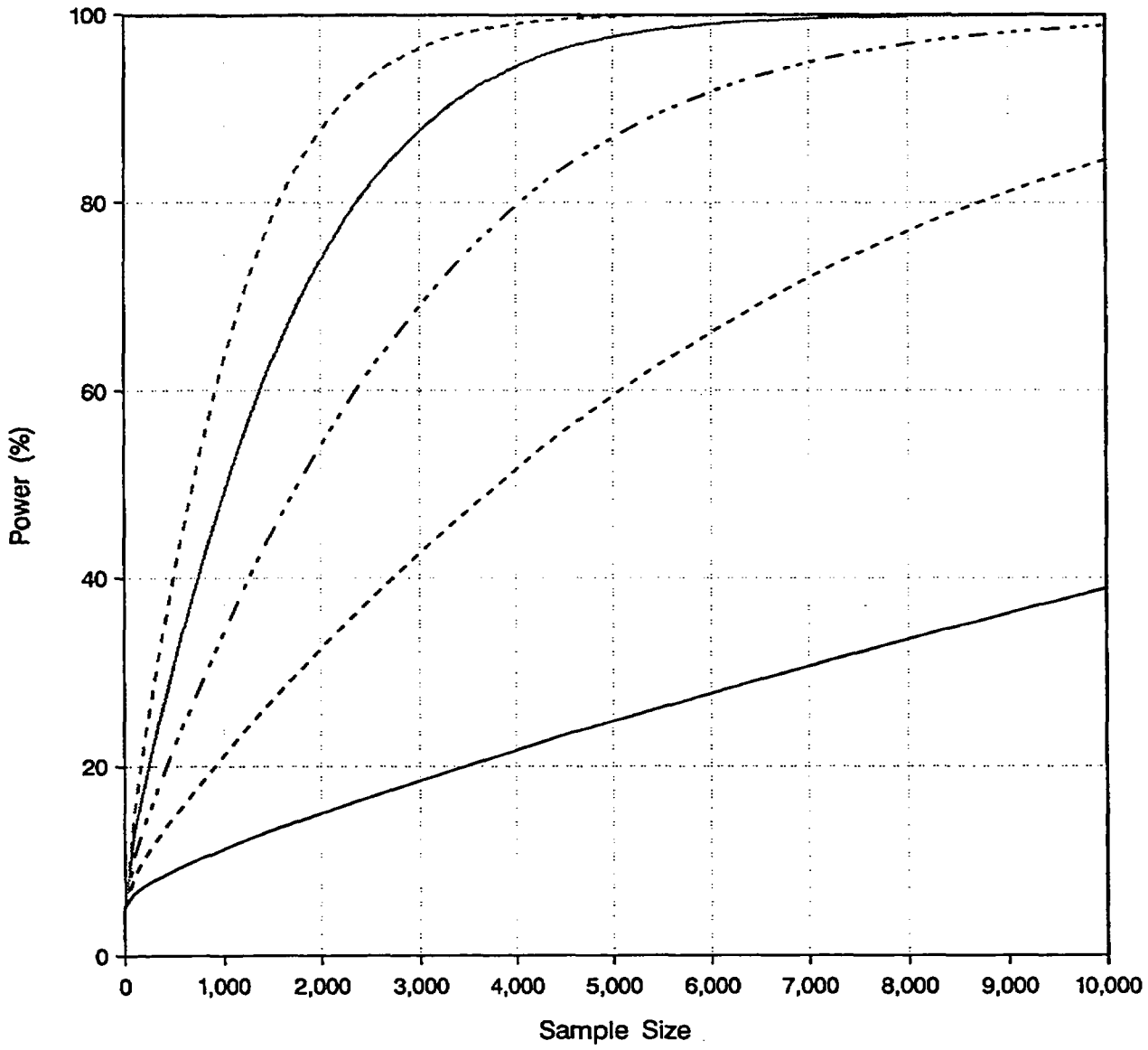


Legend
- Relative Risk = 1.1
- Relative Risk = 1.2
- Relative Risk = 1.3
- Relative Risk = 1.4
- Relative Risk = 1.5

A general population rate of 25 x 10^{-6} per year for a 30-year follow-up was assumed

Source: Beaumont and Breslow

Approximate Power Curves for Various Assumed Relative Risks



Legend
- Relative Risk=1.1
- Relative Risk=1.2
- Relative Risk=1.3
- Relative Risk=1.4
- Relative Risk=1.5

A general population rate of 650 x 10^{-6} per year for a 30-year follow-up was assumed

Source: Beaumont and Breslow

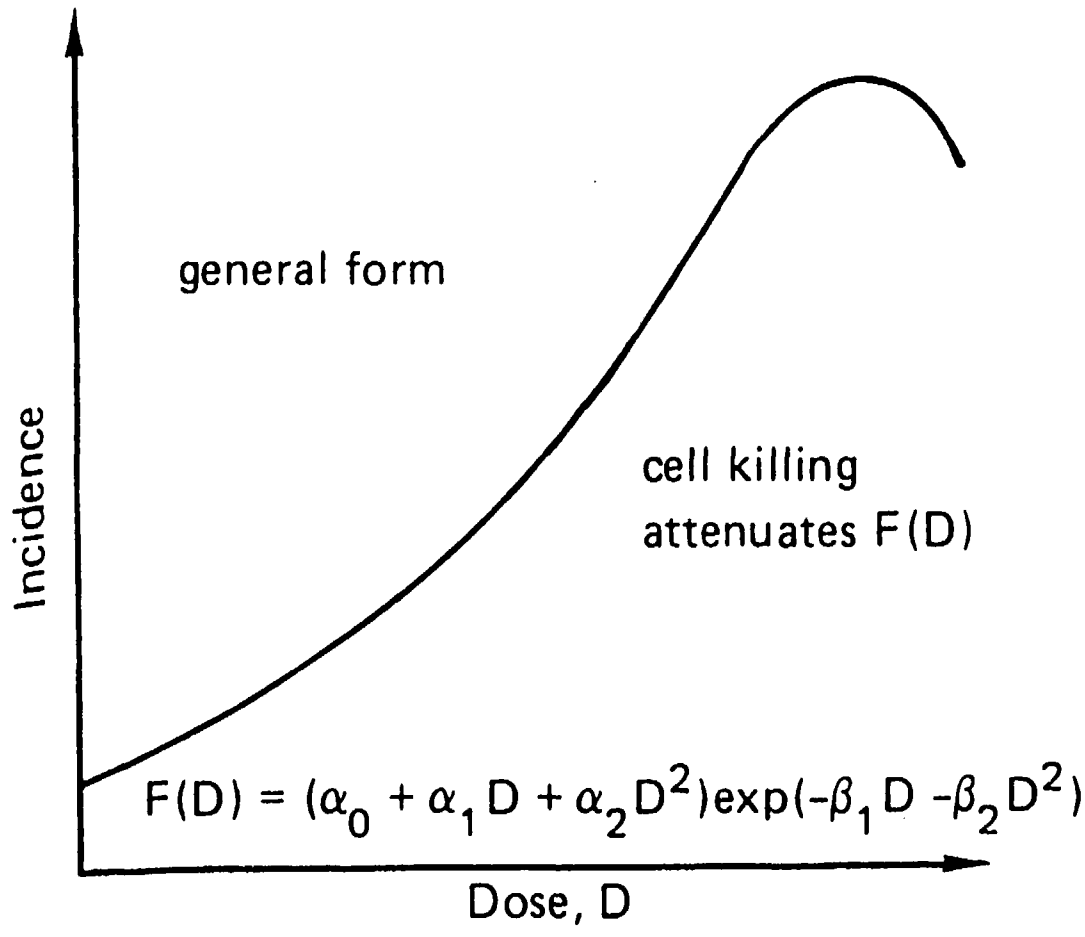
Excess Relative Risk Estimates per Sv (and 90% Confidence Intervals) for Fatal Cancers in Nuclear Workers and in Males Age (age 20-60) Atomic Bomb Survivors

Study population	All cancers excluding leukemia	Leukemia
Nuclear workers	-0.07 (-0.39 to 0.30)	2.18 (0.1 to 5.7)
Adult male bomb survivors	0.18 (0.05 to 0.34)	3.67 (2.0 to 6.5)
Adult male bomb survivors with ICRP DDREF* of 2	0.09	1.84

* Dose and Dose-Rate Effectiveness Factor

Source: IARC Study Group, 1994

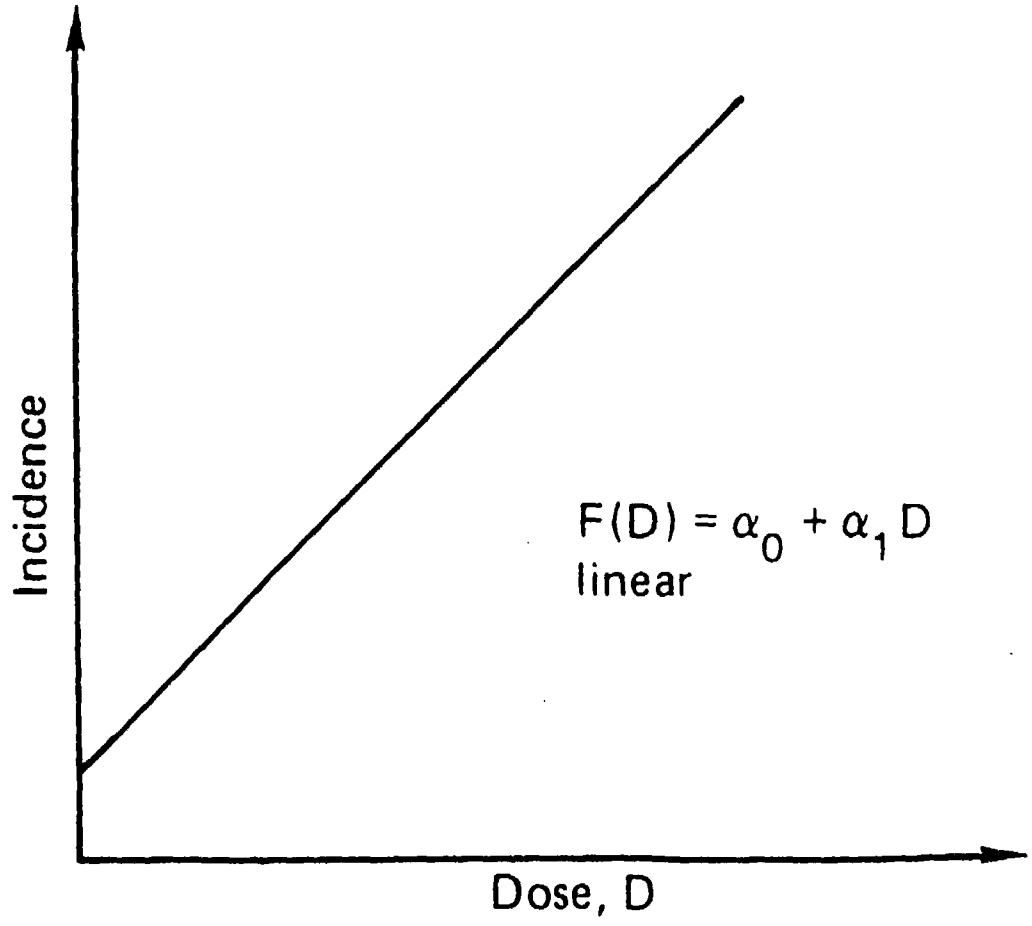
Alternative Dose-Response Curves



$$F(D) = (\alpha_0 + \alpha_1 D + \alpha_2 D^2)\exp(-\beta_1 D - \beta_2 D^2)$$

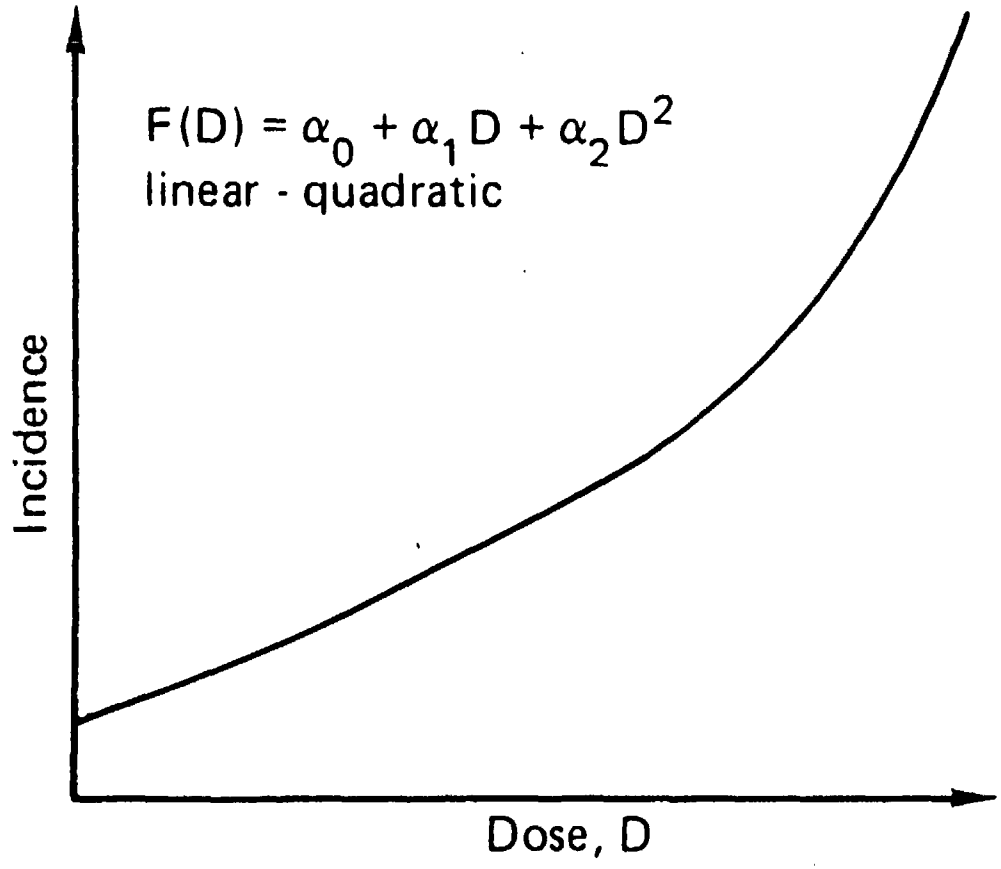
Source: NRC "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation", 1980

Alternative Dose-Response Curves



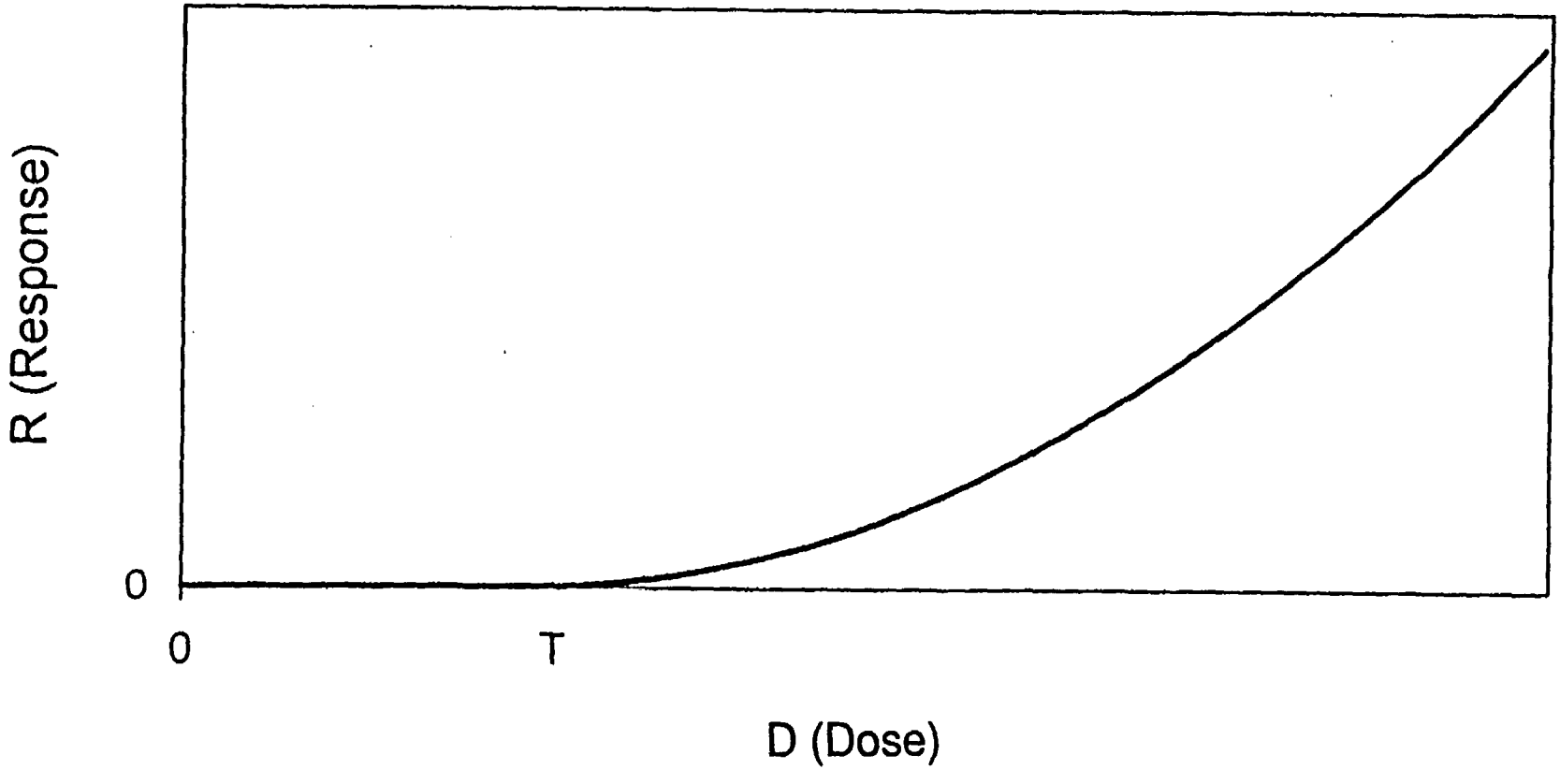
Source: NRC "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation", 1980

Alternative Dose-Response Curves



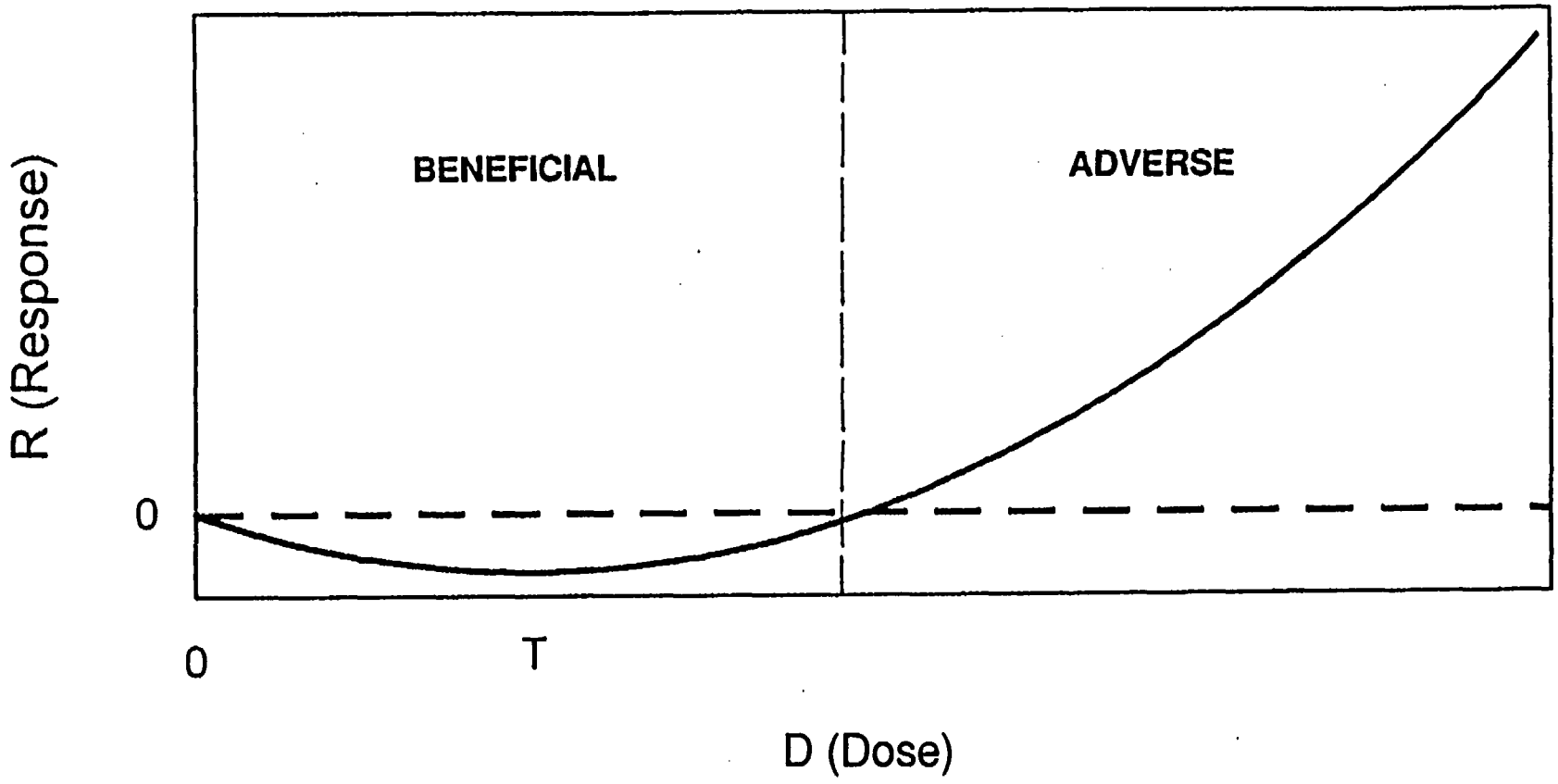
Source: NRC "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation", 1980

Threshold Dose Response



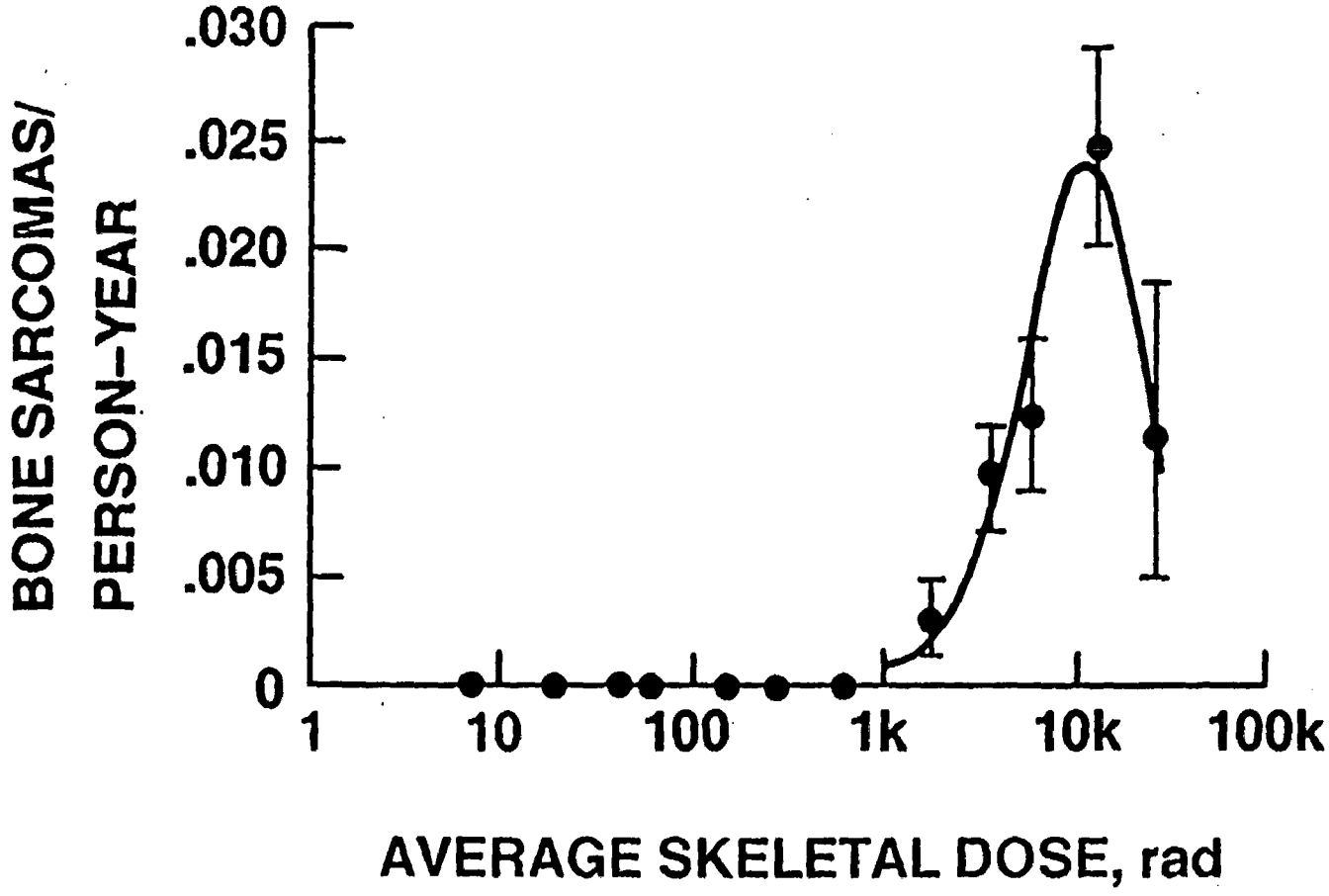
Source: K.S. Crump, 1997

U-Shaped Dose Response



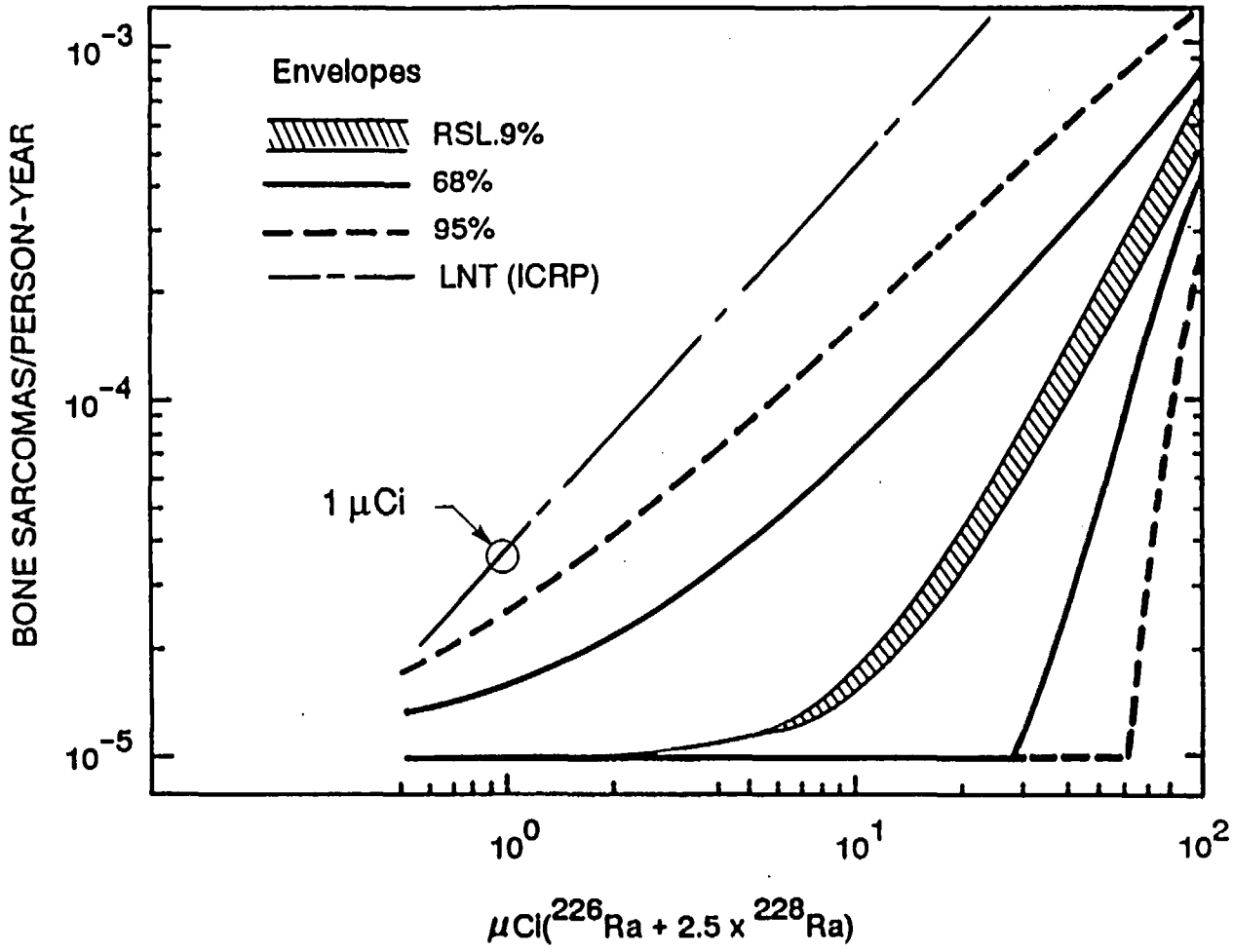
Source: K.S. Crump, 1997

Dose-Response Curve



Source: Rowland et al, 1978

Dose-Response Envelopes for $^{226,228}Ra$



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Risk per Year Using Linear Non Threshold Model (LNT)

- Lifetime Systemic Intake: 1 μCi
- Lifetime Total Intake (1/0.2): 5 μCi
- Lifetime Total Intake (3.7×10^4 Bq/μCi): 1.8×10^5 Bq
- Committed Effective Dose (x 2.8×10^{-7} Sv/Bq): 5.2×10^{-2} Sv
- Lifetime Risk of Fatal Cancer (x 0.05 Sv^{-1}): 2.6×10^{-3}
- Risk per Year of Fatal Cancer (x1/70 y): 3.7×10^{-5}

Comparison of Lifetime Risks of Radium Intakes Using ICRP and Epidemiologically-Based Risk Coefficients

Radionuclide[3]	ICRP[2]	Epidemiology[1]	
		best estimate	upper bound (95th %)
Ra-226	1.4×10^{-5}	0	6.5×10^{-6}
Ra-228	3.5×10^{-5}	0	1.6×10^{-5}

Notes:

1. Sum of head and bone cancer risks.
2. All fatal cancers.
3. Acute intake of 1000 Bq of each radionuclide.

Source: SENES Consultants, 1996

EPA Drinking Water Limit
(Risk by LNT and Radium Epidemiology)

- EPA's Drinking Water Limit: 5 pCi/L
- Daily Drinking Water Rate: 2 L/d
- Lifetime intake of Radium-226: 1.1×10^5 pCi

  5 pCi/L x 2 L/d x 365 d/y x 30y
- Lifetime Risk of Fatal Cancer (ICRP): 5.7×10^{-5}

1.1×10^5 pCi x 0.037 Bq/pCi x 2.8×10^{-7} Sv/Bq x 0.05 Sv^{-1}

- Lifetime Risk From Epidemiology Data*: 0
  - No bone sarcomas observed for systemic intakes < 10^8 pCi

Source: Rowland, 1994*

Results of Simulation Study on Absolute Risk Model for Colorado Plateau Uranium Miners

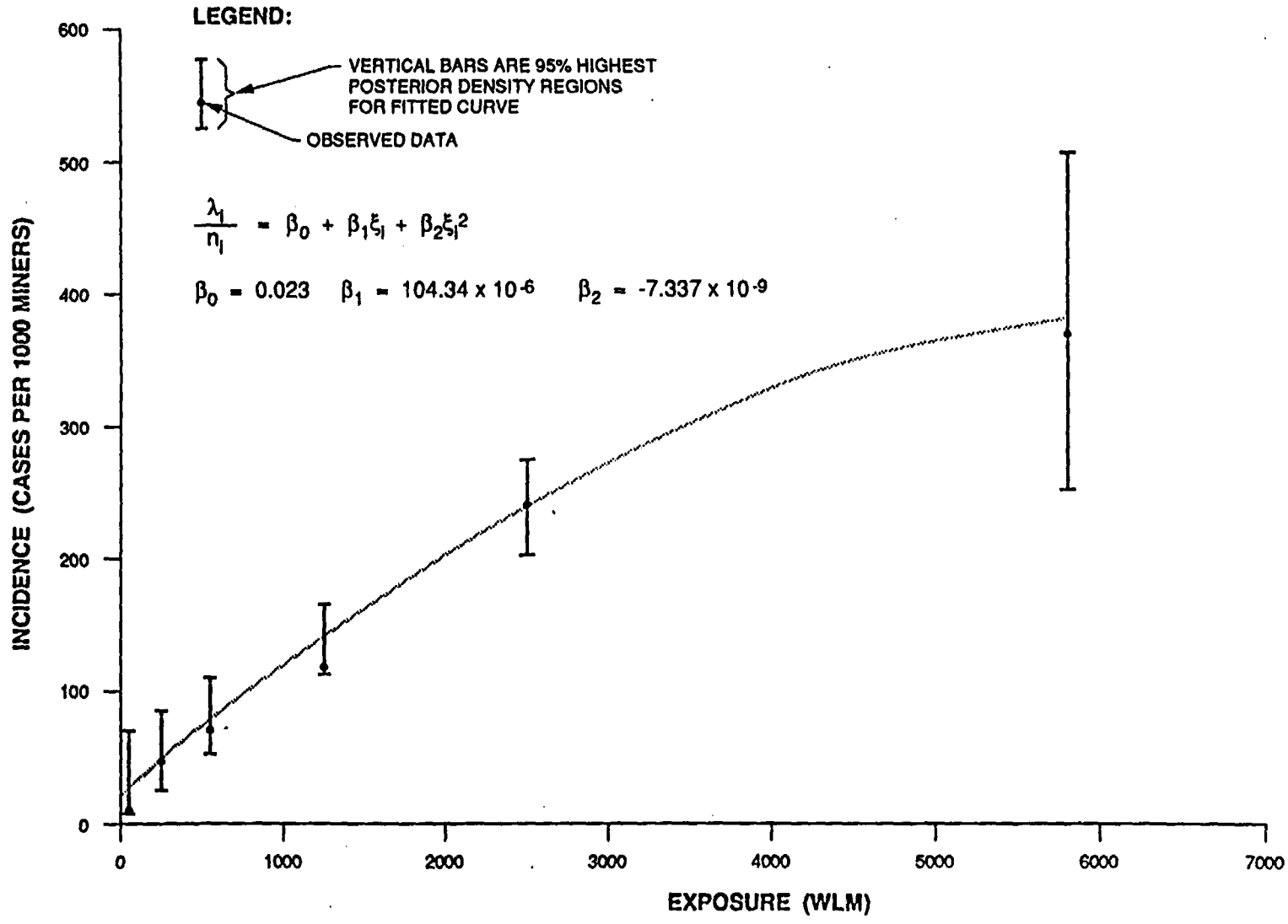
Parameter	Observed WLM (Cases)[1]	Estimated from Simulation	
		Model Parameters WLM (Cases)	95% HPD[2] region for Linear Risk Coefficients[3]
β_0	-	22.8×10^{-3} (3)	--
β_1	-	104.3×10^{-6} (4)	$(50,140) \times 10^{-6}$
β_2	-	-7.3×10^{-9} (5)	$(-15,+5) \times 10^{-9}$
ξ_1 (λ_1)	55 (7)	55.0 (18.5)	7-71
ξ_2 (λ_2)	233 (40)	233.1 (38.5)	23-87
ξ_3 (λ_3)	572 (67)	572.0 (67.7)	55-111
ξ_4 (λ_4)	1230 (75)	1229.5 (85.5)	113-165
ξ_5 (λ_5)	2510 (81)	2510.5 (79.9)	203-275
ξ_6 (λ_6)	5800 (35)	5761.8 (35.9)	253-508

Note:

1. The observed λ_i's are the actual number of lung cancers observed in i^{th} category.
2. The 95% highest posterior density (HPD) region is defined by two limits which contain 95% of the probability such that no value outside the limits has a higher probability density than any value inside the limits. The limits necessarily have equal probability density.
3. Background lung cancer rate per person per 30 years.
4. Units of lung cancer cases per person per WLM.
5. Units of lung cancer cases per person per $(WLM)^2$.

Source: SENES Consultants Limited, 1996

Fitted Absolute Risk Model



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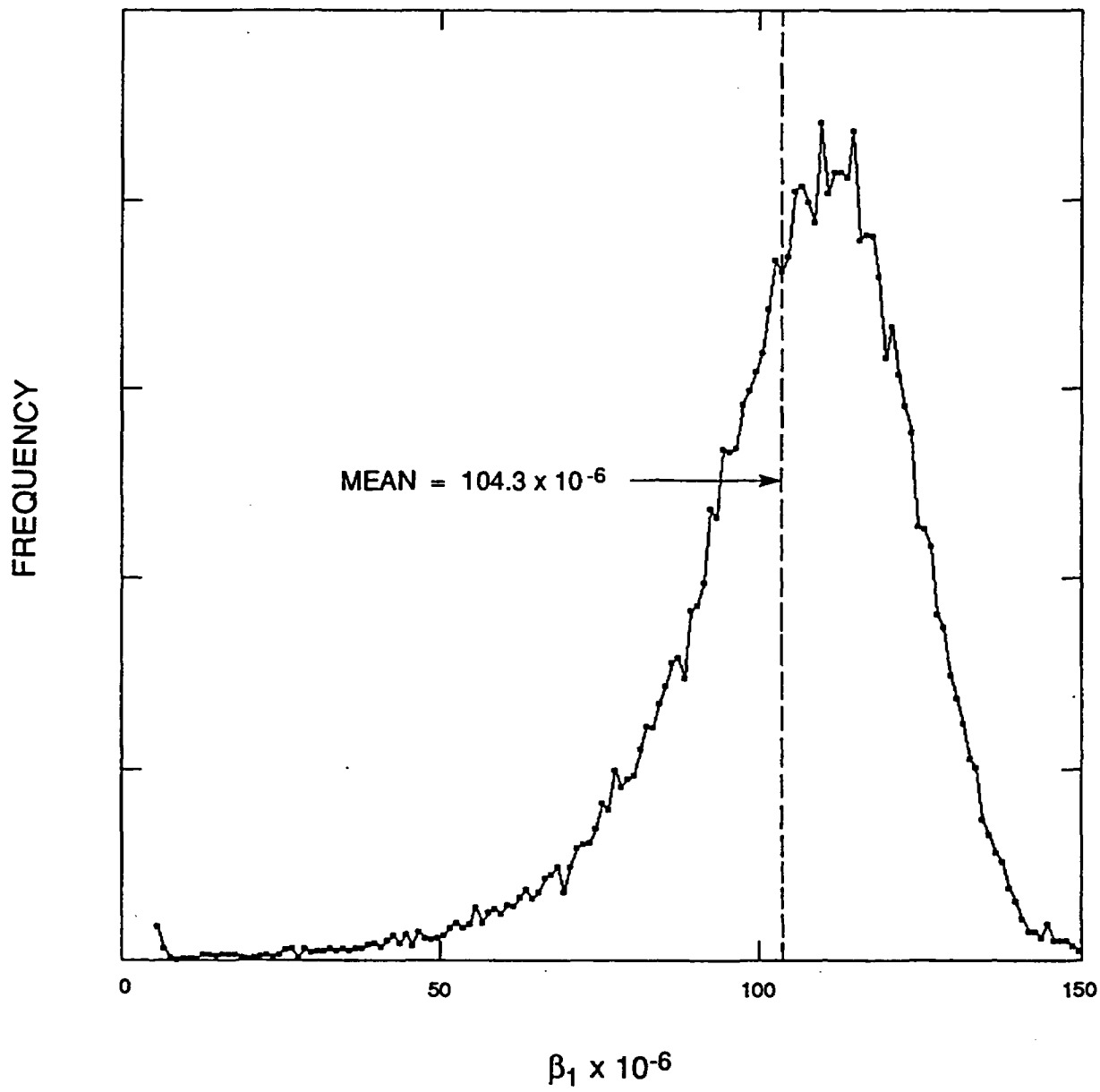
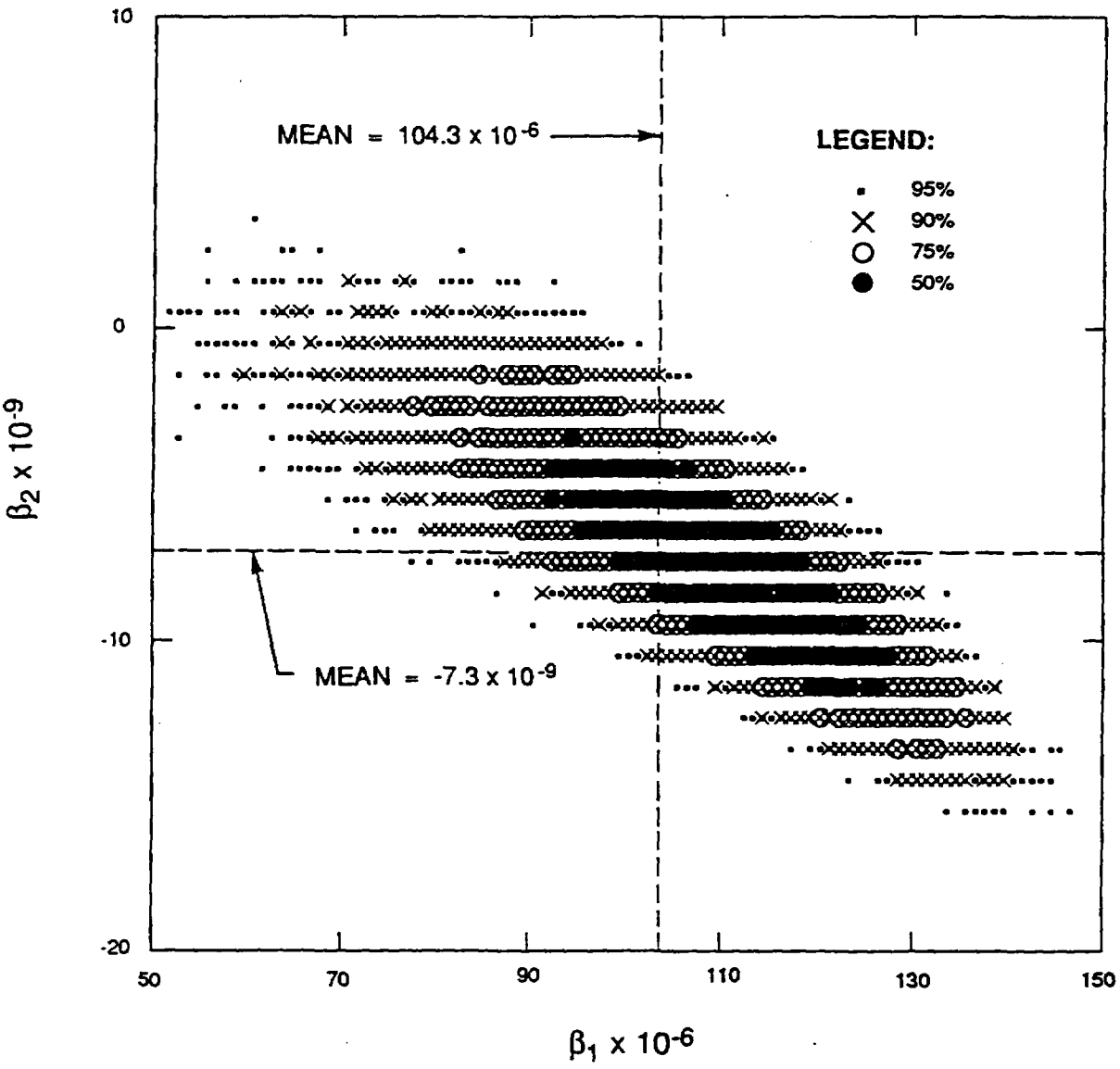
Marginal Distribution for Linear Term β_1 (cases per person per WLM) for the Absolute Risk Model



Joint Posterior Probability Contours for β_1 and β_2 for the Absolute Risk Model

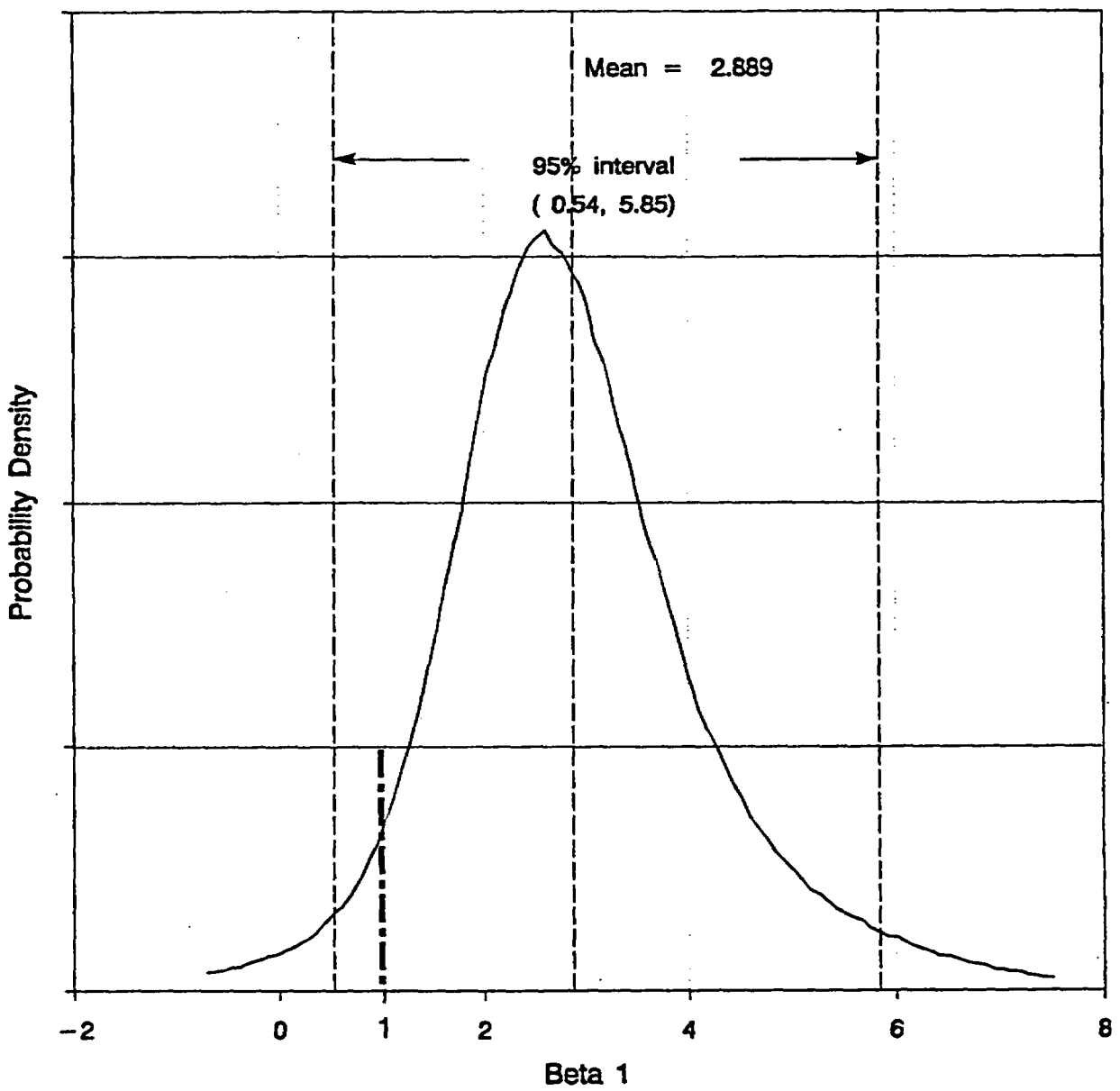


Relative Risk Model

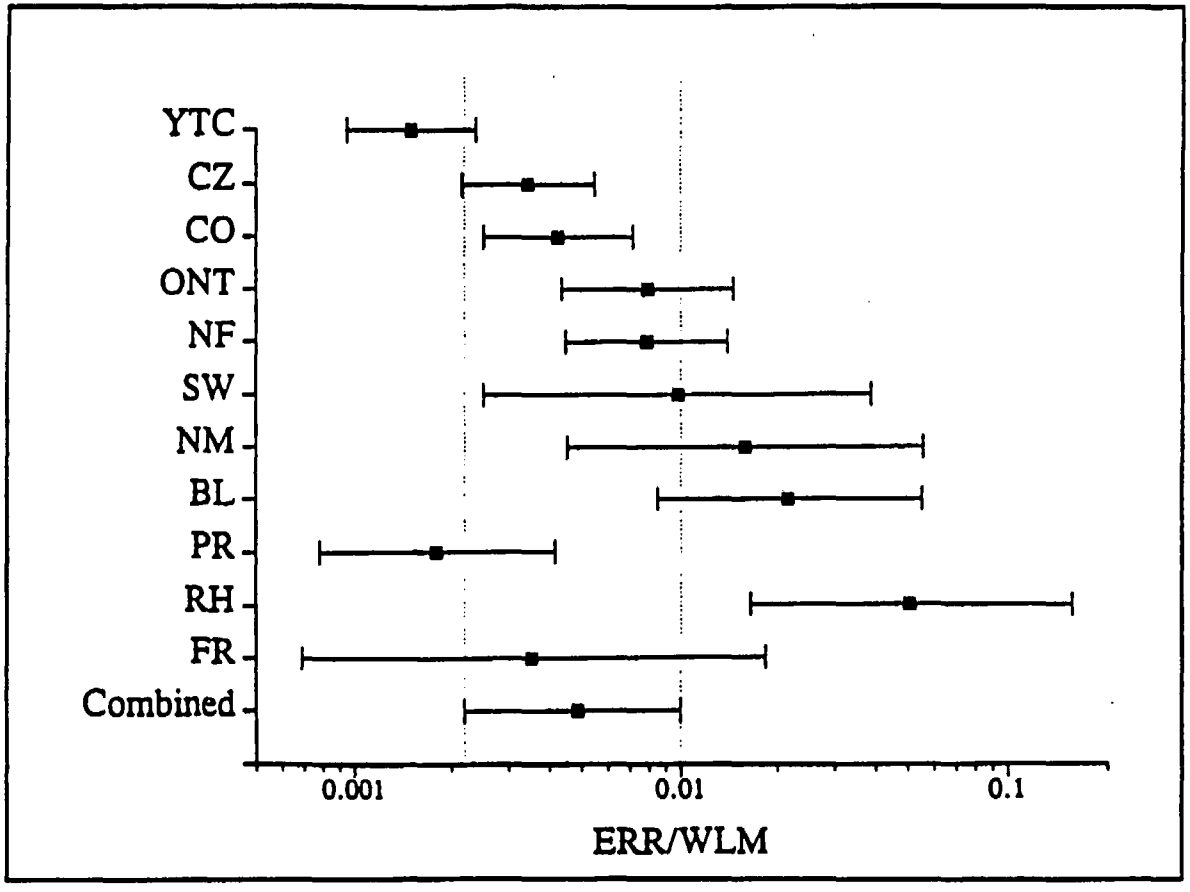
$$F = 1 + \beta_1 \, WLM + \beta_2 \, (WLM)^2$$

See Next Slide

Marginal Distribution for Linear Term β_1 for the Relative Risk Model



Estimates of Excess Relative Risk of Lung Cancer per WLM



Source: LUBIN et al, 1994

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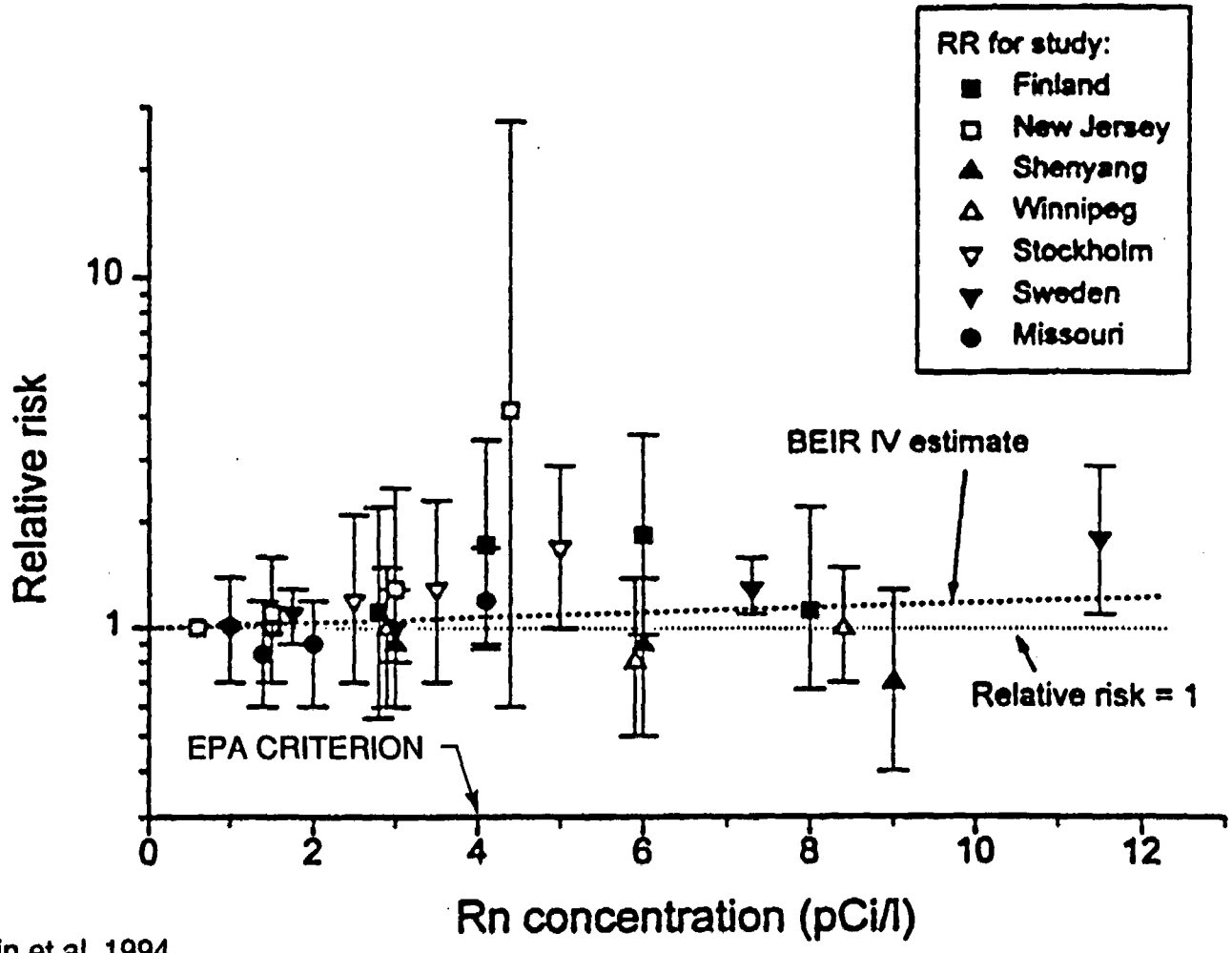
Relative Risks Case-Control Studies of Residential Radon Exposure



Source: Lubin et al, 1994

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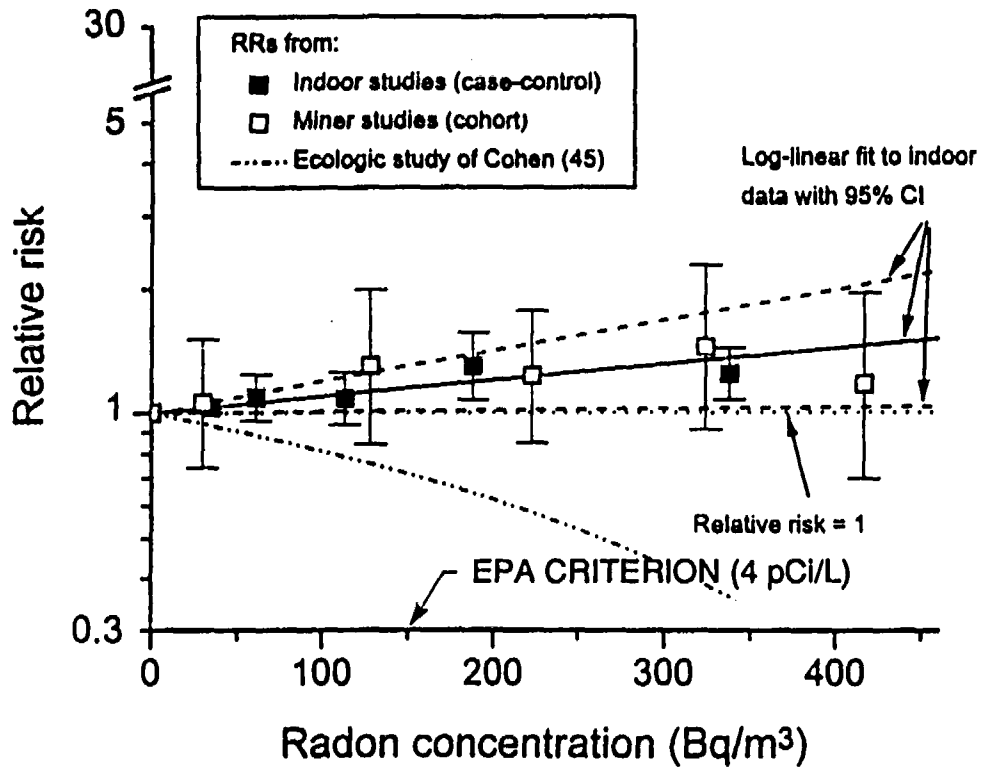
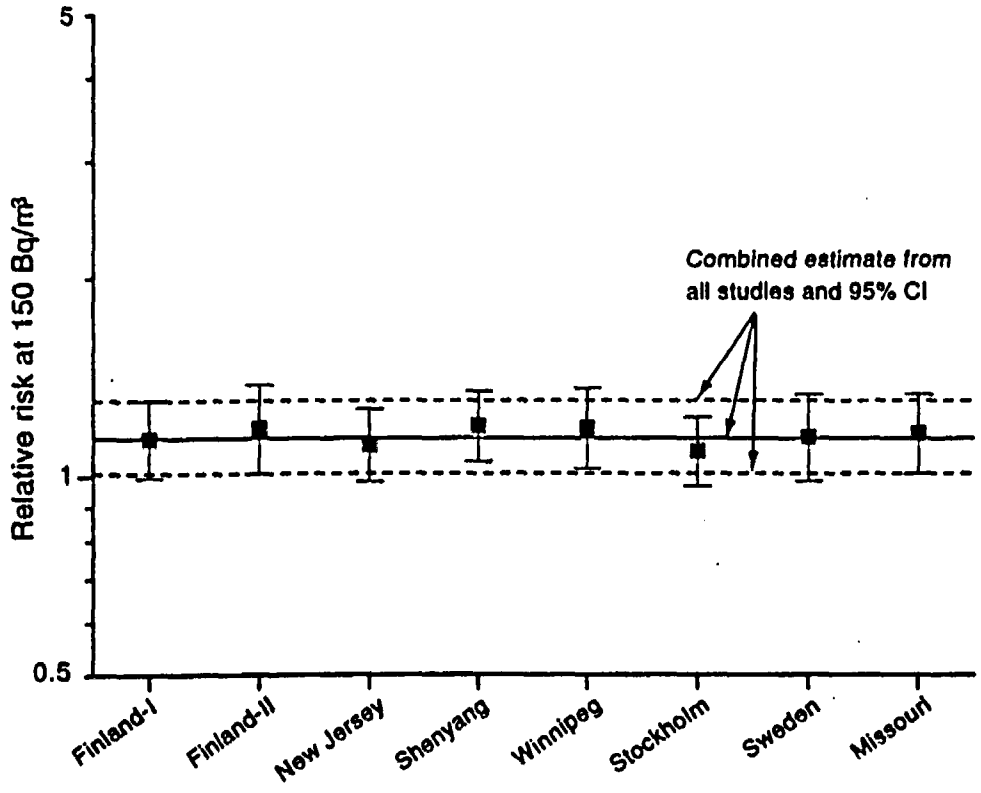
Summary Relative Risks From Meta-Analysis of Indoor Radon Studies



Source: J.H. Lubin and J.D. Boice, 1997

Influence Analysis Results Showing Estimated Summary Relative Risks (and 95% Confidence Intervals)



Source: J.H. Lubin and J.D. Boice, 1997

Radon From PG Stacks
(EPA - NESHAPS BID 1989)

- 0.021 pCi/L - Highest Average Incremental Concentration Predicted (nearby resident)
- 9×10^{-5} - Lifetime Risk of Fatal Cancer

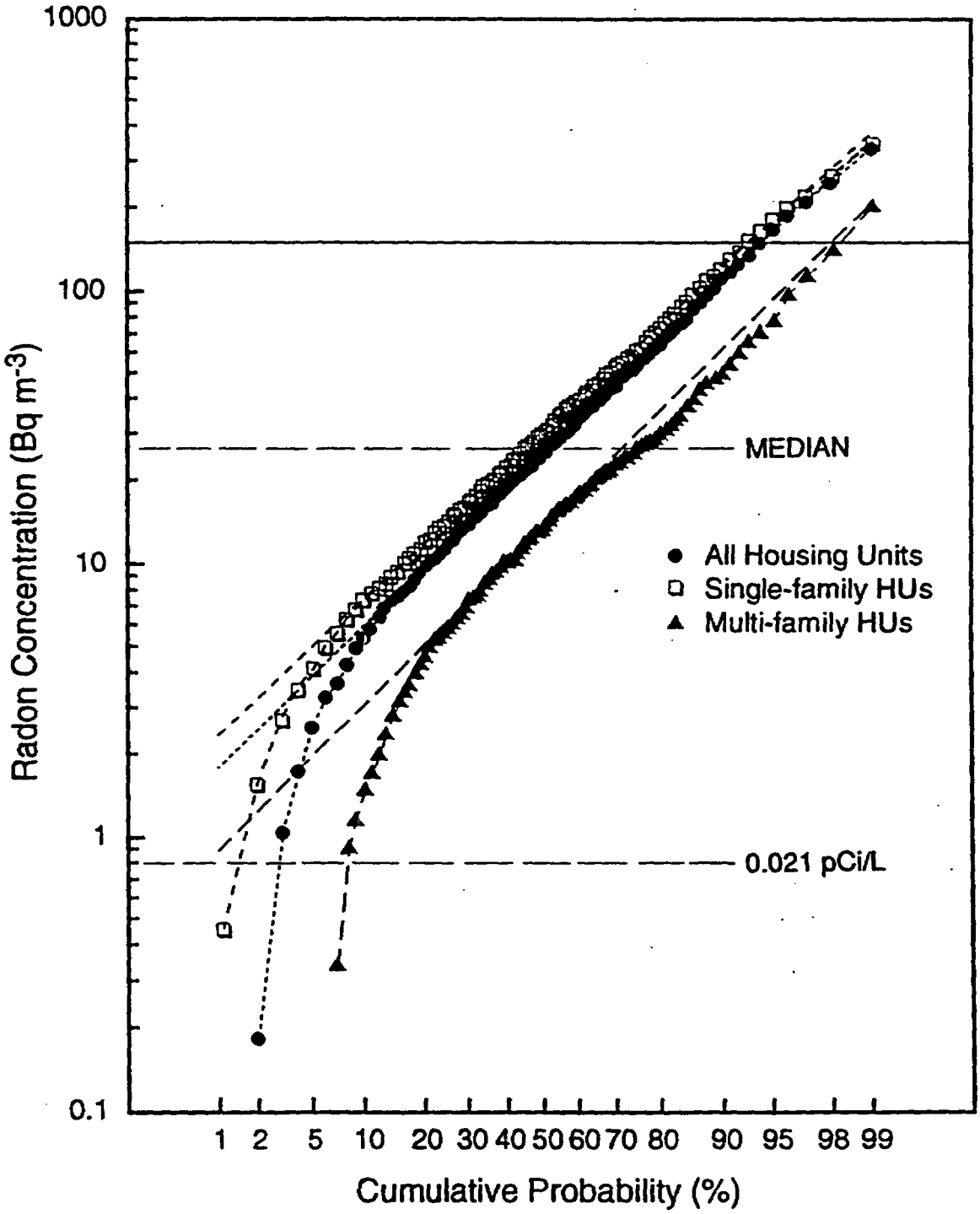
Risk Modifying Factors

PARAMETER	EPA's CALCULATION 1989	TODAY	FACTOR
RADON PROGENY EQUILIBRIUM FACTOR	0.5	0.4	0.8
EXPOSURE DURATION (years)	70	30	0.43
RADON PROGENY RISK FACTOR (per WLM)	3.6×10^{-4}	2.2×10^{-4}	0.61
		TOTAL	0.21

Highest Lifetime Risk From Radon From PG Stacks

- 9×10^{-5} - EPA 1989
- 0.21 - Correction Using Updated Factors
- 2×10^{-5} - Lifetime Risk of Fatal Cancer-Updated

Measured Average Indoor Radon Levels



Source: Marcinowski et al, 1994

Excess Relative Risk

- 0.021 pCi/L ⇨ 0.78 Bq/m^3 Highest Incremental Concentration Predicted by EPA
- 25 Bq/m^3 Measured Median Level
- Excess RR $= \dfrac{0.78}{0.78 + 25}$

  $= 3 \times 10^{-2}$

  $= 3\%$

Excess Relative Risk

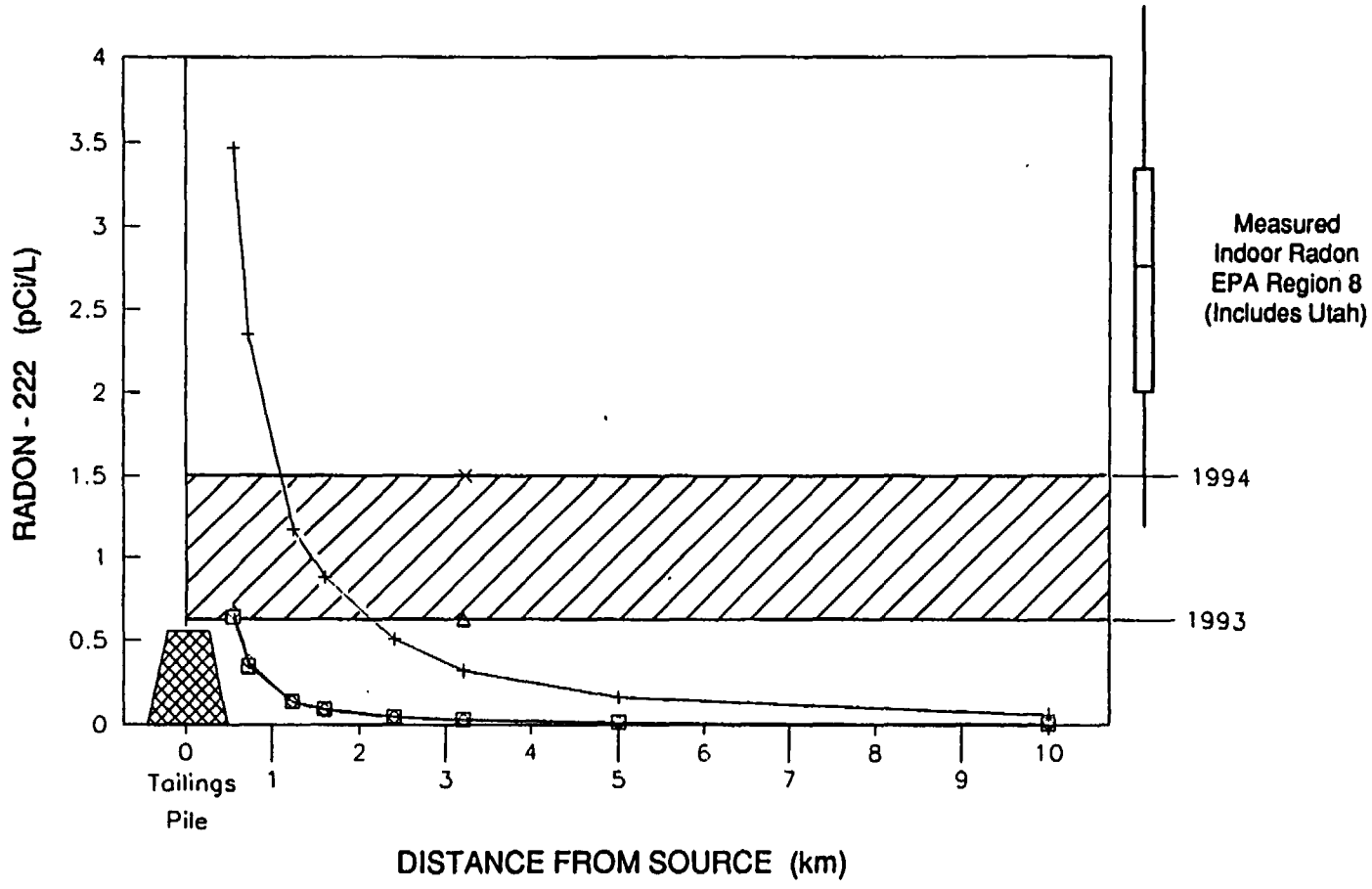
RISK INTERVAL	NUMBER OF PERSONS*	DEATHS per YEAR RADON FROM PG*	DEATHS per YEAR BACKGROUND RADON
10^{-5} to 10^{-4}	400,000	0.09	6.8
10^{-6} to 10^{-5}	17,000,000	0.50	289.
$< 10^{-6}$	77,000,000	0.30	1310.
TOTALS	95,000,000	0.9	1600.

$$\text{Excess RR} = \frac{0.9}{0.9 + 1600}$$

$$= 5.6 \times 10^{-4}$$

Source: EPA NESHAPS Bid, 1989*

Predicted Radon Concentration After Reclamation Compared to Measured Background Levels



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NCRP No. 121

" When the collective dose is smaller than the reciprocal of the relevant risk coefficient, the risk assessment should note that the most likely number of excess cancer deaths is zero."

We Need to Distinguish Scientific Estimates From Policy

Notes for Presentation

Low Dose Linearity — A Practitioner's Review of Its Science and Application

Douglas B. Chambers, Morley W. Davis and Leo M. Lowe
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Presented by D.B. Chambers to the
NRC/NMA Workshop
3 June 1997
Denver, CO

Abstract

The linear non-threshold (LNT) model has been widely used for many years for radiation protection purposes. While the assumption of linearity may be useful for such purposes, it may not always be the best model for the true relationship between dose and effect. Human epidemiology cannot demonstrate whether the risk of cancer from exposure to radiation at low doses is nil, because at such low levels the confidence interval for the risk estimates will always include the possibility that there is no risk. Low doses of radiation accumulated at low dose rates over a number of years may not induce any excess cancers at all and therefore, it can be argued that (potential) health detriments should not normally be considered below some "trivial" or "de minimis" dose. (For example, the NCRP has suggested a dose of 0.01 mSv as a de minimis dose per source or practice.) For low doses and dose rates of the same magnitude as natural background radiation, careful consideration must be given to how the LNT hypothesis is used in the calculation of collective dose and associated detriment because of the societal implications of such decisions.

This paper provides a brief overview of the recent controversy concerning the scientific validity of the LNT model for assessing cancer risk. The practical implications arising from the unqualified use of the LNT model are illustrated with the help of two examples relevant to the uranium mining industry. The first example presented is an estimation of risk from intake of radium-226 using both the LNT model and an epidemiologically based model. The second example relates to the potential risks associated with radon releases from phosphogypsum stacks.

1.0 INTRODUCTION

For the purposes of radiation protection, it is widely assumed that the probability of inducing excess genetic changes or excess cancers by exposing people to ionizing radiation is directly proportional to the total radiation dose received, even at low doses and low dose rates, and that there is no "safe" or threshold dose of radiation below which these biological effects will not be produced. This is commonly referred to as the linear non-threshold (LNT) assumption. This assumption has, for many years, been regarded as a prudent and reasonable hypothesis for radiation protection

[1,2]. However, the hypothesis is unprovable in human populations at low radiation doses due to confounding by natural incidence which is both variable and relatively large [3].

In the past few years, the LNT hypothesis has been widely debated in the scientific literature [cf bibliography]. The Health Physics Society Position Statement of March 1996 [4], in particular, opened a floodgate of discussion with its statement that:

> *"In accordance with current knowledge of radiation health risks, the Health Physics Society recommends against quantitative estimation of health risk below an individual dose of 5 rem in one year or a lifetime dose of 10 rem in addition to background radiation. Risk estimation in this dose range should be strictly qualitative accentuating a range of hypothetical health outcomes with an emphasis on the likely possibility of zero adverse health effects. The current philosophy of radiation protection is based on the assumption that any radiation dose, no matter how small, may result in human health effects, such as cancer and hereditary genetic damage. There is substantial and convincing scientific evidence for health risks at high dose. Below 10 rem (which includes occupational and environmental exposures), risks of health effects are either too small to be observed or are non-existent."*

Counter arguments have been made by authors such as Strom [11] who suggests that:

> *"I'm personally troubled by the groundswell of criticism of use of the linear, no-threshold model in radiation protection (as opposed to legitimate questions of its use in science). Those who have attended my classes on "Risk and 'Dose' in Health Physics" know that I'm among the first to cite Bond and Feinendegen and Otto Raabe and the results of the radium dial painter studies as being at odds with the LNT model. However, we as health physicists stand to do serious harm to our credibility with the public and our legislators if we persist in seeing only one side of the story on the LNT model, or if we advocate a premature departure from its application to regulation of radiation sources."*

Yet another view is put forward by Garry [13] who argues that:

> *"We are putting too much attention on the wrong issue, the validity of the linear, no-threshold theory at low doses (most of us agree it's in the range from zero to very small). Instead, in this era of "zeroing out the budget," health physicists should become more aware of the paradox risk analysts have identified, and become more concerned about reducing the cost ineffectiveness of environmental regulations."*

It should be acknowledged that much of the following discussion on radiation risk at low doses and low dose rates is adopted from a recent consensus report [3] of which one of us (Chambers) was an author.

2.0 BACKGROUND

In order to assess the literature on detrimental health effects of low doses of radiation on human populations, it is essential to have an appreciation for the normal incidence of cancers and genetic diseases in the population. In Canada, about 28% of all deaths in 1991 and 1992 were due to cancer [24, 25]. Radiation exposures from natural sources are about 2-3 mSv per year (200 - 300 mrem per year) in Canada, with about 1-2 mSv effective dose per year from inhalation of radon progeny and about 1 mSv per year from other natural sources (cosmic rays, gamma rays from the earth and natural radioactive materials in the human body).[1] Based on data given in the UNSCEAR reports of 1988 [21] and 1993 [22], the dose conversion convention given in ICRP 65 [27], and assuming an average life expectancy of 70 years and a theoretical probability of 5×10^{-5} fatal cancers per mSv (for workers, about 4×10^{-5} per mSv for non-occupational) [1], then the theoretical probability that radiation from all natural sources would induce a fatal cancer at some point during the average lifetime would be about 1.0%. This represents about 4% of the normal probability of death from cancer in Canada. Roughly two thirds of this presumed theoretical risk from radiation could be attributed to potential lung cancers from inhalation of radon progeny and the other third to induction of other types of fatal cancer. The theoretical percentages in other countries with different patterns of cancer incidence would be related but not identical to those for Canada.

Ionizing radiations are normally divided into those of high and low linear energy transfer (LET), otherwise referred to as densely and sparsely ionizing radiations, respectively. High LET radiations generally include alpha particles, neutrons, and other heavy subatomic particles, while low LET radiations include X and gamma rays (photons) and high energy electrons (beta rays) [1]. The ICRP has assigned radiation weighting factors of one to most low LET radiations and of up to twenty for high LET radiations [1].

The exact definition of low doses and low dose rates of radiation can vary appreciably depending upon the endpoints being considered. To illustrate this point, consider the original studies by Russell and co-workers at the Oak Ridge Laboratories which showed a decrease in mutation frequency in mouse spermatogonia as the dose rate of low LET radiation was lowered from 900 mSv/min through 90 mSv/min to 8 mSv/min but no further reduction in mutation frequency with further reduction in dose rate down to 0.006 mSv/min [18, p. 107]. In this particular case, therefore up to 8 mSv per minute of low LET radiation could be considered as low dose rate.

After consideration of linear-quadratic models for dose response relationships, the 1986 and 1988 UNSCEAR reports [20, 21] adopted the convention that the term low doses could be considered as less than 200 mSv regardless of dose rate, and that low dose rates for all radiations could be considered as less than 0.05 mSv per minute regardless of total dose. The 1993 UNSCEAR report [22] considered this topic in more detail and concluded that for assessing the risks of cancer induction in humans, low doses could be considered to be less than 200 mSv, whatever the dose rate, and low dose rates could be considered to be below 0.1 mSv per minute (when averaged over about an hour) whatever the total dose. At low doses or at low dose rates, no correction in observed or calculated stochastic risks in humans is required, in contrast to the results observed at high doses at high dose rates. ICRP Publication 60 [1] used similar definitions. It should, however, be noted that continuation of a low dose rate of 0.1 mSv per minute for much more than one day would bring the accumulated total dose into a region in which non-stochastic or deterministic effects would occur [1].

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(1) A recent publication by Lowe and Chambers [26] suggests that the annual effective dose from indoor radon might be closer to 0.3 to 0.6 mSv, significantly lower than conventionally assumed.

Low dose rates could also be defined in terms of the unavoidable radiation exposures from natural sources to which all humans are exposed. As noted in the UNSCEAR 1993 report [22] in Table 28 on page 74, the average annual exposures to the whole body are roughly 1 mSv per year in areas of normal background but this is increased to over 4 mSv per year in areas of high exposures due to high concentrations of primordial radionuclides in the soil. Similarly, the average annual effective dose to the lung due to inhalation of radon and its short-lived progeny from natural sources might be taken to be about 1 mSv per year, but this can be increased to 10 mSv per year (or even more; see for example graph on p. 169 of the 1982 UNSCEAR report [67]). On the basis of unavoidable natural background radiation, one might define low dose rates as anything up to say 10 mSv per year (1,000 mrem) or 0.03 mSv (3 mrem) per day.

To extrapolate from the observed excess of cancers after exposure at high doses at high dose rate (for example, as in the Japanese bomb survivors) to those expected at low doses and low dose rate, ICRP 60 [1] has recommended a dose and dose rate effectiveness factor of two.

3.0 OVERVIEW OF SCIENCE

Induction of Genetic Changes

Permanent genetic changes in the hereditary material include deletions of part of the DNA, translocations of part of this material from one chromosome to another or to another part of the same chromosome, and inversions of portions of the hereditary code. Point mutations in the form of DNA base changes can also occur but are relatively less common after exposure to ionizing radiation than in the case of radiomimetic chemicals [22]. Deletions, translocations and inversions all result from incorrect repair of initial DNA damage.

It is generally believed that the induction of genetic disorders is a one step process. That is to say, any permanent genetic change in the hereditary material of the germ cell (sperm or ovum) which does not lead to death of the developing embryo is sufficient to produce an inherited disorder in the live-born offspring.

The available evidence on induction of genetic changes in lower organisms suggests a linear, non-threshold dose-response relationship for exposure to ionizing radiation. Notwithstanding the observation that there is no substantive evidence to suggest that DNA repair processes result in a threshold for induction of genetic changes at low radiation doses, the concept of de minimis or negligible dose should be considered. Billen [31] provides a succinct discussion of spontaneous DNA damage and the concept of negligible dose pointing out that "..it seems reasonable to suggest that there does exist a "negligible" dose in the range of our terrestrial background annual radiation dose of - 1mSv (-10 DNA events /cell/year). This can be compared to the approximately 7×10^7 DNA events/cell/year produced by spontaneous causes."

Induction of Cancer

The induction of cancer is much more complex than the induction of hereditary changes in germ cells, although both are believed to involve induction of permanent changes in the structure of the hereditary material in a living cell. Cancer development is believed to involve several different steps, of which initiation of the kind of change in the genetic material (e.g. activation of a growth-promoting gene or oncogene, inactivation of growth repressing gene or anti-oncogene in a living cell) that could lead to cancer development is only one step [20,23]. A single hit which

initiates a carcinogenic change in a cell is not sufficient to produce a cancer. A number of other steps, probably with cell division between, are required before a cancer will appear. The most recent views of the ICRP on radiation-induced cancer as a stochastic event are summarized in Section 3.4.2 and Sections B.2 and B.4 of ICRP Publication 60 [1]. These views are in general consistent with more recent detailed scientific reviews in UNSCEAR reports [22,23], although the ICRP application in practice appears to be somewhat less cautious than that suggested in the UNSCEAR reports. The concept that initiation of an oncogenic transformation in a single cell, presumably a stochastic event, is likely to result in increased cancer incidence within the lifespan of the human or other animal appears to have been raised to the level of an ICRP dogma.

Cancer risks from ionizing radiation are typically assessed assuming linearity between dose and effect. While this may be a prudent approach for radiation protection purposes, various authors have questioned the appropriateness of this assumption for risk assessment. In a recent editorial in Science [10], Abelson comments:

> *"The use of linear extrapolation from huge doses to zero implies that one molecule can cause cancer. That assertion disregards the fact of natural large-scale repair of damaged DNA."*

and goes on to suggest:

> *"The current mode of extrapolating high-dose effects is erroneous for both chemicals and radiation. Safe levels of exposure exist. The public has been needlessly frightened and deceived, and hundreds of billions of dollars wasted. A hard-headed, rapid examination of phenomena occurring at low exposures should have a high priority."*

Abelson's comment is supported by a recent review of selected epidemiological data by Muckerheide [62]. Some of these data are reviewed elsewhere in this report. There is no doubt that investigators tend to assume a linear non-threshold relationship for effects of radiation exposures, even when the data do not warrant this assumption. However, it is difficult to disprove this hypothesis.

In as far as the possibility of a threshold in the dose-response relationship for radiation-induced cancer is concerned, some paragraphs from ICRP Publication 60 [1] might be cited. Paragraph 68 indicates:

> *"If, as seems likely, some types of cancer can result from the damage originating in a single cell, there can be a real threshold in the dose-response relationship for those types of cancer only if the defence mechanisms are totally successful at small doses. The balance of damage and repair in the cell and the existence of subsequent defence mechanisms can influence the shape of the relationship, but they cannot be expected to result in a real threshold."*

Paragraph 73 indicates:

> *"In short, for low LET radiations, the most characteristic form of the relationship between the equivalent dose in an organ and the probability of a resultant cancer is that of an initial proportional response at low values of equivalent dose, followed by a steeper rate of increase (slope) that can be represented by a quadratic term, followed finally by a decreasing slope due to cell killing. There are no adequate grounds for assuming a real threshold in the relationship. This*

form of response, while typical, is not necessarily the definitive form for all human cancers. Taken together with the linear approximation for increments over the dose due to natural background, it provides a suitable basis for the Commission's use of a simple proportional relationship at all levels of equivalent dose and effective dose below the dose limits recommended in this report."

The doses in question would, of course, be anything between zero and the ICRP recommended limits of an average effective dose of 20 mSv per year or an effective dose of 50 mSv in any given year.

Paragraph B61 in ICRP Publication 60 [1] might also be noted:

"Theoretical considerations and most of the available experimental and epidemiological data do not support the idea of a threshold for the carcinogenic response to low LET radiation. Nevertheless, on statistical grounds a threshold for individual tumour types cannot be ruled out with certainty in either human or experimental systems. However, if thresholds do exist their values must be less than about 0.2 Gy for most human cancers and perhaps much less."

The possibility of a threshold in the dose-response relationship for radiation-induced cancer is thus not entirely excluded by the ICRP but, more simply, is considered to be highly unlikely. The ICRP hypothesis is related to but more definite than the conclusion in the 1986 UNSCEAR report [20, p. 242]:

"However, in spite of these exceptions, absence of a threshold dose for the development of cancer is assumed by UNSCEAR as a working hypothesis for the time being."

NCRP Report 64 [40] is similarly cautious about regarding the linear dose-response model for radiation-induced cancer as a scientific fact rather than as a useful working hypothesis.

There are two related considerations in reports of other scientific committees which were not discussed in detail in ICRP Publication 60 [1]. The first is the possibility that the induction of certain types of cancer may require two successive radiation-induced events affecting the same cell. This theory was developed by Marshall and Groer as reported by UNSCEAR [20] to explain the poor fit of the linear dose-response model to human epidemiological data on incidence of bone cancer following ingestion of radium-226. With any two hit model of this kind, the second hit required to initiate cancer development may not occur early enough to produce a cancer within the normal life-span of the human being when the average accumulated doses are very low. There is no proof that this theoretical model is correct, but a similar two-step model has been developed to explain experimental data on induction of lung cancer by inhaled radon progeny in rats [41].

The second consideration also depends on the influence of normal life expectancy but is based on the pragmatic observation that the latent period to appearance of bone cancer in dogs, mice and humans increases as the dose rate of radiation from radium-226 decreases. A similar dependence of latent period on dose was observed for induction of lung cancer by plutonium in dogs, of bone cancers by strontium in dogs and mice, of liver tumours by plutonium in hamsters, of liver and spleen tumours by thorotrast in rats, of lung tumours by radon in rats, and of myeloid leukemia and thymic lymphoma by x-rays in mice [20]. The same effect, observed in humans who had ingested radium-226, lead to introduction of the term "practical threshold' by Evans [45-47]. The practical threshold would be the accumulated lifetime dose at which the time to appearance of any radiation-induced cancer exceeds the normal

hr life span [18]. Below this dose level, the chance of developing a radiation-induced cancer would be very sı r zero as the word threshold implies. The BEIR IV report [18] preferred to include the possibility that there could by chance be a small probability of a radiation-induced cancer even below this practical threshold, so that one should speak more properly of a quasi-threshold. The data on radium-226 and bone cancer in humans were interpreted by the BEIR IV committee to indicate that:

> *"The time to tumor appearance apparently increases with decreasing dose and dose rate. Below an average skeletal dose of about 0.8 Gy [16 Sv], the chance of developing bone cancer from ^{226}Ra and ^{228}Ra during a normal lifetime is extremely small - possibly zero."*

It is of interest to note that the average latent period to appearance of bone cancer in dogs also increases with decreasing doses of strontium-90, but the increase is appreciably smaller with the low LET radiation from strontium-90 than it is with the high LET radiation from radium-226.

The theoretical implications of this observation were explored in more detail by Mayneord and Clarke [48,49]. Their model assumed a strictly stochastic or linear non-threshold dose response relationship for the probability of malignant cell transformation after exposure to ionizing radiation. However, because much experimental evidence from both chemically and radiation induced tumours in experimental animals pointed to an increase in latent period with decreasing dose rate, this particular feature was also incorporated into Mayneord's model. In general:

> *"The theoretical analysis by Mayneord and Clarke (1975) does not support an overall linear [non-threshold] relationship between dose and cumulative tumor rate over finite time intervals in populations having a standard age distribution."* [20]

The concept of a practical threshold or quasi-threshold for induction of cancer by exposure to radiation at low dose rates over a major portion of the normal life span is not discussed in ICRP Publication 60 [1], even in the case of radium-226. Another recent review of the linear non-threshold hypothesis for radiation-induced cancer by Cox [50] also failed to consider the radium-226 data or the concept of a practical threshold.

In consideration of models for the dose-response relationship for radiation-induced cancer in humans, it is useful to include a summary of the lowest doses at which a statistically-significant increase in cancers in various epidemiological studies could be observed[3]:

Childhood leukemia and other cancers after X-irradiation of the fetus.	10-20 mSv
Thyroid cancers after X-irradiation of the thyroid gland in children.	60 mSv
Leukemia and other cancers after irradiation of the whole population of the Japanese bomb survivors.	200 mSv
B cancer in adults after ingestion um-226	16,000 mSv (0.8 Gy) to 200,000 mSv (10 Gy)

Stimulation of Repair Processes by Radiation

Laboratory studies have demonstrated that low doses of radiation can stimulate the activity of DNA repair systems and thus reduce the damaging effects of a subsequent second dose of radiation on the hereditary material in living cells [5,23]. The influence of this phenomenon on assessment of the stochastic effects of radiation remains to be evaluated. Paragraph 46 of ICRP Publication 60 [1] has commented on these effects:

> *"In particular, radiation may be able to stimulate the repair of prior radiation damage, thus decreasing its consequences, or may be able to improve immunological surveillance, thus strengthening the body's natural defence mechanisms. Most of the experimental data on such effects, currently termed "hormesis" have been inconclusive, mainly because of statistical difficulties at low doses. Furthermore, many relate to biological endpoints other than cancer or hereditary effects. The available data on hormesis are not sufficient to take them into account in radiological protection."*

A thorough summary of the literature on adaptive response is given in Appendix B of the 1994 UNSCEAR Report [23].

Exposure to Natural Background Radiation

Because of the availability of large populations for study, epidemiological studies of cancer mortality and exposure to terrestrial and cosmic radiation are undertaken enthusiastically but involve many serious difficulties. There are uncertainties in the dose received by persons in the study due to geographic variability in the accuracy of diagnosis, and other numerous confounding environmental factors which might have a great influence on the cancer incidence.

Using risk estimates derived from high dose Japanese Life Span Studies it can be estimated that 11% of deaths from leukemia and 4% or less from other cancers might be attributed to natural background radiation, excluding radon. However, epidemiological studies in the United States, Japan, France, Sweden and China found no significant association between leukemia and background radiation [23]. Leukemia was chosen for this comparison because of its higher yield from radiation compared to other cancers. In China, annual radiation doses to the bone marrow were estimated to be 1.96 mSv in high background radiation areas compared to 0.72 mSv in the control areas, but this study provides no evidence for radiation effects following low dose protracted exposures throughout life since leukemia rates were lower in the population with higher exposure than in the control areas. However, the statistical confidence limits on these results are again so wide that they overlap the predictions made by the linear non-threshold hypothesis on the basis of extrapolation from the epidemiological followup of the Japanese bomb survivors (Table 1).

The study of thyroid modularity in women in areas of high background radiation in China provides some evidence that a protracted dose of the order of 0.1 Gy in adult life does not appreciably increase the risk of nodular thyroid disease.

Table 1
Excess Relative Risk Estimates (and 90% Confidence Intervals) For Fatal Cancers In Populations In High Background Radiation Areas In China Which Received 60 mSv Excess Dose To Bone Marrow Over A Lifetime and For The Whole Population Of Atomic Bomb Survivors Projected To A Total Dose Of 60 mSv

Study Population	All Cancers Excluding Leukemia	Leukemia
High background area in China	-0.06 (-0.16 to 0.05)	-0.08 (-0.40 to 0.39)
Bomb survivors	0.027 (0.018 to 0.036)	0.26 (0.14 to 0.33)
Bomb survivors with ICRP DDREF* of 2	0.014	0.13

Note:

* DDREF = Dose and dose rate effectiveness factor as defined in ICRP Publication 60 [1].

Tests of the linear hypothesis at low doses of the order of natural background levels are difficult, if not impossible on simply statistical grounds. Consider for example, the work of Frigerio [15] who classified the U.S. population according to natural background radiation exposures and correlated these exposure rates with general mortality rates and cancer-specific mortality rates for various locations. Frigerio noted that:

> *"Observation of the actual population at risk shows not only no increment, but an actual decrement...".*

In discussing this type of study, it should be acknowledged that in ecological (correlational) studies of the type performed by Frigerio [15] that a correlation of rates does not ensure that the exposed people were actually those who developed the disease. In the Frigerio example, the correlation of rates may not actually apply to long-term residents of a given area. The mortality and morbidity experience that was recorded might actually reflect the health experience of recent residents. These people may have spent most of their life-time elsewhere and received very different exposures from those in the area where they died or had their disease diagnosed. Also, since the unit of measurement is the group as a whole, it is possible that exposure to other toxic substances that cause cancer may differentially affect individual members of the study population, thus confounding the risk assessment.

Further insight on the difficulties of low dose studies is provided by considering studies of risk to populations exposed to high natural background radiation such as those described in BEIR V [19, pp. 383-385] and UNSCEAR [23, Annex A, pp. 57-58].

Consider for example the Chinese study of two neighbouring regions having different levels of background radiation such that the bone marrow dose from external gamma radiation by 50 years of age would be about 2.7 times greater for a person in the high background area than in the low background area. According to UNSCEAR [23, Annex A, para. 242] doses of this magnitude would result in a relative risk for leukemia of about 1.2. UNSCEAR writes that:

> *"Relative risks of this magnitude are very difficult to detect epidemiologically, so even if observation is extended over a lifetime, it will be difficult to obtain a definitive result. Similar considerations apply to many of the smaller occupational studies, although* **some of these low-dose studies can be expected to provide an upper limit to the risk** *and therefore make a useful contribution to radiation-induced cancer risk evaluation."* (Emphasis added)

The concept of statistical power, namely the chance than an effect will be observed if there is one, is widely used in assessing the feasibility of epidemiological studies. Following the procedure of Beaumont and Breslow [16] statistical power increases with increasing relative risk and with the size of the population under study.

According to UNSCEAR [23, Annex A, para. 240] the Chinese populations are relatively stable with little in and out migration, have a high quality ascertainment of cause of death and reliable dose estimates. When the data on leukemia mortality are plotted on a power function curve using the Beaumont [16] method, it becomes evident that there is a large discrepancy between the theoretical ability to detect an effect based on standard risks coefficients and what was actually observed. **All other factors being equal (which of course may not be the actual situation in this study), the use of life span risk estimates appears to result in an overestimate of the actual risk and consequently of the chance of finding an effect. There appears to be little or no risk at exposures of the order of those from natural background radiation.**

4.0 EXAMPLES

In order to illustrate the implications of the LNT, it is useful to consider some examples that are relevant to the uranium mining sector. For present purposes, we consider the ingestion of radium-226 and the inhalation of radon-222.

EXAMPLE 1: Comments On Linear Non-Threshold Model And Results Of Radium Epidemiological Studies

Based on his analysis of the epidemiological data, Evans [47] reported that the percent tumour cumulative incidence for bone sarcomas plus head sarcomas is constant at 28% ±6% for mean skeletal doses between 1,000 and 50,000 rad. He did not fit curves to data below 1,000 rads, but all data points in this range are at zero incidence [18 p. 201]. The corresponding systemic intake (below which no bone sarcomas are reported) is 100 μCi [14 p. 80] and below which no head sarcomas are reported is >25 μCi [14 p. 87]. Evans introduced the concept of a practical threshold in which the person exposed to radium dies from other causes before any radiation-induced cancer manifests.

Rowland [14 p. 201] fitted curves to epidemiological data including those of zero sarcoma incidence and reported several curves that could be considered to have acceptable fit. According to BEIR IV [18 p. 203], Schlenker used these curves and the epidemiological data to develop uncertainty envelopes at 9%, 68% and 95% around Rowland's curves in the region of zero incidence of bone sarcoma (<100 μCi).

On Schlenker's curves, SENES superimposed the risk per year of fatal cancer that is predicted from the corresponding systemic intakes using the linear non-threshold (LNT) model. SENES assumed the following:

- absorption fraction of radium from GI tract to blood, 0.2;

- committed effective dose factor, 2.8×10^{-7} Sv Bq^{-1} (ICRP 67);
- lifetime risk of fatal cancer, 0.05 Sv^{-1} (ICRP 60) [1]; and
- period of expression of 50 years.

The risk predicted using the LNT model [62] exceeds the 95th percentile envelope calculated by Schlenker throughout the region of his predictions.

SENES compared the risk to a person consuming Ra-226 at EPA's limit on concentration in drinking water by using the LNT model and the results of the radium epidemiological studies. The risk by the LNT model was calculated using dose and risk factors reported above:

- Ra-226 concentration in water, 5 pCi/L;
- daily drinking water rate, 2 L/d; and
- duration of intake, 30 years.

The intake of Ra-226 was calculated to be 1.1×10^5 pCi (0.11 μCi), and the lifetime risk of fatal cancer was calculated to be 5.7×10^{-5}.

The lifetime risk from epidemiological data was predicted to be zero based on no bone sarcomas observed for systemic intakes of <100 μCi (10^8 pCi).

Example 2: Risks attributable to radon

In 1989, EPA published the results of an extensive analysis of the potential impacts of radon emissions from phosphogypsum (PG) stacks in the United States [82]. Based on measured radon exhalation rates from the piles, EPA modelled the atmospheric dispersion of the radon to distances of 80 km from each pile. The predicted incremental radon concentrations to which the nearest residents and the population within 80 km of each pile were exposed were calculated using local demographic data. Finally, EPA calculated maximum individual lifetime risks and population risks using parameters and models of the time.

EPA predicted the highest average incremental concentration of radon to which any resident was exposed to be 0.021 pCi/L (0.78 Bq/m^3). Assuming occupancy in the home at 75% of the year for 70 years, a radon progeny equilibrium factor of 0.5, and a risk factor of 3.6×10^{-4} per working level month, EPA predicted the highest lifetime risk of fatal cancer at 9×10^{-5}.

Since 1989, EPA has revised the accepted values of several of the parameters used in calculations of this type. EPA now considers the radon progeny risk factor to be 2.2×10^{-4}, the exposure duration at 30 years for estimating lifetime risk, and the radon progeny equilibrium factor at 0.4. Using these updated factors, the highest lifetime risk of fatal cancer to any resident attributable to radon from PG stacks becomes 2×10^{-5}.

Marcinowski et al. [83] reported on the results of a large number of indoor radon measurements that were made across the United States. The median radon concentration, 25 Bq/m^3, is approximately 30 times greater than the highest average radon concentration predicted by EPA [82], 0.78 Bq/m^3 from PG piles. Assuming that the risk is a linear function of the radon concentration to which a resident is exposed, the excess relative risk attributable to

radon from the PG stacks is 0.03 (0.78/(0.78 + 25)).

EPA [82] also calculated the incremental population risk attributable to radon from PG stacks by stratifying the 95 million residents within 80 km into risk intervals. The expected deaths per year among the subgroups in each risk interval were calculated by EPA and summed to 0.9 deaths per year. In the population of 95 million, SENES calculated the total cancer deaths per year at 1600 using US vital statistics (1.7×10^{-5} per person per year). Using these values, the excess relative population risk was calculated to be 5.6×10^{-4} (0.9 / (0.9 + 1600)).

Incremental radon concentrations in air that are attributable to other anthropogenic sources are also insignificant at distance from the source. SENES recently completed an evaluation of the potential incremental concentrations of airborne radon near a uranium tailings pile in Utah that will be remediated to comply with the regulatory limit of 20 pCi m^{-2} s^{-1}. The background outdoor radon concentrations were measured at 0.6 and 1.5 pCi/L in 1993 and 1994, respectively. EPA has reported that indoor radon concentrations in Region 8 (which includes Utah) have a mean value of approximately 2.7 pCi/L, and the 98th percentile is above 4 pCi/L. However, the incremental average radon concentration from the remediated pile was predicted to be less than the average outdoor concentration in 1993 (0.6 pCi/L) at all distances greater than 2 km from the pile.

In this case, the assumption of LNT is important as the incremental risks are very small even for the maximum exposed individual whose lifetime risk is (conservatively estimated at 3%, a population risk of the order of 1×10^{-4} to 1×10^{-3} and whose exposures to radon are small with respect to natural background variability. In such a case, it should be acknowledged that the excess risk could in fact be zero.

5.0 CONCLUSIONS

The following conclusions seem reasonable:

1) we do not know if low doses of radiation at low dose rate have any harmful effects on human health;

2) if there are harmful effects at low doses and low dose rates, they must be quite small and the opportunity to use epidemiology to investigate them is limited by practical considerations of study size and confounding, for example, by the relatively large and variable contribution of natural background radiation;

3) for radiation induced cancer, there is some evidence against the LNT hypothesis such as the evidence of the radium dial painters;

4) the LNT hypothesis has been useful for regulating exposures to ionizing radiation; however, in view of the observation that the risk from low doses, delivered at low dose rates over a large portion of the human lifespan includes the possibility of no excess risk, risks ascribed to doses in the order of those from natural background should be qualified and referred to as hypothetical;

5) If the LNT hypothesis is used to calculate collective doses, then the doses should be categorized by dose level, and dose rates below about 10 microsievert per year (1 mrem/y) should be

considered as negligible even where the LNT hypothesis is assumed to be correct; and

6) following the NCRP No 121 [85], when the LNT is used to calculate a collective dose, it should be noted that "when *the collective dose is smaller than the recriprocal of the relevant risk coefficient, the risk assessment should note that the most likely number of excess cancer deaths is zero.*"

[SLIDES FOR PRESENTATION ARE ATTACHED]

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United States
Nuclear Regulatory Commission

NRC Contracting Process

Mary Lynn Scott
US Nuclear Regulatory Commission

CONTRACTING WITH THE PRIVATE SECTOR

PLANNING

- ADVANCE PROCUREMENT PLANNING
- PROGRAM OFFICES BUDGET FUNDS

PREAWARD PHASE

- DEVELOP PROJECT STATEMENT OF WORK
  - -- BACKGROUND & OBJECTIVE
  - -- WELL-DEFINED TASKS
  - -- IDENTIFICATION OF DELIVERABLES
  - -- DELIVERY SCHEDULE
  - -- PERIOD OF PERFORMANCE
  - -- MEETINGS/TRAVEL

PREAWARD PHASE

- DEVELOP INDEPENDENT GOVERNMENT COST ESTIMATE
  - -- LEVEL OF EFFORT
  - -- SKILL MIX
  - -- COSTS
    - DIRECT LABOR
    - OVERHEAD/G&A
    - TRAVEL
    - EQUIPMENT/MATERIALS

PREAWARD PHASE

- DEVELOP TECHNICAL EVALUATION CRITERIA
  - -- STANDARD AGAINST WHICH PROPOSALS ARE EVALUATED
  - -- WEIGHTED TO INDICATE RELATIVE IMPORTANCE
  - -- APPLY SPECIFICALLY TO ACQUISITION
  - -- EXAMPLES
    - ORGANIZATIONAL EXPERIENCE AND PAST PERFORMANCE
    - TECHNICAL QUALIFICATIONS AND AVAILABILITY OF PERSONNEL

PREAWARD PHASE

- REQUEST FOR PROCUREMENT ACTION (RFPA)
- ISSUE SOLICITATION DOCUMENT
  - -- STATEMENT OF WORK
  - -- EVALUATION CRITERIA
    - CAN BE LIMITED TO PAST PERFORMANCE AND QUALIFICATIONS OF KEY PERSONNEL
  - -- INSTRUCTIONS TO OFFERORS IN PREPARATION OF TECHNICAL AND COST PROPOSAL
    - MAY REQUEST ORAL TECHNICAL PRESENTATIONS IN LIEU OF A WRITTEN TECHNICAL PROPOSAL
  - -- DUE DATE FOR PROPOSAL RECEIPT

PREAWARD PHASE

- EVALUATION OF OFFEROR PROPOSALS
  - -- AGAINST CRITERIA STATED IN SOLICITATION
  - -- IMPARTIAL EVALUATION OF SOURCE EVALUATION PANEL MEMBERS
  - -- COMPETITIVE RANGE
- FEDERAL ACQUISITION REGULATION PART 15, "CONTRACTING BY NEGOTIATION"
  - -- BEING REWRITTEN TO STREAMLINE EVALUATION PROCESS
    - DOWNSELECT - REQUEST FULL PROPOSALS ONLY FROM THOSE MAKING "FIRST CUT" BASED ON LIMITED INFORMATION DESCRIBED IN SOLICITATION

PREAWARD PHASE

- NEGOTIATION OF CONTRACT TERMS AND CONDITIONS
  - -- DISCUSSION OF OFFEROR WEAKNESSES, DEFICIENCIES AND OMISSIONS
  - -- MEETING OF THE MINDS
  - -- BEST AND FINAL OFFER

THE ACQUISITION TEAM

- CONTRACTING OFFICER
- PROJECT MANAGER
- DESIGNATING OFFICIAL

CONTRACT ADMINISTRATION PHASE

-- MONITOR CONTRACTOR PROGRESS

-- REVIEW PROGRESS REPORTS

-- PROVIDE FEEDBACK ON DRAFT REPORTS

-- REVIEW VOUCHERS FOR PAYMENT

CONTRACT ADMINISTRATION PHASE

PERFORMANCE PROBLEMS

- -- TECHNICAL PROGRESS/COST DISPARITIES
- -- UNSATISFACTORY DELIVERABLES
- -- SCHEDULE SLIPPAGE
- -- FAILURE TO PROVIDE 75% COST COMPLETE NOTICE
- -- UNSATISFACTORY SUBCONTRACTOR PERFORMANCE
- -- COST OVERRUNS

CONTRACT ADMINISTRATION PHASE

- REMEDIES
  - -- STOP WORK ORDER
  - -- TECHNICAL DIRECTION
  - -- FREQUENT COMMUNICATION WITH CONTRACTOR
  - -- MODIFY TASKS
  - -- TERMINATION

CONTRACT ADMINISTRATION PHASE

FINAL EVALUATION OF PERFORMANCE

- QUALITY OF DELIVERED PRODUCT OR SERVICE
- COMPLIED WITH CONTRACT TERMS AND CONDITIONS
- MET SCHEDULES
- COST CONTROL
- PERFORMANCE OF PERSONNEL
- BUSINESS RELATIONS
- CUSTOMER SATISFACTION (END USERS)
- INFORMATION KEPT FOR FUTURE PROCUREMENTS AS "PAST PERFORMANCE"

  -- CONTRACTORS GIVEN CHANCE TO COMMENT

SIMPLIFIED QUISITIONS

PURPOSE

- REDUCE ADMINISTRATIVE COSTS
- PROVIDE GREATER OPPORTUNITIES FOR SMALL BUSINESS
- AVOID UNNECESSARY BURDEN
- UP TO $100,000 AND $5,000,000 FOR COMMERCIAL ITEMS
- MICRO PURCHASES
- SYNOPSIS
- FACNET
- GSA ADVANTAGE! & BANKCARDS

PLACING/MONITORING DOE WORK

NRC MANAGEMENT DIRECTIVE 11.7

- NRC/DOE AGREEMENTS
- DOE LABORATORIES
- GOVERNMENT OWNED CONTRACTOR OPERATED
- UNIQUE SOURCE

DOE SOURCE SELECTION JUSTIFICATION

- BASIS FOR SELECTION MADE BY NRC PROGRAM OFFICE
- PROJECT MANAGER
- RECOMMENDED-ASSOCIATE COMPETITION ADVOCATE
- APPROVAL - OFFICE DIRECTOR OR DESIGNEE
- COMPETITION IN CONTRACTING ACT

- THE PRIMARY TOOL TO BE USED BY THE PM TO ENSURE SUCCESSFUL PROJECT MONITORING IS THE MONTHLY LETTER STATUS REPORT (MLSR). THE MLSR DISCUSSES:

  -- TECHNICAL PROGRESS

  -- PROBLEM AREAS

  -- PLANS FOR NEXT REPORTING PERIOD

  -- FINANCIAL STATUS OF PROJECT

United States
Nuclear Regulatory Commission

Strategic Issues

Anthony Thompson
National Mining Association

REGULATORY ISSUES AFFECTING URANIUM RECOVERY FACILITIES

NRC's Strategic Assessment Rebaselining Initiative (SARI)

- Provoked NMA to consider request for strategic assessment of issues impacting uranium recovery licensees
- Over time NRC has addressed a variety of issues that affect uranium recovery licensees on an ad hoc basis as they arise, rather than as part of a coherent, strategic assessment
- Result is inconsistent and confusing regulatory applications that have both short and long term implications for licensees, NRC, DOE and Agreement States

URANIUM RECOVERY ISSUES IN NEED OF STRATEGIC ASSESSMENT

- ISL JURISDICTION
- EFFLUENT DISPOSAL GUIDANCE
- NON 11(e)2 DISPOSAL POLICY
- CONCURRENT JURISDICTION

ISL JURISDICTION

- NRC'S ASSERTION OF JURISDICTION OVER ISL WELLFIELDS HAS LED TO DUPLICATIVE REGULATORY OVERSIGHT BETWEEN AND AMONG NRC, EPA AND NON-AGREEMENT STATES

- URANIUM BEING REMOVED FROM THE WELLFIELD IS NOT LICENSABLE SOURCE MATERIAL UNTIL IT REACHES THE ION EXCHANGE TANK AND YET THE ORE BODY IS NOT 11E.(2) BYPRODUCT MATERIAL

STAFF GUIDANCE ON EFFLUENT DISPOSAL

- TREATS PROCESS WASTES AS 11.E(2) BYPRODUCT MATERIAL, BUT TREATS RESTORATION WASTES AS NON-11E.(2) MINE WASTES
- THE SURFACE WASTES GENERATED BY PROCESSING THE ORE BODY FOR ITS SOURCE MATERIAL CONTENT ARE 11.E(2) BYPRODUCT MATERIAL, BUT CONTAMINATION IN THE ORE BODY IS NOT

EFFLUENT GUIDANCE CON'T

- RESTORING THE ORE BODY ARE NOT 11.E(2) BYPRODUCT MATERIAL BECAUSE THE ORE BODY IS NOT BEING PROCESSED FOR ITS SOURCE MATERIAL CONTENT
- RADIUM/BARIUM SLUDGES IN THESE PONDS ARE A MIXTURE OF 11.E(2) AND NON-11.E(2) BYPRODUCT MATERIAL (I.E., NORM)
- THE LATTER IS NOT SUBJECT TO NRC JURISDICTION UNDER THE AEA/UMTRA

NON-11E(2) DISPOSAL POLICY

- ISL 11E.(2) WASTES ARE DISPOSED OF IN URANIUM MILL TAILINGS IMPOUNDMENTS

- NON 11E.(2) WASTES ARE NOT TO BE DISPOSED OF IN SUCH FACILITIES PURSUANT TO THE "FINAL REVISED GUIDANCE ON DISPOSAL OF NON-ATOMIC ENERGY ACT OF 1954, SECTION 11E.(2) BYPRODUCT MATERIAL IN TAILINGS IMPOUNDMENTS"

NON-11E(2) DISPOSAL POLICY CON'T

- NUMEROUS TITLE II URANIUM MILL TAILINGS IMPOUNDMENTS HAVE TAKEN SLUDGES FROM ISL FACILITIES WHICH INCLUDE NON-11.E(2) MATERIALS IN VIOLATION OF THE POLICY

CONCURRENT JURISDICTION

- NRC LEGAL GUIDANCE SUGGESTS THAT NON-AGREEMENT STATES HAVE CONCURRENT JURISDICTION WITH NRC OVER THE NON-RADIOLOGICAL COMPONENTS OF 11E.(2) BYPRODUCT MATERIAL

- NON-AGREEMENT STATES HAVE INSERTED THEMSELVES INTO THE GROUNDWATER CORRECTIVE ACTION PROCESS AT TITLE II URANIUM FACILITIES

CONCURRENT JURISDICTION CON'T

- ADDITIONALLY, STATES HAVE INSERTED THEMSELVES INTO THE REVIEW AND APPROVAL OF SURFACE STABILIZATION PLANS

- RESULT IS REMINISCENT OF THE MIXED WASTE DILEMMA

CONCURRENT JURISDICTION CON'T

- RAISES QUESTIONS ABOUT THE VALIDITY AND VIABILITY OF THE AGREEMENT STATE PROGRAM
- RAISES QUESTIONS ABOUT THE LONG TERM INTEGRITY OF NRC LICENSE TERMINATION DECISIONS UNDER UMTRCA
- INCREASES DIFFICULTY AND COST OF DISPOSING OF WASTES GENERATED EITHER BY CONVENTIONAL OR ISL ACTIVITIES

United States
Nuclear Regulatory Commission

NRC Response

Joseph J. Holonich
US Nuclear Regulatory Commission

United States
Nuclear Regulatory Commission

U.S. Nuclear Regulatory Commission Response to National Mining Association Strategic Issues

Joseph J. Holonich, Chief
Uranium Recovery Branch
U.S. Nuclear Regulatory Commission

June 1997

Background

- Concerns about consistency among different policies
- Issues discussed with National Mining Association (NMA)
- Identification of concerns
  - Bimonthly meetings
  - Nuclear Energy Institute Fuel Cycle 97
  - May 1997 Commission Briefing
  - June 1997 workshop
- U.S. Nuclear Regulatory Commission (NRC) needs to provide its perspective on the concerns

Summary of All NMA Concerns

- **Jurisdiction over in situ leach (ISL) wellfields**
  - **Definition of 11e.(2) byproduct material**
  - **Waste created by restoring ore body**

- **Disposal of radium/barium sludge in tailings ponds**
  - **Definition of mine water in effluent guidance document**
  - **Implementation of non 11e.(2) guidance**

- **Concurrent jurisdiction**
  - **State authority over nonradiological constituents**
  - **Concern with state authority in non 11e.(2) disposal guidance**

Jurisdiction Over ISL Wellfields

- **Three major concerns**
  - **Ore has not been removed from its place in nature**
  - **Quantities below 0.05%**
  - **Ore body not defined as 11e.(2) byproduct material**

- **NRC regulatory authority over in situs well documented**
  - **Long-exercised licensing jurisdiction under the Atomic Energy Act (AEA)**
  - **Responsibility for byproduct material**
  - **Potential contamination of groundwater clearly within NRC scope under AEA**
  - **Regulatory authority over surface material sound legal basis for groundwater regulation**

- **AEA legislative authority clearly established**
  - **Clear legislative record on regulation of all aspects of in situs**
  - **Wallop/Hart discussion indicates in situs within NRC jurisdiction**
  - **House committee report that similar controls as EPA be imposed**

- **National Environmental Policy Act**
  - **Authorizes the Commission to exercise power it unquestionably has**
  - **Minimize to extent practical adverse impacts**
  - **Judicial decisions that NRC obliged to minimize adverse impacts**

- **Generation of 11e.(2) byproduct material**
  - **All material is 11e.(2) including ore body**
  - **Commission exercised discretion of not requiring transfer**
  - **In situ licensees should consider long-term care payment of $560,000**

Disposal of Pond Sludge

- **Definition of mine water**
  - **Genesis in industry review of effluent discharge guidance**
  - **Concern that application of 40 CFR 440 not allowed**
  - **NMA wanted differentiation between process and mine water**

- **NRC prepared final guidance to address NMA concern**
  - **Agreed to view wellfield sweep water as mine water**
  - **Provided relief to licensees from 10 CFR Part 20 effluent limits**

- **NMA review of final effluent guidance document raised second concern**

- **NMA position is that sludge are legally different**
  - **Chemical, physical, and radiological characteristics the same**
  - **Sludge from process water 11e.(2) byproduct material**
  - **Sludge from mine water is not 11e.(2) byproduct material**

- **NRC position**
  - **Pond must have predominantly process water**
  - **NRC will view all sludge as 11e.(2) byproduct material in these ponds**
  - **Makes no sense to view sludge from same pond differently**
  - **NRC will not require mills to have special amendments to take this sludge**

- **Resolution is in industry hands**
  - **One site has separate ponds for process and mine water**
  - **Implement NRC common sense approach for disposal of sludge**

Shared Regulation with States

- **Derived from two different legislative bases**
  - **Implementation of Uranium Mill Tailings Radiation Control Act (UMTRCA)**
  - **Atomic Energy Act (AEA) preemption only for radiation safety issue**

- **Interpretation of UMTRCA**
  - **NRC policy since 1980**
  - **Deals only with nonradiological constituents**
  - **Close call on concurrent jurisdiction**
  - **More prudent approach was concurrent jurisdiction**

- **Guidance for disposal of material other than 11e.(2) byproduct material**
  - **Developed to identify acceptable approach for mill licensees**
  - **Concern about radioactive material not covered by AEA**
  - **Radioactive material not covered by AEA subject to state regulation**

- **Clear difference between two policies**

UMTRCA Concurrent Jurisdiction

- **Deals with nonradiological matters**
  - **UMTRCA assigned NRC both radiological and nonradiological responsibility**
  - **Analysis of law found States also had jurisdiction of nonradiological**

- **Disposal of radioactive material not covered by AEA**
  - **Issue of concern in staff guidance**
  - **NRC does not want States setting other standards for radioactive material**

- **Clear difference in two policies**
  - **One deals with nonradiological**
  - **Rare NRC responsibility, but routine State responsibility**
  - **One deals with standards for radioactive material**
  - **NRC wants to avoid dual standards for regulating radioactive material**

- **There is no conflict between the two policies**

Summary

- The NRC policies do not conflict with one another
- Each policy developed for a specific reason
- Policies are essential pieces to a complete regulatory program
- The policies complement each other
- Industry holds key to flexibility desired
  - Can continue to believe there is a conflict
  - Industry interpretations will impact operational flexibility of sites
  - No need for any changes on NRC's part
  - NRC cannot save operators from themselves
- Overall, NRC has a sound regulatory program that is in harmony

- **Continued discussion on topics**
  - **Take management and staff time**
  - **Delay casework (licensing)**
  - **No real problems identified**

United States
Nuclear Regulatory Commission

NRC Operations Center

Melanie A. Galloway
US Nuclear Regulatory Commission

PERSPECTIVE FROM THE NRC OPERATIONS CENTER

June 3, 1997

Melanie A. Galloway
Senior Emergency Response Coordinator

NRC OPERATIONS CENTER
ROCKVILLE, MARYLAND

- Notification must be by phone
  (301) 816-5100

  Backups: (301) 951-0550
  (301) 415-0550

- Supplemental information may be faxed
  (301) 816-5151

The NRC Uranium Recovery Field Office (URFO) officially closed on August 1, 1994. All event notifications previously made to URFO will be directed to the NRC's 24 hour-per-day Operations Center in Two White Flint.

1. COMPLETE the Fuel Cycle and Materials Event Notification Worksheet (NRC Form 361A) including:

   a. Licensee, location, and facility.
   b. License number.
   c. Time and date of discovery/determination.
   d. For in-situ leach mine operations or uranium mills:
      (1) Spills or radiological releases
         - Type of material involved
         - Location of the spill within the process/facility.
         - Did the spill reach a drainage area? river? stream?
         - Did the spill move offsite?
         - Does the spill involve recovery solution known as "pregnant lixiviant"? OR mining solution known as "barren lixiviant"?
         - Quantity of material spilled and content of U_3O_8 or other hazardous substances such as selenium and radium.
         - Status of spill (i.e., Has the spill been stopped and/or contained?)
      (2) Monitor well(s) placed in "excursion status"[1]
         - Well identification no.
         - Which parameters monitored (i.e., chlorides, bicarbonates or conductivity) placed well in excursion status [typically 2 out of 3]?
      (3) Action and assessment
         - Proximity to and likely impact on people, livestock, wildlife, etc.
         - What is the licensee's assessment of risk?
         - What action has been taken or is planned to address the situation?

2. NOTIFY a uranium mining expert to ask them to assess the event.[2] (LIST 32) Ask if the event does or could potentially have adverse impact on persons or the environment.

If there is an **adverse impact** or the potential for such, then

- Establish a BRIDGE between the uranium mining expert,
  the R4DO, (LIST 24)
  the NMSS EO, and (LIST 24)
  the IRD Manager to assess agency response. (LIST 14)

- Ask the mining expert to convey the details of the adverse impact and to be available for subsequent questions from other Federal agencies.

If there is **no adverse impact**, then

- NOTIFY the R4DO/Region 4 (LIST 24)
  Inform the R4DO that the event has been assessed, no adverse impact is anticipated, and **no response is required**. Remind the Region to so inform the affected State(s). The call may be delayed until the next business day, as necessary.

3. NOTIFY the following for all spills or radiological releases[1]. Indicate whether the NRC assessment has concluded that there is an **adverse impact** or **no adverse impact**. If there is no adverse impact, clearly state that the event has been assessed, no adverse impact is anticipated, and **no response is required**. If the event has no adverse impact, calls may be delayed until the next business day, as necessary. Direct any questions related to the impact to the mining expert or related to NRC actions to the EO.

   a. DOE (LIST 19)
   b. EPA (LIST 19)
   c. USDA (LIST 19)
   d. HHS (LIST 19)
   e. FEMA (LIST 19)

4. ENTER the event into the computer and HOO Log.

--End--

1. Per conversations between Mike Layton (NMSS) / Tim McGinty (AEOD) on 9/13/94 and Mike Layton (NMSS) / John MacKinnon (AEOD).

NRC RESPONSE MODES

MODE	RESPONSE TEAM	LEAD POSITION
Monitoring	Base Team	Base Team Manager
Standby	Headquarters	Executive Team Member
Initial Activation	Headquarters	Executive Team Director
Expanded Activation	Site Team	Director of Site Operations (DSO)
Deactivation	Site Team	DSO

NRC Response Modes

NORMAL MODE MONITORING PHASE

Circumstances: An event which is well understood, with no likely safety consequences projected given existing conditions.

Response: Regional office (Base Team) in the lead. HQ Operations Center staffed with a cadre of technical experts.

STANDBY MODE

Circumstances: Actual or potential event with uncertain prognosis. Additional events could threaten public health and safety.

Response: HQ in the lead. HQ Operations Center near full staffing for most functional teams. Other Federal agencies notified. Augmented inspection team (AIT)/Incident Investigation Team (IIT) may be sent to site.

INITIAL ACTIVATION MODE

Circumstances: Events have occurred which will warrant an NRC presence on site in an emergency response capability.

Response: HQ in the lead while the Region sends a team to the site. HQ Operations Center is fully staffed. Other Federal agencies notified and provided with periodic status updates. Some agencies send representatives to the NRC Operations Center.

NRC Response Modes (Continued)

EXPANDED ACTIVATION MODE

Circumstances:	Events have occurred which will warrant an NRC presence in an emergency response capability.
Response:	The Site Team has arrived on Site and assumes the NRC Lead. HQ Operations Center reduced staffing to those required to provide technical and logistical support to the Site Team.

DEACTIVATION

Circumstances:	No further risk from the facility/event.
Response:	Recovery plan implemented.

NRC's PRINCIPAL RESPONSE ROLE

Monitor the event and perform an independent assessment of protective action recommendations (PARs) developed by the licensee.

EMERGENCY RESPONSE ROLES

Licensee or Certificate Holder* -

- Mitigate the Accident and its Consequences
- Make Protective Action Recommendations (PARs) to State/Local Authorities for Public Safety

State/Local Authorities -

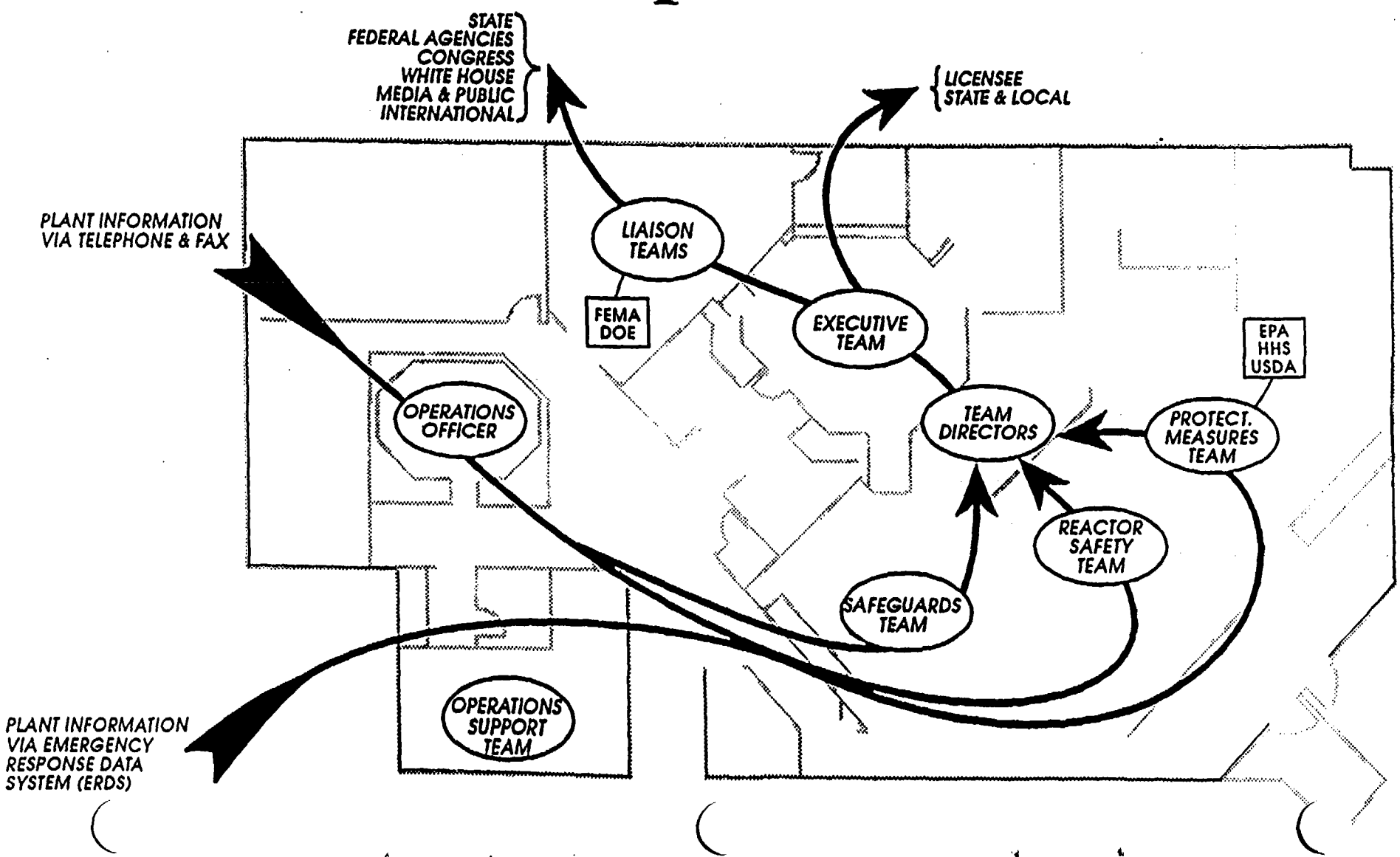
- Evaluate the Licensee's PARs
- Implement Protective Actions to Protect the Public

Members of Public -

- Take Action to Minimize Exposure/Health Effects

*The term "licensee" will be used herein to refer to both.

Principal Information Flow Within the Operations Center



NRC RESPONSE 1988 - 1997

NRC RESPONSE MODE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997 to date
Monitoring Phase of Normal	2/0	6/0	7/0	12/2	9/2	7/1	3/2	2/0	6/1	2/0
Standby	0	0	0	1/1	1/0	2/0	0	0	0	0
Initial Activation	0	0	0	0	0	0	0	0	0	0

a/b: a = total number
b = materials events

FEDERAL RADIOLOGICAL EMERGENCY RESPONSE PLAN (FRERP)

- Describes Federal coordination for any peacetime radiological emergency
- Concept of Lead Federal Agency

NRC IS THE LEAD FEDERAL AGENCY (LFA)

- Nuclear Facilities Licensed by NRC or an Agreement State
- Shipment of Radioactive Material Licensed by the NRC or an Agreement State

LFA RESPONSIBILITIES

- Assist State and Local Authorities
- Facilitation and Coordination of Technical Information
- Convene EPA, HHS, USDA (The Advisory Team for Environment, Food and Health)
- Review all Recommendations to Ensure Consistency

United States
Nuclear Regulatory Commission

Research Activities

William H. Ford
US Nuclear Regulatory Commission

RESEARCH ON METHODOLOGY TO PREDICT *IN SITU* MINE RESTORATION PORE VOLUMES

PRESENTED BY

WILLIAM FORD

Hydrologist
U.S. Nuclear Regulatory Commission

NEED FOR RESEARCH

- The NRC requires licensees to bond for the cost of ground-water restoration at uranium *in situ* mines.

- The major cost of ground-water restoration activities is related to the volume of water (usually expressed as pore volumes) pumped from or recirculated through the mine zone (aquifer).

- At this time, a proven methodology to calculate this volume is not available to the NRC or to other state and federal agencies. As a result, there is considerable debate over appropriate ground-water restoration the bonding amounts associated with *in situ* mining.

- A methodology is needed to calculate ground-water restoration surety requirements.

RESEARCH OBJECTIVES

- Develop a methodology to calculate the appropriate pore volumes necessary for ground-water restoration.

- Develop a methodology to estimate the level of surety required to restore the ground-water quality at uranium *in situ* mines.

RESEARCH APPROACH

- Conduct research using staff from the NRC Office of Nuclear Regulatory Research.

- Review approaches presently being used or that have been used to estimate the appropriate pore volumes necessary for ground-water restoration. Gather information from:

    1. Licensees,
    2. NRC files,
    3. Agreement States (Texas),
    4. Nonagreement States (i.e., Wyoming, New Mexico, Nebraska),
    5. Literature and relevant technical experts.

- Develop methodology to calculate pore volumes necessary for ground-water restoration. Test methodology against data bases for a range of water qualities.

- Develop a methodology to evaluate the level of surety required to restore the ground-water quality at uranium *in situ* min.

RESEARCH PRODUCTS

- NRC technical document(s) (NUREG/CR) that describe methodologies for:

  1. Reviewing pore volume estimates.
  2. Evaluating surety requirements.

- Databases, and analyses used to test the methodology.

- Computer codes used in the methodology.

United States
Nuclear Regulatory Commission

Research Activities

Katie Sweeney
National Mining Association

United States
Nuclear Regulatory Commission

Report on Center for Nuclear Waste Regulatory Analyses

Patrick C. Mackin
Center for Nuclear Waste Regulatory Analyses

REPORT ON CNWRA PROGRESS IN URANIUM RECOVERY LICENSING ACTIVITIES

Presented to Joint NRC/NMA Workshop
June 3–5, 1997

Presented by
Pat Mackin
CNWRA Uranium Recovery Project Manager

CNWRA TASKING FOR NRC
URANIUM RECOVERY LICENSING SUPPORT

- Fee-Recoverable

  - License Renewals
  - Reclamation Plans
  - Alternate Concentration Limit Applications
  - Groundwater Corrective Action Plans
  - License Amendments
  - Inspections
  - Other

- Non-Fee-Recoverable

  - *In Situ* Leach (ISL) Standard Review Plan (SRP) Development
  - Title I Groundwater, Geotechnical, Radon Barrier, and Soil Cleanup SRP Update
  - Title II Groundwater, Geotechnical, Radon Barrier, and Soil Cleanup SRP Development
  - Seismic Stability Reviews

STATUS OF FEE-RECOVERABLE LICENSING ACTIVITIES

LICENSE RENEWALS:

- COGEMA Mining, Inc.
  - Acceptance Review
  - Detailed Technical Review
  - Technical Evaluation Report for Performance-Based License Condition to Open New Wellfields
- Crow Butte Resources, Inc.
  - Acceptance Review
  - Detailed Technical Review
- North Butte Resources, Inc.
  - Pending Submission of Renewal Application

STATUS OF FEE RECOVERABLE LICENSING ACTIVITIES (cont'd)

RECLAMATION PLANS:

- Pathfinder Mines Corporation, Shirley Basin
  - Detailed Technical Review
  - Supplemental Request for Additional Information
- Plateau Resources Limited, Shootaring Canyon
  - Acceptance Review
- Energy Fuels Nuclear, Inc., White Mesa Mill
  - Commencing Acceptance Review

STATUS OF FEE RECOVERABLE LICENSING ACTIVITIES (cont'd)

GROUNDWATER CORRECTIVE ACTION PLANS:

- Umetco Minerals Corporation, Gas Hills
  - Detailed Technical Review

LICENSE AMENDMENTS:

- Western Nuclear, Inc., Split Rock
  - Acceptance Review
  - Detailed Technical Review
  - Surety Review
- Homestake Mining Company, Grants Project
  - Review in Progress

STATUS OF FEE-RECOVERABLE LICENSING ACTIVITIES (cont'd)

INSPECTIONS:

- 10 Sites Pending

OTHER:

- Envirocare of Utah, Inc., Evaluation of Background Aquifer Aqueous Activity
  - Acceptance Review

STATUS OF NON-FEE-RECOVERABLE LICENSING ACTIVITIES

SEISMIC STABILITY REVIEWS:

- Quivira Mining Company, Ambrosia Lake
- Four Sites Pending

SRP DEVELOPMENT:

- Drafts Have Been Completed for all SRP Tasks
- ISL and Groundwater Sections of Title I and Title II SRPs will be Discussed in the Groundwater Mini-Workshop

STANDARD REVIEW PLAN DEVELOPMENT PROCESS

- Build on Existing Title I SRP
- Incorporate all Available Sources of Licensing Guidance and History
  - Regulations
  - Regulatory Guides
  - Docket Files
  - Agreement State Experience
  - Interactions with NRC/State Regulatory Staffs
  - Interaction with Industry Representatives
  - General Public Comments
  - Experience from Licensing Reviews

TITLE I SRP UPDATE
GEOTECHNICAL, RADON BARRIER DESIGN, SOIL CLEANUP

- Incorporate Lessons Learned
- Reflect Most Current Guidance
- Provide More Definitive Acceptance Criteria

TITLE II SRP DEVELOPMENT
GEOTECHNICAL, RADON BARRIER DESIGN, SOIL CLEANUP

- Use Title I SRP as a Foundation
- Incorporate Lessons Learned
- Reflect Most Current Guidance
- Prepare Review Procedures and Acceptance Criteria Based on 10 CFR Part 40, Appendix A
  - Slope Stability and Design
  - Static Analysis
  - Dynamic and Pseudostatic Analyses
  - Settlement
  - Liquefaction Potential
  - Soil Cover Engineering Parameters

TITLE II SRP
GEOTECHNICAL, RADON BARRIER DESIGN, SOIL CLEANUP

- Review Procedures and Acceptance Criteria Based on 10 CFR Part 40, Appendix A (cont'd)
  - Construction Considerations
  - Radon/Infiltration Barrier Hydraulic Conductivity
  - Radon Attenuation
    - Long-term moisture content
    - Density, specific gravity, and porosity
    - Material thickness
    - Radon diffusion coefficient
    - Radium content
    - Emanation coefficient
    - Radon attenuation model

TITLE II SRP
GEOTECHNICAL, RADON BARRIER DESIGN, SOIL CLEANUP

- Review Procedures and Acceptance Criteria Based on 10 CFR Part 40, Appendix A (cont'd)
  - Site Cleanup
    - * Site characterization
    - * Standards for cleanup
    - * Verification

SCHEDULE FOR SRP COMPLETION

• NRC Staff Review of Drafts	June 1–July 15
• Public Comment Period	July 15–September 1
• Resolution of Comments	September 1–November 15
• CNWRA Submits Final SRPs	November 15
• NRC Publishes SRPs	December 31

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Other Federal Agencies Impact on Final Environmental Impact Statement

Joseph J. Holonich
US Nuclear Regulatory Commission

Other Federal Agencies impact on Final Environmental Impact Statement

- NRC sends draft EIS to all interested parties and invite comments
- Cooperating Agencies
  - Defined as any Federal agency other than the lead agency which has jurisdiction by law or special expertise with respect to any environmental impact.
  - Any other Federal agency with an interest can opt to be involved in the FIES; BLM, BIA, National Park Service

- **NRC and Cooperating Agencies**
  - **Share drafts of EIS**
  - **Consult/Interact in preparation of EIS**
- **Cooperating agency responsibilities**
  - **Participate in NEPA process**
  - **Participate in Scoping process (identify significant issues)**
  - **Develop information if needed**
  - **Provide staff support when needed**
- **Cooperating agency does not necessarily echo the views of the NRC**

- **EPA plays a special role in EIS identified in NEPA**
  - **NRC sends draft EIS to EPA**
  - **EPA rates environmental impact of action and adequacy of impact statement**

- **Endangered Species Act (1973)**
  - **Requires consultation with the Fish and Wildlife Service**
  - **Must note any threatened or endangered species in area of proposed action and evaluate impact of action to the species.**
  - **If any threatened or endangered species is present, potential for adverse impact on the species' habitat must be evaluated**

- ***Endangered Species Act (1973) - continued***

  - **NRC must prepare Biological Assessment**

  - **Fish and Wildlife Service must prepare a Biological Opinion**

  - **If there is a threatened or endangered species in the area, Fish and Wildlife Service and the licensee look at mitigatation**

- **EIS also points out other permits licensee must obtain from other agencies (e.g., State, Local) , but NRC has no regulatory role in those permits**

- **Environmental Assessments**
  - **provide sufficient evidence and analysis for determining whether to prepare an EIS or FONSI**
  - **compliant with NEPA when no EIS is needed**
  - **aids in preparing EIS when necessary**
  - **contains discussion of environmental impacts of proposed action and alternatives**
  - **contains listing of agencies and individuals consulted on relevant environmental issues**

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Uranium Recovery Inspection Program

Charles L. Cain
US Nuclear Regulatory Commission

URANIUM RECOVERY

INSPECTION PROGRAM

INSPECTION FREQUENCIES

- Twice per year for operating facilities
- Once per year for others, unless special inspections are required

INSPECTION TECHNIQUES

- Inspections Conducted in Accordance with NRC INSPECTION MANUAL CHAPTERS
  - Two are being prepared -
    - for conventional milling facilities
    - for ISL facilities
  - MANUAL CHAPTERS reference INSPECTION PROCEDURES

INSPECTION TECHNIQUES

- Some performance topics may be reviewed with "VERTICAL SLICE" technique

  Particularly applied for major topics such as "Radiation Protection" and "Environmental Monitoring"

United States
Nuclear Regulatory Commission

General Uranium Recovery Issues

Joseph J. Holonich
US Nuclear Regulatory Commission

SURETY TRANSMITTALS

Transfer of surety Instruments

- **Address to Chief, Uranium Recovery Branch**
- **cc Project Manager**
- **Addressee Only**
- **Cover Letter which includes**

  - site name

  - site docket number
- **Certified Mail is best but not required**

NRC CONTACTS

NRC Project Manager

- **License amendments or concerns**
- **non-operational emergency**
- **NRC Operator (301-415-7000) to get in touch with your PM if outside of working hours**

License Letters

- Addressed to Joseph J. Holonich, Chief Uranium Recovery Branch
- cc: Region IV, CNWRA if applicable
- good idea to include the NRC cc: list

Operational Emergency

- NRC Operations Center (301-816-5100)
- OP center will contact key personnel

Groundwater Monitoring for License Termination

- **Prior to License Termination, all uranium mills implement single measure of contaminants of concern.**

- **Constituents of concern:**

  - Previously identified in tailings liquor

  - 10 CFR Part 40, Appendix A, Criterion 13

  - Any other constituents added by license condition

- **At License termination, licensee must**

  - submit final groundwater measurement for these constituents

  - demonstrate they meet standards in Appendix A, Criterion 5

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URANIUM RECOVERY BRANCH PROGRAM ACCOMPLISHMENTS 1997

Presented to:

URANIUM RECOVERY INDUSTRY

By:
Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material Safety and Safeguards

TITLE I ACCOMPLISHMENTS

- Completed evaluation of Remedial Action Selection for 1 site (Maybell)
- Completed 3 Completion Report Reviews (Ambrosia Lake, Falls City, and Grand Junction Processing Site)
- Licensed 1 site for long-term care (Tuba City)
- Two sites pending for long-term care - complete except for the land transfer (Falls City, Ambrosia Lake)
- Completed 16 other Title I actions

TITLE II ACCOMPLISHMENTS

- Published Atlas/Moab final TER
- 2 ACL applications under review
- Approved License application for Shootaring
- Completed EFN renewal
- Published final EIS for HRI
- Issued 2 Performance based licenses.
- Issued 35 License amendments
- SRP guidance under development

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Performance Based License Conditions

Joseph J. Holonich
US Nuclear Regulatory Commission

United States
Nuclear Regulatory Commission

Implementation of Performance-Based License Condition

Presented by

Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management

June 1997

Background on Performance Based License Condition

- Basis in 10 CFR 50.59
- Permits changes that do not erode the basis for NRC's licensing decision
- Provides needed flexibility
- Where implemented properly, continues to be successful in preserving safety
- Threshold for determining when prior approval of a change is needed
- Not a safety or acceptability test

Information on 10 CFR 50.59

- Defines conditions under which Part 50 licensees can make changes to facilities
- Originally promulgated in 1962
- Staff and industry have over 30 years experience with implementation
- 10 CFR 50.59 Evaluation
  - Required when changes described in application are made
  - Controls changes to that part of plant design and operation described in application

- **Licensee must first determine proposed change is safe, then conduct 50.59 evaluation**
- **Difference between safety of change and 10 CFR Part 50.59 review**
- **Safety and 10 CFR 50.59 determination are closely related**
- **10 CFR Part 50.59 used to determine if a change requires review prior to implementation**
- **A licensee can determine a change is safe, but still require an NRC review**

NRC Perspective on Licensed Sites

- Bases for accepting application and issuing license are acceptance limits and design analyses
- NRC accepted during its review of a license application
- Regulatory commitments voluntarily agreed to or offered by licensee
- Deviation from licensing basis puts facility in a condition where it functions differently from accepted design and operation

Licensing Basis

- **Several different documents**
  - **Application and environmental report**
  - **Subsequent letters supporting licensing actions**
  - **Staff Safety Evaluation Report**
  - **Staff Environmental Assessment**
  - **License and all conditions**
- **Other activities**
  - **Not part of licensing basis**
  - **Not controlled by NRC license**

Relationship to Uranium Recovery

- **Same regulatory philosophy applied to uranium recovery licensees**
  - **Operate facilities within licensing basis**
  - **Come to NRC for any changes beyond licensing basis**
  - **Use performance-based license condition (PBLC) to achieve flexibility**

- **Difference between safety and environmental acceptability and PBLC implementation**
  - **Licensee must determine change is safe or environmentally acceptability**
  - **PBLC allows licensees to determine if change requires prior NRC review**
  - **Safety or environmental acceptability review may still require NRC review**

- **Required NRC review include changes to**
  - **Those things described in application or subsequent submittals**
  - **Procedures conditioned in license or outlined, summarized, or included in application**
  - **Things specifically conditioned in the license**

Implementation of PBLC Flexibility

- **Improper PBLC analysis places the facility in an unanalyzed condition**
  - **NRC has not determined the facility meets requirements**
  - **Licensee must preserve the licensing basis**
- **Requirements include**
  - **Regulations**
  - **Anything conditioned in license**

- **Potential for enforcement actions**
  - **Violations of requirements**
  - **Failure to properly implement PBLC**

- **Proper PBLC implementation may even be an improvement**

- **Objective evidence to support action**
  - **Sufficiently detailed information**
  - **Conclusions logically supported**
  - **Independent review without extensive reference**

Summary

- **Facility license is based on design and operations proposed by licensee**
- **Licensees are allowed to make changes to facility within analyzed conditions**
- **Constant regulatory approach being implemented by NRC**
  - **Part 50 licensees: 10 CFR 50.59**
  - **Part 60 repository: 10 CFR 60.44**
  - **Fuel facility licensees: Individual licenses**
  - **Uranium recovery licensees: PBLC**

- **Responsibility rest with licensee to ensure facility constructed and operated within licensing basis**
- **NRC will confirm through inspection process**
- **Uranium Recovery Branch closely following Commission review of 10 CFR 50.59 process**

United States
Nuclear Regulatory Commission

DOE Title II Experience

Joseph Virgona
Department of Energy

U.S. Department of Energy
Status of Title II Sites

June 4, 1997

U.S. Department of Energy
Albuquerque Operations Office

Joe Virgona
U.S. Department of Energy
Grand Junction, Office
2597 B 3/4 Road
Grand Junction, Colorado 81503
(970) 248–6006

Doris Sandoval, DOE–GJO (970) 248–6073
Carl Jacobson, MACTEC–ERS (970) 248–6568
Mark Plessinger, MACTEC–ERS (970) 248–6571

U.S. Department of Energy

Status of DOE Site Transfer Actions

- ARCO-Bluewater LTSP comments received from NRC
- ARCO-Bluewater LTSP comments addressed
- ARCO-Bluewater site transfer is imminent
- WNI-Sherwood site transfer actions in progress

U.S. Department of Energy

1997 Anticipated Title II Site Visits by DOE Grand Junction Office

- Umetco-Maybell
- Hecla-Durita
- WNI-Sherwood V&O inspection (1997 or 1998)
- Others potentially

Other Title II Activities

- DOE, EPA, and NRC staffs have met and opened discussions regarding the administration of NPL Title II sites
- DOE has provided input to NRC staff regarding DOE site records requirements
- DOE has provided a list of documents/information required from licensees for LTSP development and permanent site files
- Draft *Guidance Document for Operation of LTSM Sites* was prepared to standardize requirements as much as possible for Title I, Title II, and other sites that will be under DOE custodial care

Documents/Information DOE Will Use for LTSP Preparation and Permanent Site File Records

- Reclamation Plan, including design-basis documentation
- Site history (summary history of site operations and previous owners)
- ACL application and supporting documentation, if applicable
- Description of groundwater model
- Groundwater monitoring/data report
- Water Sampling and Analysis Plan
- Aerial photograph of site after reclamation is completed
- As-built drawings
- Environmental assessment report, or equivalent
- Adjacent property ownership map(s), including any rights-of-way across site property, if applicable
- Final, postreclamation site topographic map
- Well completion logs for all wells transferred to DOE
- Legal description of final "restricted area" boundaries
- Title documentation
- Specific reports on hydrogeology and geology of disposal site area
- Construction completion report

Additional site-specific information needs may develop during the site transfer process.

United States
Nuclear Regulatory Commission

DOE Title I Experience

Department of Energy

U.S. Department of Energy

DOE Title I Experience

June 4, 1997

Donald Metzler
Grand Junction Office
2597 B 3/4 Road
Grand Junction, Colorado 81503
U.S. Department of Energy
(970) 248-7612

Title I History

- UMTRCA ACT of 1978
  - identified 24 former processing sites
  - authorized Secretary of Energy to perform remedial actions
    - with NRC concurrence
    - full participation of States
    - in consultation with tribes
  - EPA promulgated standards
    - 40 CFR 192
    - proposed gw standards 1987
    - published final standards 1995
    - Subparts A, B, & C

40 CFR 192 History (continued)

- Subpart A
  - standard for the control of RRM (disposal)
- Subpart B
  - standard for cleanup of land and buildings contaminated with RRM
- Subpart C
  - implementation
  - criterion for supplemental standards

DOE's Method Approach

- Decoupled surface cleanup from ground water cleanup
  - surface remedial action included GW protection strategies for disposal cells
- Conducted remedial actions based on risk priorities
- Addressing GW cleanup in a second phase

24 Inactive Processing Sites

- 2 sites "de-listed"
- 10 sites with on-site disposal
- 12 sites with off-site disposal
- volume of RRM ranged from 58,000 cubic yards to 5.8 million cubic yards

Subpart A :GW Protection Compliance Strategies

- MCLs and or Background
  - Durango, CO
  - Gunnison, CO
  - Lakeview, OR
  - Lowman, ID
  - Tuba City, AZ

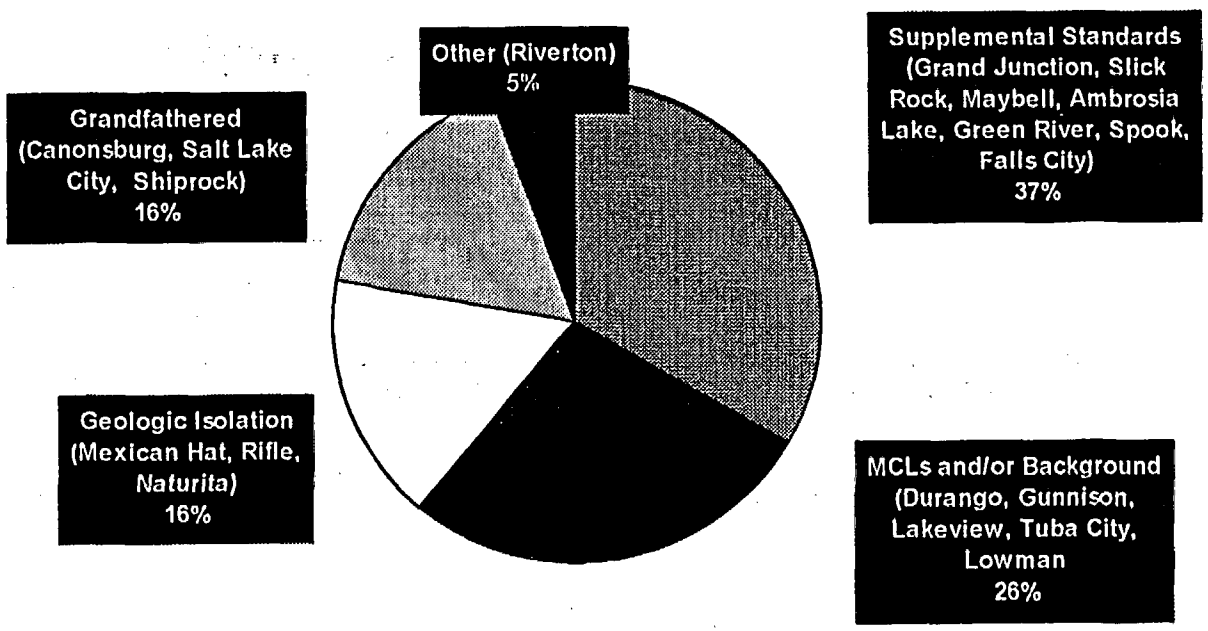
Subpart A :GW Protection Compliance Strategies

- Supplemental Standards
  - Grand Junction, CO
  - Slick Rock, CO
  - Maybell, CO
  - Ambrosia Lake, NM
  - Green River, UT
  - Falls City, TX
  - Spook, WY

Subpart A :GW Protection Compliance Strategies

- Geologic Isolation
  - Naturita, CO
  - Rifle, CO
  - Mexican Hat, UT
- Grandfathered
  - Salt Lake City, UT
  - Canonsburg, PA
  - Shiprock,NM
- Other
  - Riverton, WY

Types of Title I GW Protection Compliance Strategies



Experiences

- Adequate data sufficiency
  - define data collection objectives
- Data Quality
  - define data quality objectives
    - field screening
    - level of quality assurance
- Utilize the observational approach
  - define the most probable conditions
  - plans for deviations and contingencies
- Involve all stakeholders upfront

Examples of Lessons Learned On Developing GW Protection Strategies

- Utilize ASTMs where appropriate
  - don't reinvent the wheel
- Develop a calculation protocol
  - organized calc sets
  - reference to calculations

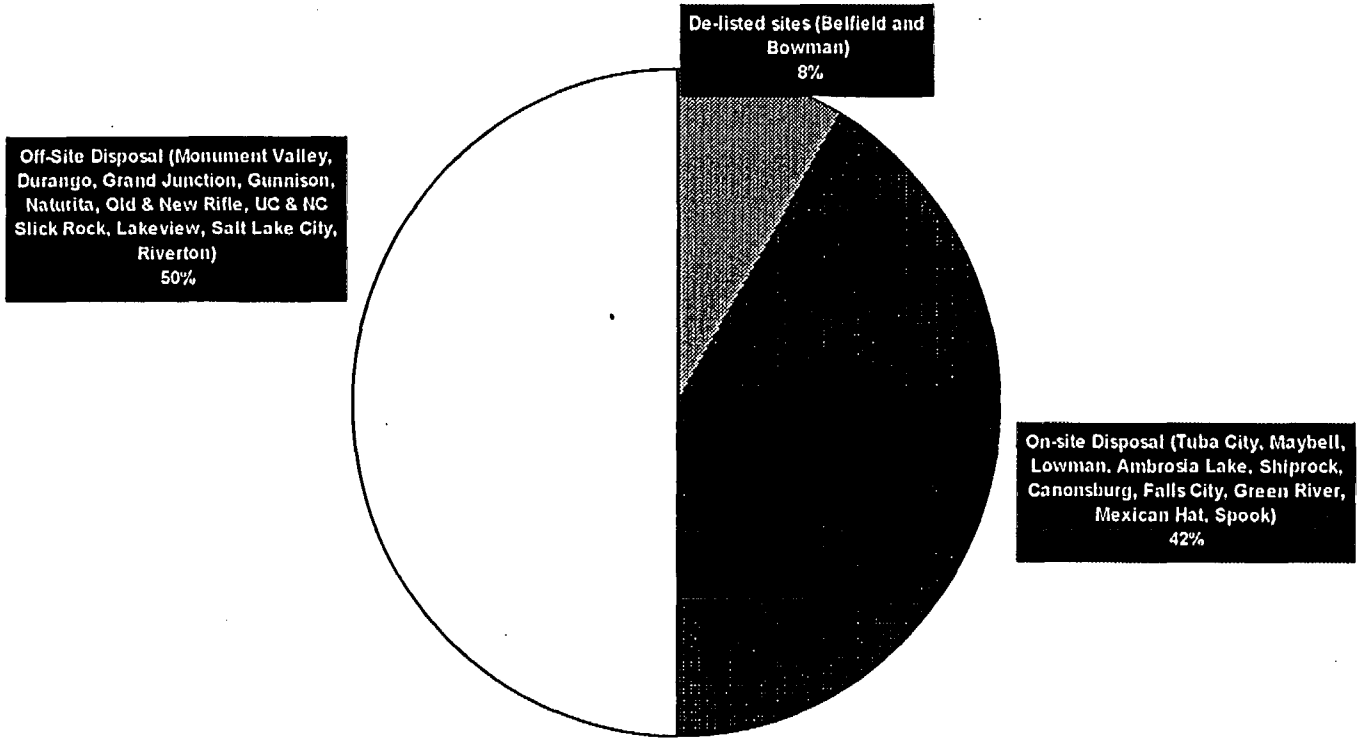
Examples of Lessons Learned On Developing GW Protection Strategies (continued)

- Expedited site characterization
  - real time data for field decisions
  - computer codes for optimization
  - use modeling to assist in identifying data collection needs
    - sensitivity analyses
    - parameter estimation

Experiences With Monitoring

- May be granted if:
  - groundwater at a site is of limited use [192.11(e)] in the absence of contamination from residual materials; or
  - complete restoration would cause more environmental harm than it would prevent; or
  - complete restoration is technically impracticable from an engineering perspective.

Disposal Types



Experience with Monitoring

- required with MCLs and/or background
  - optimize locations, frequency, and analytes
- optional with supplemental standards
  - can be very effective as best management practice
  - need to ensure protection of beneficial uses
- optional with geologic isolation
  - example-seep monitoring

Summary of Title I Ground Water Experiences

- Know the regulations
  - EPA ground water standards
  - state standards if applicable
- Build consensus upfront
  - involve stakeholders

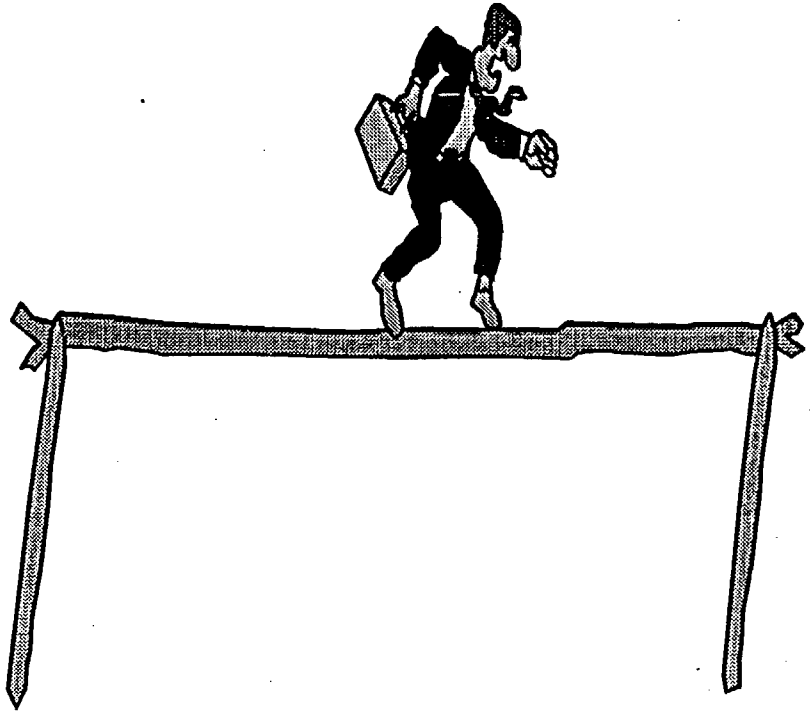
Looking to the Future

- Better understanding of risk/benefits
- Utilizing more tools
  - uncertainty analysis
    - monte carlo
    - geostatistics
- Optimization codes
  - assist in well placement
- Public outreach and involvement
  - communications

Summary of Title I Ground Water Experiences (continued)

- Establish programmatic framework
  - example-UMTRA PEIS
- Compliance strategies and design attributes
  - need to be quantifiable
    - calculation sets
  - verification plan sometimes required

- An Approach to Balancing Dollars, Risk, and Perceptions



United States
Nuclear Regulatory Commission

Overview of MILDOS

Duane W. Schmidt
US Nuclear Regulatory Commission

United States
Nuclear Regulatory Commission

UPDATE OF THE MILDOS-AREA DOSE ASSESSMENT CODE

Presented to:

JOINT NMA/NRC WORKSHOP
JUNE 4, 1997

By:
Duane W. Schmidt
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material Safety and Safeguards
phone: (301)415-6919 e-mail: dws2@nrc.gov

REVIEW OF MILDOS-AREA

- **MILDOS-AREA is used to calculate radiological impacts from airborne emissions of uranium-238 series.**
- **Human impacts are given by: annual average air concentrations and by committed doses.**
- **MILDOS-AREA is a modification (in 1989) of the original MILDOS code (of 1984)**

CURRENT REVISIONS TO MILDOS-AREA

- Argonne National Laboratory has performed the upgrade (S.Y. Chen, E.R. Faillace, Y.Yuan, and D.J. LePoire).
- Task A: Upgrade MILDOS-AREA code.
- Task B: Construct source term example for ISL facility.
- Task C: Create patch program.

TASK A: UPDATE MILDOS-AREA CODE

- **Prior version used Maximum Permissible Concentrations (MPCs); now called Allowable Concentrations (ALC) in the MILDOS-AREA code.**
- **Old MPC values were superseded by Effluent Concentrations given in 10CFR20, Appendix B, Table 2, Column 1.**

Allowable Air Concentrations (pCi/m^3) Used in Updated MILDOS-AREA

Radionuclide	Concentration (Inhalation Class)	Default Class
Uranium-238	3 (D), 1 (W), 0.06 (Y)	Y
Uranium-234	3 (D), 1 (W), 0.05 (Y)	Y
Thorium-230	0.02 (W), 0.03 (Y)	W
Radium-226	0.9 (W)	W
Radon-222	1/900 WL *	n/a
Lead-210	0.6 (D)	D
Bismuth-210	500 (D), 40 (W)	W
Polonium-210	0.9 (D), 0.9 (W)	W

* Allowable concentration is given for short-lived progeny of radon-222, in units of working level (WL).

TASK B: EXAMPLE SOURCE TERM FOR ISL

- **Methodology accounts for releases from:**
  - **new well field drill tailings pits (Rn)**
  - **production and restoration well fields (Rn)**
  - **satellite ion exchange facility (Rn)**
  - **radium settling ponds (Rn)**
  - **land application areas (particulates)**
  - **main process area—drying/packaging (particulates)**
- **This is only intended as an example; NOT TO BE USED AS A SUBSTITUTE FOR SITE-SPECIFIC CALCULATIONS.**

MILDOS-AREA UPDATE: DELIVERABLES

- **Letter report from Argonne National Laboratory: *MILDOS-AREA: An Update with Incorporation of In Situ Leach Uranium Recovery Technology*.**
- **Revised version of the code and upgrade patch program with included sample problem for ISL (Task C of contract).**
- **Report and software are available at this workshop and upon request from the NRC**

United States
Nuclear Regulatory Commission

Open Regulatory Forum

Joseph J. Holonich
US Nuclear Regulatory Commission

United States
Nuclear Regulatory Commission

Attachments

U.S. Nuclear Regulatory Commission Staff Response
to Concerns Raised by the National Mining Association

1.0 INTRODUCTION

On May 12, 1997, representatives from the uranium recovery industry briefed the Nuclear Regulatory Commission. Besides providing information on the different industry organizations and types of uranium recovery facilities, the presentation also discussed four areas of the staff's uranium recovery program where industry believed there were inconsistencies among several different NRC policy positions and staff guidance documents. Because of this perception, the industry believed Commission attention was required. In addition, the industry had raised with the staff a fifth issue. The five issues are as follows:

1) NRC jurisdiction over the wellfields at in situ leach facilities (ISLs);

2) the concern that some evaporation pond sludge from ISLs would not be considered 11e.(2) byproduct material given the definitions for process and mine water in the staff's effluent discharge guidance document;

3) a conflict between the effluent discharge guidance document and the staff guidance on disposal of material other than 11e.(2) byproduct material in uranium mill tailings impoundments;

4) concurrent jurisdiction over the nonradiological components of 11e.(2) byproduct material by the NRC and the states; and

5) a conflict between the role of states in the different NRC guidance.

All of the concerns raised by the industry briefing are not new to the staff. These concerns had been previously raised by industry in a number of different forums including bimonthly meetings held between the NRC and the National Mining Association (NMA), the NRC/NMA sponsored workshops, and a paper presented at the Nuclear Energy Institute Fuel Cycle 97. Essentially, the industry believes that the five areas of concern discussed above result in inconsistencies in the NRC staff regulation of uranium recovery facilities. This paper discusses the concerns raised by the industry, and provides the NRC staff perspective.

2.0 STAFF RESPONSE TO CONCERNS

2.1 Jurisdiction Over ISL Wellfields (Item 1)

This issue arises from two different interpretation of what authorities the Uranium Mill Tailings Radiation Control Act of 1978 as amended (UMTRCA) provides NRC with respect to the groundwater aspects of ISL operations. In industry's view, NRC should not exercise jurisdiction over the groundwater protection aspects of ISL wellfield operations. The industry position is based on: 1) the fact that the ore at that point in the process is still underground, and therefore has not been removed from its place in nature; 2) the concentration of uranium is below 0.05%; and 3) the ore body is not defined as 11e.(2) byproduct material in 10 CFR Part 40. In addition, industry raises the concern that the Environmental Protection Agency (EPA) or individual EPA permitting States have jurisdiction over the groundwater aspects of ISL operation. Therefore, for the above reasons, industry believes that NRC does not have the legal authority to regulate the groundwater aspects of ISL operations, and that the current NRC position results in the dual regulation of these wellfields.

The basis for the NRC regulation of ISL wellfields is documented in an April 28, 1980. As noted in that memorandum, the NRC authority for regulating the groundwater aspects of ISL operations is based on the long-exercised jurisdiction established under the AEA for NRC regulation of the production of uranium. In addition, the NRC regulatory authority provided in the AEA is reinforced by UMTRCA and the National Environmental Protection Act of 1969 (NEPA).

The Congressional record on the enactment of UMTRCA establishes a clear legislative record that Congress intended NRC to regulate all aspects of ISL operation. Discussions held between Senator Wallop and Senator Hart indicate that the regulatory program established under UMTRCA would apply to all aspects of ISL operation including groundwater. The House committee report stated that NRC should exercise similar controls for ISL groundwater protection as those imposed by EPA.

NRC responsibilities under NEPA further fortify the Commission's ability to exercise the power it unquestionably has over the groundwater aspects of ISL operation. Under NEPA, the Commission is to minimize, to the extent practical, the adverse impacts from ISL operations. In addition, judicial decisions obligate NRC to minimize environmental impacts from NRC licensed activities. Based on the legislative requirements established by Congress under NEPA, and judicial decisions reaffirming the Congressional intent, NRC

clearly has the responsibility under NEPA to ensure that environmental impacts from all aspects of ISL operation, including groundwater, are minimized.

Finally, the industry position that the ore body is not 11e.(2) byproduct material is a hollow argument. Under the definition of 11e.(2) byproduct material in UMTRCA, the ore body would be covered, and therefore, the depleted ore bodies would be transferred to a long-term custodian. However, Congress also gave the Commission the discretion of not requiring transfer of 11e.(2) byproduct material to a long-term custodian. For the depleted ore body that remains underground, the Commission decided to exercise this discretion, and not include the ore body in the definition of 11e.(2) byproduct material in 10 CFR Part 40. Exercising this discretion makes sense since the ore body remains underground, and does not need the long-term monitoring that large tailings impoundments require. In addition, the definition eliminates the need for ISL licensees to establish and make the long-term care payment which is currently at approximately $560,000.

In summary, the potential contamination of groundwater from ISL operation is clearly within the NRC scope under the AEA, and the NRC regulatory authority is further fortified through UMTRCA and NEPA.

2.2 ISL Evaporation Pond Sludge Classification and Conflict With Guidance on Disposal of Material (Items 2 and 3)

The genesis of these issues is in the definition of process and mine water contained in the staff guidance document entitled "Staff Technical Position on Effluent Disposal at Licensed Uranium Recovery Facilities." The guidance was developed as a document to provide options to ISL and conventional mill licensees for the disposal of process and restoration water from ISL operations, and for the disposal of groundwater pumped as part of corrective action programs at uranium mills. In the draft guidance, the staff took the position that any water from ISL operations that was discharged to surface water was subject to the effluent discharge standards in 10 CFR Part 20, Appendix B (Appendix B).

Because the water generated at ISLs comes from two distinct sources, the industry commented that the draft staff guidance would not allow "mine water" to be discharged under the less stringent requirements of 40 CFR Part 440. To address this concern, the final guidance differentiated between process bleed and mine water. In the final guidance, process bleed is defined as the groundwater extracted from the aquifer during uranium recovery operations. Because this water is directly related to the extraction of uranium and thus under NRC jurisdiction, the effluent discharge requirements in Appendix B are

applied. Water from wellfield restoration was defined as mine water because this water was not directly related to the uranium extraction process. The discharge of mine water from impoundments to surface water is not regulated by NRC, but is subject to the discharge limits of 40 CFR Part 440. The staff believed these interpretations would address the industry concerns on the draft guidance. The approach outlined in the final guidance provided industry with operational flexibility by not applying the Appendix B effluent discharge limits to water produced at stages in the ISL process where uranium is not being recovered.

Independent of the effluent discharge guidance, the staff had also issued guidance on the disposal of AEA regulated material other than 11e.(2) byproduct material in tailings impoundments (hereafter the disposal guidance). After consultation with the Commission on the final disposal guidance, the gudiance was published in the Federal Register on September 22, 1995. Essentially, the final guidance lays out 10 criteria that licensees should meet before the NRC would authorize the disposal of AEA material other than 11e.(2) byproduct material in tailings impoundments. One of these criteria is the exclusion of radioactive material not covered by the AEA. Regulation of radioactive material not covered by the AEA would be the responsibility of individual States. Therefore, the staff included this criterion because it wanted to avoid a situation where States could also be setting standards for the disposal of radioactive material in tailings impoundments.

Industry raised the current concerns based on its review of the two guidance documents. The industry position is that using the definitions of process bleed and mine water in the effluent guidance document, the resulting sludges left in the evaporation ponds at ISL facilities are legally different. At most ISL facilities, operators will use a single evaporation pond for the storage of both process bleed and mine water. Once the ponds are decommissioned, the ISL operator must dispose of the remaining sludge. Although the sludges created from either process bleed or mine water are chemically, physically, and radiologically the same, the industry contends that the source of origin makes them legally different.

Industry views one part of the sludge as 11e.(2) byproduct material since it is the residue remaining from the evaporation of process bleed water. On the other hand, industry views the sludge remaining from groundwater restoration activities as naturally occurring radioactive material since that residue comes from mine water, which was not part of the uranium extraction process. When these interpretations are coupled with the NRC disposal guidance that excludes radioactive material not covered by the AEA from disposal in mill tailings impoundments, the industry is concerned that there is no disposal

option for the sludges from ISL evaporation ponds where process bleed and mine water have been mixed.

The NRC staff has told the industry that it would view all sludges remaining in the evaporation ponds as 11e.(2) byproduct material if the ponds contained predominantly process water during their life. Essentially, the staff believes it makes no sense to view the sludge from the same pond differently. This position has been explained to the industry, and the NRC staff has noted that mill operators with authority to take ISL 11e.(2) byproduct material would not need to get special amendments to take the sludge remaining at ISL evaporation ponds. The staff notes that the resolution of this issue rests with the industry. At least one operator has separate ponds for process and wellfield restoration water. This approach eliminates the need to address the discharge of process and mine water from the same pond under different discharge limits. Plus the approach clearly keeps the sludges apart, and allows the operator to dispose of the residue from the mine water pond under appropriate State requirements for mine waste. The other approach open to industry is to implement the staff's common-sense approach for disposal of all sludges coming from ponds which predominantly contained process water by recognizing that all of the sludges from a "mixed" poind can be viewed as 11e.(2) byproduct material.

In conclusion, the staff does not believe any action is warranted on NRC's part. Uranium recovery licensees have available to them two very reasonable and effective ways of addressing the problem that industry has created.

2.3 Concurrent Jurisdiction (Item 4)

The NRC position that individual States have the authority to regulate nonradiological aspects of 11e.(2) byproduct material comes from the authority given the NRC in UMTRCA. Under the AEA, the NRC was given the responsibility for regulating the commercial use of nuclear material. This authority was clearly preemptive, and as such, there is no question that NRC has sole authority, notwithstanding the Agreement State program, over the material specified in the AEA. UMTRCA, on the other hand, has two unique aspects to it that preclude preemptive regulation of 11e.(2) byproduct material. First, unlike the AEA which only deals with radiological matters, UMTRCA requires NRC to regulate both the radiological and nonradiological aspects of 11e.(2) byproduct material management. Second, Congress did not provide for sole NRC jurisdiction over 11e.(2) byproduct material whenever it enacted UMTRCA. Because protection of public health and safety for nonradiological matters is routinely the responsibilities of the States, the NRC responsibility for nonradiological aspects of 11e.(2) byproduct material established by UMTRCA

and the absence of clear preemptive language create a situation of concurrent jurisdiction. The basis for this conclusion is detailed in the April 28, 1980 memorandum.

The NRC staff has explained the agency position to the uranium recovery industry on multiple occasions. However, the industry strongly disagrees with the NRC position, and has repeatedly asked the staff to change the NRC view. Given the extensive time this position has stood, 17 years, and the fact that the industry has not chosen to pursue a binding interpretation of UMTRCA in Federal court, the staff concludes that the existing interpretation is legally and regulatorily sound. Staff is continuing to work with States, industry, and the Department of Energy (DOE) to develop ways to successfully implement the uranium recovery program within the legal framework established by Congress.

Whenever possible, the staff is relying on State reviews as a mechanism for ensuring compliance with NRC regulations. In some States, however, the regulations do not provide for the same type of groundwater regulation as the NRC allows. Because of this, licensees often look to the NRC to conduct reviews, and determine if applicable Federal standards can be met. Licensees focus on the Federal standards because those are the ones that must be met for NRC to terminate the uranium mill license.

2.4 Conflicts Between NRC Positions (Issue 5)

This concern comes from an industry position that the NRC concurrent jurisdiction interpretation of UMTRCA conflicts with the staff guidance addressing disposal of other AEA material that is not 11e.(2) byproduct material in uranium mill tailings impoundments. One of the criteria contained in the staff guidance on the disposal of other AEA material in tailings impoundments is that licensees should not dispose of radioactive material other than material covered by the AEA. The basis for this staff position is that non-AEA radioactive material would be regulated by individual States, and the staff does not want individual States setting standards at uranium mill tailings impoundments for the disposal of radioactive material. The industry contends that this position is in conflict with the NRC interpretation of UMTRCA that allows for concurrent jurisdiction of nonradiological aspects of 11e.(2) byproduct material.

What the industry fails to understand is that the UMTRCA interpretation on concurrent jurisdiction and the staff guidance on the disposal of other AEA material in tailings impoundments are derived from two different legislative bases. Essentially, the concurrent jurisdiction interpretation under UMTRCA

deals with the regulation of the nonradiological aspects of 11e.(2) byproduct material. As stated previously, this regulatory authority is unique for NRC, but routine for States. As such, the staff recognizes that given the fact that UMTRCA is not preemptive, the regulation of nonradiological aspects of 11e.(2) byproduct material is the responsibility of both NRC and the State. On the other hand, the staff position on the disposal of radioactive material other than 11e.(2) byproduct material in tailings impoundments deals directly in an area where NRC has been given preemptive responsibility under the AEA. It must be recognized that because there is a preemption for the regulation of radioactive material in the AEA, the NRC wants to avoid a situation where States would also be setting standards for the disposal of radioactive material. To achieve this, the NRC was selective in only allowing the disposal of AEA regulated material in uranium mill tailings impoundments. In fact, the particular application of the disposal guidance would only allow the disposal of source-material contaminated soil.

In summary, it must be understood that the staff UMTRCA interpretation and staff guidance on disposal of AEA material other than 11e.(2) byproduct material in tailings impoundments are not in conflict. Rather, one deals with the NRC and State regulation of nonradiological aspects of 11e.(2) byproduct material management covered by UMTRCA. The other deals with the regulation of radioactive material not covered by the AEA. Because of this, the two policies were developed consistent with their legislative frame work, and no changes are needed to either.

3.0 CONCLUSION

In summary it is important to note that none of the five concerns raised by industry are valid. Each policy or guidance document was developed for a specific reason, and adds to a complete regulatory program. The industry can continue to believe there is a conflict, and this interpretation will limit the operational flexibility of sites. On the other hand, the industry can begin to work within the common-sense, and regulatorily sound approach being implemented by NRC. To continue the dialogue on these issues is diverting management and staff time, and is impacting the staff's ability to complete the necessary casework. Overall, the fundamental conclusion that can be made is that the NRC has a technically and regulatorily sound uranium recovery program that is internally consistent.

United States
Nuclear Regulatory Commission

June 5, 1997

Groundwater Mini-Workshop

MINI-WORKSHOP
June 5, 1997

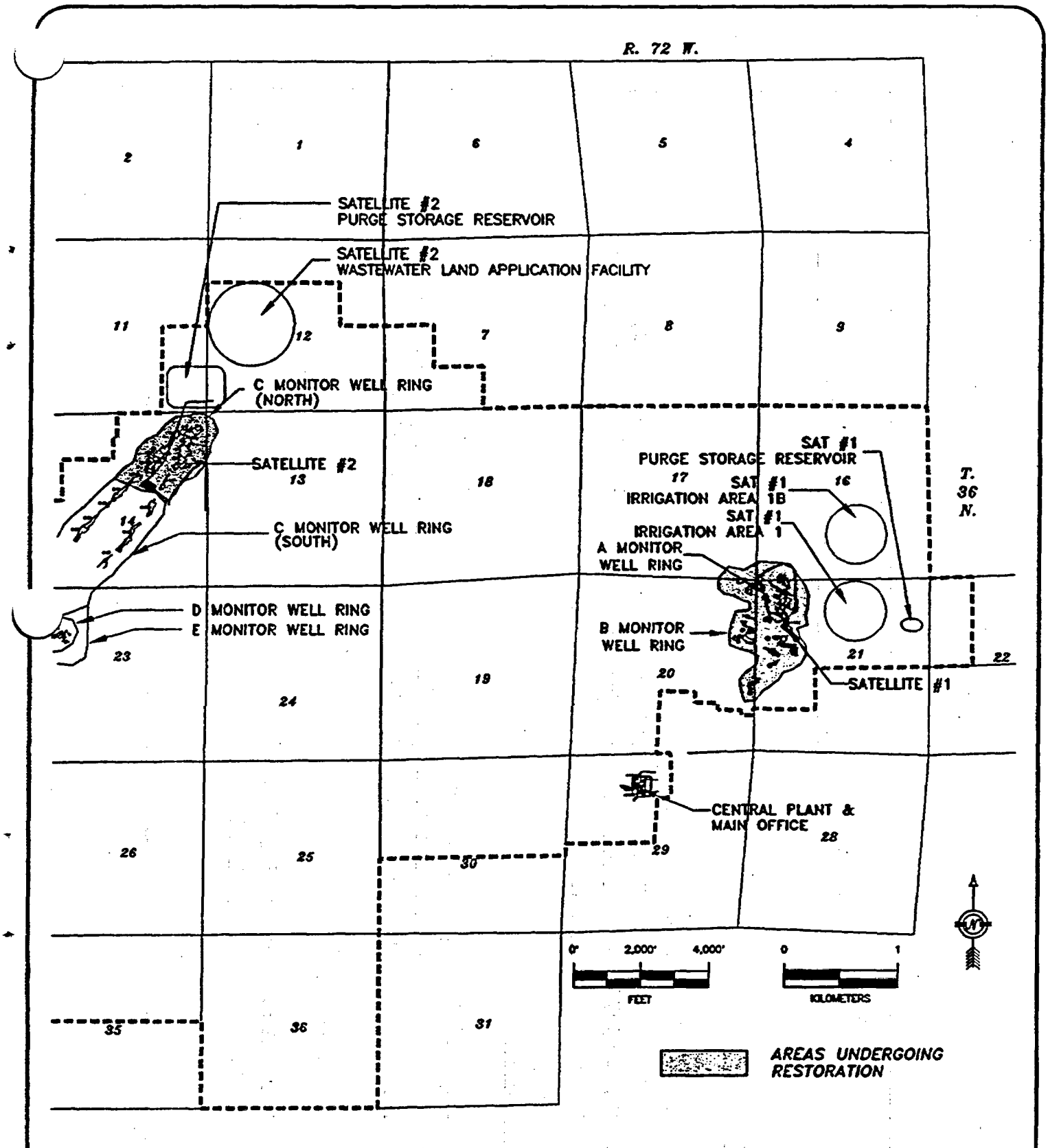
Ground Water Issues

8:30 - 9:30	Industry Experiences - ISL Ground Water Restoration - Power Resources, Inc. - COGEMA Mining, Inc. Discussion/Break
9:45 - 10:45	DOE Experience - Ground Water Compliance Title I; Views on Title II Program - DOE Grand Junction Project Office Discussion/Break
11:00 - 11:45	ALARA Practices as Applied to ACL Reviews - NRC Uranium Recovery Branch Discussion
12:00 - 1:00	Lunch
1:00 - 1:45	Outlook for Ground-Water Compliance at Uranium Mill Tailings Sites - UMETCO - Petrotomics Discussion/Break
2:00 - 2:45	NRC Standard Review Plans, New ISL SRP and Revised Mill SRP - CNWRA Discussion/Break
3:00 - 4:30	State Perspectives - Wyoming Dept. of Environmental Quality - Land Quality Division - Washington Dept. of Health - Division of Radiation Protection - Colorado Dept. of Health - Radiation Control Division - Texas Natural Resource Conservation Commission Discussion and Summary

United States
Nuclear Regulatory Commission

Industry Experiences-
ISL Groundwater Restoration

Power Resources, Inc.



HIGHLAND URANIUM PROJECT

GROUNDWATER RESTORATION AREAS

POWER RESOURCES, INC.

Highland Uranium Project - Restoration Program According to Permit

A Wellfield

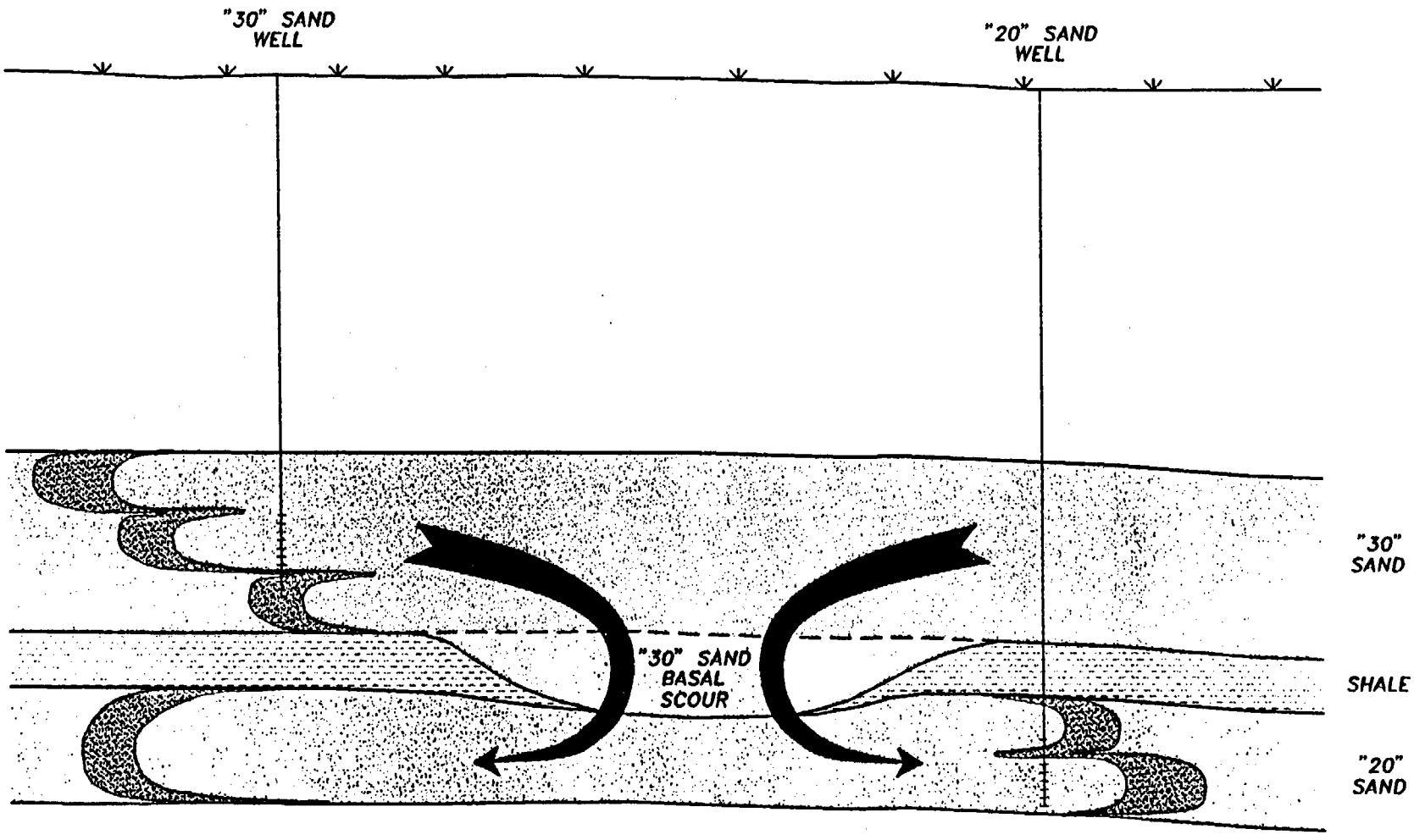
- 1988 - 1991: Production Phase
- 1991 - 1994: Restoration Phase I, 4PV of Ground Water Sweep (10gpm)
- 1994 - 1997: Restoration Phase II, Injection of 3PV of RO Permeate (Unit 1. - 75gpm)
- 1997: Restoration Phase III, Injection of H_2S Reductant

B Wellfield

- 1988 - 1991: Production Phase
- 1991 - Restoration Phase I, 2PV of Ground Water Sweep (50 - 80gpm)
- 1997 - Restoration Phase II, Injection of RO Permeate (Unit 2. - 125gpm)

C Wellfield (North)

- 1989 - 1996 Production Phase
- 1997 - Restoration Beginning



HIGHLAND URANIUM PROJECT
SCHEMATIC CROSS SECTION SHOWING
INTERCONNECTION BETWEEN "20" & "30" SAND AQUIFERS

POWER RESOURCES, INC.

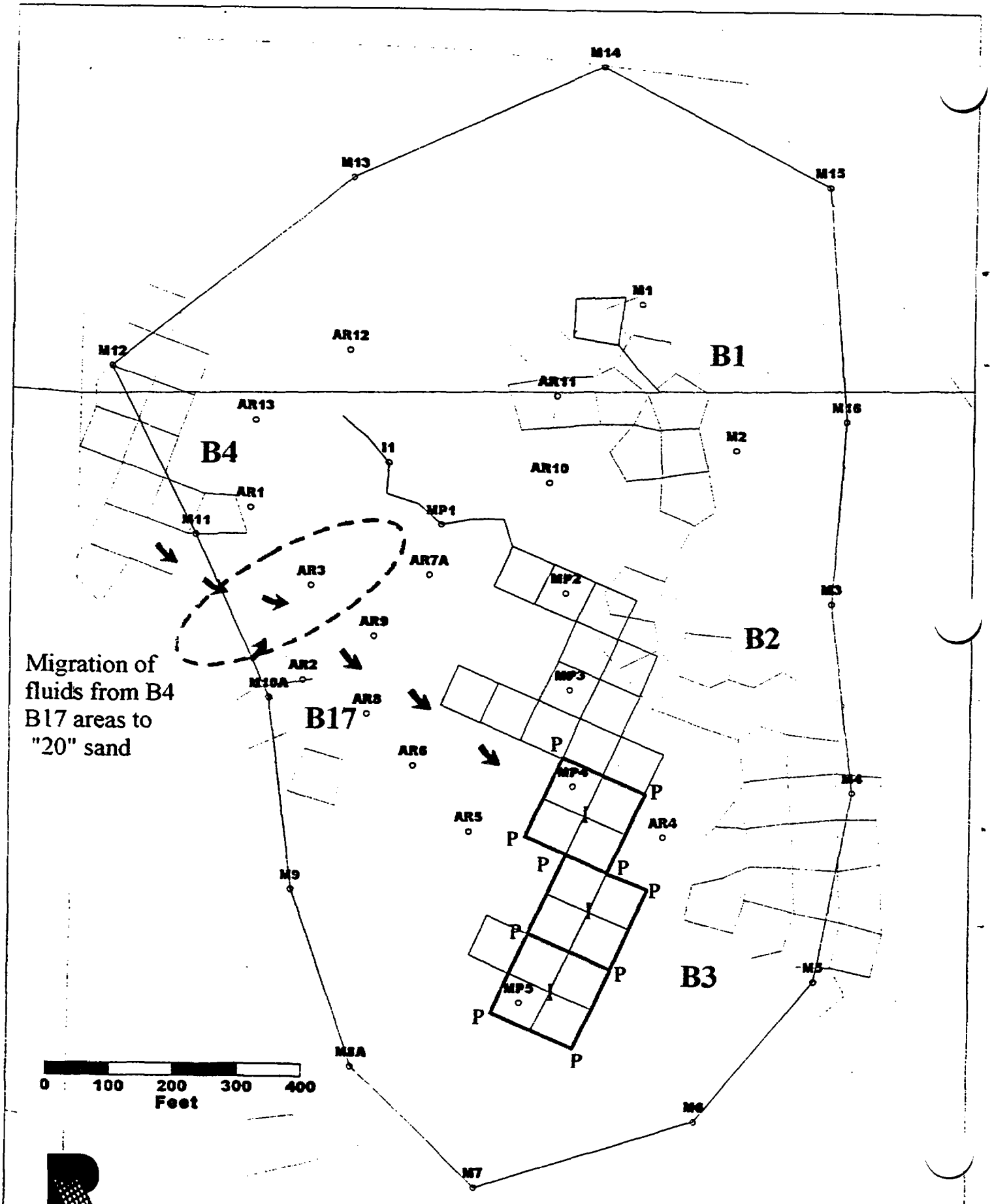


Figure.2., A-Wellfield Map Showing Locations of B Wellfield Patterns

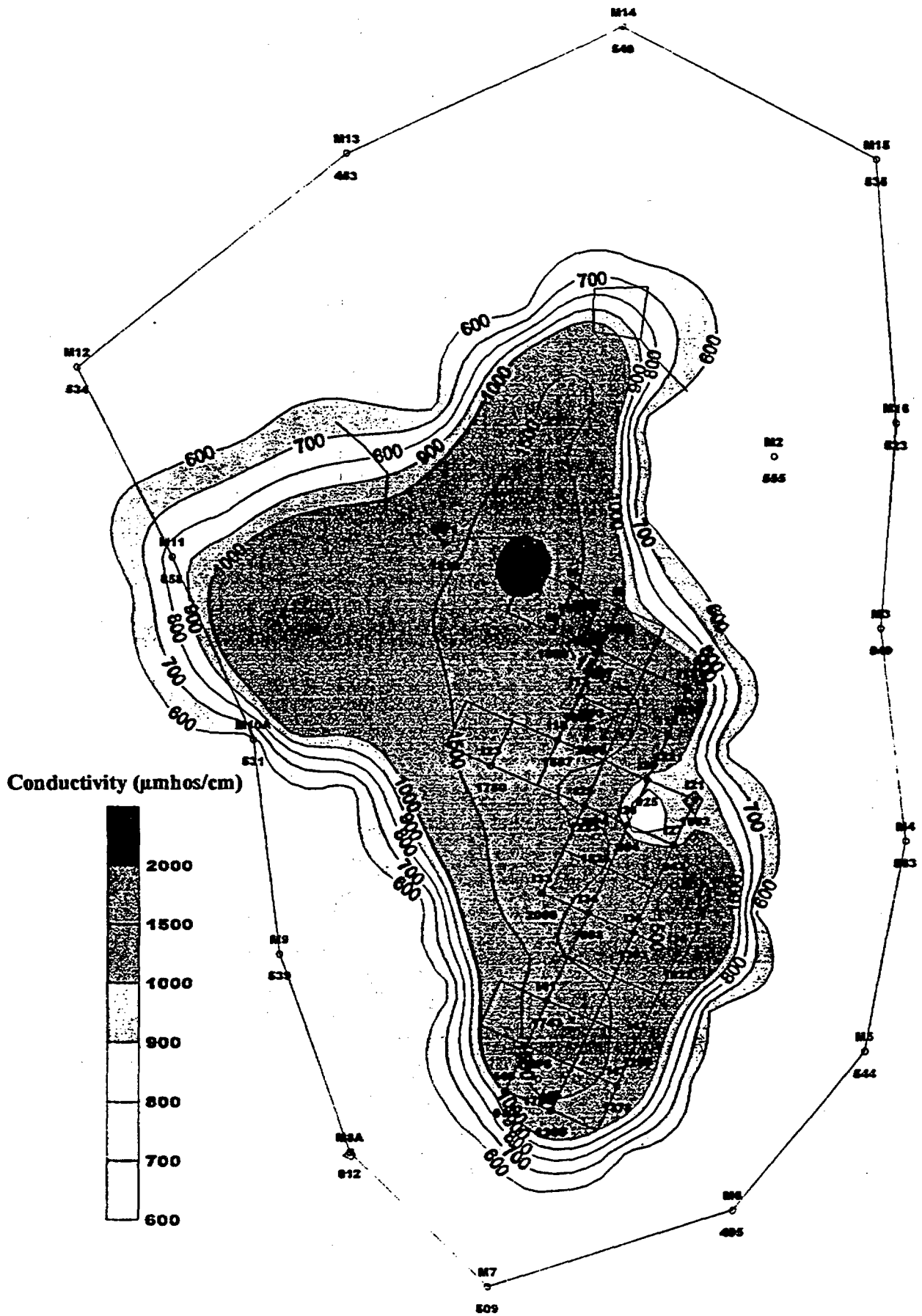


Figure 3., Contoured A-Wellfield Conductivity Levels in May 1994

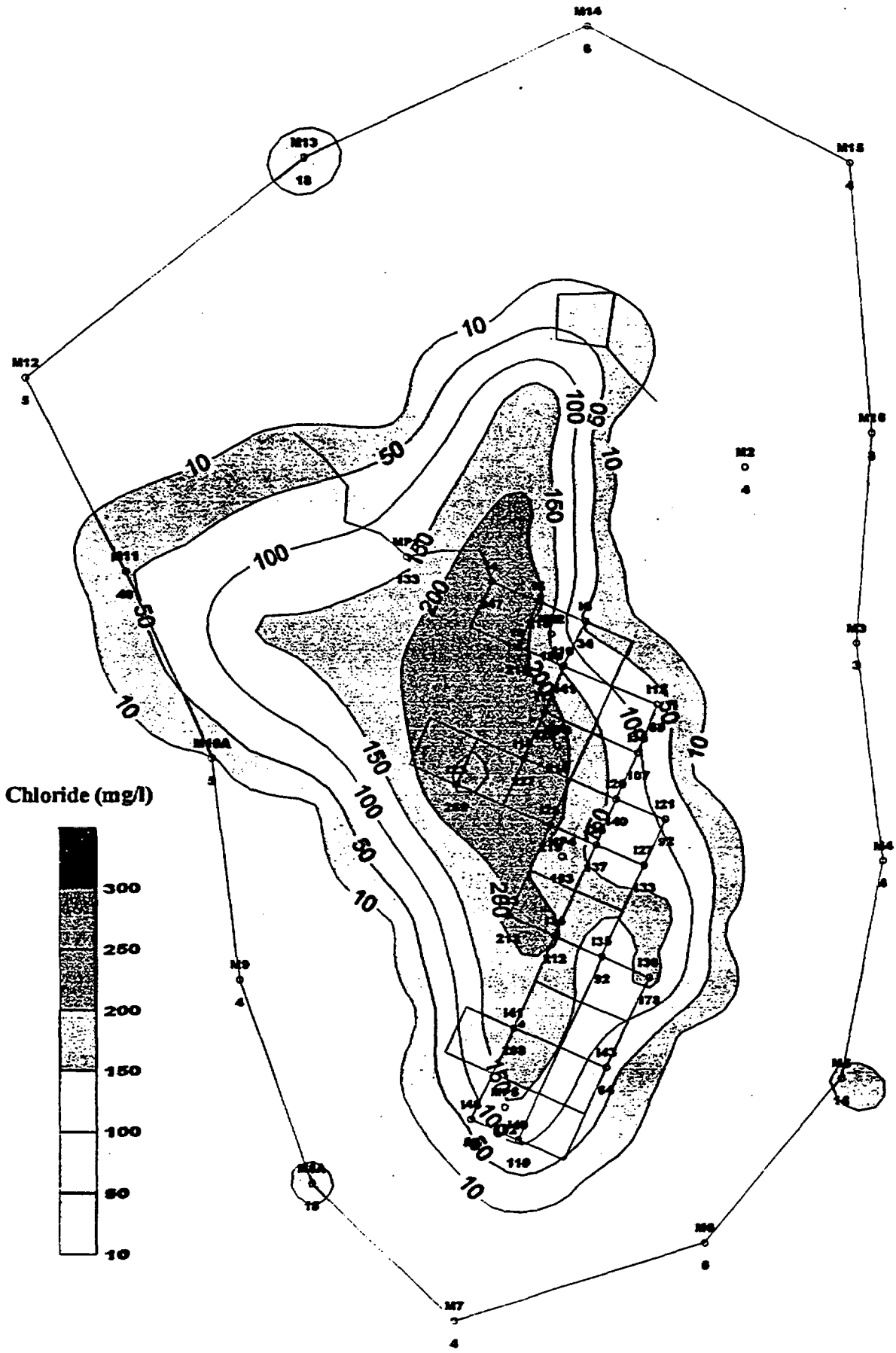


Figure 5., Contoured A-Wellfield Chloride Concentrations in May 1994

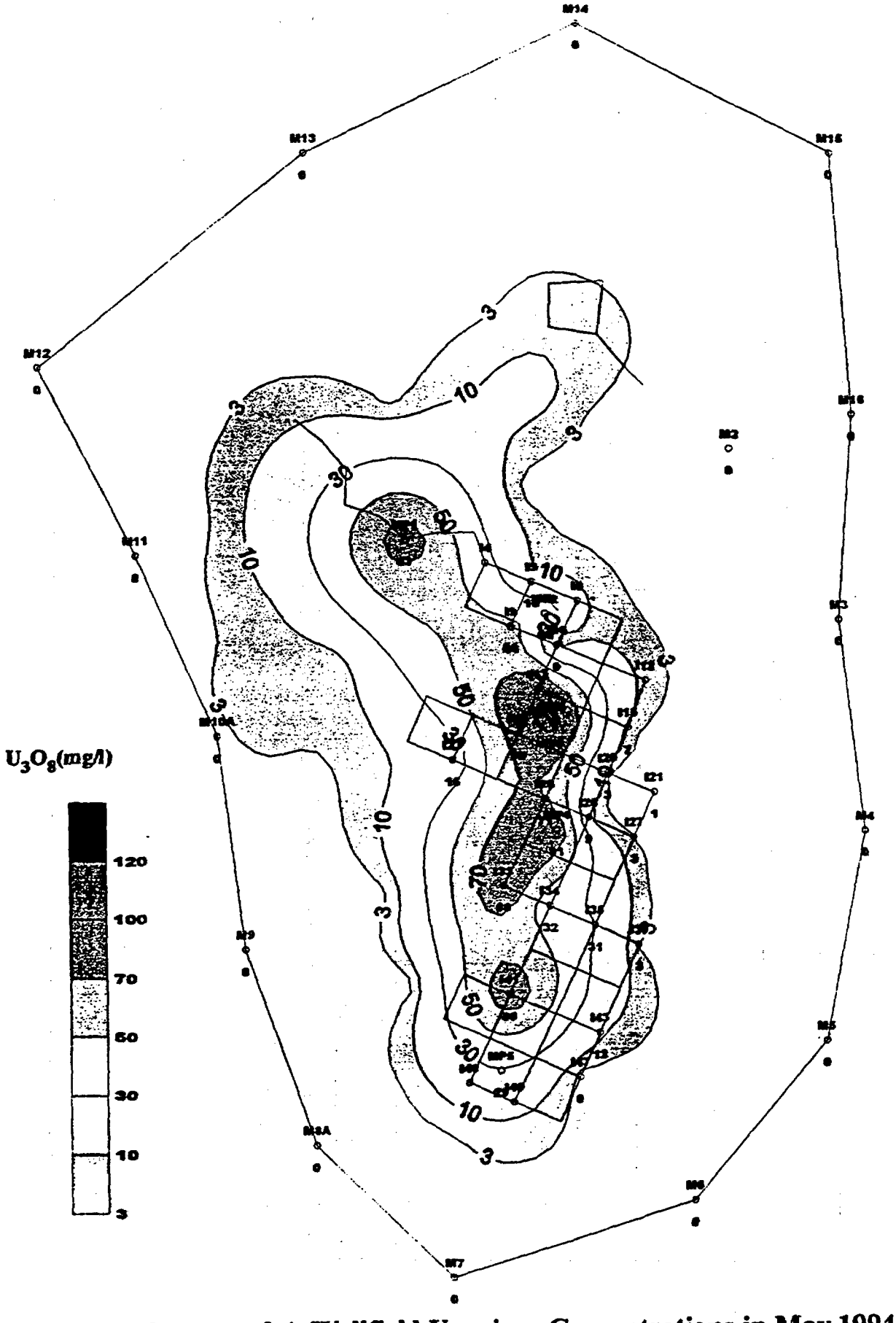


Figure 9., Contoured A-Wellfield Uranium Concentrations in May 1994

Highland Uranium Project - Ground Water Sweep in The 'A' Wellfield

Delays Caused by:

- **Low Pumping Rates From Thin Sand With Limited Yield**
- **Waste Water Treatment Capacity Limitations And Seasonal Restrictions**
- **Connection With '30' Sand Aquifer Allowed Continuous Plume to be Pulled Down**
- **Excursions at M10 & M11 Monitor Wells Caused by Plume**
- **Precipitation of Dissolved Iron, Particularly From Area Affected by Plume**
- **Loss of Surface Facilities, Winter Downtime Due to Freezing Lines**

Conclusions on Effectiveness of GWS:

- **Benefits Neutralized by Plume**
- **3 Years of Pumping & Treatment Costs, Labor, Maintenance & Repairs**
- **No Net Benefit**

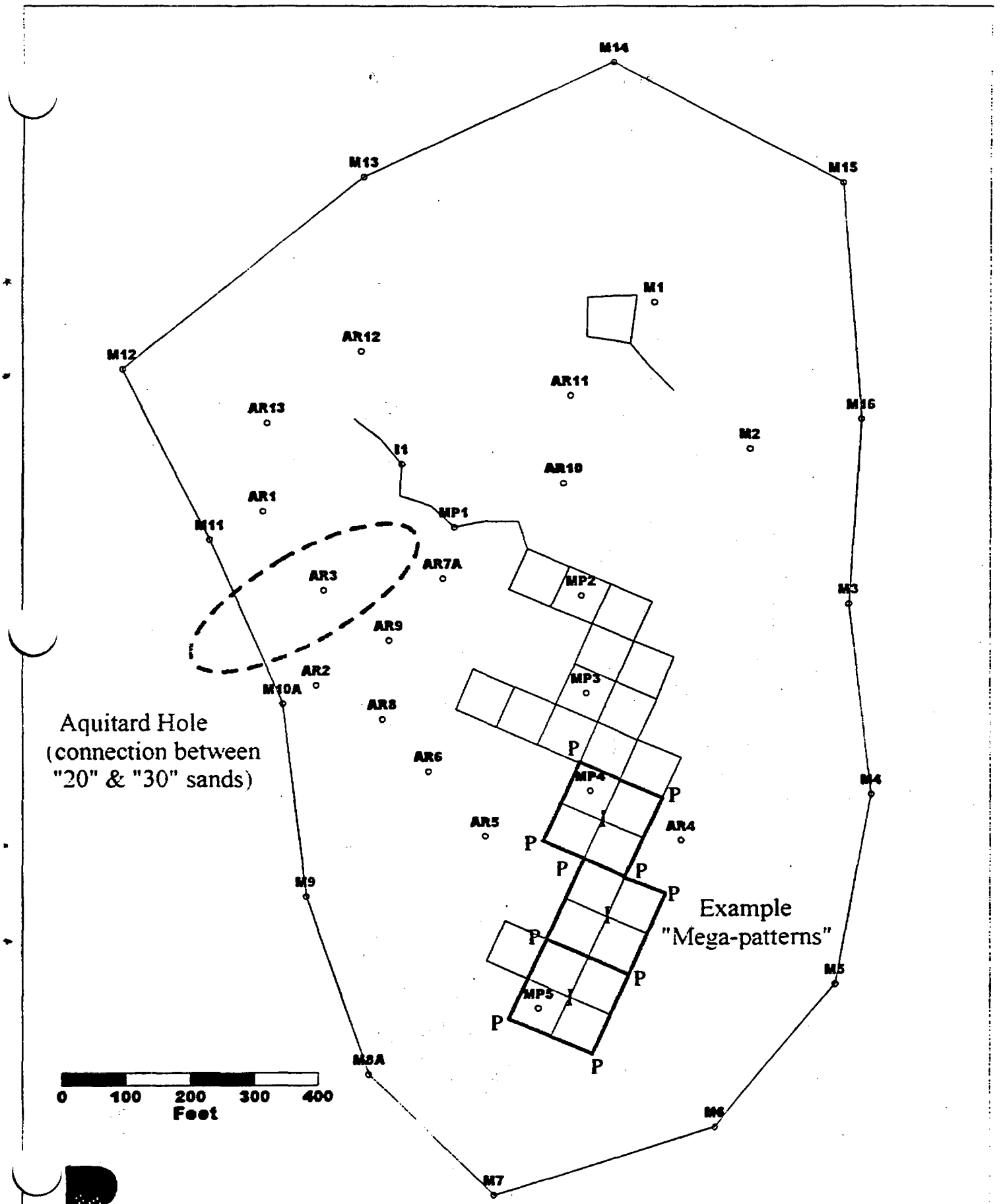


Figure.2., A-Wellfield Map Showing Locations of AR Remediation Wells

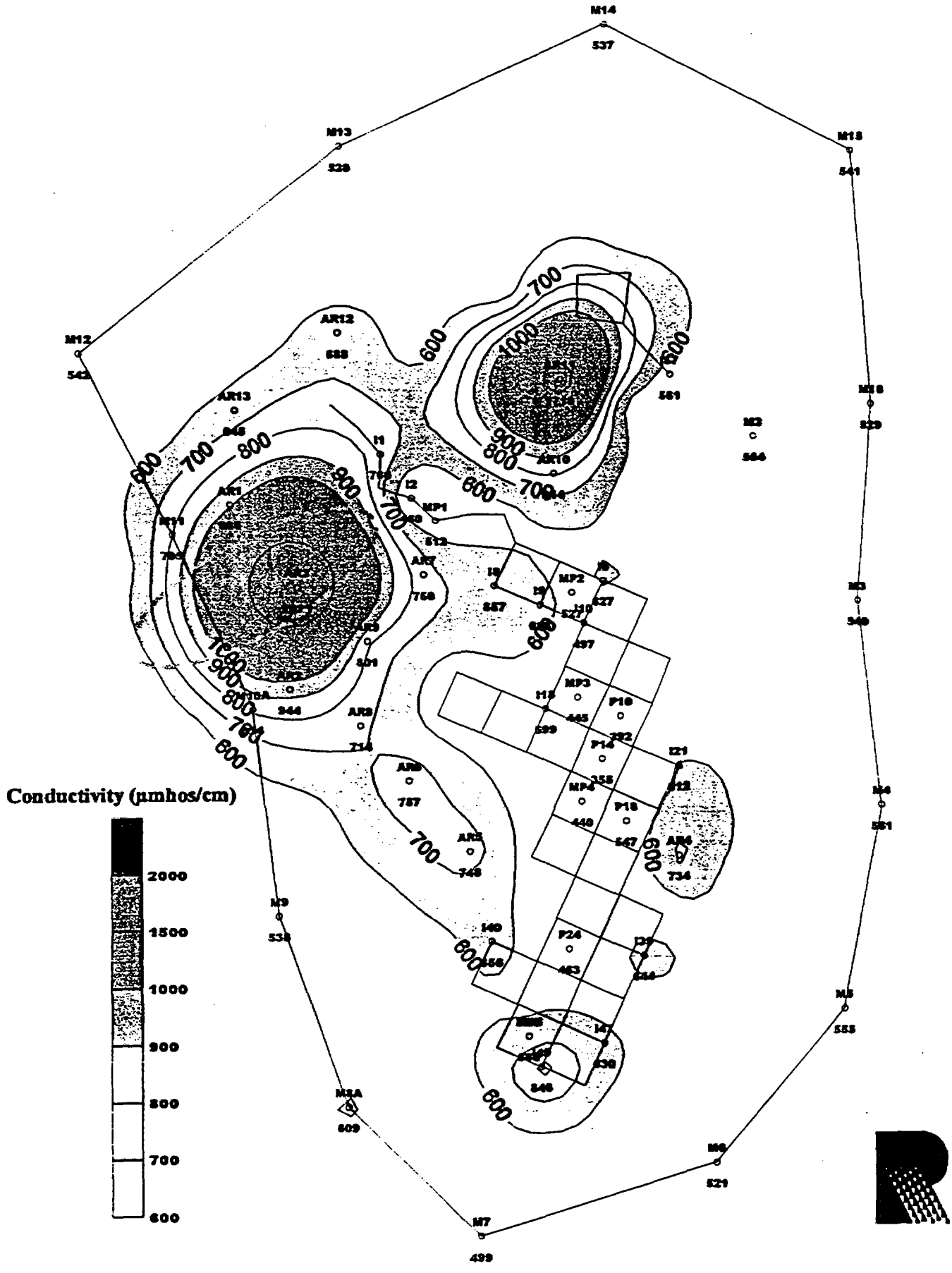


Figure 4., Contoured A-Wellfield Conductivity Levels in Sept. 1996

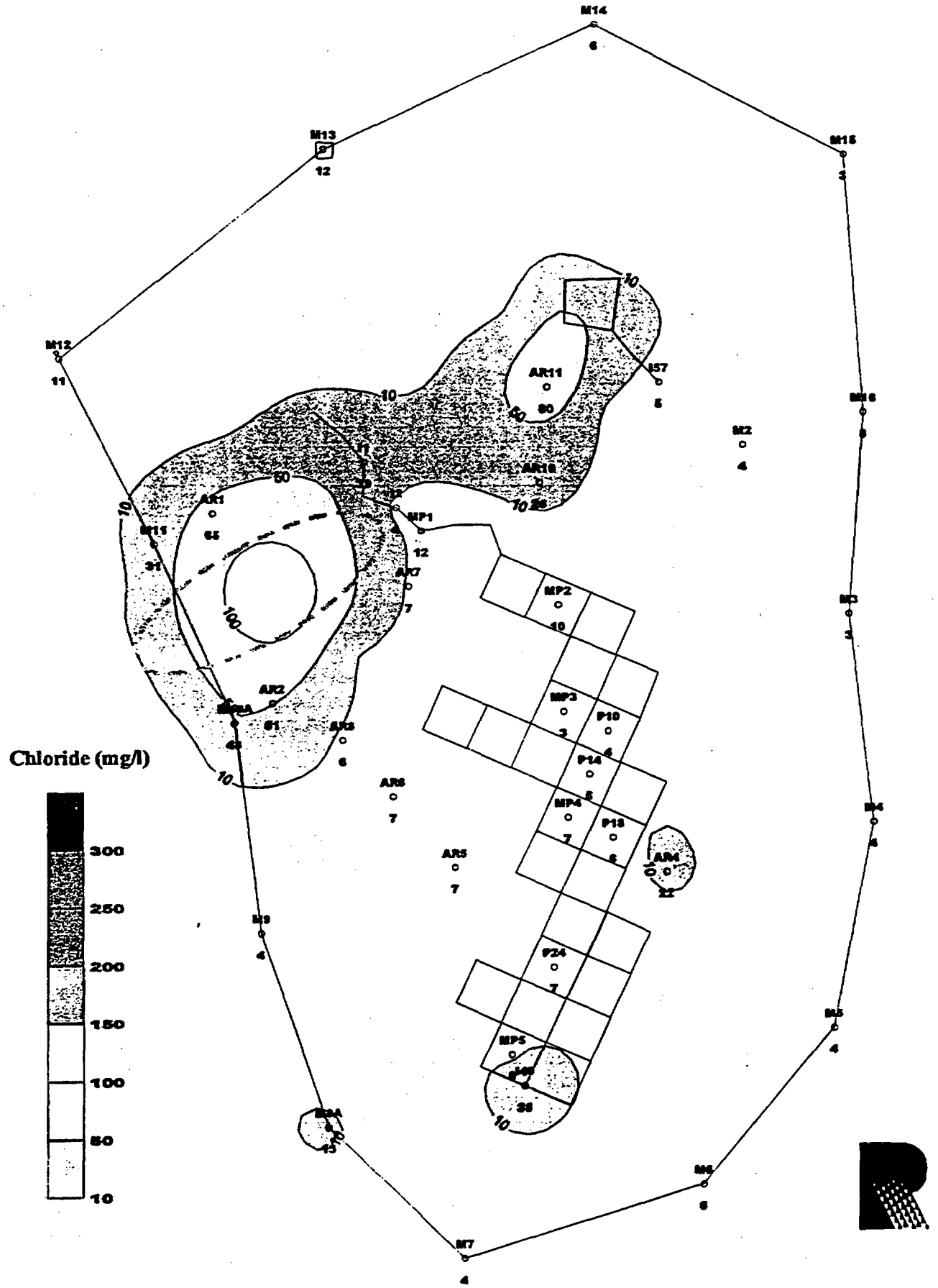


Figure 6., Contoured A-Wellfield Chloride Concentrations in Sept. 1996

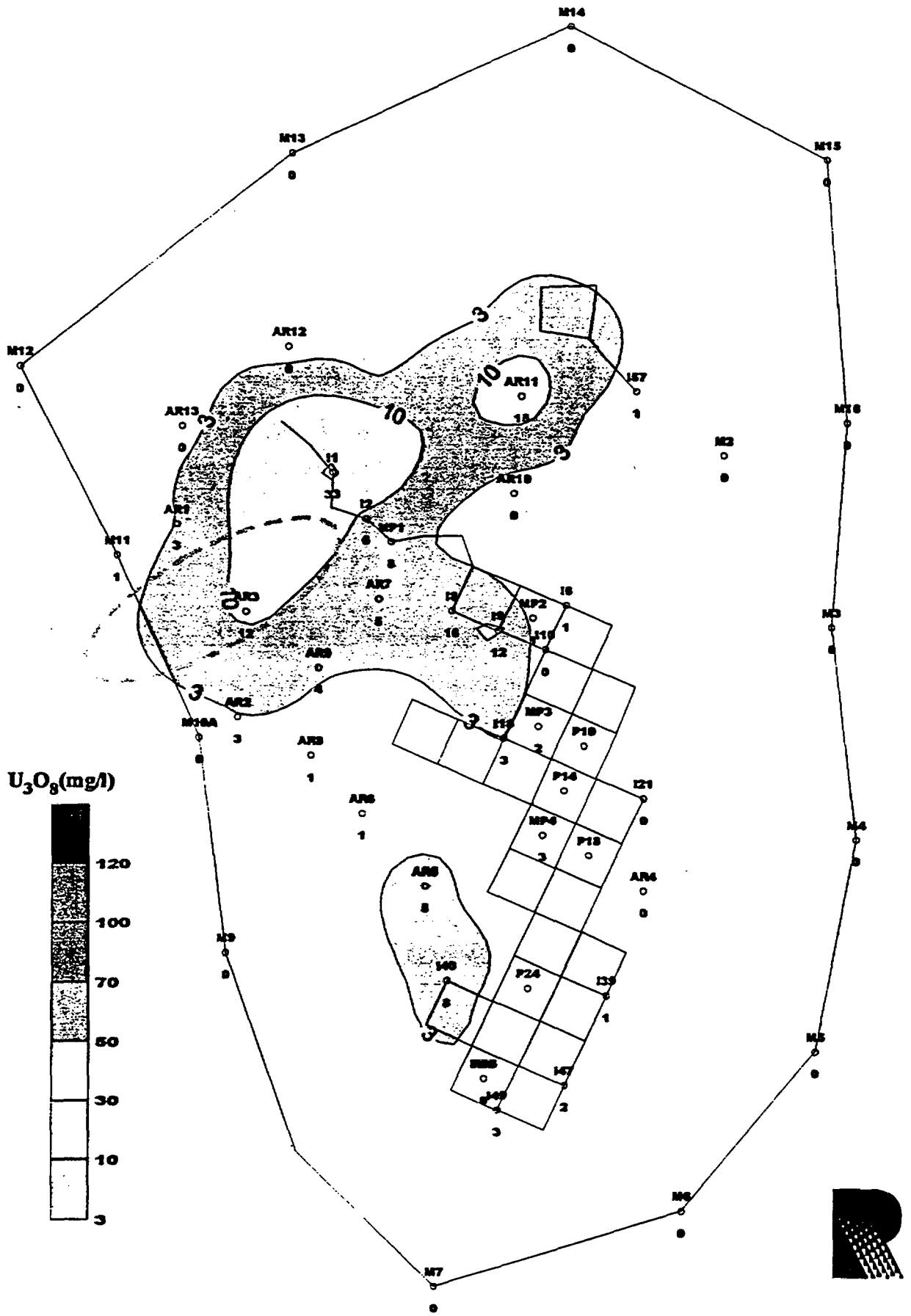
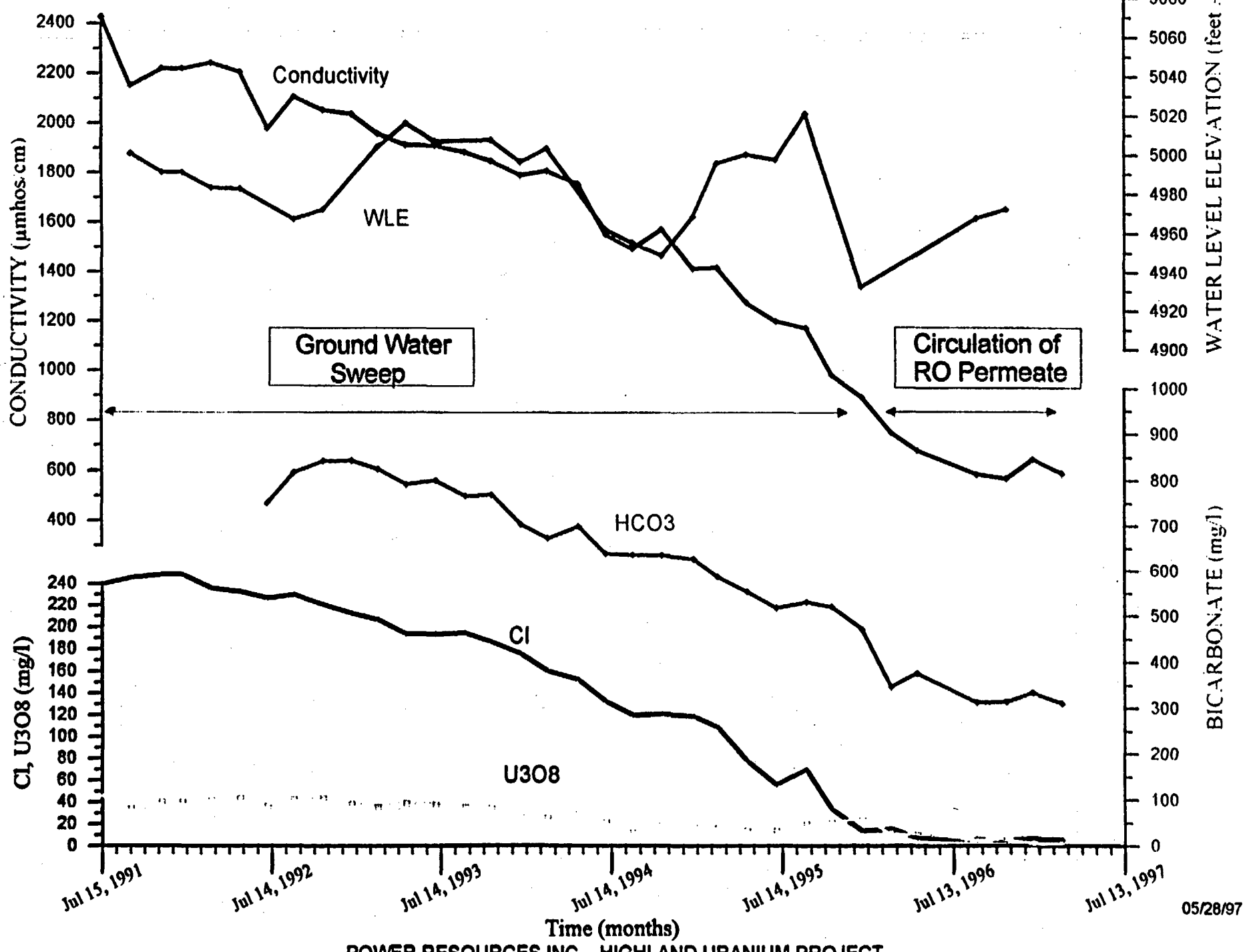


Figure 10., Contoured A-Wellfield Uranium Concentrations in Sept. 1996

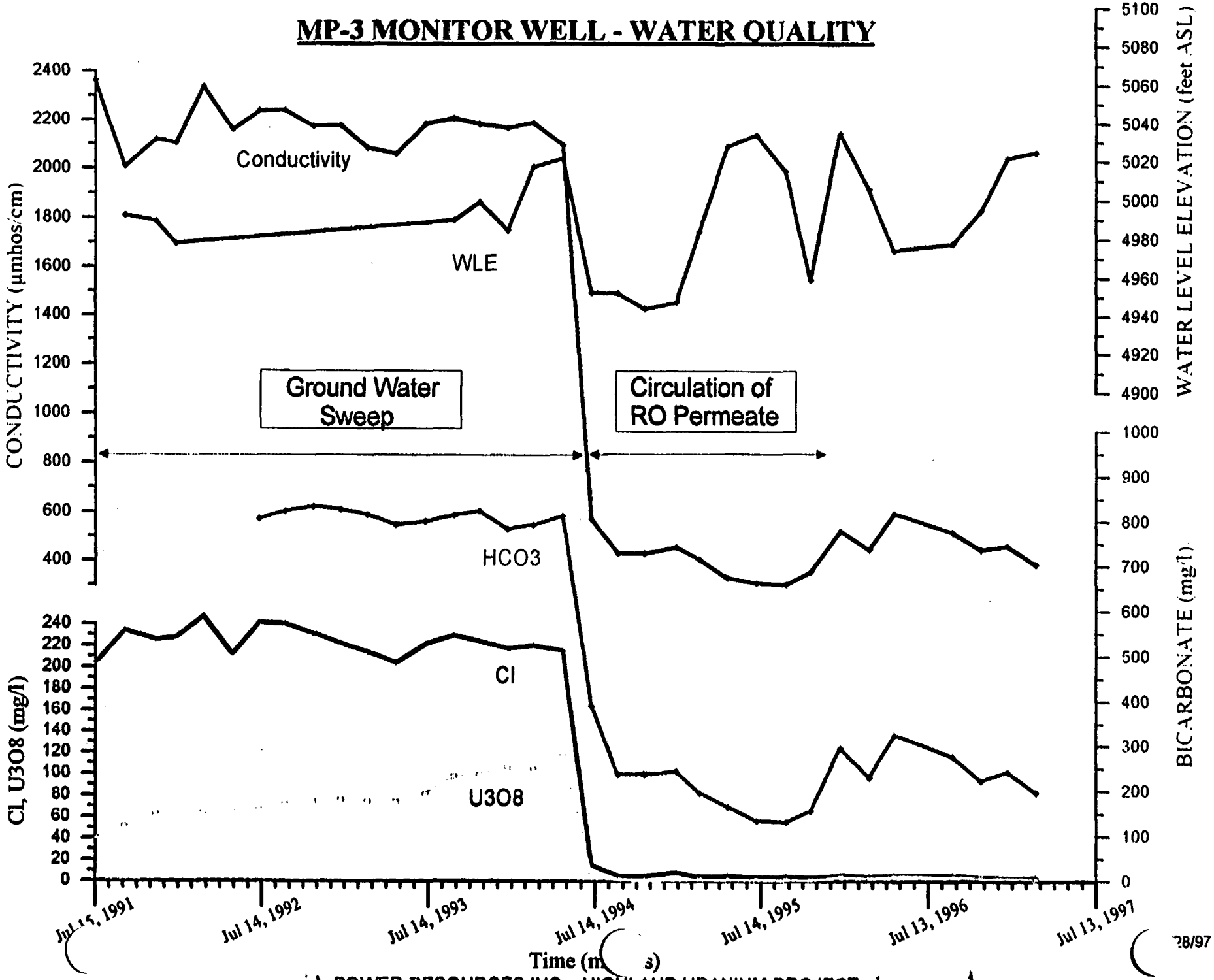
MP-5 MONITOR WELL - WATER QUALITY



05/28/97

POWER RESOURCES INC., HIGHLAND URANIUM PROJECT

MP-3 MONITOR WELL - WATER QUALITY

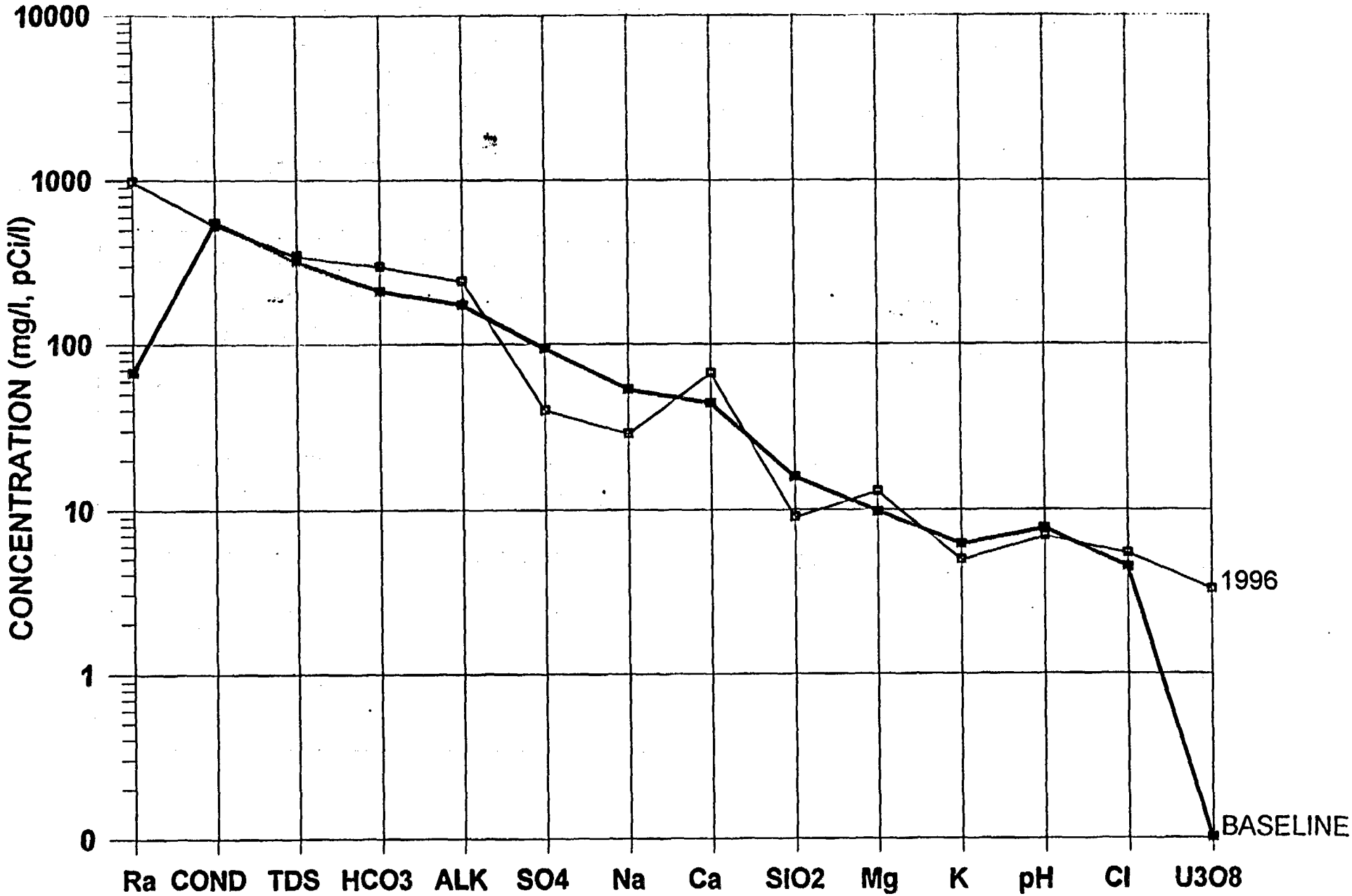


POWER RESOURCES INC., HIGHLAND URANIUM PROJECT

28/97

Monitor Well MP-3, Annt Guideline 8 Analyses

Concentration of Major Ion Species, Radium & Uranium



Highland Uranium Project - Injection of RO Permeate in The 'A' Wellfield

Inside Pattern Areas:

- Very Effective in Reducing Most Parameters to a Level at or Near Baseline
- Higher Flow Rates Than GWS
- Lower Consumptive Use of Ground Water Than GWS
- Lower Operating Costs Due to Newer Technology (Thin Film Membranes)

Plume Area:

- Needed to Install Additional Wells
- Slower Response Than RO Within Patterns (Fewer Wells, Longer Flow Lengths)
- Dissolution of Calcite May Sustain Dissolved Bicarbonate Levels (Temporarily)
- Dissolution of Iron Causes Filtration Problems

Conclusions on Effectiveness of RO:

- More Efficient Than Ground Water Sweep in Flushing the Aquifer
- Should Have Been Utilized Earlier
- Restoration Would Have Been Complete by Now if B4 / B17 Patterns Had Not Been Installed Next to a Hole in The Aquitard And Resulted in a Plume

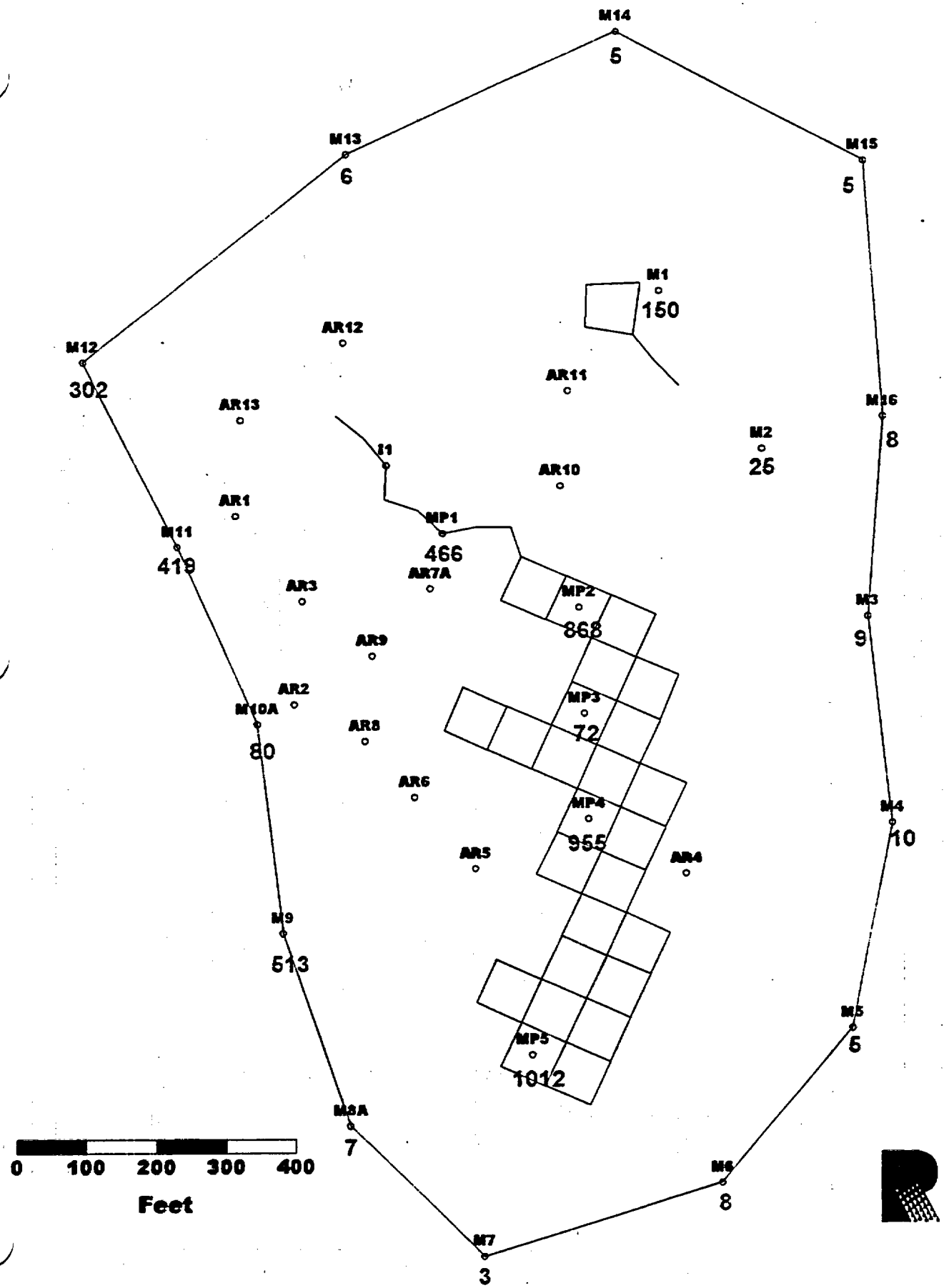
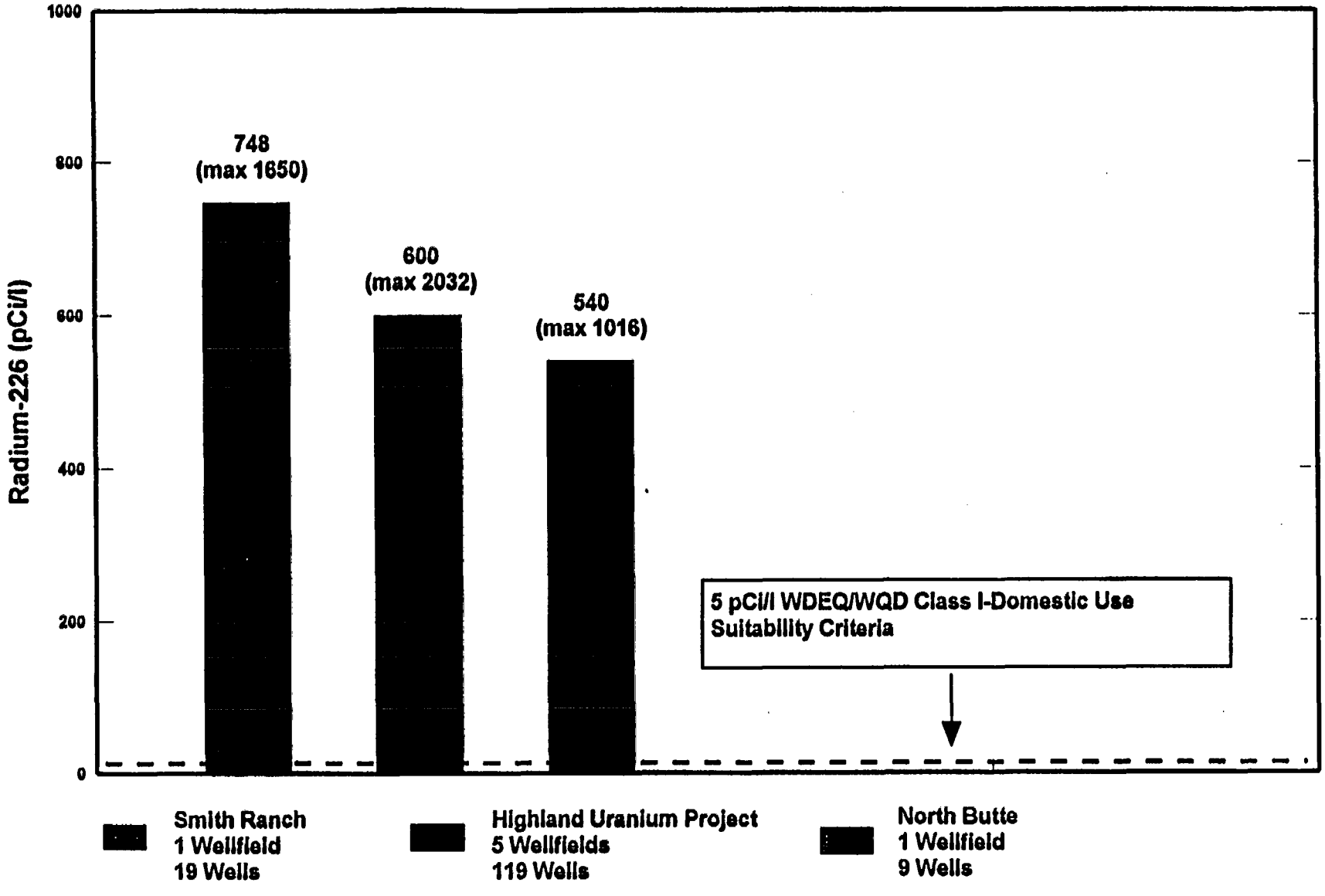


Figure.2., A-Wellfield Map Showing Baseline Radium Values (pCi/l)

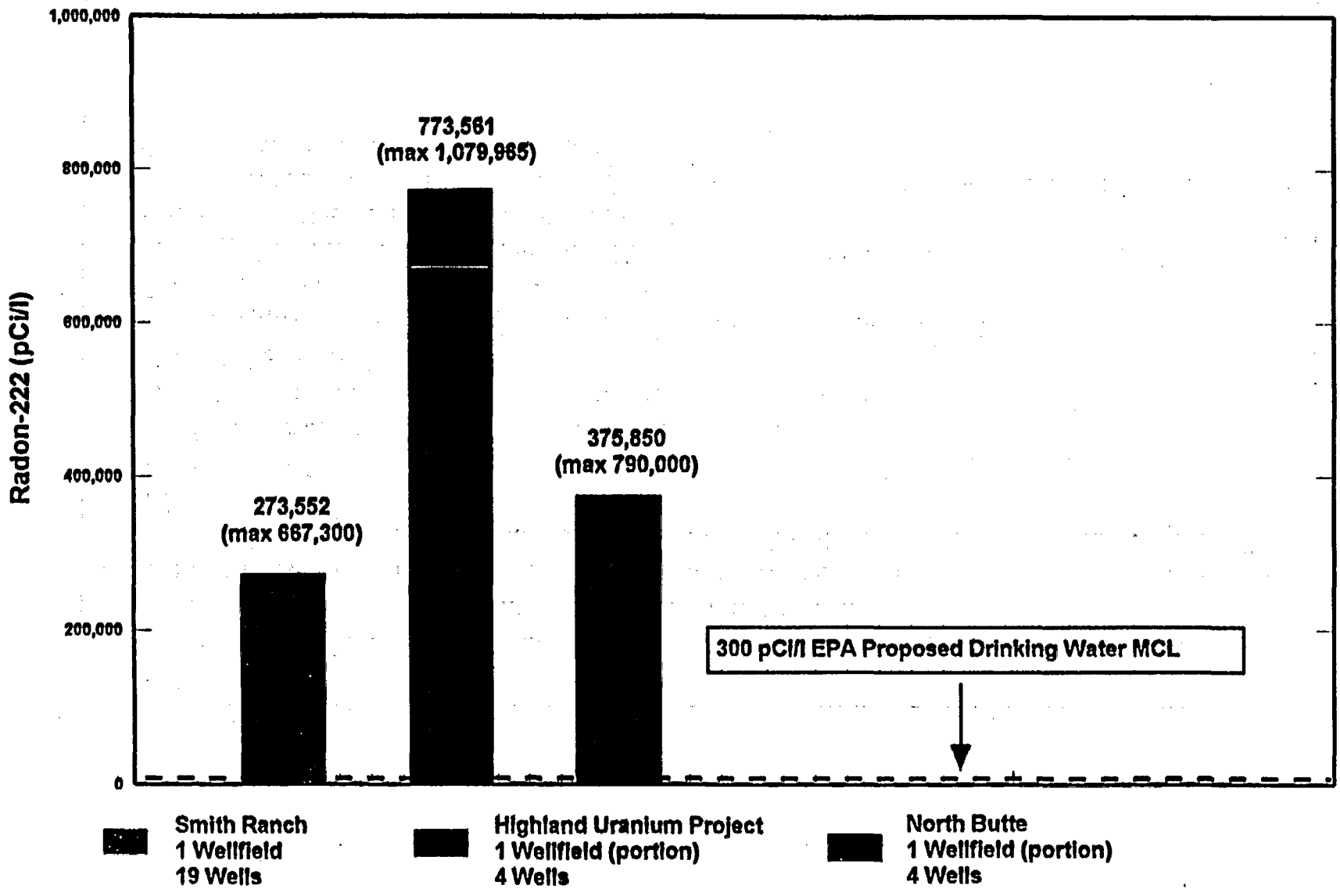
MEAN BACKGROUND RADIUM-226 CONCENTRATION

In Ground Water within the Production Zone at 3 Wyoming In Situ Sites



MEAN BACKGROUND RADON-222 CONCENTRATIONS

In Ground Water within the Production Zone at 3 Wyoming In Situ Sites



Highland Uranium Project - Conclusions From Restoration Experience to Date

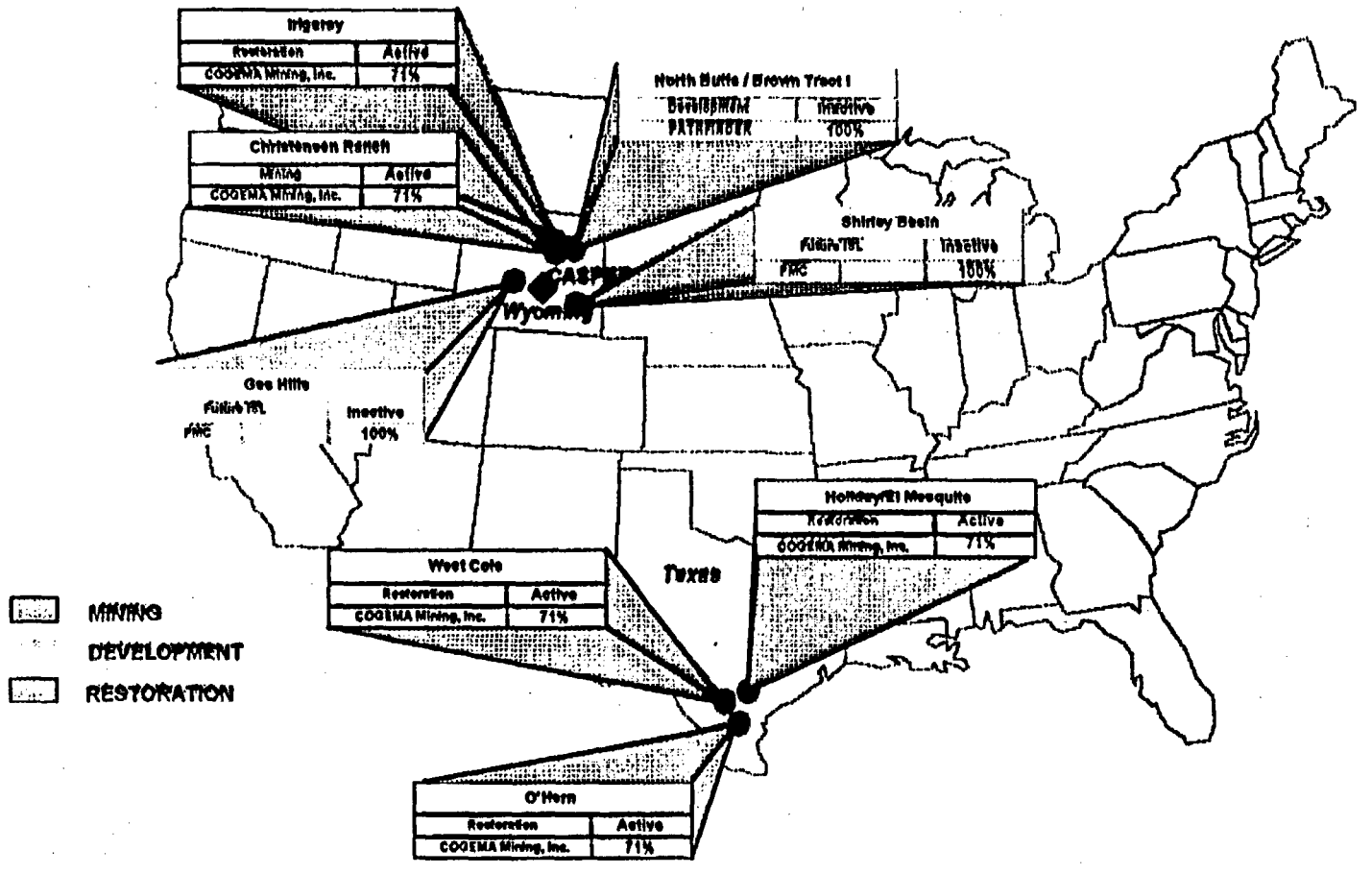
- Ground Water in These Uranium Orebodies is Excluded From Any Use by The Naturally High Concentrations of Radionuclides (Radium and Radon)
- Although Treatment for Radium is Possible, it is not Practicable, Nor Desirable, to Treat The Ground Water in These Uranium Orebodies and Therefore it has no Use Other Than In Situ Mining
- Restoration of Non-Toxic Parameters to Baseline Concentrations (e.g. HCO_3, Cl, SO_4) is Not Realistic Nor Justifiable on The Basis of Health Risk
- From Pre- And Post-Mining Evidence, There is no Significant Migration of Dissolved Radium Beyond the Orebody
- Where Appropriate, Early Injection of RO Permeate Can be More Effective Than an Extended "Phase 1" Period of Ground Water Sweep
- Prolonged Ground Water Sweep May Cause Unnecessary Migration of Mining Fluids and , in Some Cases, Result in More Harm Than Good
- Ground Water Restoration is Most Effective When Actively Managed on a Daily Basis in The Same Manner as Production Wellfields

United States
Nuclear Regulatory Commission

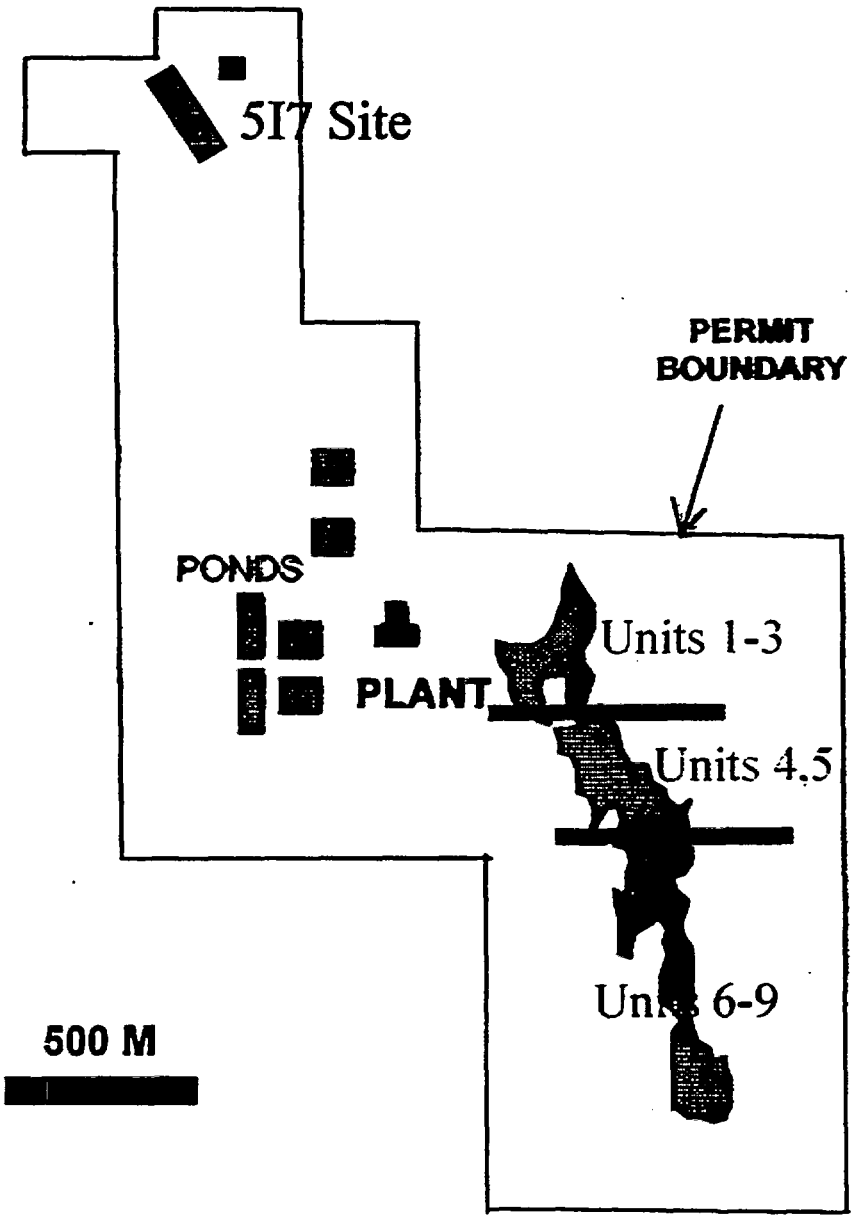
Industry Experiences-
ISL Groundwater Restoration

Donna L. Whichers
COGEMA Mining, Inc.

COGEMA
United States Mining Operations

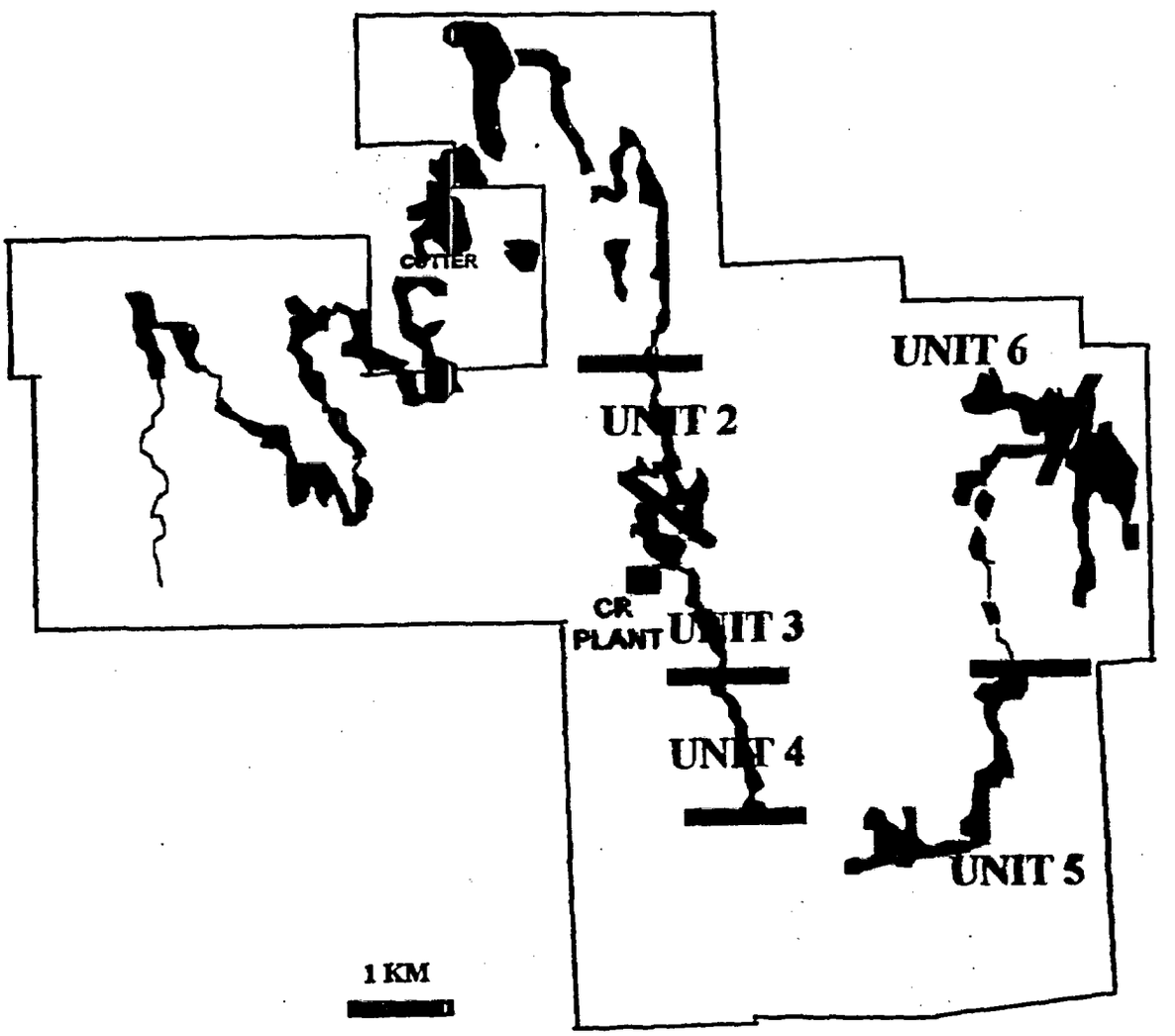


IRIGARAY MINE



COGEMA
Mining, Inc.

CHRISTENSEN MINE



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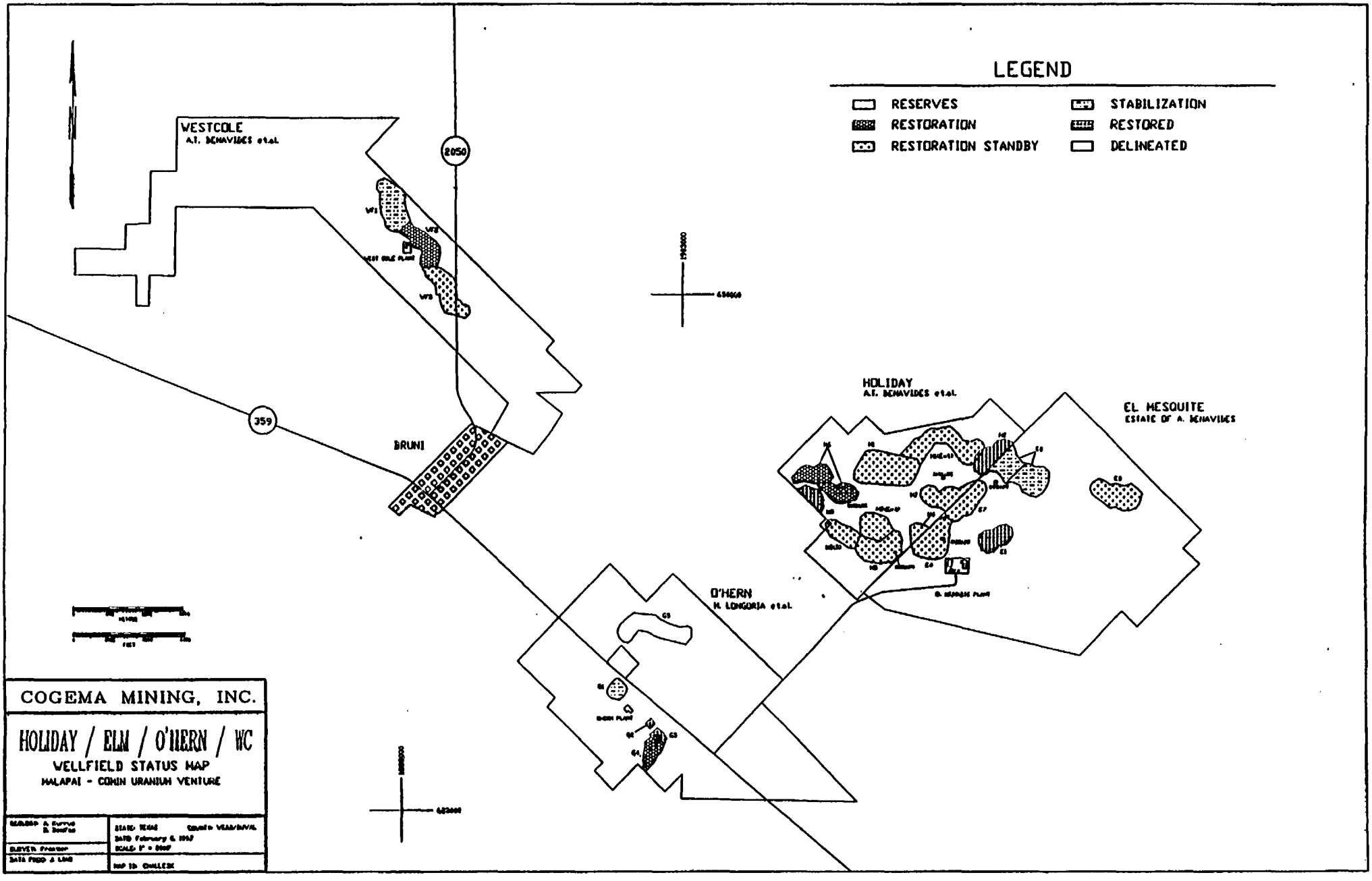
LEGEND
RESERVES
RESTORATION
RESTORATION STANDBY
STABILIZATION
RESTORED
DELINEATED
WESTCOLE
A.I. BENAVIDES et.al.
2050
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COGEMA MINING, INC.
HOLIDAY / ELM / O'HERN / WC
WELLFIELD STATUS MAP
MALAPAI - COMIN URANIUM VENTURE

RESTORATION DEFINITIONS

Goal of Restoration:

Pursuant to NRC License - restore to baseline. Pursuant to Wyoming regulations - restore to baseline; if baseline cannot be met, then restore to use classification using BPT. Pursuant to Wyoming Statutes - restore to quality of use using BPT.

Groundwater Sweep (GWS):

Involves the recovery of groundwater from the wellfield with no re-injection of solutions (100% consumptive removal). Typically creates large volumes of groundwater that must be disposed of through treatment and NPDES discharge, irrigation, evaporation in lined ponds or injection into a disposal well. Typically the first step in groundwater restoration.

Cleanwater Sweep:

Consists of the treatment of the groundwater recovered from a wellfield using any of the following treatments and the subsequent injection of the clean water fraction back into the wellfield.

- Reverse Osmosis, 70:30 to 90:10
- Lime Softening
- Freshwater injection
- others, or any combinatio of the above

Reductant:

A chemical treatment of the circulating groundwater that removes oxygen; helps to bring the aquifer back to the naturally reducing state prior to mining (introduction of oxygen). Good for precipitating metals. H2S, sulfites, etc.

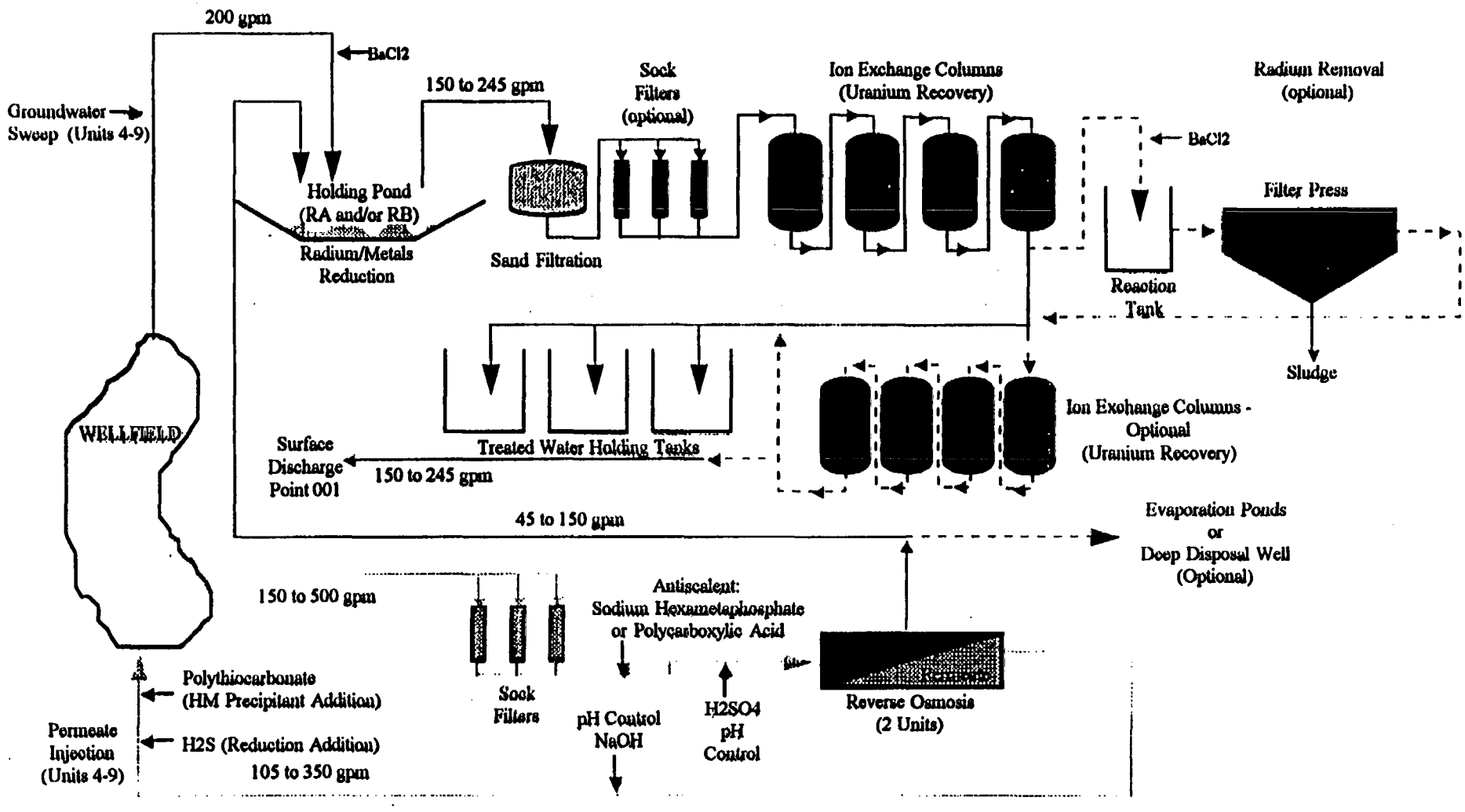
Pore Volume (PV):

An estimate of the volume of aquifer water within the wellfield that has been affected by mining.

WY: WA x AT (20% for horizontal flare, 20% for vertical flare) x porosity

TX: WA + 20' x AT + 10' (5' above, 5' below) x porosity

Pore volume displacement (PVD) is essentially the removal of one pore volume of groundwater from the aquifer.

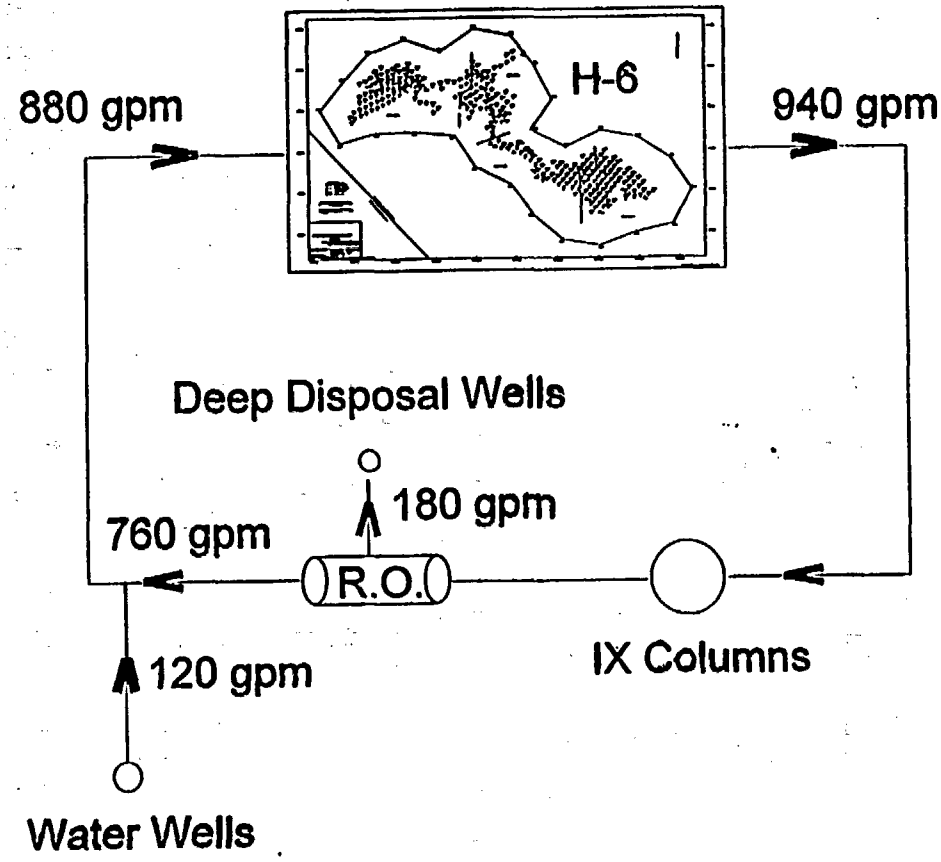


Groundwater Sweep and Treatment for Surface Discharge; Includes Brine from Reverse Osmosis Treatment

Permeate Injection

COGEMA Mining, Inc.	
CHRISTENSEN MINE TYPICAL RESTORATION PROCESS FLOW DIAGRAM	
DATE: 9/5/96	RE

Flow Schematic for a Typical Restoration Wellfield



IRIGARAY - 517

HISTORY

1. Three (3) large 5-spot patterns
2. Mined with ammonium bicarbonate: 1975-77
3. Tried combination of various treatment methods targeted at ammonium reversal.
4. Restoration: 1988

RESTORATION SUMMARY

PVD	Restoration Process
1.7	Mg lixiviant - exchange Mg with NH_4
1.8	TDS reduction - lime softening to remove HCO_3, Mg, Ca
0.5	Uranium reduction - high pH sweep to reduce uranium (precip. as insoluble calcium diurante), possibly radium
2.0	TDS reduction - R.O.
0.2	Final GWS
6.2	TOTAL

DETERMINATIONS

- 4.5 PVD of treatment for parameters other than NH_4
  - 45% R.O.
  - 40% Lime Softener
  - 11% High pH Flush
  - 4% GWS

- Parameters restored to essentially baseline - 63%:
  TDS, Na, SO_4, CO_3, NO_2, SiO_2, pH, Al, As, Ba, B, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Mo, Ni, V, Zn

- Parameters not restored to baseline, within WY Class I Drinking Water - 31%:
  Ca, Mg, HCO_3, Cl, F, Tot. Alk., U, Se, NO_3, Cond., K

- Exceeds Baseline, Class I Standards - 6%:
  NH_4, Ra-226

	Class I	Baseline	Restored	Mining
Ra-226 (pCi/l)	5.0	26.8	146.0	1370.0
NH_4 (mg/l)	0.5	<1.0	19.0	400.0
			50.0 (Target Value)	

IRIGARAY - E-Field

HISTORY

1. 12 patterns mined with sodium bicarbonate: 1980
2. Restoration 1: 1981
3. Restoration 2: 1984-85

RESTORATION SUMMARY

Restoration 1

PVD	Restoration Process
7.8	Clean water recycle utilizing ion exchange Anion exchange: Cl, SO_4, HCO_3, Uranium Cation exchange: Ca, Mg, Na, etc. High pH adjustment prior to injection Circulation

Class of use met on all parameters; baseline not met. Restoration not accepted by State of Wyoming. Said BPT was not used.

Restoration 2

PVD	Restoration Process
5.0	Reverse Osmosis Treatment
12.8	TOTAL

DETERMINATIONS

- Steady-state condition for conductivity approached after 3.5 PVD of R.O. treatment. Minimal change seen after next 1.5 PVD of Reverse Osmosis treatment.

- Parameters restored to baseline - 83%:
  Ca, Mg, Na, K, CO_3, SO_4, NO_3, TDS, pH, As, Ba, B, Cd, Cr, Cu, Fe, Pb, Hg, Mo, Ni, Se, V, Zn, NH_4, Ra-226

- Parameters not restored to baseline, within WY Class I Drinking Water - 17%:
  HCO_3, Cl, F, U, Mn

- Exceeds Baseline and Class of Use - 0%:
  None

IRIGARAY UNITS 1 THROUGH 3

HISTORY

1. Operated on and off for four different episodes of mining, with downtime between episodes as long as 5 years, by four different operators: 1978-1990
2. 61 patterns mined with ammonium bicarbonate, sodium bicarbonate, CO_2, hydrogen peroxide, oxygen, pH ranges from 6.0 to 9.5.
3. Severe formation damage assumed by prolonged operations and calcite cementation.
4. First in situ mine in Wyoming licensed for commercial operations beginning in 1978.
5. Restoration: 1990-93

RESTORATION SUMMARY

PVD	Restoration Process
3.0	Groundwater Sweep
10.0	Reverse Osmosis
2.0	Reverse Osmosis with H_2S gas (reductant)
1.0	Recirculation
16.0	TOTAL

DETERMINATIONS

- Parameters restored to essentially baseline - 69%:
  Mg, K, SO_4, Cl, NO_2, NO_3, F, SiO_2, pH, Al, As, Ba, B, Cd, Cr, Cu, Fe, Pb, Hg, Mo, Ni, Se, V, Zn

- Parameters not restored to baseline, within Target Values or Class of Use -26%:
  Ca, Na, HCO_3, Cl, NH_4, Cond., Tot. Alk., U, Mn

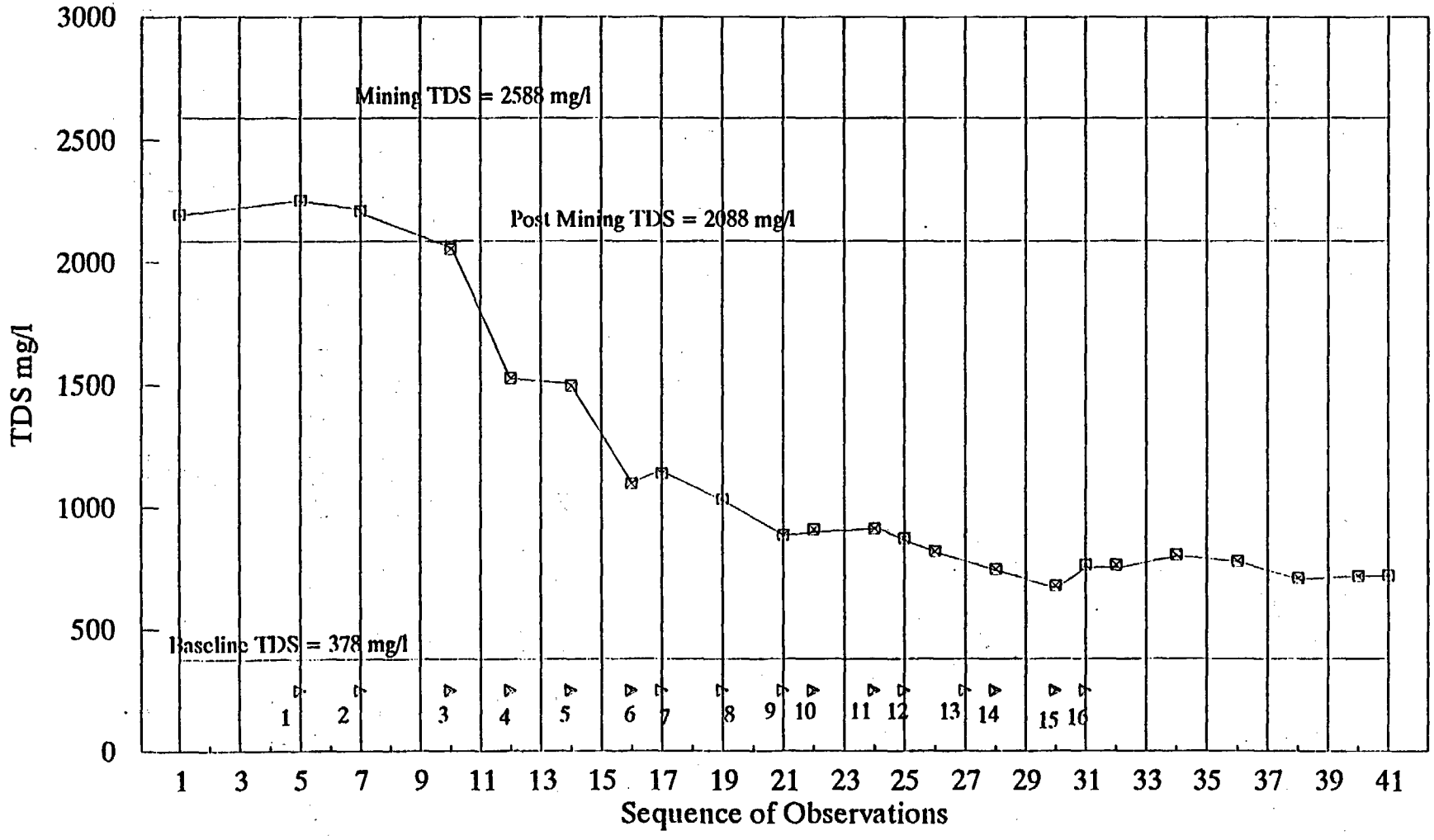
- Parameters Exceeding Baseline and Class of Use - 5%:
  TDS, Ra-226

	Class I	Baseline	Restored
Ra-226 (pCi/l)	5.0	39.3	141
TDS (mg/l)	500.0	378.0	741

- Only an 8% reduction in TDS seen in the 3 PVD of GWS (2198 mg/l to 2054 mg/l) - baseline is 378 mg/l.
- Believe that initial affected area may have been larger than originally anticipat
- PVDs No. 6, 9, 10, 11 and 12 (5 PVD) almost ineffective in reducing TDS level
- Final circulation felt to be unnecessary.

COGEMA Mining, Inc. – Irigaray Production Units 1–3 ORE ZONE Restoration Wells

Total Dissolved Solids Summary



Units 1–3 Mean TDS During Restoration Pore Volumes Displaced

CHRISTENSEN WILLOW CREEK R & D

HISTORY

1. Two (2) patterns mined with sodium bicarbonate: 1986
2. Restoration: 1987
3. Used as demonstration for Christensen License application

RESTORATION SUMMARY

PVD	Restoration Process
8.4	Groundwater Sweep
3.3	Reverse Osmosis
1.0	H_2S gas (reductant)
0.4	Recirculation
13.1	TOTAL

DETERMINATIONS

- Achieved an 83% reduction towards goal of 425 mg/l TDS after 8.4 PVD of GWS (2406 mg/l to 776 mg/l). However, left with reducing the 776 mg/l by 55% to reach 425 mg/l.

- Parameters restored to baseline - 65%:
  Ca, Mg, K, CO_3, NO_3, NO_2, F, SiO_2, pH, Al, Ba, B, Cd, Cr, Cu, Pb, Hg, Mo, Ni, V, Zn, NH_4

- Parameters not restored to baseline, within WY Class of Use (I) - 30%:
  HCO_3, Na, Cond., Tot. Alk., SO_4, As, Se, Fe, U, Mn

- Exceeds Baseline and Class of Use (I) - 5%:
  TDS, Ra-226

	Class I	Baseline	Restored
Ra-226 (pCi/l)	5.0	73.2	142 (average)
TDS (mg/l)	500.0	425.0	572 (last stability sample)

TEXAS - EL MESQUITE E2 WELLFIELD

HISTORY

1. Mined with sodium bicarbonate.
2. Placed in restoration in 1986, completed in 1996.

RESTORATION SUMMARY

PVD	Restoration Process
2.4	GWS (1986 to 1992)
2.1	Reverse osmosis permeate injection (1992 to 1993)
1.1	GWS (1993 to 1995)
0.8	Reverse osmosis + freshwater sweep (May 1995 to December 1995)
6.4	TOTAL

DETERMINATIONS

- Parameters restored to essentially baseline - 54%:
  K, SO_4, CO_3, NO_3, SiO_2, pH, Cl, F, As, Cd, Fe, Pb, Hg, NH_4

- Parameters not restored to baseline, within Texas Drinking Water - 38%:
  Ca, Mg, Na, HCO_3, TDS, Tot. Alk., Mn, U, Mo

- Exceeds Baseline and Drinking Water Standards - 8%:
  Se, Ra-226

	TX DW	Baseline	Restored
Ra-226 (pCi/l)	5.0	22.6	44.0
Se (mg/l)	0.05	.003	.08

TEXAS - HOLIDAY H2 WELLFIELD

HISTORY

1. Mined with sodium bicarbonate.
2. Placed in restoration in 1986, completed in 1995.

RESTORATION SUMMARY

PVD	Restoration Process
3.0	GWS (1986 to 1992)
1.5	Reverse osmosis permeate injection (1992 to 1993)
1.0	GWS (1993 to 1995)
0.5	Reverse osmosis + freshwater sweep (March 1995 to May 1995)
6.0	TOTAL

DETERMINATIONS

- Parameters restored to essentially baseline - 65%:
  K, SO_4, CO_3, NO_3, SiO_2, pH, Cl, F, As, Cd, Fe, Pb, Mn, Hg, NH_4, Mo, Ra-226

- Parameters not restored to baseline, within Texas Drinking Water - 35%:
  Ca, Mg, Na, HCO_3, TDS, Cond., Tot. Alk., Se, U

- Exceeds Baseline and Drinking Water Standards - 0%:

TEXAS - WEST COLE WELLFIELD 1 (WF1)

HISTORY

1. Mined with sodium bicarbonate.
2. Placed in restoration in 1989, completed in 1996.

RESTORATION SUMMARY

PVD	Restoration Process
4.0	GWS
3.7	Reverse osmosis permeate injection
3.0	Reverse osmosis + freshwater injection
10.7	TOTAL

DETERMINATIONS

- Parameters restored to essentially baseline - 62%:
  K, SO_4, CO_3, NO_3, SiO_2, pH, Cl, F, As, Cd, Fe, Pb, Mn, Hg, NH_4, Ra-226

- Parameters not restored to baseline, within Texas Drinking Water - 38%:
  Ca, Mg, Na, HCO_3, TDS, Cond., Tot. Alk., Se, U, Mo

- Exceeds Baseline and Drinking Water Standards - 0%:

TEXAS - O'HERN GRID 3 WELLFIELD

HISTORY

1. Mined 1977 to 1986
2. Placed in restoration in 1989, completed in 1996.

RESTORATION SUMMARY

PVD	Restoration Process
6.3	GWS (1989 to 1995)
3.4	Reverse osmosis permeate injection (June 1995 to February 1996)
9.7	TOTAL

DETERMINATIONS

- All parameters were restored to essentially baseline.
- High high baseline values; one of first wellfields installed and operated.

RESTORATION SUMMARY - ALL WELLFIELDS

Wellfield	PVD GWS	PVD Cleanwater Sweep	PVD Reductant	PVD Recirculation	TOTAL PVD	% Parameters Meeting Baseline	% Parameters Meeting Drinking Water	% Parameters Exceeding Both
Wyoming 5I7	0.2	4.3	0	1.7	6.2	63	31	6
E-Field	0	12.8	0	Included	12.8	83	17	0
CR R & D	8.4	3.3	1.0	0.4	13.1	65	30	5
IR 1-3	3.0	10.0	2.0	1.0	16.0	69	26	5
Texas E2	3.5	3.2	0	0	6.4	54	38	8
H2	4.0	2.0	0	0	6.0	65	35	0
WF1	4.0	6.7	0	0	10.7	62	38	0
G3	6.3	3.4	0	0	9.7	100	-	-
AVERAGE	3.7*	5.7*	0.4	0.4	10.0			

*Feel that 5 PVD of cleanwater sweep is the most effective restoration technique, with 1 to 2 PVD of GWS = 6 to 7 PVD. Many of the PVD shown in the table were not effective at lowering water quality values.

CONCLUSIONS

1. Effectiveness of groundwater restoration, when attempting to reach baseline conditions, appears to be dependent upon the treatment of recovered groundwater and the re-injection of a better quality water (clean water sweep). Accomplished with reverse osmosis treatement, lime softening or freshwater injection.

2. Generally speaking, at our operations it appears that from 3 to 5 PVD of clean water sweep are necessary to achieve economic restoration, or ALARA. Feel that GWS, should be limited to 1 to 2 PVD, especially in areas where permeabilities are poor and disposal capabilities are limited. Appears that approximately 6 PVD is a reasonable number to use for restoration cost estimates.

3. Some amount of GWS appears necessary, but question the benefit when large volumes of water are consumed and disposed:
   - GWS causes severe water level drawdowns in low permeability formations, thus lowering head levels above the recovery well pumps making the recovery process very inefficient.
   - GWS creates very large volumes of groundwater that requires disposal; disposal methods are very limited (evap. ponds, deep well, NPDES, irrigation).

4. Difficulties have been encountered with restoring TDS due to sodium bicarbonate, the primary additive to the mining solution.

5. Management of the wellfield undergoing restoration is extremely important:
   - Must operate as if mining, with full injection pressure and maximum flow rates (assures contact with the same area mined).
   - Small amount of GWS with few wells over a long period of time is not as effective as operating the wellfield as was done during mining.
   - Requires monitoring PVDs from each pattern area operated to assure areas are cleaned equally.
   - Weekly production and restoration planning meetings have been very helpful to monitor progress.

6. If the groundwater is not suitable for any use other than mining due to elevated radium-226 levels, or radon-222 gas, why continue to require restoration to baseline levels or drinking water standards just because other parameters meet drinking water standards (TDS, etc.).

- Must use ALARA principle: take into account the state of technology (BPT), the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, in relation to utilization of nuclear energy and licensed materials in the public interest.

- Restoration must be performance-based; it make take 10 PVDs or 2 PVDs to return the groundwater to a condition that meets ALARA. Suggest using 6 PVD for planning and reclamation bonding purposes.

- Wyoming treatability limit for radium-226 of 100 pCi/l in otherwise "drinkable" water, because it can be treated with a home water softener, should be seriously scrutinized. Don't want ranchers doing their own treatment, creating gamma sources in their basements. Disregarding radium, water is still not usable due to high radon-222 levels.

7. Water Management

- Disposal of wastewater is the most critical process in the restoration program. The largest volume of wastewater are produced during restoration.
- Due to constraints on the amount of wastewater we can dispose of, need to look at ways to limit the consumption of groundwater during restoration.
- This is accomplished by limiting GWS doing more in-plant treatment, and managing the 'wellfield' as if in the mining phase.

CURRENT PROGRAM

WYOMING

- Former plan: 3 PVD GWS
  3 PVD RO permeate injection
  1 PVD recirculation
  7 TOTAL PVD

- Plan instituted 1995: 1 PVD GWS
  5 PVD RO permeate injection
  1 PVD recirculation
  7 TOTAL PVD

- Current Status, Irigaray:

  100% restoration - 30% of wellfields restored
  Remaining 70% in active restoration

- Current Status, Christensen:

  Two wellfields undergoing active restoration (40%)
  One wellfield in standby awaiting restoration (20%)
  Two wellfields undergoing mining (40%)

- Have just completed the construction of a new restoration plant at CR.

TEXAS

- Former plan: 3 PVD GWS
  3 PVD RO permeate injection
  6 TOTAL PVD

- Plan instituted 1995: 4 to 6 PVDs of combined GWS and FWI

- Current Status: 100% restoration - all 20 wellfields

  Six wellfields restored (30%)
  Four wellfields restored, in stability monitoring period (20%)
  Ten wellfields undergoing active restoration (50%)

United States
Nuclear Regulatory Commission

DOE Experience
Groundwater Compliance Title I

DOE Grand Junction Project Office

NRC/NMA Mini Ground Water Workshop

(Experience to Date)

by

Donald R. Metzler

U.S. Department of Energy

DOE Title I Approach to Groundwater Compliance

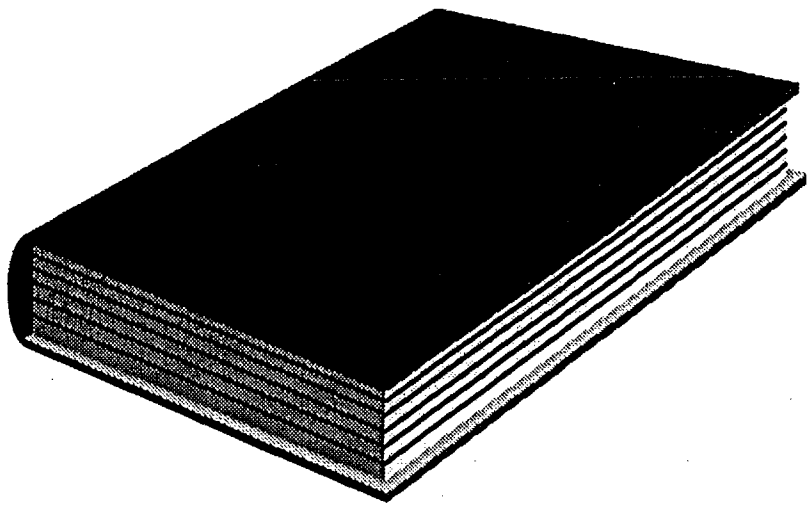
- Philosophy
  - Protect human health and the environment
  - Make informed objective decisions
  - Select cost - effective strategies
  - Involve stakeholders
  - Verify conceptual model using reasonable monitoring practices

Title I GW Logic Framework for Decision Making

- Goals:
  - Sound technical basis
  - Consistent from state to state and from tribe to tribe
  - Considers risk and cost
  - Couples risk based approach with prescriptive standards

Logic Framework

- Identified in the Final Groundwater PEIS October 1996
- found on DOE www.



40 CFR Part 192

- Provides for unique regulatory provisions in Subpart A, B, and C
  - Supplemental standards
  - Natural Flushing with Institutional Control
  - Alternate Concentration Limits

DOE has targeted many of the Title I sites for groundwater compliance based on these provisions.

Supplemental Standards Overview

- Purpose
- Criterion
- Implementing Supplemental Standards

Purpose

- Supplemental Standards may be applied as compliance actions under certain site conditions in lieu of prescriptive standards.
- Conditions must be protective of human health and the environment.

Criterion

- The criterion for applying supplemental standards addressing the residual contaminated groundwater are identified in 40 CFR Part 192.21 Subpart C.

Implementing Supplemental Standards

- May be granted if:
  - groundwater at a site is of limited use [192.11(e)] in the absence of contamination from residual materials; or
  - complete restoration would cause more environmental harm than it would prevent; or
  - complete restoration is technically impracticable from an engineering perspective.

Limited Use Groundwater

- Means groundwater that is not a current or potential source of drinking water
  - Because:
    - TDS > 10,000 mg/L; or
    - Widespread, ambient contamination not due to activities involving RRM, that cannot be cleaned up using treatment methods reasonably employed in public water systems; or
    - Sustained yield < 150 gpd

Natural Flushing

- Applicability
- Title I Targeted Sites
- Target Basis
- Data Needs
- Modeling
- Future Approach

Applicability

- Sites where groundwater currently exceeds EPA standards
- Sites where groundwater is not currently nor projected to be a drinking water resource
- Sites where advection, dispersion, and attenuation can achieve cleanup goals
- Meet EPA standards (MCLs or background) within 100 years

Target Title I Sites

- Durango, CO
- Grand Junction, CO *
- Gunnison, CO
- Naturita, CO
- Rifle, CO (2 sites) *
- Riverton, WY
- Slick Rock, CO (2 sites)

Basis for Targeted Strategy

- 13 years baseline monitoring period
- Constituents of concern, hydrologic and geochemical properties identified
- Preliminary analytical modeling
- Identification of data needs
- Revised modeling (numerical)

Identification of Data Needs

- Reduce uncertainties in conceptual model
  - Source term properties
  - Hydraulic conductivities
  - Flow gradient and direction
  - Retardation factors
  - Boundary conditions
  - Ecological considerations

Modeling

- Tool for assisting in identifying data uncertainties and sensitivities
- Predicting natural flushing duration to meet cleanup goals
- Build understanding of site flow and transport

Future Approach

- Site Observational Work Plans
- Remedial Action Plan modifications, or
- Groundwater Compliance Action Plans
- NRC Technical Evaluation Report
- NRC concurrence
- 100 year clock begins
- Transfer to LTSM program
- Verification monitoring

Institutional Controls

- An institutional control is defined by the EPA in 40 CFR Part 192, III. "Changes and Clarifications in Response to Comments"

Goals

- Least restrictive to property owners and general public
- Protective of public health and safety
- Enforceable, but flexible

Definition

- "Having a high degree of permanence and which will effectively protect public health and the environment and satisfy beneficial uses of the groundwater... and which is enforceable by the administrative or judicial branches of government entities."

Authority Under Local Government Jurisdiction

- County or city level
- Can restrict new water development
- Ordinance to require proof of potable water with a zone of contamination
- Case history - Rifle, CO

Authority Under State Government Jurisdiction

- Most states have control over their water sources
- Western states generally follow appropriation system of water law
- Most states have regulatory powers to restrict access to contaminated groundwater
- Case histories - Vitro (SLC) and Green River, UT

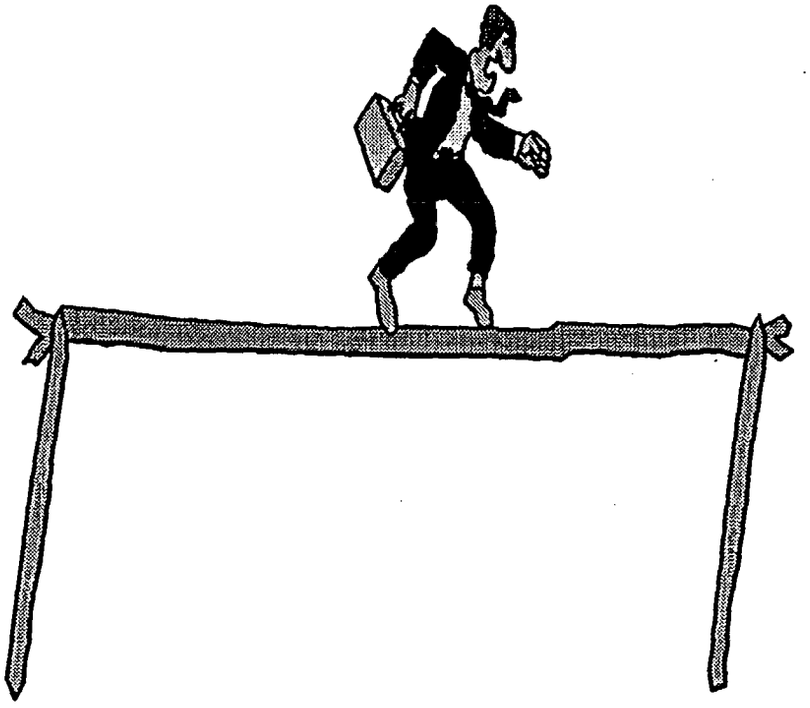
Authority Under Tribal Government Jurisdiction

- Many tribes have comprehensive water codes
  - govern the use of surface and groundwater
- Case history - Arapahoe-Shoshone Tribes, Riverton, WY

Authority Under Federal Jurisdiction

- The U.S. Department of Energy (DOE) could exercise its broad regulatory authority under Section 109 of the Uranium Mill Tailings Radiation Control Act (UMTRCA) to control access to the contaminated groundwater.

- An Approach to Balancing Dollars, Risk, and Perceptions



United States
Nuclear Regulatory Commission

ALARA Practices as Applied to ACL Reviews

NRC Uranium Recovery Branch

United States
Nuclear Regulatory Commission

ALARA PRACTICES AS APPLIED TO ACL REVIEWS

presented to

NRC/NMA Uranium Recovery Workshop

by

Michael Layton
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material Safety and Safeguards
June 5, 1997

10 CFR 20.1003 Definitions.

ALARA (acronym for "as low as is reasonably achievable") means making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

ALARA and ACLs

40 CFR 192.32 (a)(2)(iv) "..... after considering practicable corrective actions, these limits are *as low as reasonably achievable*, ..."

10 CFR 40, Appendix A, Criterion 5B(6) "Licensee must provide the basis for any proposed limits including consideration of practicable corrective actions, that limits are *as low as reasonably achievable*, and information on the factors the Commission must consider."

STAFF TECHNICAL POSITION

ALTERNATE CONCENTRATION LIMITS FOR TITLE II URANIUM MILLS

STANDARD FORMAT AND CONTENT GUIDE, AND STANDARD REVIEW PLAN FOR ALTERNATE CONCENTRATION LIMIT APPLICATIONS

JANUARY 1996

U.S. NUCLEAR REGULATORY COMMISSION

Point of Compliance - Location where hazardous constituents must be at or below the ground-water protection standards (background, MCL, ACL)

Point of Exposure - Location where hazardous constituent concentrations must be protective of human health and the environment, usually in reference to the perpetual care boundary.

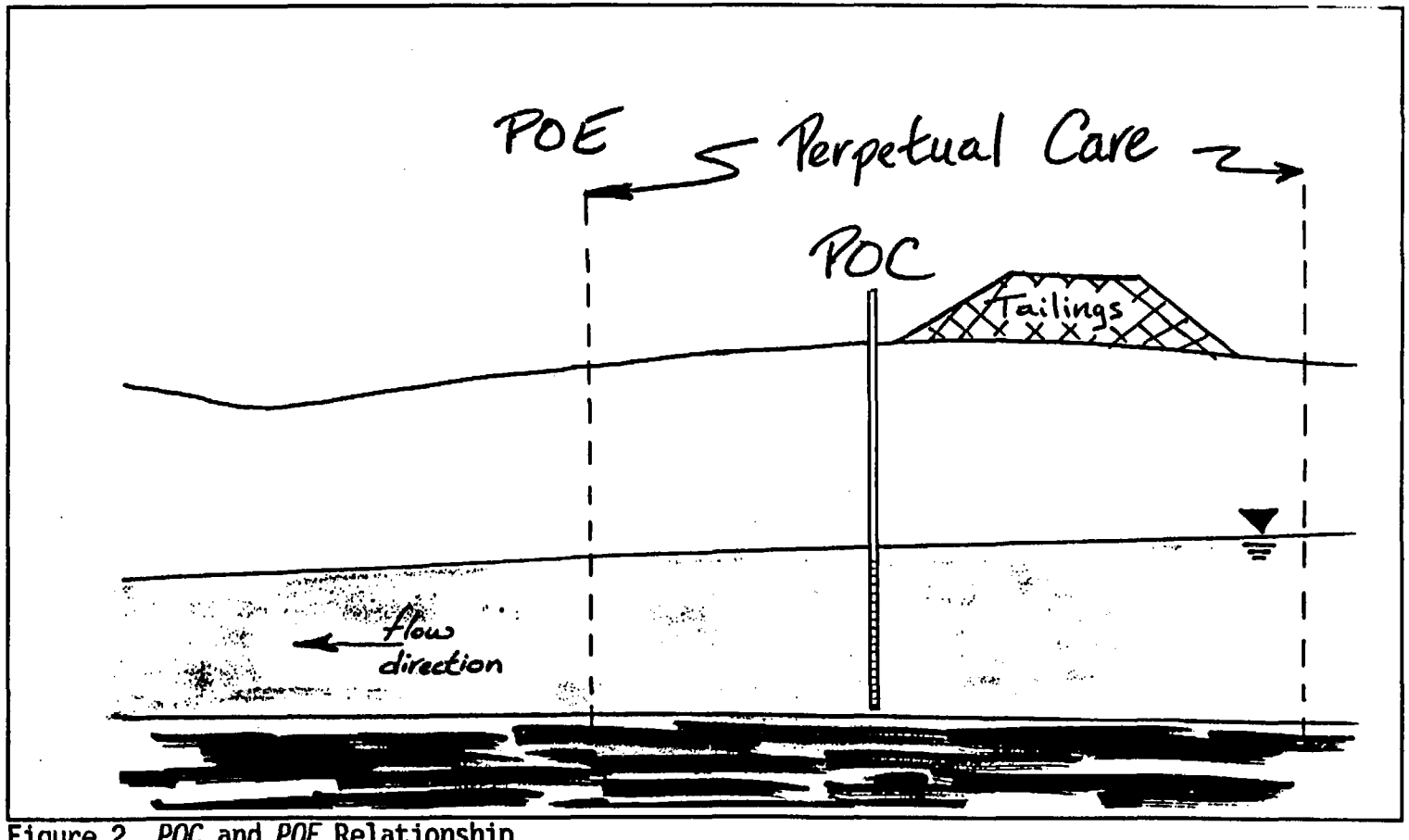


Figure 2 *POC* and *POE* Relationship

ALARA DEMONSTRATION

- Target Concentration Levels at the POE
- Corrective Action Assessment (Evaluation of Alternatives)
- Cost and Benefit Comparison of Practicable Alternatives

EXAMPLE
ALARA DEMONSTRATION

<u>The Situation</u> A hazardous constituent, chemical symbol M, exceeds the established standard (background) downgradient of licensed uranium mill tailings pile. An MCL does not exist for this constituent. The licensee established an approved Corrective Action Program and monitors the concentrations of M at several locations downgradient of the tailings pile.

EXAMPLE (continued)

<u>Target Concentration</u> The licensee's literature research identified the following characteristics for M:

- Potential human carcinogen with a Reference Dose (RfD) 0.05 mg/L
- Chemical toxicity in humans above 0.60 mg/kg
- Environmental toxicity - no data

The licensee calculated a target concentration for M, protective of human health and the environment, at the POE of 0.01 mg/L, based on threshold toxicity.

EXAMPLE (continued)

Is the ACL [based on the Target Concentration] *as low as is reasonably achievable* [considering practicable Corrective Actions] ?

EXAMPLE (continued)

<u>Corrective Action Assessment</u> **The licensee had previously performed an engineering feasibility evaluation for several corrective action alternatives to comply with Criterion 5D. Four alternatives were identified as engineering feasible for reducing concentrations of M to the standard in the license (background of 0.002 mg/L). Alternative 1 was selected for the current Corrective Action Program.**

EXAMPLE (concluded)

Cost and Benefit Comparison

Alternative 2: *COSTS*; Capital $500,000 O/M $1.75 per kgal
***BENEFITS*; reduce M to 0.02 mg/L at POC and 0.008 mg/L at the POE in 7 yrs**

Alternative 3: *COSTS*; Capital $750,000 O/M $1.25 per kgal
***BENEFITS*; reduce M to 0.015 mg/L at POC and 0.005 mg/L at POE in 10 yrs**

Alternative 4: *COSTS*; Capital $912,000 O/M $3.37 per kgal
***BENEFITS*; reduce M to 0.01 mg/L at POC and, 0.003 mg/L at POE in 20 yrs**

What is not an ALARA Demonstration:

- Only a narrative describing that the other corrective action alternatives are not economical.
- Presenting the economic analysis as the determination of appropriate engineering alternatives.
- Stating that the current concentration levels are ALARA because the CAP has reached a point of diminishing returns, and no analysis of what level is protective of human health and environment.

United States
Nuclear Regulatory Commission

Outlook for Groundwater Compliance at Uranium Mill Tailings Sites

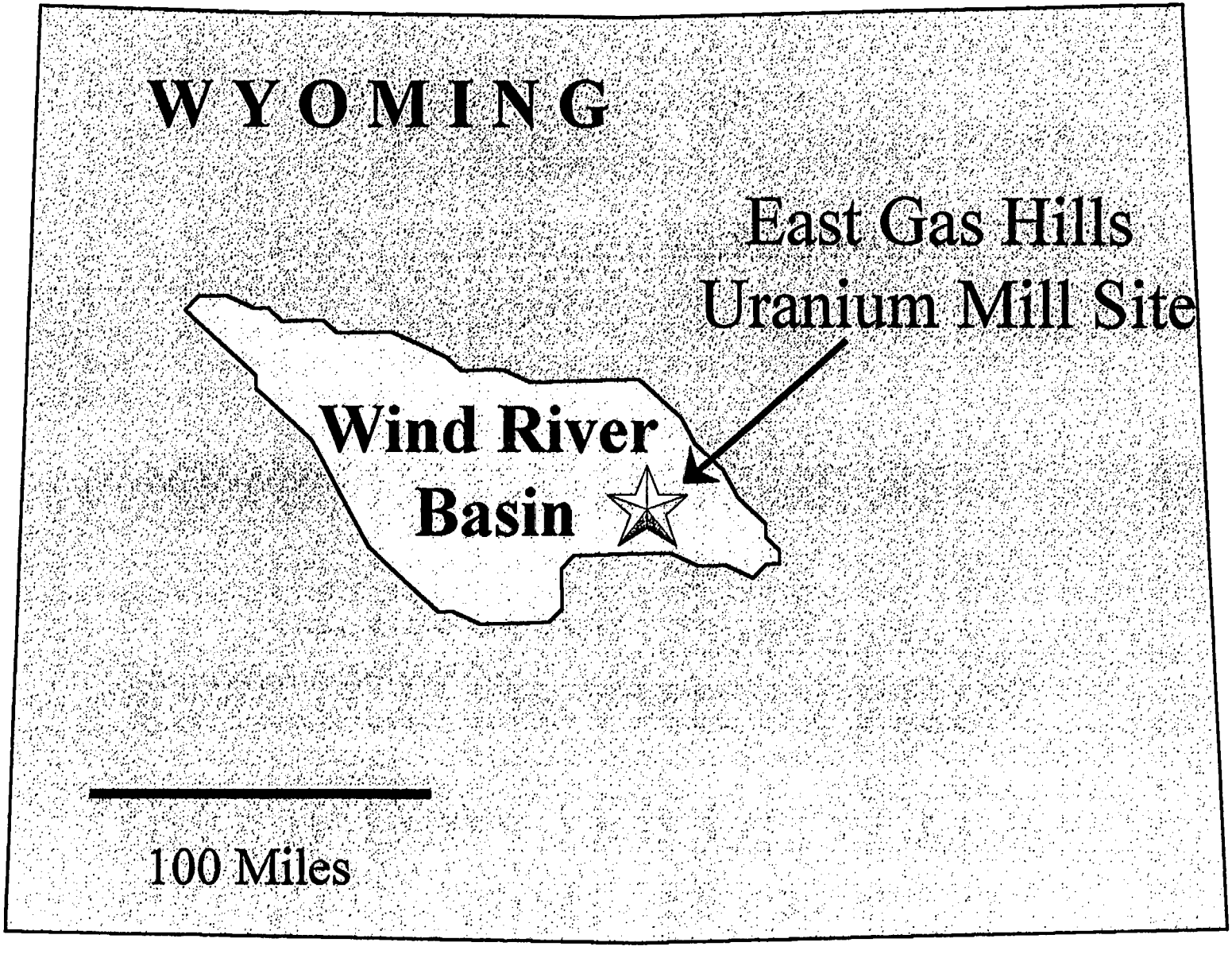
UMETCO

BACKGROUND/BASELINE GROUNDWATER QUALITY

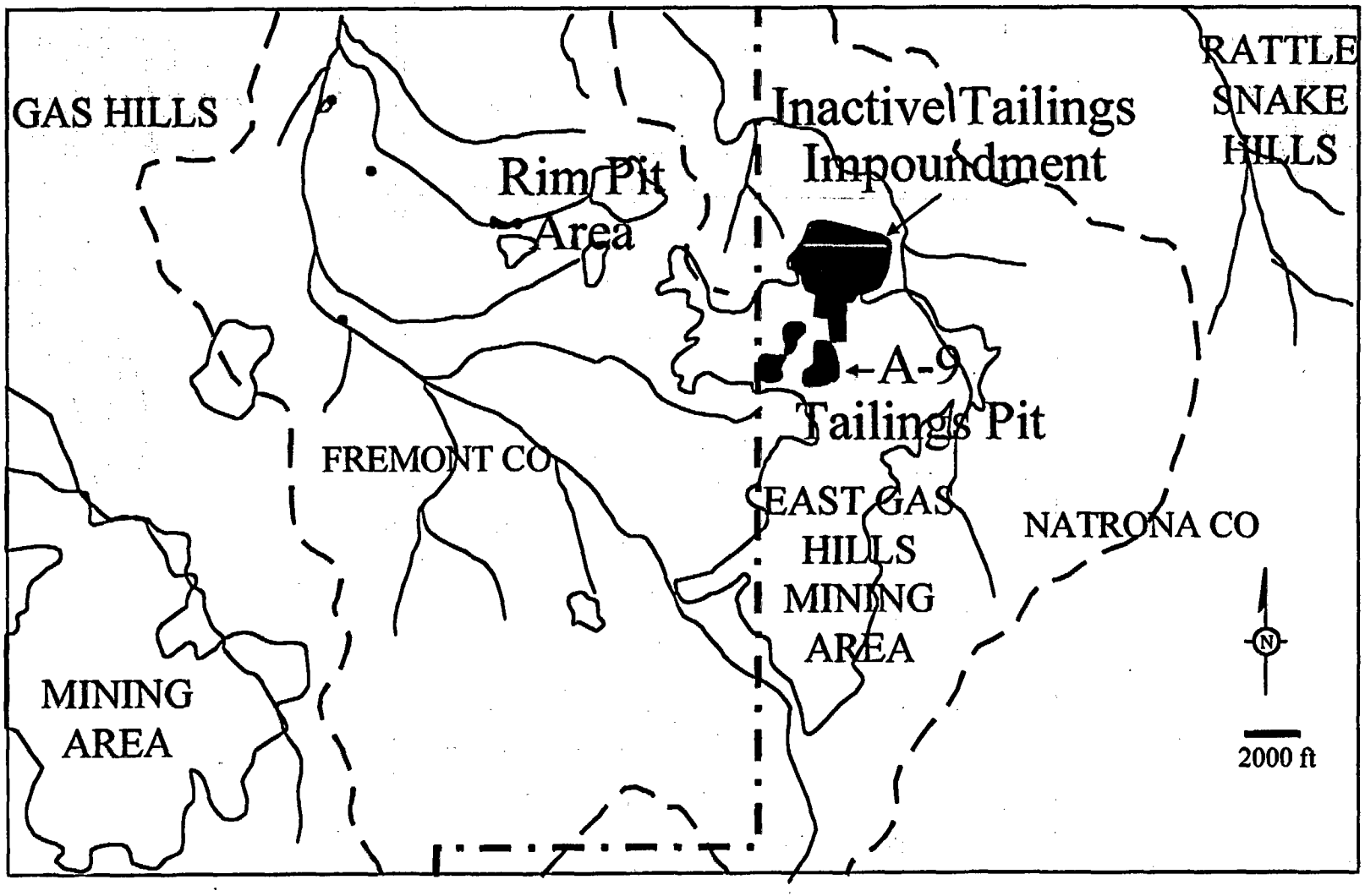
UMETCO URANIUM MILL TAILINGS SITE

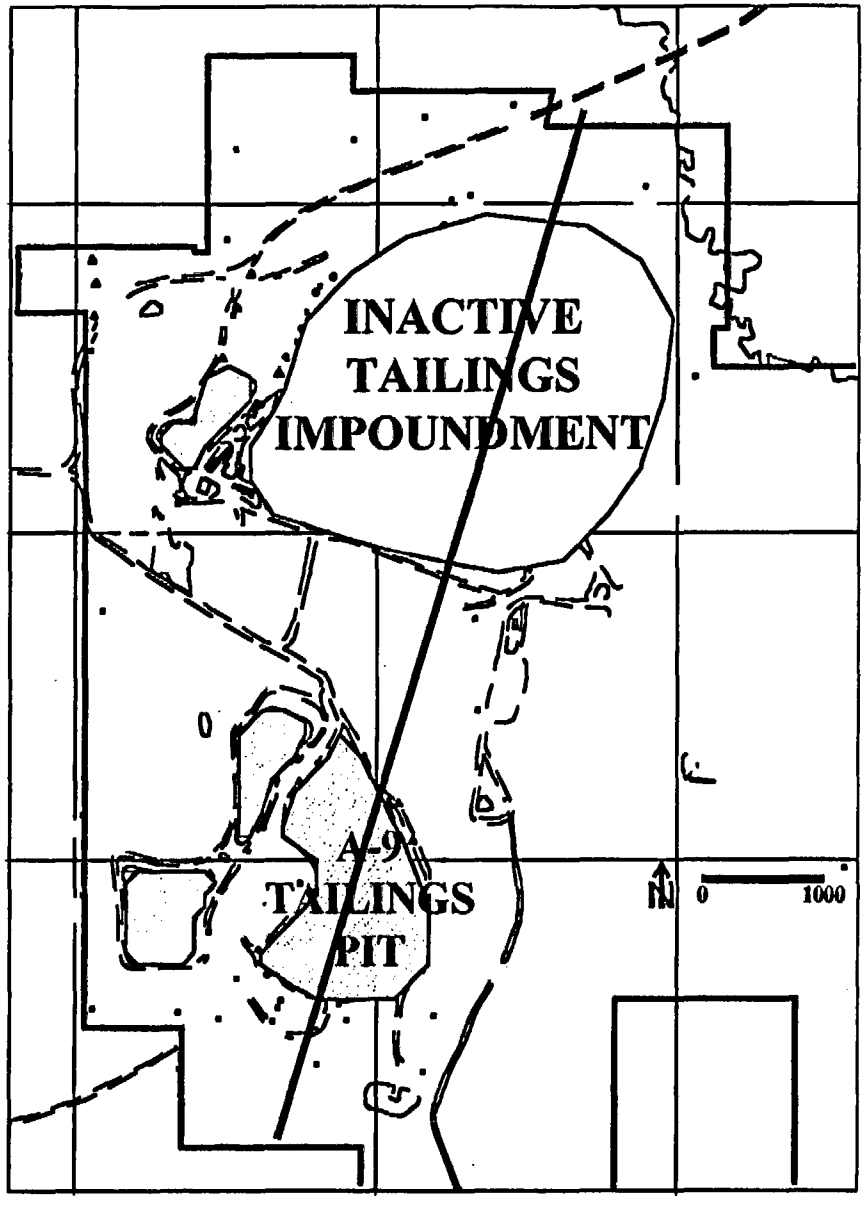
GAS HILLS, WYOMING

Presented by
Umetco Minerals Corporation
and
Yancey & Associates

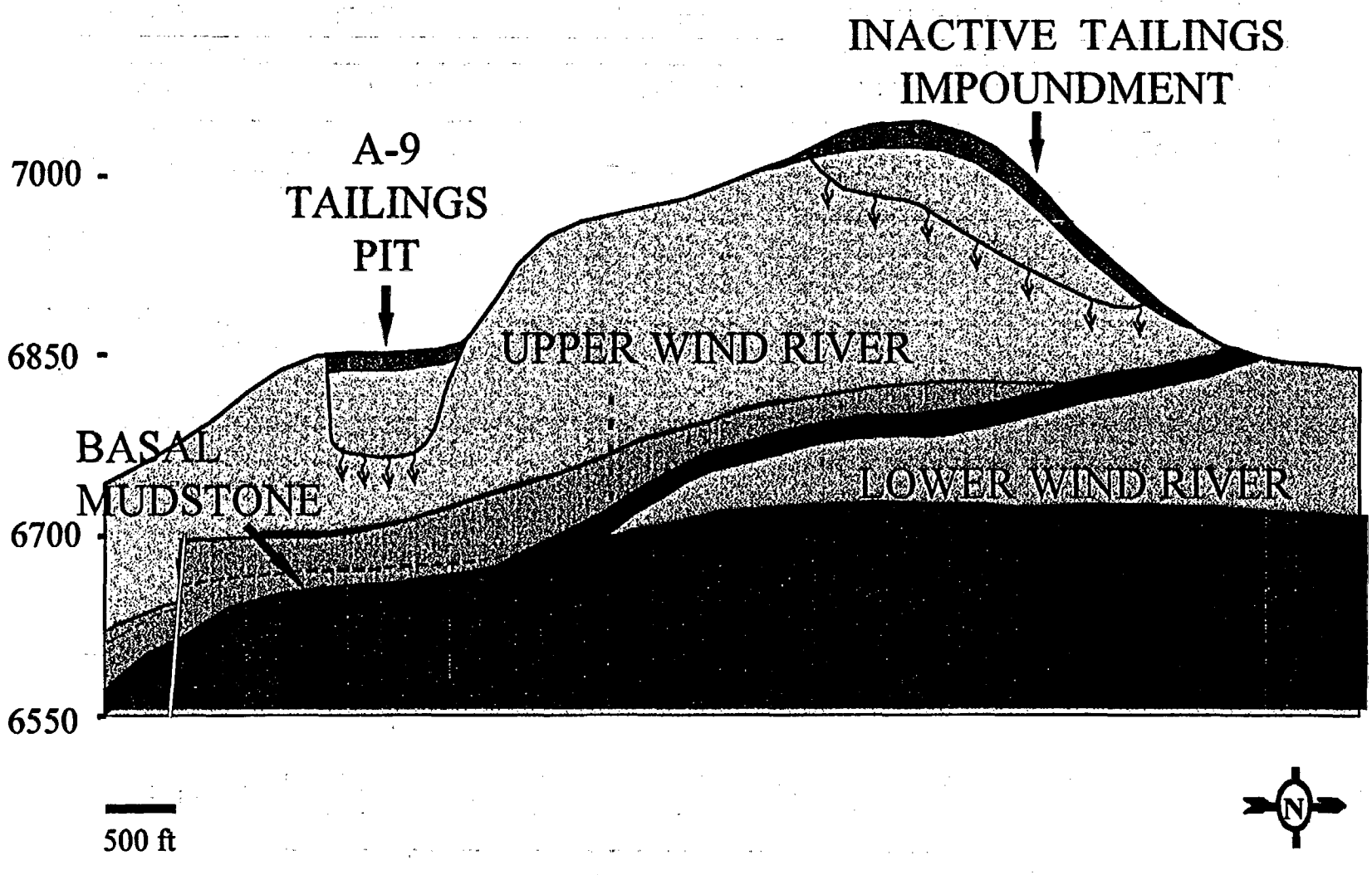

WYOMING
East Gas Hills
Uranium Mill Site
Wind River
Basin
100 Miles

LOCATION MAP
UMETCO URANIUM MILL SITE
GAS HILLS, WYOMING

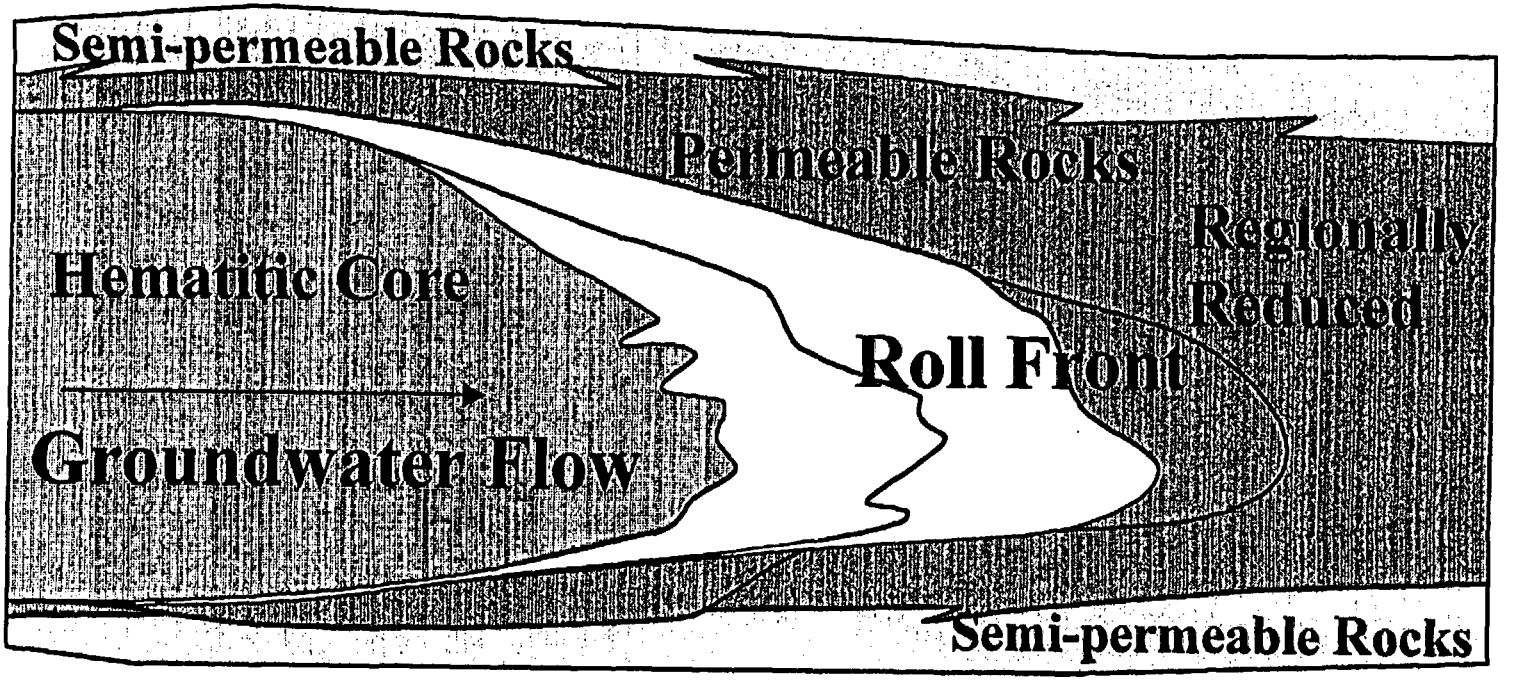




UMETCO URANIUM MILL SITE
Gas Hills, Wyoming

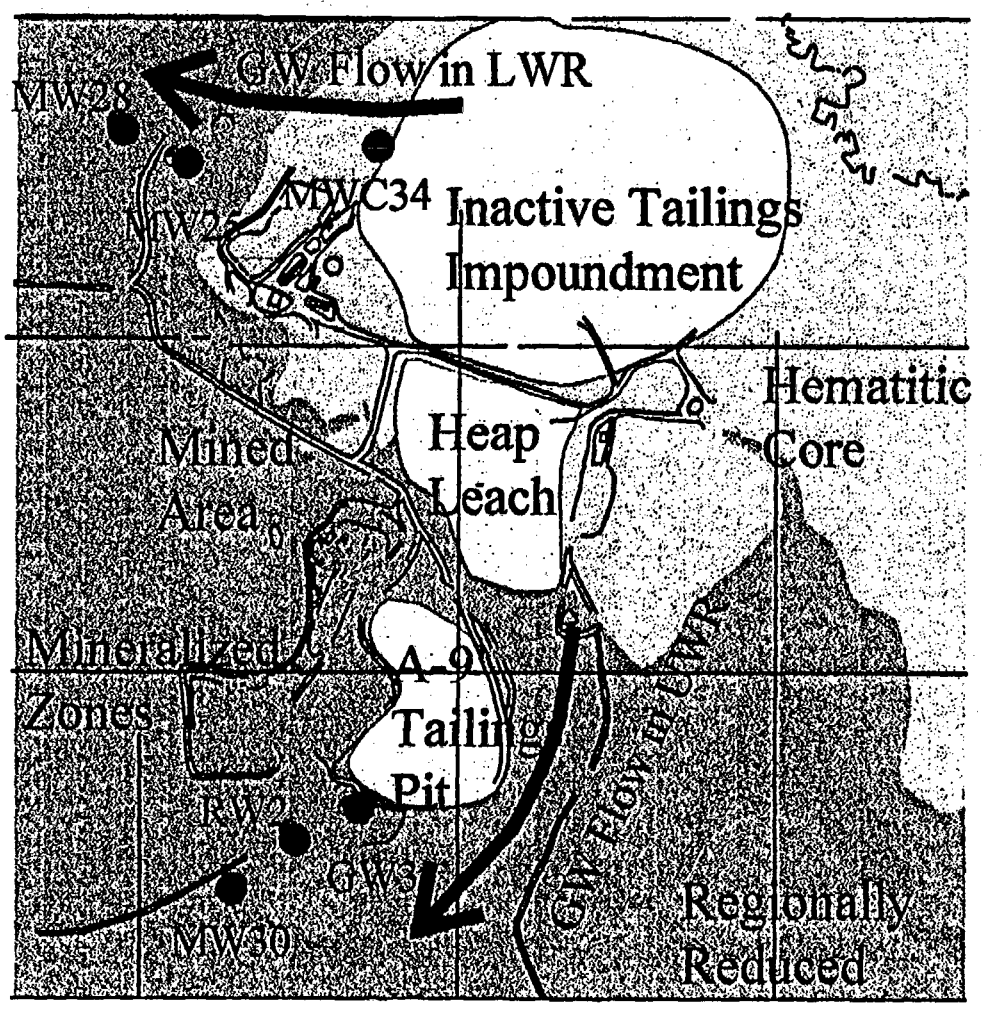

INACTIVE TAILINGS
IMPOUNDMENT
A-9
TAILINGS
PIT
7000
6850
6700
6550
UPPER WIND RIVER
BASAL
MUDSTONE
LOWER WIND RIVER
500 ft
N

CONCEPTUAL MODEL OF URANIUM ROLL FRONT DEPOSIT (After Devoto, 1978)



Hematitic Core	Alteration Envelope	Ore-Stage Uranium	Ore-Stage Pyrite	Reduced Sandstone
Hematite Magnetite	Siderite Sulfur-S° Ferroselite Goethite	Uraninite Pyrite FeS Selenium Ilsmannite	Molybdenite Pyrite Jordisite Calcite	Pyrite Jordisite Calcite

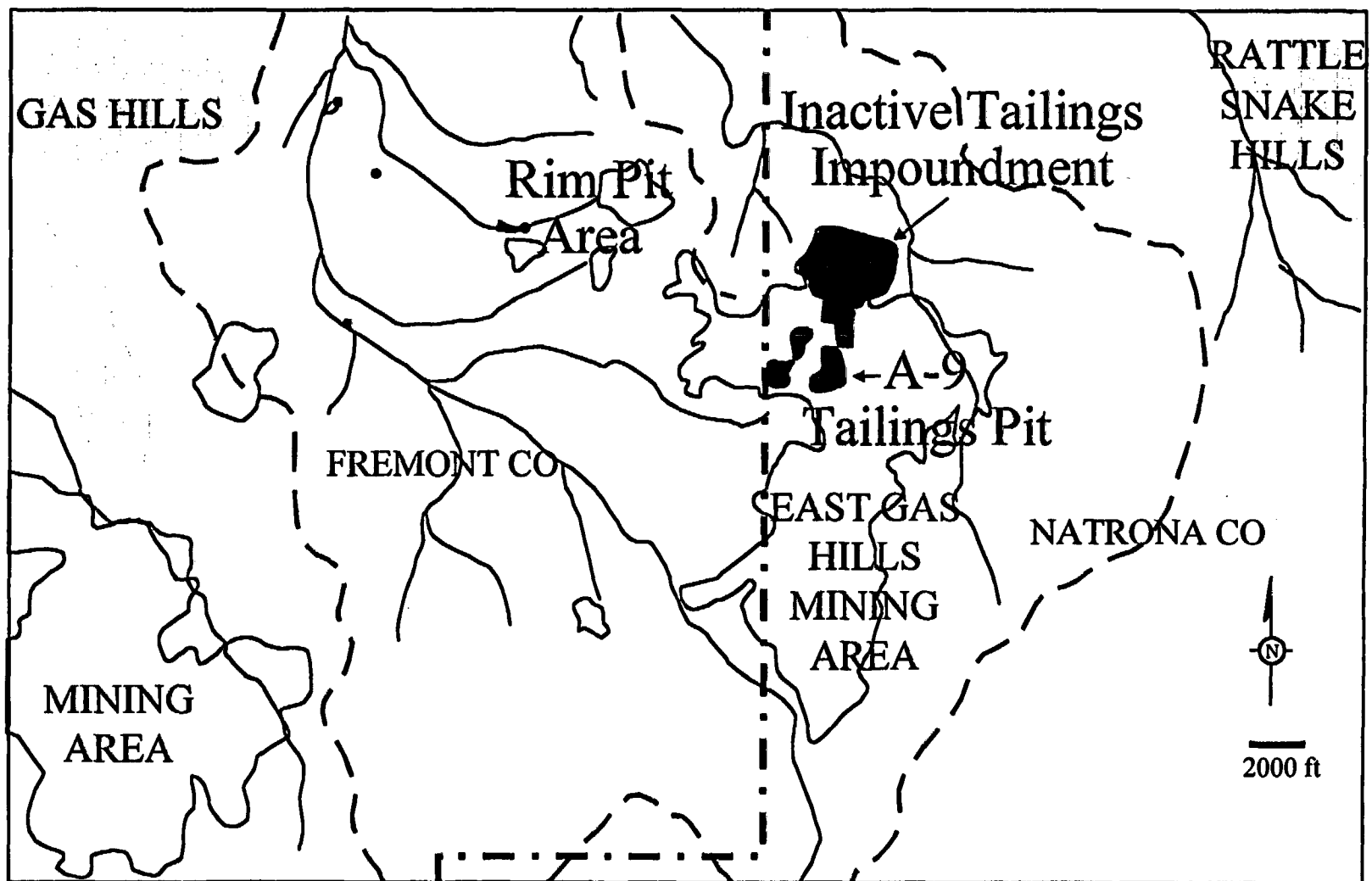
Contaminant Sources and Monitor Wells
Gas Hills, Wyoming



Uranium Roll Front Mineralogy in the Upper Wind River

- Tailings material and spent ore.
- High-grade uranium ore removed.
- Depleted hematitic core, abundant Fe-oxides, lacks calcite
- Uranium ore - pyrite, uranium oxides, some calcite
- Reduced sandstone - pyrite and calcite.

LOCATION MAP
UMETCO URANIUM MILL SITE
GAS HILLS, WYOMING



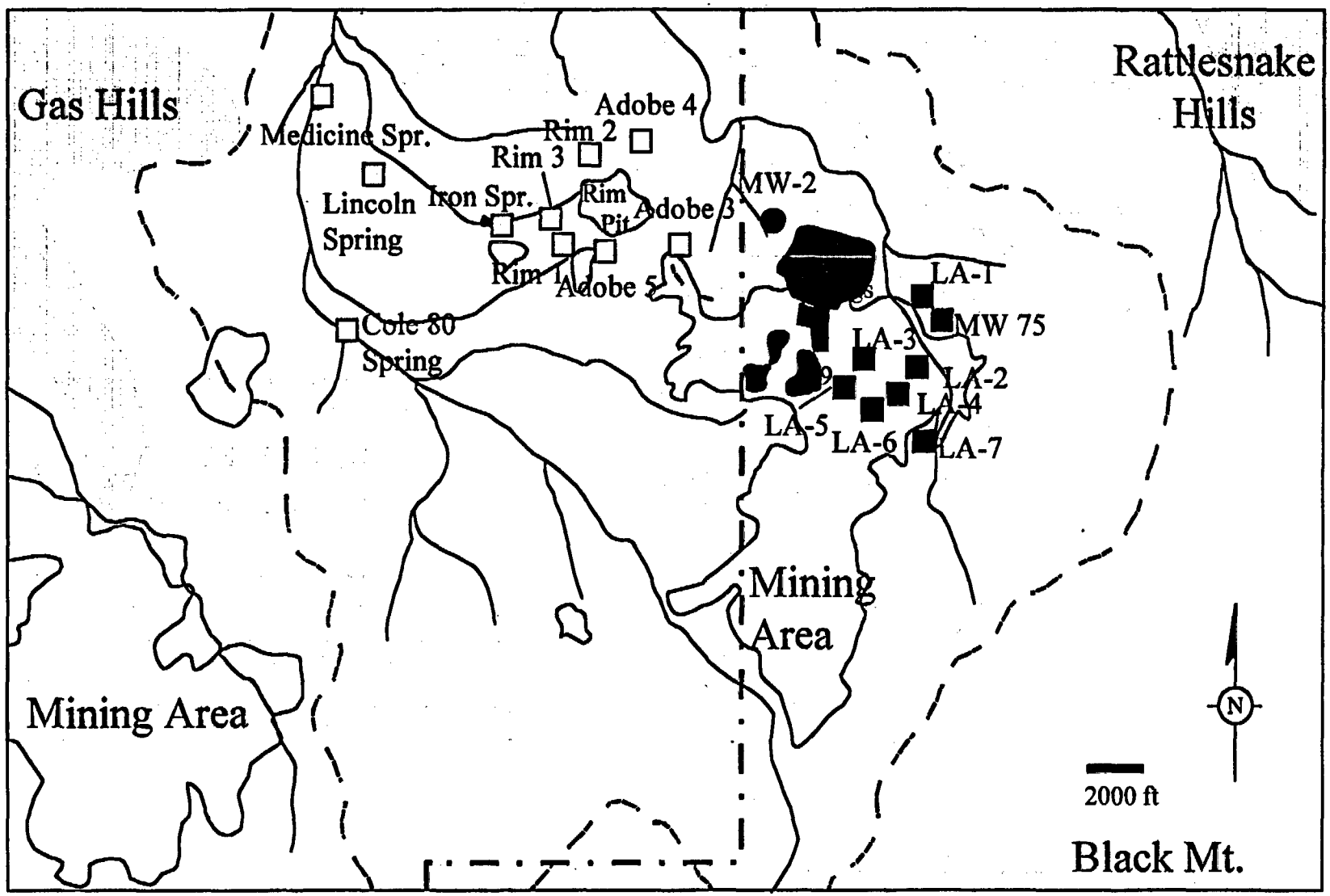
KEY POINTS

- Background Typically Based on Cleanest (Lowest Concentration) Wells at Site
- Pre-Mining, Pre-Milling Groundwater Quality Covered a Broad Range
- Mining at East Gas Hills Impacted Groundwater
- Groundwater Impacts from Mining are Regulated Independently of Milling Activities

POTENTIAL SOURCES OF BACKGROUND WATER QUALITY DATA

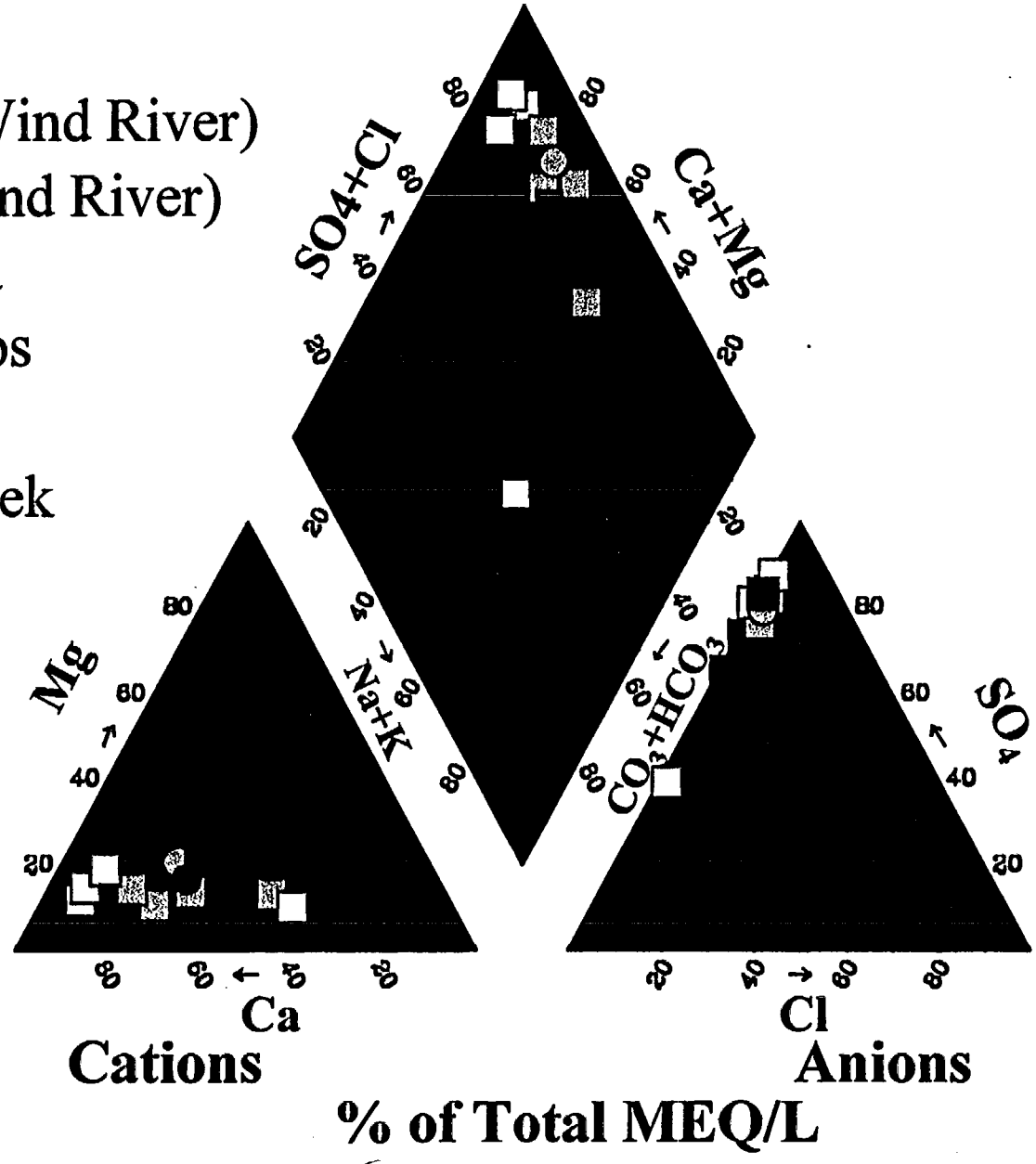
- Surrogate Locations with Similar Geologic Conditions
- Areas Upgradient of the Mill Site
- Seeps and Springs (non-impacted)
- Data from other Uranium Companies
- Public Sources of Historical Data for the Region

Location of Springs and Background Wells



Background Water Quality

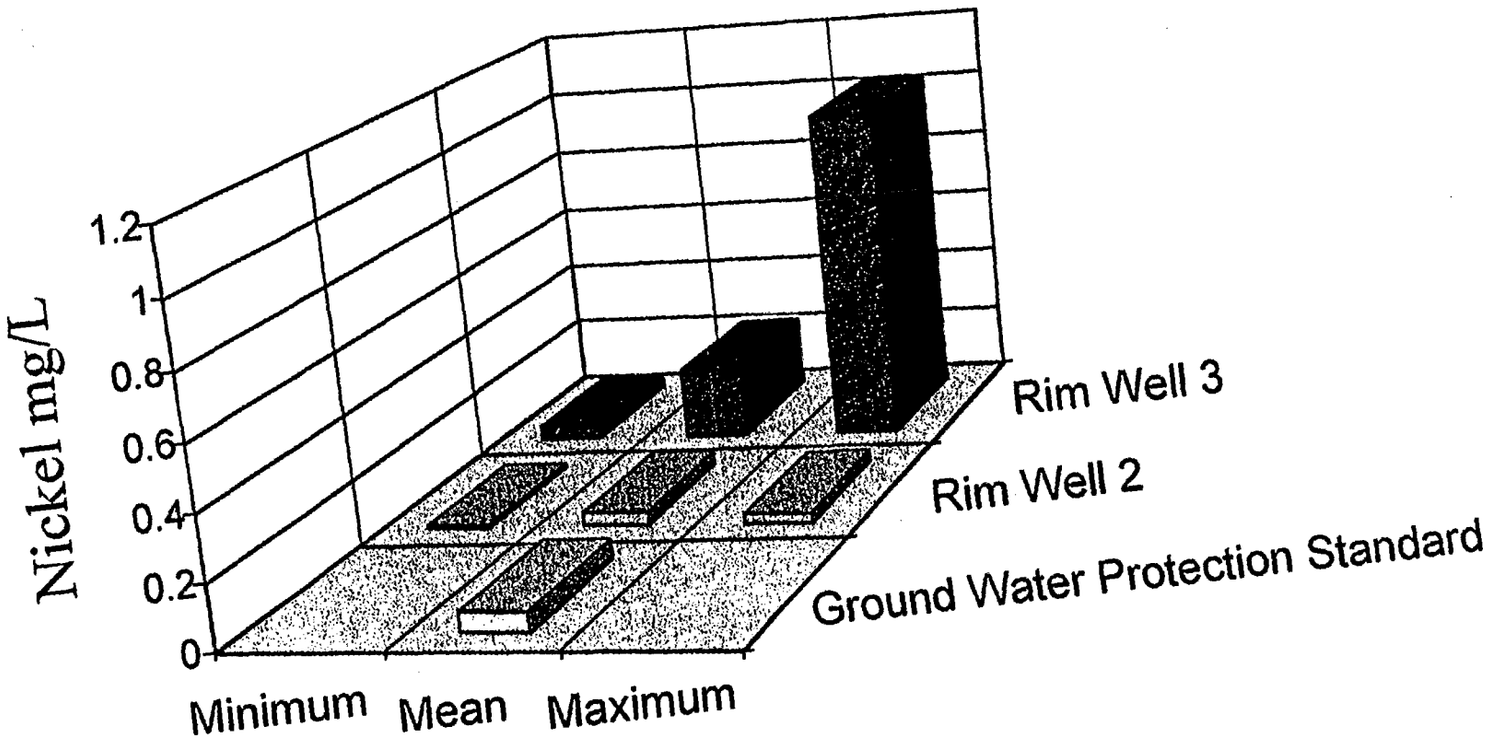
- MW-2 (Lower Wind River)
- LA-2 (Upper Wind River)
- Rim Permit Area
- Springs and Seeps
- LA Series Wells
- East Canyon Creek



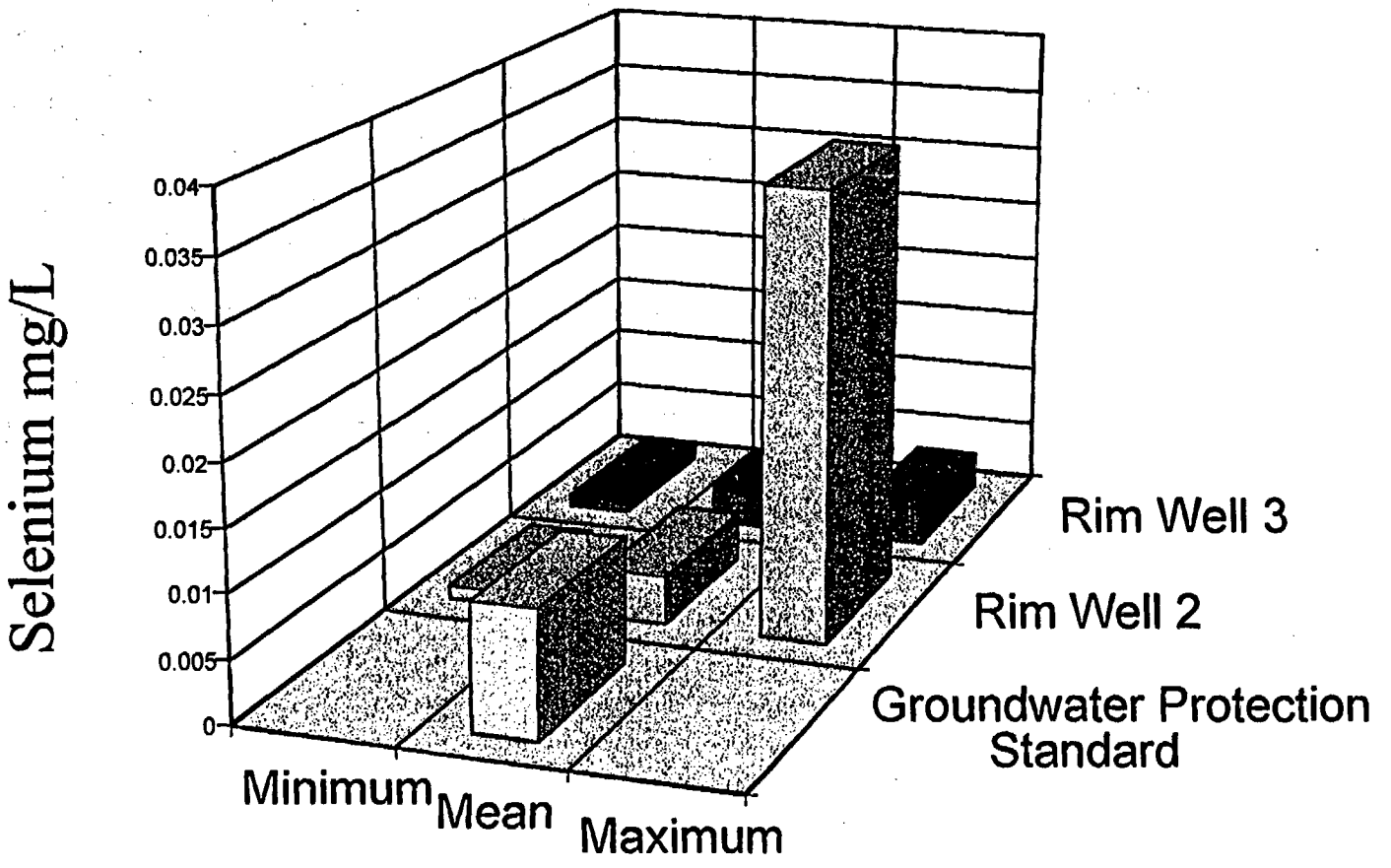
Groundwater Protection Standards
Gas Hills Uranium Mill Site
(License Condition 35)

Constituent	LWR	UWR
Arsenic (mg/L)	0.05	0.05
Berylium (mg/L)	0.05	0.01
Nickel (mg/L)	0.06	0.04
Selenium (mg/L)	0.01	0.01
Uranium (pCi/L)	89	199
Radium(pCi/L)	31.6	24.9
Thorium-230(pCi/L)	6.6	4.8
Lead 210 (pCi/L)	5.0	4.6
Gross alpha (pCi/L)	146	17.8

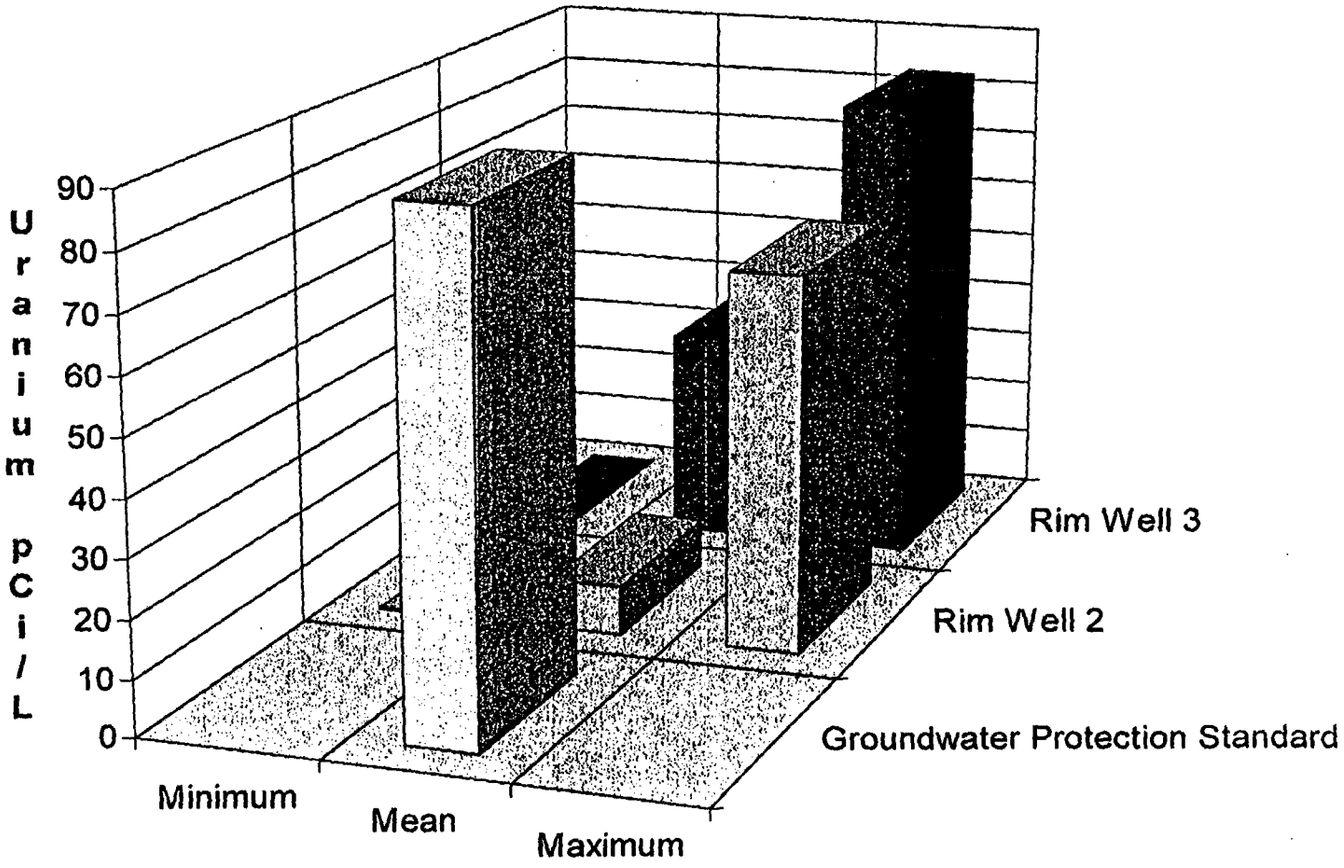
Nickel


Nickel mg/L
1.2
1
0.8
0.6
0.4
0.2
0
Minimum
Mean
Maximum
Rim Well 3
Rim Well 2
Ground Water Protection Standard

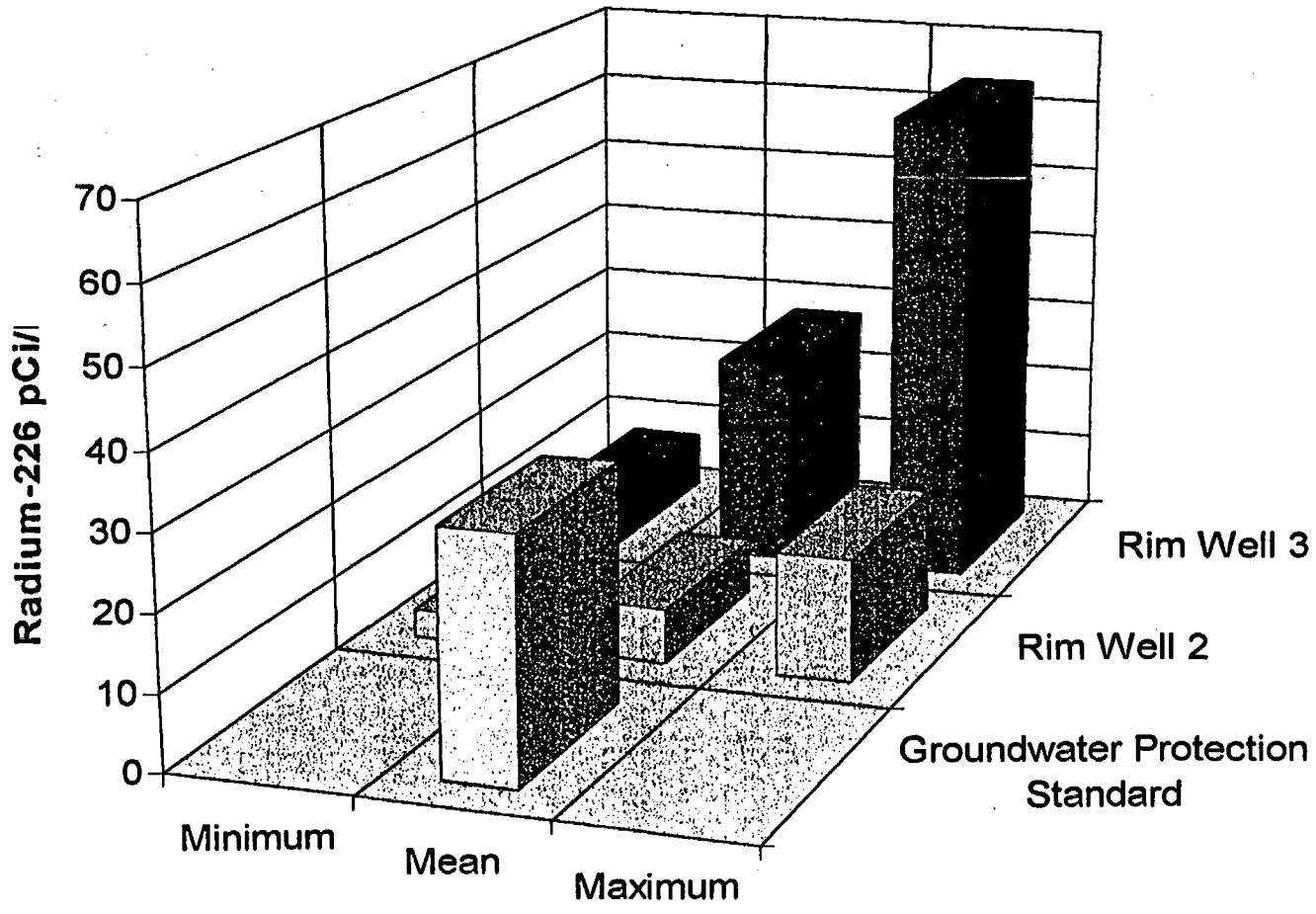
Selenium


Selenium mg/L
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Minimum
Mean
Maximum
Rim Well 3
Rim Well 2
Groundwater Protection Standard

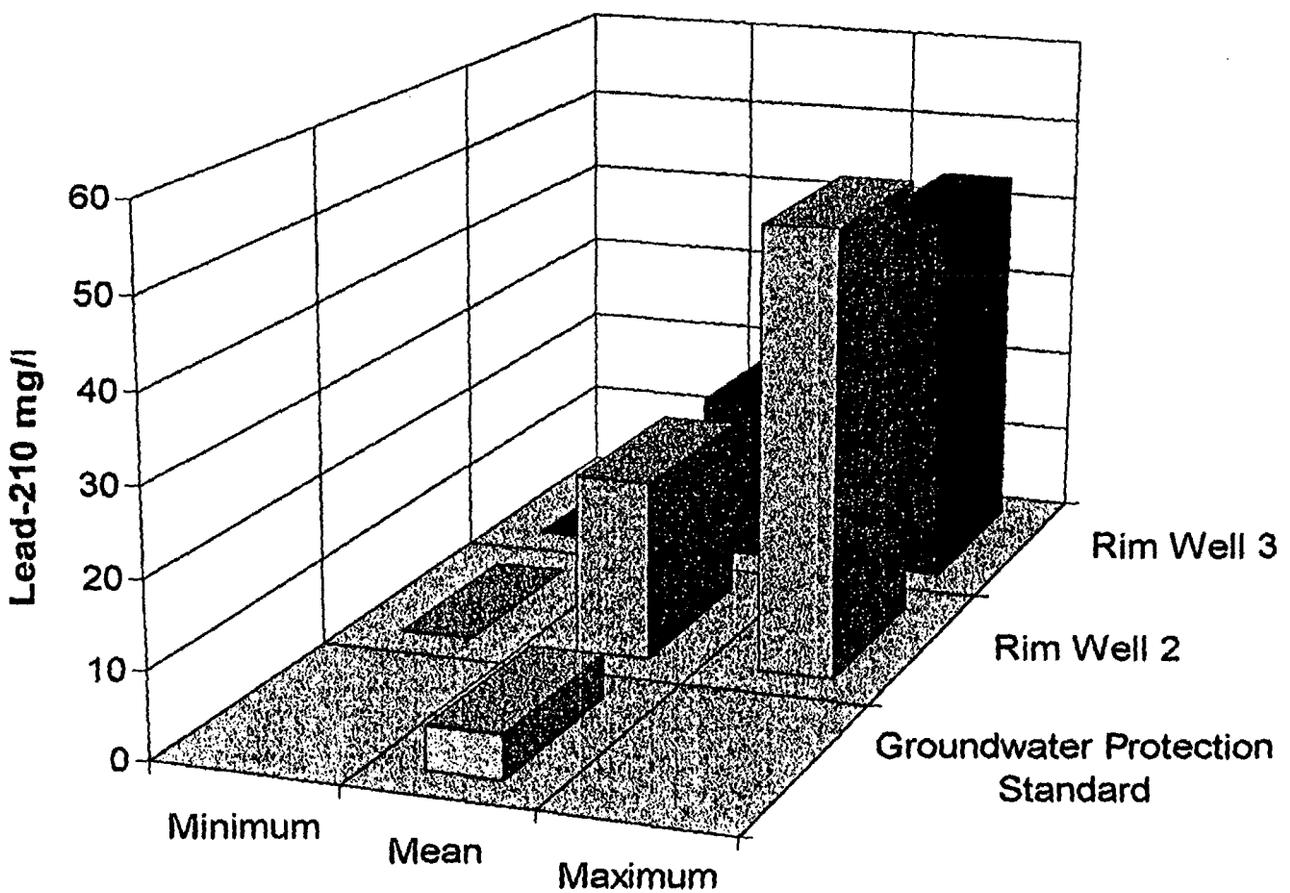
Uranium


Uranium pCi/L
90
80
70
60
50
40
30
20
10
0
Minimum
Mean
Maximum
Rim Well 3
Rim Well 2
Groundwater Protection Standard

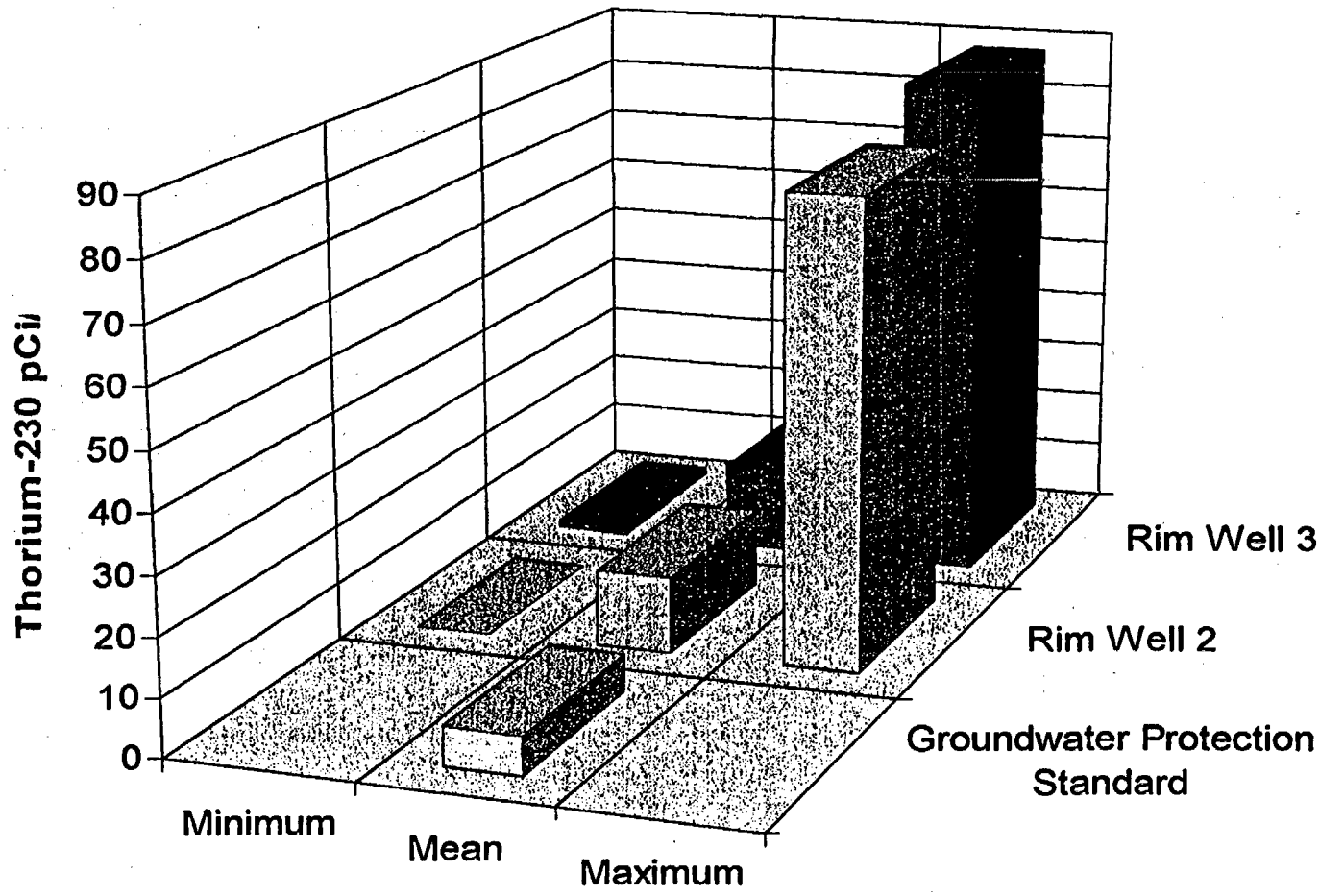
Radium-226

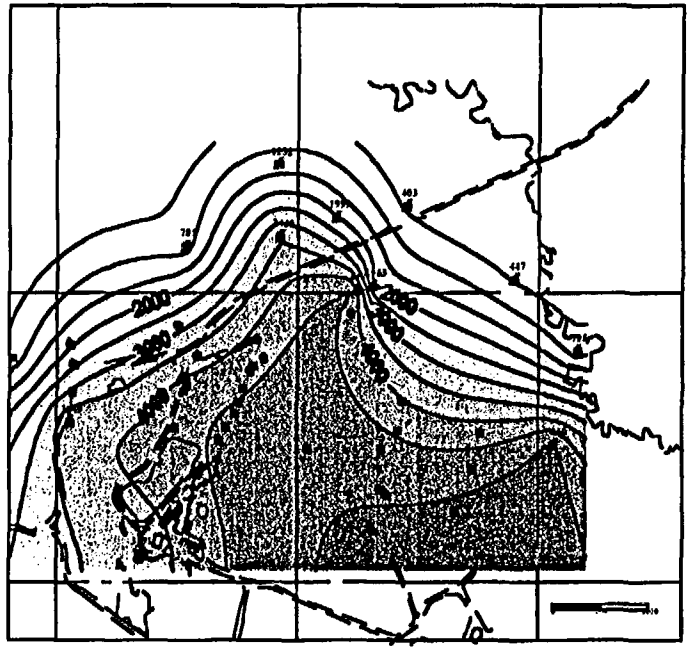

Radium-226 pCi/l
70
60
50
40
30
20
10
0
Minimum
Mean
Maximum
Rim Well 3
Rim Well 2
Groundwater Protection Standard

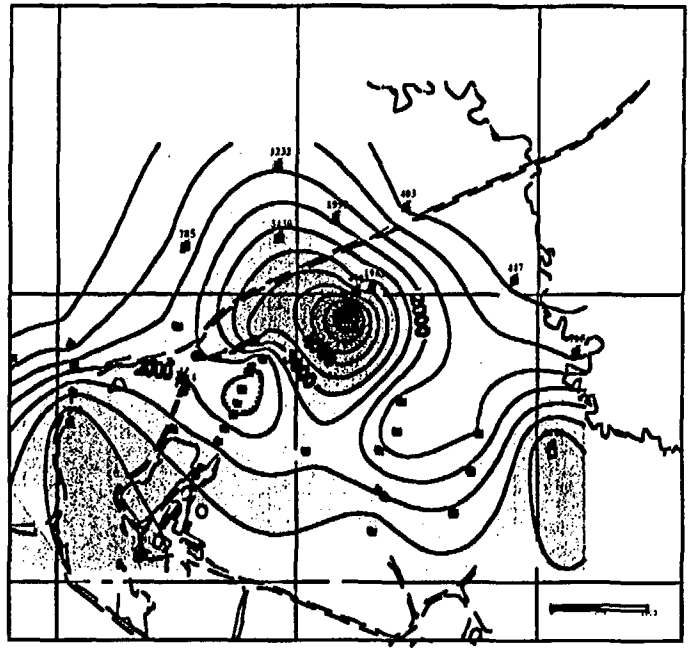
Lead-210


Lead-210 mg/l
60
50
40
30
20
10
0
Minimum
Mean
Maximum
Rim Well 3
Rim Well 2
Groundwater Protection Standard

Thorium-230


Thorium-230 pCi/
90
80
70
60
50
40
30
20
10
0
Minimum
Mean
Maximum
Rim Well 3
Rim Well 2
Groundwater Protection Standard





TDS IN GROUNDWATER
LOWER WIND RIVER
April-June 1990 vs Feb-March 1995
Gas Hills, Wyoming

HIGHER Eh → LOWER Eh

UPPER WIND RIVER

Oxidized Uranium Minerals
Fe/Al Oxides and Hydroxides
Sulfates

Sulfates

Fe/Al Oxides and Hydroxides
Sulfates
Sulfides

LOWER WIND RIVER

Oxidized Uranium Minerals
Fe/Al Oxides and Hydroxides
Sulfates

Fe/Al Oxides and Hydroxides
Sulfates
Carbonates

Fe/Al Oxides and Hydroxides
Sulfates
Sulfides

Conclusions

Official background monitor wells do not capture the wide range of naturally occurring background and baseline conditions in the Gas Hills area

Ambient geochemical conditions at the Gas Hills site result in natural attenuation of groundwater contamination within a relatively short distance from sources.

United States
Nuclear Regulatory Commission

Outlook for Groundwater Compliance at Uranium Mill Tailings Sites

Petrotomics

United States
Nuclear Regulatory Commission

NRC Standard Review Plans
New ISL SRP and Revised Mill SRP

Center for Nuclear Waste Regulatory Analyses

United States
Nuclear Regulatory Commission

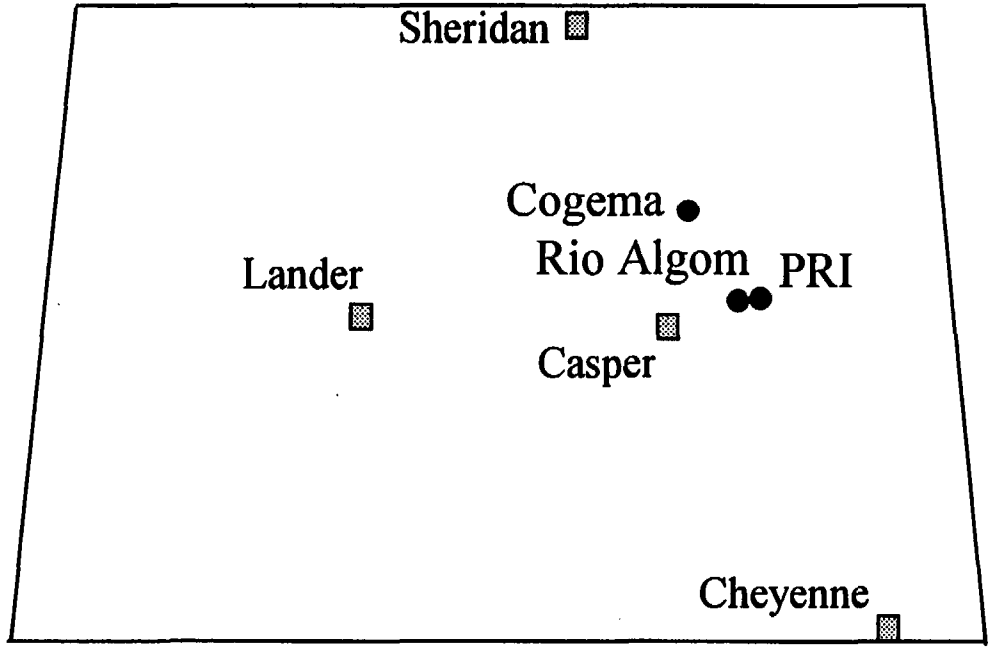
State Perspectives

Wyoming Department of Environmental Quality, Land Quality Division

Wyoming In-Situ Uranium Ground Water Issues

April Lafferty
DEQ/LQD

Wyoming In Situ Mines



Mining Issues

- *Monitoring Well Placement*
  - *minimize distance*
  - *capture zone*
- *Wellfield Ground Water Classification*
  - *Chapter 8, WQD Rules and Regulations*
    - *production pattern average*
    - *well by well for monitoring wells*
    - *parameter by parameter determination*

Mining Issues

- *Long Term Excursions*
  - *typically vertical excursions*
  - *identify cause*
  - *additional bonding*
- *Waste Water Disposal*
  - *deep well injection*
  - *evaporation ponds*
  - *land application*

Mining Issues

- *Injection and Production Fluid Spills*
  - *defined as pollution under Wyoming Statute*
  - *must be reported if:*
    - *spills enter a Water of the State*
    - *threaten to enter a Water of the State*

Restoration Issues

- *Pore Volume Estimate*
  - *flare vs. impacted volume*
  - *method of pore volume estimation*
  - *number of pore volumes restored*
- *Timeliness of Restoration*
  - *waste disposal limitations*
  - *restoration aggressiveness*

Restoration Issues

- *Excursions During Restoration*
  - *causal factors*
- *Restoration of Long Term Excursions*
  - *may require innovative techniques*

Restoration Issues

- *Baseline vs. Class-of-Use*
  - *using best practicable technology (BPT) :*
    - *goal of restoration is to achieve baseline*
    - *if baseline is not achievable, ground water must be restored to Class-of-Use*
- *Stability Period*
  - *6 months*
  - *1 year or longer*

Restoration Issues

- *Determination of Restoration Success*
  - *wellfield average*
  - *Will the restored ground water affect surrounding water with a higher Class-of-Use?*

Wyoming Department of Environmental Quality
Land Quality Division

Uranium Tailings Issues

Roberta Hoy

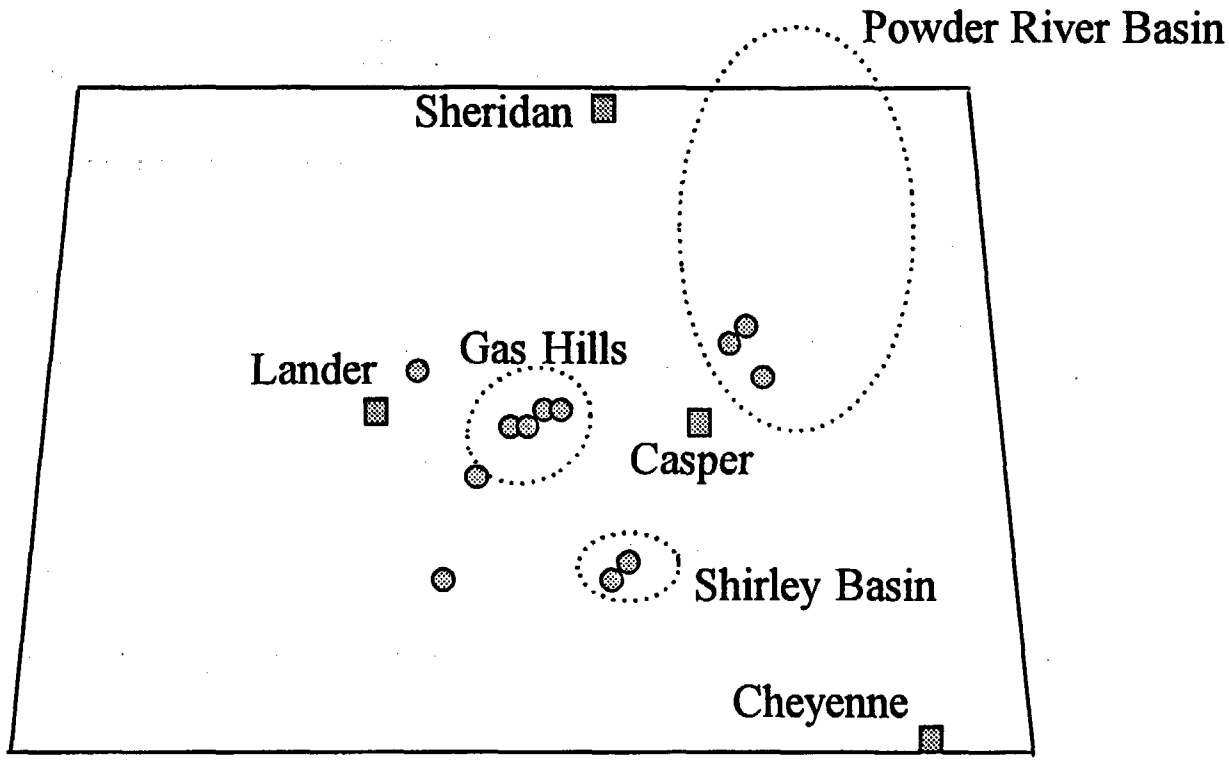
Wyoming Department of Environmental Quality
Land Quality Division

Uranium Tailings Issues

2 Title I Sites
(Coordinator in Lander)

9 Title II Sites
(Coordinated by District Supervisors -
4 sites in District I/ 5 sites in District II)

Wyoming Tailings Sites



WY Uranium Tailings Issues

- The Variety of Issues
  - Technical & Regulatory Issues
    - » Hydrogeologic Settings
    - » Regulatory Agencies, Responsible Parties, & Landowners
    - » Remediation Goals
- Making the Variety Useful
  - 'Cooperative Ventures'
  - Sources of Innovative Techniques

The Variety of Issues (Technical & Regulatory)

- Hydrogeologic Settings
- Regulatory Agencies
- Remediation Goals

Hydrogeologic Settings

- Geologic 'Location'
  - On an Alluvial Plain between Rivers
  - In Shallow Draws across Outcrop of Sedimentary Formations
  - In Deep Draws Adjacent to Alluvial Valley
  - In a Sedimentary Basin
- Geochemical 'Environment'
  - Predominance of Carbonate vs. Non-Carbonate
- Hydraulic 'Evolution'
  - Ground Water Mound Dissipating
- Construction

Regulatory Agencies

- Federal
  - NRC
  - DOE
  - BLM
  - EPA
  - BIA
- Tribal
  - Shoshoni
  - Arapaho
- State
  - WDEQ
    - » LQD*
    - » WQD
  - SEO
  - 'ERO'

* LQD is more than just an RA.

Remediation Goals

- Background
  - No Degradation
- Class-of-Use
  - No Loss of Use
- Supplemental Standards
- Risk Assessment
  - Human Health Risks
  - Ecological Risks

Making the Variety Useful

- ‘Cooperative Ventures’
- Sources of Innovations

'Cooperative Ventures'

- Flow of Technical Information across Jurisdictional Lines
  - Non-Radiological Data needed to complete evaluation of Radiological Data (& vice versa)
- Flow of Information among Mines and Regulatory Programs
  - Five-Mine, Two-Agency Cooperation to Protect Spring Flow & Allow Mining & Petroleum Product Production
- Corrective Action Policy
  - Agency Wide

Sources of Innovative Techniques*

- Water Rights Transfers
- Petroleum Industry
- Superfund Sites
- Federal Facilities
- ....

*Beyond Pump-Back Systems & Natural Flushing

'Cooperative Remediation Goal'

- Background
  - No Degradation (Primary Goal per R&R)
- Class-of-Use
  - No Loss of Use
  - (Secondary Goal per R&R, Critical to WDEQ)
- Supplemental Standards
- Risk Assessment (for interim measures only)
  - Human Health Risks (Perceived Emphasis)
  - Ecological Risks (Techniques Developing)
  - Sacrifice Areas (Not Acceptable to WDEQ)

United States
Nuclear Regulatory Commission

State Perspectives

Dorothy Stoffel
Washington Department of Health
Division of Radiation Protection

Reclamation Coordination with the Clean Water Act

Dawn Mining Company Millsite
Ford, Washington

Washington Department of Health

Wa. Dept. Health/EPA/ Wa. Dept of Ecology

- EPA delegated authority to Washington State Department of Ecology for Clean Water Act
- Ecology ruling of no discharge to Chamokane Creek (40 CFR Part 440 Subpart C, Part 440.32b(1)
- Thou Shall Not Pollute Waters of the State
  Chapter 90.48 Revised Code of Washington
- Ecology State Waste Discharge Permit Program
  Chapter 173-216 WAC
- Ground Water Quality Standards (Chapter 173-200 WAC)

Washington State Water Regs Parallel NRC Ground Water Requirements

- Washington State WQ Regs
- AKART
- POC
- Early Warning Value
- Enforcement Limit

- Radiation WQ Requirements
- ALARA
- POC
- GW Protection Standards

Evaporation Pond Construction

- Ecology State Waste Discharge Permit Chapter 173-216 WAC
- Ecology Engineering Plan and Spec Review (Chapter 173-240 WAC)
- Ecology Dam Safety Engineering Review

Clean Water Act Citizens Lawsuit

- Citizens lawsuit filed 2/20/96 in US District Court
- Complaint alleged DMC discharging pollutants to creek without permit (seeps)
- DMC Position - seeps/pollutants 11(e)2.by-product material, regulated under AEA not CWA

Summary Judgement

- Ruling in favor of DMC - September 3, 1996
- Reference: 1976 US Supreme Court Ruling (Train v. Colo Public Interest Research Group)
- Note: interpretation by Ecology contaminants = tailing solutions
- Appeal 9th Circuit San Francisco

Western Nuclear, Inc Ground Water Monitoring Program

Establishing a ground water program when the tailings impoundment is located in a mineralized zone

Washington Dept. of Health

GW &Tailings Characterization

* Review of GW Quality data
  no contaminant plume/mineralized zone
* Operations History (neutralization prior to discharge/hypalon liner)
* Tailings Solution Chemical Characterization

Selection of Indicator Parameters

* Chloride
* Sulfate
* Nickel
* Thalium
* Static Water Level

Leak Detection Monitoring

Monthly- static water level

Quarterly- static water level, TDS, U-nat, EC, temp,pH, chloride,sufate,nickel

* Action Criteria - swl increasing = further investigation, UCL for Cl,SO4,Ni (99%confidence interval for site data) NOTE: Cl=6ppm,drinking water standard =250ppm)

Intermediate Monitoring

- Weekly - swl
- Monthly - swl,TDS, U-nat,EC, Temp,pH, Cl, SO4, Ni
- * Review of Trend

Compliance Monitoring

* Quarterly Sampling
* Hazardous Constituents - As, Ni, Tl, Ra-226,Ra-228, U-nat
* Secondary Parameters - swl, TDS, pH, EC, temp,Cl, SO4
* Corrective Action (unlikely based on modeling)

United States
Nuclear Regulatory Commission

State Perspectives

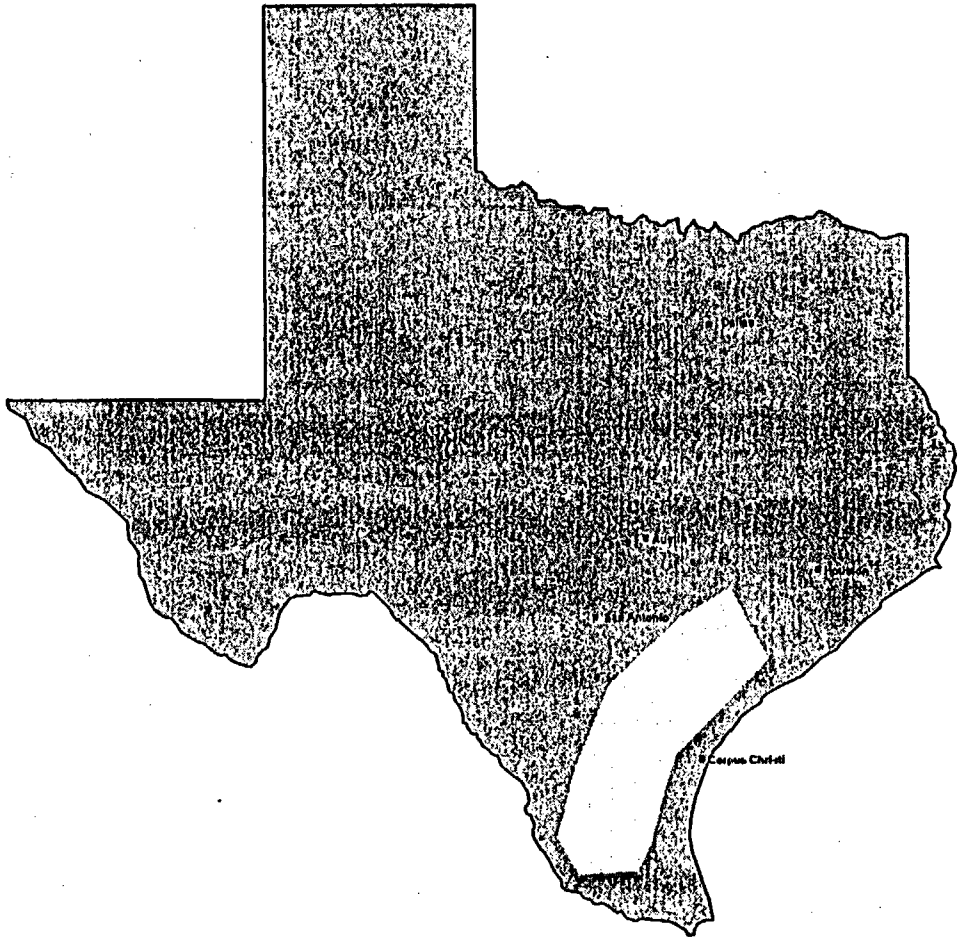
Colorado Department of Health
Division of Radiation Protection

United States
Nuclear Regulatory Commission

State Perspectives

George FitzGerald
Texas Natural Resource Conservation Commission

Texas Uranium



Texas Groundwater

275,000 Sq. Miles of Aquifers

57% of Texas Water Needs

Mining Wells

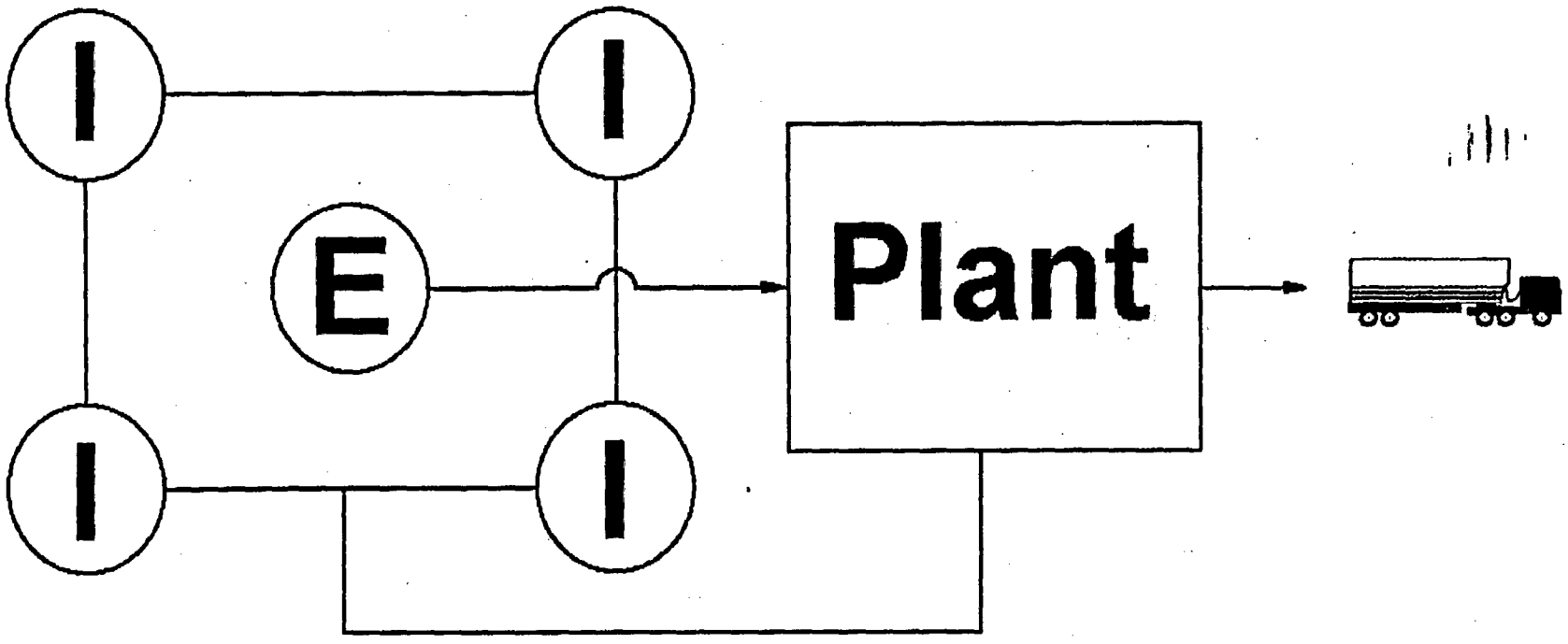
- UIC: Underground Injection
- Production: Inject/Extract
- Monitor

TNRCC Regulates Mining Wells since January 1982

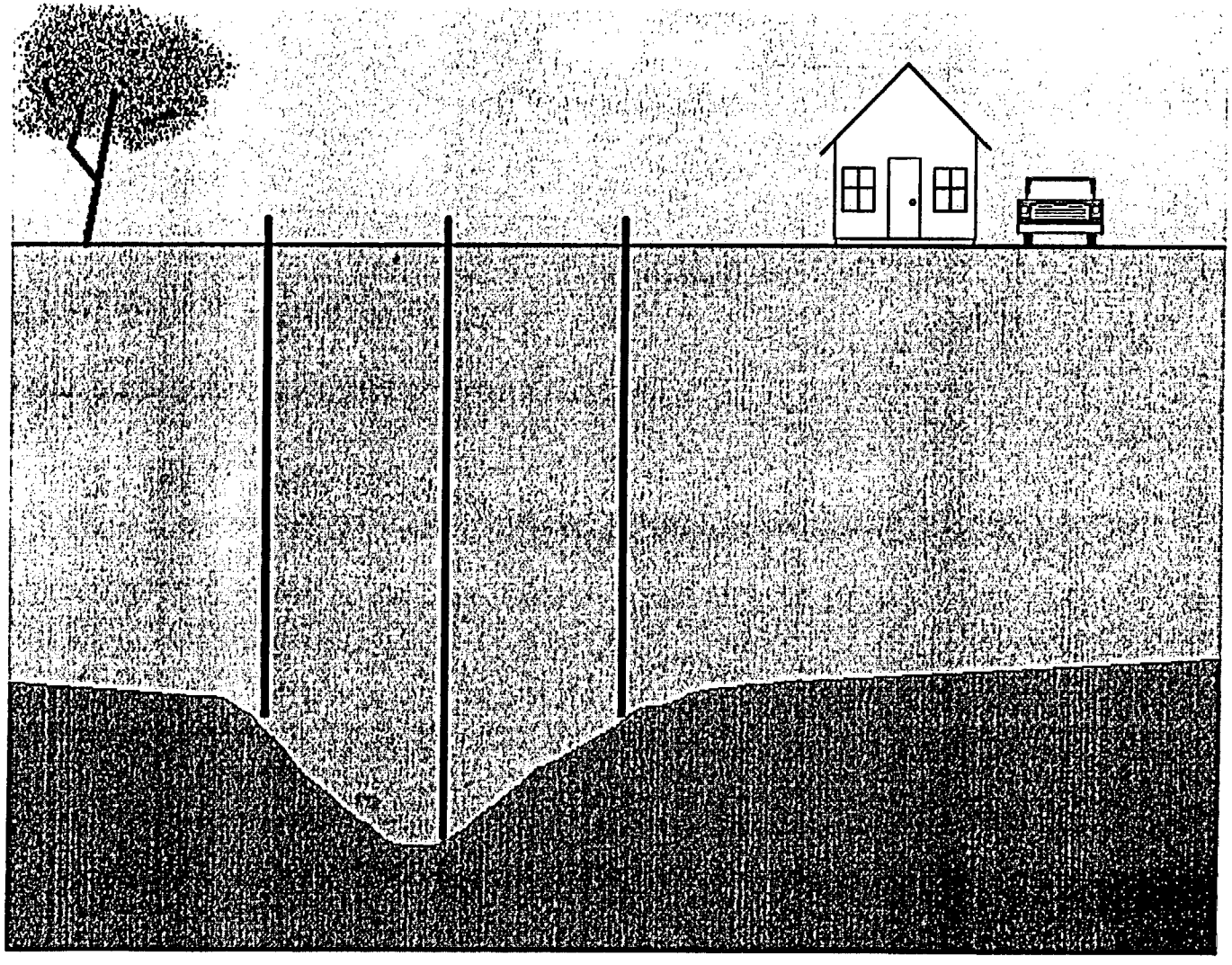
56,000 Acres at 35 Uranium Sites

ISL Mining Process

$$UO_2 + O_2 + H_2O \rightarrow H_2O + U_3O_8$$



Maintain Mining Cone of Depression



Monitoring Wells

Geohydrology: Horizontal & Vertical

Baseline

Production

Restoration

Monitor

- ☞ Chemical Constituents
- ☞ Radioactive Constituents
- ☞ Containment

ISL Advantages Over Conventional

- If geohydrology allows...
- Simple groundwater sweep
- Rather benign chemicals introduced
- Ongoing monitoring
- Ongoing restoration

Environmental Benefits

- ☞ Physical preservation of groundwater aquifer
- ☞ Minimal surface disturbance
- ☞ No mill tailings

George T. FitzGerald, Jr.

28 Years: Geology, Engineering, Economics, Management.

CHRONOLOGY:	1996:	TNRCC: Manager, Radioactive Materials Licensing - Professional Scientists, Engineers, Health Physicists. Licensing Uranium Mines, LLW Disposal Site.
	1994-96:	TNRCC: Project Manager, Superfund Investigation Section - Remedial Investigation, Risk Assessment, Feasibility Studies.
	1989-93:	IT Corp.: Manager, Hazardous Waste Operations - Geoscience and Engineering Staff, QA/QC, H&S, Profit and Loss.
	1986-89:	Illinois Dept. of Nuclear Safety: Environmental Geologist - Low-level Radioactive Waste Management.
	1984-86:	Boliden, S.A.: Project Geologist - Copper, Zinc, Silver, Gold Mine.
	1980-84:	Minatome, S.A.: Manager - Mining Evaluation: Geology, Engineering, Economics.
	1975-80:	SOHIO: Chief Geologist - 1000 TPD Uranium Mine.
	1968:	University of New Mexico - Mathematics Instructor.
	1968-75:	Kerr-McGee: Mine Geologist - Uranium.

STRENGTHS: Management: Scope, Schedule, and Budget; Geologic Interpretation; Economic Evaluation.

CERTIFICATIONS/ ACHIEVEMENTS: Certified Professional Geologist No. 6582: American Institute of Professional Geologists.
Expert Witness: Geology.
Member: Association of Ground Water Scientists and Engineers;
Association of Mining Engineers.

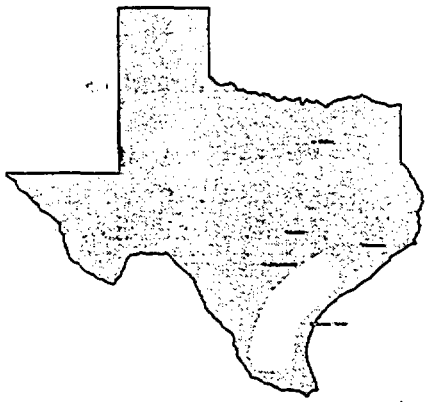
EDUCATION: B.A., Geology: Humboldt State University, Calif.

POST-GRAD: Economics: Colorado School of Mines, Colo.
Education: Humboldt State University, Calif.

TRAINING: Human Relations: Dale Carnegie.
Supervision, Project Management, Contract Negotiation, QA/QC, H&S, Computer: Industrial Courses.

UBLICATIONS: "Project Management and Cost Control": IT Corporation Management and Technical Symposium, Scottsdale, Ariz., 1994.
"Geology of Little Glass Mountain": Thesis, Humboldt State University, Arcata, Ca., 1968.

Texas Uranium



◂1
2▸

Texas Groundwater

275,000 Sq. Miles of Aquifers

57% of Texas Water Needs

◂3
4▸

Mining Wells

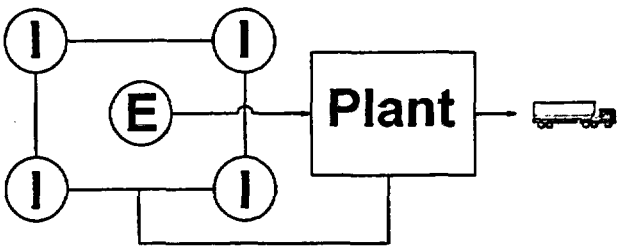
- UIC: Underground Injection
- Production: Inject/Extract
- Monitor

TNRCC Regulates Mining Wells since January 1982

56,000 Acres at 35 Uranium Sites

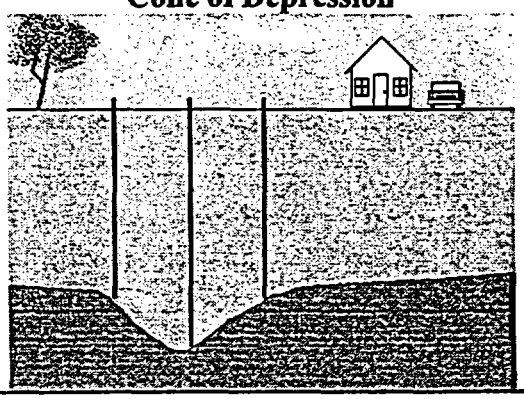
ISL Mining Process

$$UO_2 + O_2 + H_2O \rightarrow H_2O + U_3O_8$$



◂5
6▸

Maintain Mining Cone of Depression



◂7
8▸

Monitoring Wells

Geohydrology: Horizontal & Vertical

Baseline ↘ Production ↘ Restoration

Monitor

- Chemical Constituents
- Radioactive Constituents
- Containment

◂9
10▸

ISL Adavantages Over Conventional

- If geohydrology allows...
- Simple groundwater sweep
- Rather benign chemicals introduced
- Ongoing monitoring
- Ongoing restoration

Environmental Benefits

- Physical preservation of groundwater aquifer
- Minimal surface disturbance
- No mill tailings