From: Candace Head-Dylla
To: Parrott, Jack
Subject: [External_Sender] Proposed changes radiation monitoring Homestake-Barrick Gold site
Date: Thursday, October 15, 2015 2:20:17 PM

Hello Mr. Parrott,

Please share this email with the other people who were in the room at the meeting in MD yesterday between NRC and Homestake-Barrick Gold representatives. As I said, this is the first time community members have been invited to listen in on one of these meetings. I know you said that doing so is part of normal NRC protocol but your predecessors--William Von Till III, John Buckley, and one other whose name eludes me at the moment, never afforded us this opportunity. So this was a wonderful first for us after more than 30 years of NRC oversight. Again, thank you.

I am copying Ron Curry, Sam Coleman, Sai Appaji, and Mark Purcell on this email as well since BVDA was surprised and concerned that the EPA did not have a representative listening in after commenting on the suitability of the model used for this proposal earlier on in the process. I understand NRC is confused by the EPA's comments on modeling and needs clarification. I am hoping that a conversation between EPA and NRC will happen and that the community, including MASE members, Susan Gordon and Laura Watchempino--who were also on the call--will be asked to participate in or updated on the results of that conversation over modeling and any other points that may concern the EPA. I am copying Katie Richardson at Senator Heinrich's office as well since they could not be on the call but I know the Senator has asked for updates in the past.

You said you had not seen any baseline reports on radon from the 70s regarding this site so I am attaching what should be a very helpful report that Paul Robinson and Chris Shuey from Southwest Research and Information Center prepared for our BVDA community under an EPA TASC grant. This report has those citations as well as others and I think Mike (sorry couldn't catch his last name or title) might be interested in reading it in full since some of his questions appear related to information contained in several of the reports cited.

Again, I hope you will continue to keep BVDA and MASE updated on this process and on the decision toward which the NRC is moving. I am currently in England until February on family business but you can always call my mom at 505-290-0171 or Susan Gordon (copied here).

Sincerely,
Candace Head-Dylla, BVDA/MASE

Tailings radiationTASC.pdf

Technical Assistance Services for Communities
Contract No.: EP-W-07-059
TASC WA No.: R6-TASC-002
Technical Directive No.: R6-Homestake Mining-02

Comments on Air Monitoring and Radon Issues Raised in the U.S. Army Corps of Engineers' Draft Remediation System Evaluation (Supplement) for the Homestake Mining Company (Grants) Superfund Site, New Mexico

May 6, 2010

1.0 Introduction

This document provides the Bluewater Valley Downstream Alliance (BVDA) with comments on air monitoring and radon issues raised in the U.S. Army Corps of Engineers' "Draft Remediation System Evaluation (Supplement) for the Homestake Mining Company (Grants) Superfund Site, New Mexico," a February 2010 draft document prepared by the U.S. Army Corps of Engineers' (USACE) Environmental and Munitions Center of Expertise for the U.S. Environmental Protection Agency (EPA), Region 6.

The USACE Draft Remediation System Evaluation (Supplement), hereinafter referred to as the "DRSE Report," provides a concise review of the air monitoring system at the Homestake Mining Company (HMC) site, with an appropriate focus on radon emissions. The DRSE Report identifies several shortcomings in the monitoring system that could affect whether HMC can demonstrate compliance with the U.S. Nuclear Regulatory Commission (NRC)'s 100-millirem-per year (mrem/y) public dose limit. The DRSE Report's findings track closely with those of the TASC Report No. R6-Homestake Mining-01 ("TASC Report," November 18, 2009), which showed how doses could exceed the limit if a lower radon background value and higher radon-radon progeny equilibrium factor were used in calculations of the Total Effective Dose Equivalent (TEDE) (TASC, 2009; pp. 15-18, Appendix B). The RSE Team recommends changes in the monitoring system to better define background radon, measure radon progeny to develop a site-specific equilibrium factor, improve radon detection around tailings piles and effluent ponds, and better understand site and local meteorology. NRC and EPA should review the findings of both recent reports and consider developing a regulatory strategy to implement the recommended changes in the HMC air monitoring program.

What the DRSE Report lacks with respect to air monitoring issues is a sense of urgency to address the potential public health impacts of persistently high levels of radon measured at monitoring stations located closest to homes in the communities located south and southwest of the HMC site. The TASC Report (pp. 15-16) noted that some of the highest ambient levels of radon recorded anywhere around Homestake's property in 2008 were at the two nearest-residence monitor stations, HMC #4 and HMC #5. An analysis of 10 years of perimeter radon monitoring, presented later in these comments, shows that these two stations have had the highest average annual radon concentrations of *any* of Homestake's eight monitoring stations, and that the levels are significantly higher than those recorded at the HMC site's background monitor location, HMC #16. Like the DRSE Report, the TASC Report questioned the appropriateness of HMC #16 serving as the sole background monitor station.

No outdoor or indoor radon monitoring has been conducted outside of HMC's property boundary since 1987-1988, when the Homestake Subdivision Radon Study detected average annual "corrected" radon levels that were four to nine times greater than background (EPA 1989). In recent sworn testimony, Bluewater Valley Downstream Alliance (BVDA) members raised concerns about the potential health impacts of high radon levels and requested that a formal health study be conducted in the community (NMED Secretary, 2010; testimony of Arthur Gebeau, pp. 268-270, and testimony of Candace Head-Dylla, 281-282). The comments that follow supplement and expand on the issues addressed in both the TASC Report and the DRSE Report to provide all stakeholders, including BVDA members, with a more complete knowledge of historic and recent ambient radon levels, an increased understanding of the range of sources of radon, and an appreciation of the potentially significant health risks associated with chronic exposure to radon at the levels observed in the community.

2.0 Review of Historic and Recent Radon Levels

2.1 Documentation. Six major studies of air monitoring for ambient radon in the region surrounding the HMC site and in the residential areas near the plant were identified and reviewed for these comments. The studies span 39 years, from 1972 to 2009, and are annotated briefly in **Table 1**. Each of the studies used common radon detection equipment and sampling techniques, and conducted calibration tests against sources having known concentrations of radon. While all sampling techniques have some level of measurement and analytical error, and monitoring devices and methods have improved over time, there is no reason to believe that the results of these studies are not comparable for the purpose of gaining a broad understanding of trends in radon levels in the Grants Mineral Belt generally and in the area of the HMC site over the past four decades.

2.2 Data Extraction and Summaries. Ambient radon levels reported in these studies and data sets were extracted and are summarized in **Table 2**. The NMEI study (1974) of radon in the Village of San Mateo was conducted to determine baseline environmental levels prior to the opening of the Mt. Taylor Uranium Mine. No non-background, or mining-influenced, sites were selected for assessment. The 1975 EPA study (Eadie et al., 1976) and 1978-1980 NMEID study (Buhl et al., 1985) included measurements at both background and non-background monitoring sites. The background sites were located in both nearby communities (e.g., Bluewater Lake and the Village of San Mateo) and communities farther away (e.g., the Town of Crownpoint) where no uranium mining or milling had occurred previously. Non-background monitors were set up in active uranium mining and milling areas in Ambrosia Lake, Milan and Bluewater village.

The 1983-1984 NMEID radiological assessment (Millard and Baggett, 1984) and the 1987-1988 Homestake Subdivisions Radon Study (HMC 1989; EPA 1989) were conducted to assess radon levels in Broadview Acres, Murray Acres and Pleasant Valley Estates, the residential areas that bordered the HMC site on the south and southwest at that time. The NMEID study designated two of seven monitor locations as "background" (both were located 10 to 20 miles outside of the area surrounding HMC and in opposite directions), while none of the monitoring locations in the Homestake Subdivisions study was designated "background" or "non-background." Accordingly, the overall mean "corrected" radon concentration of 1.9 picoCuries per liter-air (pCi/l) was not designed background or non-background in **Table 2**. As discussed in Section 2.3, radon levels reported in the two subdivision studies are grouped with concentrations at designated background monitoring sites for analysis of time trends.

The last large data set, also summarized in **Table 2,** contains the results of 10 years of fenceline monitoring conducted by HMC and reported semi-annually to NRC and the New Mexico Environment Department (NMED). The data were extracted from the company's semi-annual environmental monitoring reports (SAEMRs) and compiled in an Excel spreadsheet. They are tabulated in **Table 3a**, and discussed in more detail in Section 2.5. Locations of seven fenceline monitors and one background monitor, HMC #16, are shown in **Figure 1**, a map prepared by HMC and presented as an exhibit in the January 12-13, 2010 public hearing on DP-725 (Baker 2010b). (See, also, DRSE Report, Figure 21[1], p. 39.)

Results for monitor station HMC #16 are included in the background column of **Table 2** because this station, which is located about 2.75 miles northwest of the Large Tailings Pile (LTP), is designated as the background monitoring site for the facility. Results for HMC #4 and HMC #5, designated as "nearest-residence" monitoring sites, are shown in the "non-background" column of **Table 2** to differentiate them from HMC #16, the designated background monitor. Radon levels for monitors HMC #1, HMC #2, HMC #3, HMC #6 and HMC #7 were pooled into one average concentration and placed in the "non-background" column because these stations are sited at locations predicted to have the highest concentrations of airborne particulates (DRSE Report Supplement, p. 37).

Results of air monitoring conducted by HMC at its perimeter monitor stations in the 1980s and 1990s were not reviewed or reported here because they are not available from the NRC's ADAMS electronic document retrieval system. SAEMRs and other reports containing radon levels for that period are likely housed in NRC's document repository in paper copies only. To close the 20-year gap in radon monitoring data, HMC should compile, summarize and report all fenceline radiological monitoring data from the 1980s and 1990s.

2.3 Analyses of the Historic Radon Data. Descriptive statistics for the historic radon data were derived from the six studies listed in **Table 1** or were generated anew using statistical applications contained in Microsoft Excel. Means of average annual radon levels at background monitoring stations and radon levels recorded at monitors in or next to the residential areas were used to construct a plot of radon levels over time. This plot is shown in **Figure 2**. Standard deviations reported by the studies' authors or calculated using Excel spreadsheet software are depicted as error bars around mean values.

The plot in **Figure 2** appears to depict two groups of data: (i) concentrations at background sites ranging from 0.19 pCi/l to 0.71 pCi/l during the period 1972 to 1983; and (ii) average annual radon levels in the two residential studies (1983-84 and 1987-88), at HMC's background monitor (HMC #16) and at the nearest-residence monitor (HMC #4) between 1999 and 2009. The levels in the more recent group were significantly higher than those in the earlier group. A trendline applied to the data suggests an increasing trend in radon levels over time.[2]

[1] DRSE Figure 21 is a copy of a map that HMC has used many reports for at least the last decade, but which is now known to be incorrect with respect to the location of HMC #16. The more recent figure that is reproduced as Figure 1 in this report not only is stated to be accurate with respect to the location of HMC #16 (see, testimony of Kenneth L. Baker, January 12, 2010 (HMC, 2010; Exhibit 36B)), but is also more legible.

[2] Not depicted on **Figure 2** is an average Rn-222 concentration of 2.1 pCi/l was detected at Monitor #803 in the November 1975 EPA radon study. According to the EPA report of the study (Eadie et al., 1976, pp. 8-10), this monitor was located 1.0 miles south-southwest of the tailings pile in or next to Broadview Acres. The report categorized Monitor #803 as a non-background monitoring site, and included in one of the data tables the following

Several factors may explain the apparent differences in radon levels between the two periods. At the time of the earliest studies, more than 60 uranium mines and three uranium mills were operating in the region bounded by Interstate 40 on the south, the Mt. Taylor volcanic fields and highlands on the east, and uplifted sedimentary sequences on the west and north (NMMMD, 2009). The investigators carefully selected sites for determination of background, ranging from the Village of San Mateo on the northwest flank of Mt. Taylor to the Town of Thoreau 20 miles west of the area, and the Town of Crownpoint, 35 miles northwest of the Ambrosia Lake mining district. Even then, Buhl and colleagues (1985) reported that some of the monitoring locations designated as background may have been influenced by mining and milling releases. The authors stated that this finding explains why the average annual background concentrations of 0.57 pCi/l (1979) and 0.50 pCi/l (1980) were two to three times higher than background levels at other locations not experiencing uranium mining. The high levels recorded in the residential areas in the 1980s and the high levels reported at the nearest residence monitor (HMC #4) indicate a source or sources of radon not found in the other communities.

The data in **Table 2** and **Figure 2** clearly show that outdoor radon levels approaching or exceeding 2 pCi/l have been detected in the residential areas next to the HMC site since at least the early 1980s. An overall increase above background of between 1.2 pCi/l and 1.7 pCi/l Rn-222 has been observed in or near the residential area over this time. At times, the radon levels in the neighborhoods next to the HMC site have been more than 10 times higher than the lowest background concentrations. The outdoor levels near the residences on average are five to six times higher than the average U.S. level (0.4 pCi/l) reported by EPA (2010). The persistence of average annual radon levels of 1.8 pCi/l and 1.63 pCi/l at the two nearest-residence monitors over the last 10 years indicates that the problem is not going away.

2.4 Homestake Subdivisions Radon Study and EPA 1989 No-Action Record of Decision. The Homestake Subdivisions Radon Study merits further discussion for two reasons. First, the study documented high outdoor and indoor radon levels in the residential area through an extensive sampling program. Second, the study resulted in a finding by EPA Region 6 that the high ambient and indoor levels could not be correlated with emissions from HMC's operations. As a result, EPA implemented a "No-Action Alternative" that did not require HMC to take any remedial actions to lessen radon levels in the communities (EPA 1989). The Agency's Record of Decision (ROD) recommended that residents living in eight homes having indoor radon levels at or exceeding the EPA "action level" of 4.0 pCi/l take one, two or three actions to reduce indoor radon levels: (i) increase ventilation of crawl space, (ii) install high-efficiency, forced-air heating, and (iii) seal cracks and openings in floors (EPA 1989, Table 8). The extent to which these recommended repairs were made by the particular eight homeowners is not known.

As shown in **Table 2**, the average outdoor radon level of the 28 monitors in the community was 1.9 ± 0.4 pCi/l, bounded by extremes of 1.2 pCi/l to 2.7 pCi/l. These were "corrected" values that were reduced from "measured" radon levels by subtracting a calibration factor derived from exposing the Track-Etch detectors to a known quantity of radon. The outdoor calibration factors

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remark: "Elevated radon due to milling?" (Eadie et al., 1976, Table 3). The radon level for this monitor is not placed in **Figure 2** because the monitoring location was not categorized as a background site, but deemed a site possibly influenced by releases from the HMC uranium mill. If this average radon level were to be included in **Figure 2**, it would appear as a outlier nearly three times greater than the average radon level of the five background monitors sampled in the EPA/Eadie study.

ranged from 0.47 pCi/l in the second quarter of the study to 0.95 pCi/l-air in the fifth quarter (EPA 1989, p.7). The average measured outdoor radon concentration was 5.2 ± 1.53 pCi/l on a range of 2.8 pCi/l to 8.2 pCi/l. As discussed in Section 4 below, these levels, when coupled with an average corrected indoor radon concentration of 2.7 pCi/l, present lifetime lung cancer risks on the order of 7 in 1,000.

2.5 Trends in Radon Levels at HMC Monitoring Stations. The RSE Team noted (DRSE Report, p. 37) that HMC #6, the perimeter monitor station that is located one mile west of the LTP and is designated as the background site for radioactive particulates, had a radon concentration of 2.8 pCi/l in the second half of 2008 — the single highest radon level recorded at any of the monitors since 1999. However, a close examination of 10 years of radon levels at all eight monitors (**Table 3a**) shows that HMC #6 had the fourth *lowest* annual average radon concentration. As noted above, the two nearest-residence monitors, HMC #4 and HMC #5, had the highest average annual radon levels over the 10-year sampling period, as shown in **Figure 3**. The designated background monitor, HMC #16, did not have the lowest annual radon level; HMC #3, which is located 0.8 miles east of the LTP, had the lowest annual radon level. The nearest-residence monitors had the highest annual average radon levels, and *all eight monitors* had average radon levels greater than 0.71 pCi/l, which was the highest average concentration of the background levels recorded between 1972 and 1983 (**Table 2** and **Figure 2**).

The results of a statistical analysis to test whether radon levels recorded at the two nearest-residence monitors, HMC #4 and HMC #5, are significantly higher than levels recorded at the background station, HMC #16, are shown in **Table 3b**. A t-Test for two samples (assuming unequal variance) was performed on the data set using the Excel Data Analysis function and assuming a normal distribution of the data.[3] Only two monitors, HMC #3, located 0.8 miles east of the LTP, and HMC #7, located within 1,000 feet of the Small Tailings Pile (STP), had radon levels that were no different than those levels recorded at HMC #16. Radon levels at the rest of the monitors were all significantly different than those levels measured at HMC #16. HMC #4 and HMC #5, the two nearest-residence monitors, had average annual radon levels significantly higher than those at HMC #16, with p values of 0.0000001 and 0.0002, respectively. This means that the probability that the average levels in the nearest-residence monitors were different than the average level in HMC #16 by chance only is infinitesimally small.

These analyses suggest that HMC #16 may be sampling a different population of ambient radon gas than all but two of the other perimeter monitors, and perhaps all of them. While the populations may be different, radon concentrations at all of the monitors around the HMC site and at the background site are still far greater than the background levels recorded elsewhere. These analyses validate the TASC Report's concern that HMC #16 may not represent true background radon levels (it is located within 3 miles of abandoned mines located next to Haystack Road), and add support to the RSE Team's recommendation for fresh characterization of background by adding two or three new monitoring stations (DRSE Report, pp. iv, 37, 47).

2.6 Sources of Radon and Other Radioactive Materials. The HMC mill, which opened in 1958 and closed in 1990, was still operating at the time the Subdivision Radon Study was

[3] This assumption was based on an examination of the differences between mean and median Rn concentrations shown in **Table 3b**. The largest difference was -0.08 pCi/l in HMC #5, and four of the eight monitors had mean-median differences ranging from -0.02 to 0.01 pCi/l. These small differences mediated against using non-parametric methods for the analysis.

conducted in 1987-88. The mill was decommissioned and demolished between 1993 and 1995, and interim soil covers were placed on the sides of the LTP and STP during that time (DRSE Report Supplement, pp. 3, 38). The top of the LTP has a thin dirt cover, but has not been fully covered in order to accommodate operation of the wells used in the ground-water remediation flushing program.

2.6.1 HMC Waste Management Units. In addition to the LTP and STP, other sources of radioactive emissions from the site include the reverse osmosis effluent treatment plant located at the southwest corner of the LTP and the four existing collection and evaporation ponds located on the south side of the LTP. Evaporation Pond #1 (EP-1) was built on top of the STP in 1990 and is still in operation today. On-site tests conducted for HMC in 2009 determined that the radon flux from EP-1 was 1.13 pCi/m^2-sec, according to a draft report prepared by consultants to HMC (Simonds et al., 2009). Evaporation Pond #2 (EP-2) is sandwiched between EP-1 on the east and the East and West Collection Ponds on the west. Exposed tailings and unwetted berms on the ponds are sources of radon.

2.6.2 Effluent Spraying. Spraying of pond effluent by Homestake to increase evaporation of wastewater generated by the ground-water remediation system may also be a source of radon and radon progeny, as noted in both the November TASC Report (pp. 18-19) and in the DRSE Report (pp. iv, 38). Deposition of precipitates from the high-salinity wastewater onto the berms and sides of EP-1 and EP-2 was documented in photographs taken by Wm. Paul Robinson and appended to Mr. Robinson's testimony in the January 2010 hearing on DP-725 (Robinson, 2010; slides 13, 14, 17, 18; attached hereto as **Appendix A**). No radiochemical or trace-element data for the precipitates have been disclosed, a concern noted in the first Remediation System Evaluation sanctioned by EPA Region 6 (EQM, 2008, p.35). The extent of deposition of precipitates from the spraying is unclear from an examination of uranium and radium-226 concentrations in soils sampled east of EP-1 and State Route 605. Those concentrations are shown in a map of the area provided by Homestake at the January 12-13, 2010 hearing on DP-725 (Baker, 2010c), and included in this report as **Figure 4**. A radium-226 concentration of 9 picoCuries per gram (pCi/g) was detected in the first six inches of soil at sampling location EP-4, and a uranium concentration of 13 milligrams per kilogram dry weight, or parts per million (mg/kg-dw and ppm), was detected in the first six inches of soil at nearby sampling location EP-1. As discussed in Section 2.6.1.2 below, these concentrations are not considered to be within the range of background absent site-specific data to the contrary.

The TASC Report (p. 18) noted that local residents had reported in a letter to NMED in 2008 that sprays were being blown beyond the perimeter of the evaporation ponds. More recently, residents of the adjacent neighborhoods reported observing the effluent spray "drifting" into the community, and provided photographs to document their observations and concerns. (See, NMED Secretary, 2010; testimonies of Jonnie Head, pp. 291-292, Mark Head, pp. 294-295, and John Boomer, pp. 297-299.) The first RSE report concluded that the "completion elimination" of spraying "seems appropriate," given the reports of local residents and "the potential for human health and environmental exposure" (EQM, 2008, p. 48).

DP-725, issued as amended by NMED on April 12, 2010, is conditioned to require HMC to "operate the forced spray system such that the spray remains within the confines of the ponds to the extent practicable" (NMED, 2010, Condition 8, p. 6). The permit also requires HMC to submit to NMED a plan that outlines the specific atmospheric conditions, such as wind speeds and wind directions, under which the sprayers would not be operated or would automatically shut off (*Ibid*.). Neither DP-725 nor SUA-1471, the NRC license for the facility, currently contains specific limitations on sprayer operations.

As soon as possible, Homestake should conduct and submit to NMED, NRC and EPA radiochemical analyses of precipitates deposited by the sprayers on the berms of the evaporation ponds. Data on particulates detected at the seven perimeter air monitors should be analyzed to determine if radionuclide levels are correlated with wind patterns (velocities and directions) and/or spraying events. Minimally, DP-725 and SUA-1471 should be amended to prohibit spraying when weather conditions would cause mists and precipitates to be deposited outside of the perimeters of the ponds. The final RSE report should assess whether, based on existing monitoring data, effluent spraying is protective of public health.

<u>2.6.3 Contaminated Soils</u>. Another source of radon at the HMC site would be contaminated soils. A wide area of contaminated soils located north, northeast and east of the LTP were excavated in 1993-1995 to meet NRC and EPA cleanup standards. Data presented by HMC at the January 2010 public hearing on DP-725 showed 7 ppm uranium and 6 pCi/g radium in soils near the location of HMC #5 (**Figure 4**). These concentrations may or may not be in the range of normal levels for the alluvial soils that cover the San Mateo Creek drainage area around the HMC site. For comparison, uranium levels in undisturbed soils located on non-uraniferous Cretaceous rocks in Church Rock, Coyote Canyon, Nahodishgish and Pinedale chapters of the Navajo Nation ranged from 0.3 ppm to 2.61 ppm, based on nearly 70 sampling points (Shuey et al., 2007; deLemos et al., 2008). Crustal average radium concentrations are widely reported in the published literature to be around 1 pCi/g. The EPA's clean-up standard for soils contaminated by windblown uranium mill tailings is 5 pCi/g radium-226 in the first 15 centimeters of soil, *excluding* background. (See, 40 CFR 192.32.)

<u>2.6.4 Subdivisions Radon Study and 1989 EPA ROD</u>. EPA's 1989 ROD for the Radon Operable Unit listed building materials and soils under homes as possible sources of indoor and outdoor radon (EPA 1989, p. 8). However, the ROD stated that gamma radiation surveys turned up no evidence that radioactive materials were used in home construction. Uranium and radium levels in soils collected from beneath and adjacent to homes with elevated indoor radon levels "were indicative of background levels and provided no evidence that tailings were significant in the soil in the vicinity of these residences" (EPA 1989, p. 9). Despite this finding, the ROD states that "the primary source of indoor radon in homes in the subdivisions is local soil which emits radon gas." Results of the soil monitoring cited to conclude that soil uranium and radium levels "were indicative of background" were not provided in the ROD, and there was no indication given in the ROD that soil-gas experiments were conducted.

<u>2.6.5 Aerial Radiation Surveys, 2009</u>. In fall 2009, contractors to EPA Region 6 conducted aerial gamma radiation surveys in several subregions of the Grants Mineral Belt, including in the vicinity of the HMC site. A draft report containing color maps and orthophotomosaics documenting gamma radiation rates and uranium-in-soil concentrations was released for public comment in January 2010 (EPA 2010a). Images 14, 26, 38 and 53 of the report cover the residential and agricultural areas located south and southwest of the HMC site. The overflights touched the southern half of EP-1 and the edge of EP-2, and these locations are easily discernible on the maps because they have colors representing higher gamma activity levels or higher uranium concentration levels. While precise locations of elevated gamma radiation and uranium cannot be discerned from these maps because of their large scale, the color contours that represent radiation levels do not identify activities or concentrations that would indicate the

presence of an anthropogenic source or sources of radiation and uranium in the residential areas near the HMC site. In fact, some of the images suggest that soils in the residential area exhibit uranium in concentrations within the natural range. Image 38, for instance, shows colors indicating uranium concentrations in soils in the residential areas of less than 4 pCi/g, compared with colors indicating concentrations >9 pCi/g at the edge of the HMC evaporation ponds.

2.6.6 Inventory Needed of All Radon Sources. The *only* source of human-made or technologically enhanced, naturally occurring radioactive materials in the vicinity of the subdivisions is the HMC site, including its crop irrigation plots located northwest and west of Pleasant Valley Estates. All other anthropogenic sources of radon — abandoned uranium mines and closed uranium mills — are located six miles east, six to seven miles north, and four to five miles west of the community, according to the New Mexico Mining and Minerals Division uranium mine database (NMMMD, 2009). As noted in the DRSE Report (p. 42), EPA Region 6 is planning to conduct a new round of environmental sampling in the neighborhoods next to the HMC site later this year in support of a new risk assessment. Minimally, the assessment should include outdoor and indoor radon monitoring, soil surveys for gamma radiation and uranium and radium concentrations, surveys of structures for indications of the use of contaminated materials, an inventory of natural and human-made sources of radioactive materials, and recalculation of radiation doses to the public. An objective of the assessment should be a complete inventory of all sources of radon to further investigate why levels exceeding 1 pCi/l-air have persisted in the neighborhoods next to the HMC site for more than 35 years.

3.0 Air Monitoring Issues and Dose Calculations

3.1 Adjustments in Current Monitoring System. As noted in the Overview of these comments, the principal objective of HMC's air monitoring program is to determine compliance with NRC's 100-mrem/y dose limit to the nearest member of the public exposed to releases of radioactive materials from licensed activities (DRSE Report, Section 7.2.1, p. 36). HMC operates the eight perimeter air monitoring stations to measure airborne concentrations of radon and radioactive particulates of uranium, thorium-230 and radium-226, and direct gamma radiation rates. While the DRSE Report states (p. 37) that the eight monitors meet the minimum requirements of NRC Regulatory Guide 4.14, the report also notes that NRC Regulatory Guide 4.14 requires monitoring for lead-210, which is not presently being done by HMC. HMC should begin monitoring for Pb-210 in particulates immediately or provide an explanation of why it is not required or why HMC is exempt from doing so.

The NRC Regulatory Guide 4.14 (Section 2.1.2) also requires that "[a]ir particulate samples should be collected continuously at…the residence or occupiable structure within 10 kilometers of the site with the highest predicted airborne radionuclide concentration…" As noted previously, no air monitoring for radon or other radionuclides is being conducted outside of HMC's restricted area boundary, with the exception of uranium in soils at the two crop irrigation plots located 1.5 and 2.5 miles west and southwest of the LTP. Absent a specific legal or technical reason not to select a monitoring site *next to a residence*, HMC should consult with BVDA, EPA and NRC to propose and select a suitable monitoring location in Murray Acres or Broadview Acres.

The DRSE Report (p. 37) also points out that HMC furnishes no meteorological data to support its air monitoring program. However, HMC has acknowledged that it maintains an on-site meteorology station from which it gathers data on wind speeds, wind directions, ambient temperature and other atmospheric conditions. In the January 2010 public hearing on DP-725, HMC presented a wind rose diagram that showed the highest frequency of winds moving from the northeast across the tailings piles toward the community to the southwest. (A copy of this diagram is contained in **Figure 5**.) While those "northeasterlies" appear to travel at less velocity than winds coming from the west and southwest, their presence at the HMC site may explain why high radon levels have been observed at monitor stations HMC #4, HMC #5 and HMC #6. As suggested in the DRSE Report (p. 37), the LTP itself may act as a funnel carrying low-lying wind currents toward the community.

HMC should compile and report all previous meteorological data, and commit to including all future meteorological data in its SAEMRs. HMC should also undertake a study of localized wind patterns to determine if the tailings piles or other land features contribute to a channeling of currents into the adjacent community. HMC also should establish a met station in the residential area, perhaps co-located with a new air monitoring station as recommended above. The final RSE Report should include these expanded recommendations.

3.2 Assumptions Influencing Calculation of the TEDE. To demonstrate compliance with the NRC dose limit, HMC calculates the TEDE from all releases of radioactive materials on an annual basis. The calculation and rationale for its assumptions are contained in Attachment 4 of each SAEMR, titled "Annual Effective Dose Equivalent to Individuals of the Public" (HMC, 2000-2009). The dose from radon exposure dominates the TEDE calculation; contributions to the TEDE from particulate emissions and direct gamma rates make up a small portion of the dose. The DRSE Report (pp. iv, 38) questions HMC's use of certain values for two assumptions that significantly influence the TEDE calculation: the residential occupancy factor (OF) and the radon-radon daughter equilibrium factor (EF).

3.2.1 Occupancy Factor (OF). The RSE Team cites NRC staff guidance that requires use of an OF of "unity," or 1.0, because "10 CFR 20.1302 (b) (2) (ii) involves the assumption that an individual is continually present in the area." (See, http://www.nrc.gov/about-nrc/radiation/protects-you/hppos/qa68.html.) HMC cites an NRC technical document (NUREG-5512, p. 6.37) for its use of an OF of 0.75 (HMC, 2000-2009, Attachment 4, p. 1). Notwithstanding the NRC staff technical position, the time and activity patterns of many residents living in the vicinity of the HMC site warrants use of an occupancy factor of 1.0. The character of the surrounding neighborhoods is semi-rural and agricultural. Most local residents engage in outdoor activities related to farming and gardening, tending to livestock, and raising and caring for horses. Whether working indoors or outdoors, they tend to be in the vicinity of their homes most of the time.

3.2.2 Equilibrium Factor (EF). The EF refers to the proportion of radon activity that comes from radon's short-lived decay products, called "progeny" or "daughters." As radon-222 decays after being emitted from a source, its decay progeny takes time to "catch up." Distance and time dictate how rapidly the progeny come into equilibrium with the parent. Eventually, radon will be present in an equal proportion with its progeny; in that case, the radon-radon progeny equilibrium is 100 percent or 1.0.

In every SAEMR submitted to NRC and NMED since at least 2000, HMC has used an EF of 0.2 (20 percent) based on the same rationale:

> "Since the nearest residence is within a few hundred feet of the site perimeter and within 3,500 feet of the major source of radon, the radon daughter equilibrium should be low. We have selected 20 percent radon daughter equilibrium as an estimate for use in the calculations." (HMC, 2000-2009; see, SAEMR dated December 31, 2009, Attachment 1, p. 3; NRC Document No. ML100970422.)

Verifiable and site-specific EFs can be calculated from radon and radon progeny concentrations measured in air. Three of the six radon studies listed in **Table 1** included estimated EFs based on air monitoring data. **Table 4** summarizes the technical bases for these estimates. The estimates in the studies ranged from 28 percent to 73 percent. The 28 percent EF estimated by Millard and Baggett (1984, p. 2) was for the closest residence to the LTP. Indoor and outdoor radon levels exceeding 2.0 pCi/l were observed in and around homes located more than 1.5 miles west and southwest of the closest residence in the 1989 Subdivisions Radon Study (HMC, 1989; USEPA 1989, Tables 1 and 2). The increased travel time and distance from the radon source at HMC to residences in Pleasant Valley and Valle Verde Estates would allow increased in-growth of radon daughters, increasing the EF.

HMC provides no calculations to support its choice of an equilibrium factor of 0.2, and none of the historic studies examined for these comments justify the use of an EF of 20 percent. The 50 percent factor estimated by NMEID staff based on results of the 1978-1980 Radon Study is technically justifiable and more conservative from a public health perspective.

3.2.3 Effects of OF and EF on TEDE Calculations. The November 2009 TASC Report (Table 2, p. 17) demonstrated how selection of an inflated background radon concentration acts to *reduce* the TEDE and facilitate compliance with the 100-mrem/y rule. The TASC Report also showed that a low radon-radon daughter EF also diminishes the final dose calculation (TASC, 2009, Appendix B).

The November 2009 TASC analysis can now be updated to show the effects of overstating background radon levels and underestimating the OF and EF on the TEDE calculation. **Table 5** below presents HMC's 2009 TEDE calculation as the "base case" – a "background" radon level of 1.3 pCi/l, an OF of 0.75 and an EF of 0.2. As the background level is reduced and the OF and EF are increased to 1.0 and 0.5, respectively, the calculated doses exceed the 100-mrem/y limit by up to four times. Even if an inflated background level is retained but higher occupancy and equilibrium factors are used, the TEDE exceeds the 100-mrem/y limit. As suggested by the RSE Team, HMC should reassess all input parameters to the TEDE calculation. NRC staff should review all assumptions and rationales presented by HMC in the annual TEDE calculation provided in the semi-annual environmental monitoring reports.

4.0 Public Health Risks

Radon and its decay products are well-documented radiotoxicants that attack human and animal cells with high linear-energy transfer alpha particles the size of helium nuclei. More than a dozen epidemiological studies of underground uranium miners has demonstrated substantial increased risks of lung cancer and lung cancer mortality from exposure to radon and radon progeny (see, e.g., Samet et al., 1984; Wagoner et al., 1975). These effects have been demonstrated in the largely non-smoking Navajo uranium miner cohort (see, e.g., Gilliland et al., 2000; Roscoe et al., 1995); cigarette smoking has been identified as having a multiplicative effect on incidence and mortality. Studies of uranium miners have been applied to measured levels of radon indoors to generate estimates of the impact of indoor radon on lung cancer incidence and mortality (Samet and Maple, 1998). EPA (2010), for instance, estimates that 14,000 to 21,000 lung cancer cases result from exposure to indoor radon annually in the United States, and that radon ranks second only to cigarette smoking as the leading cause of lung cancer in the United States. The World Health Organization (WHO, 2009) recently recommended a 33 percent decrease in the indoor radon "action level," from 4 pCi/l to 2.7 pCi/l, in recognition of the fact that "there is no known threshold concentration below which radon exposure presents no risk. Even low concentrations of radon can result in a small increase in the risk of lung cancer."

For these reasons, HMC, EPA, NRC and all other stakeholders should be concerned about chronic exposure to levels of radon that have averaged nearly 2 pCi/l in the residential areas near the HMC site since at least the mid-1970s. The lung cancer risk at this level is significant. As shown in **Table 6**, a nonsmoker exposed to 2 pCi/l of radon indoors has a lifetime lung cancer risk of 4 in 1,000, or 1 in 250. A person exposed to 4 pCi/l who is not a smoker has a lifetime lung cancer risk of 7 in 1,000, or 1 in 143. (These cancer risk levels are high compared with the range at which EPA usually regulates carcinogens: from 1 in 1 million chance to 1 in 10,000.) A smoker or a former uranium miner faces even greater risks. To put those numbers into perspective, BVDA members estimate that about 300 people live in the subdivisions that lie in the shadow of the Homestake mill tailings site. (See, slides 23 and 24 of **Appendix A**.) Accordingly, one to two residents could contract lung cancer during their lifetimes from long-term exposure to the levels of outdoor and indoor radon observed in the community.

The final RSE Report should review the public health risks associated with chronic exposure to levels of radon observed in the community. Furthermore, it is advisable for the regulatory agencies to identify sources of funding for health studies, and to engage uninvolved third-party organizations with appropriate credentials to design and implement health studies in the affected community. Facilitation of health studies could be done through the RSE Advisory Committee, which includes BVDA members. This approach would help ensure that all stakeholders have a part in selecting the health study providers.

5.0 Recommendations

All recommendations contained in these comments are consolidated in this section to facilitate their review and consideration.

5.1 Environmental Monitoring.

The DRSE Report should be revised to recommend that —

(i) HMC compile, summarize and report all fenceline radiological air monitoring data from the 1980s and 1990s. These data are expected to be stored in hard copies in the NRC's public document repository.

(ii) Any new air monitoring stations be sited consistent with locations of monitors that had average annual radon concentrations of less than 0.7 pCi/l-air, which is the upper range of average levels reported in previous studies.

(iii) The planned EPA Region 6 risk assessment include outdoor and indoor radon monitoring, soil surveys for gamma radiation and uranium and radium concentrations, surveys of structures to detect the use of contaminated materials, and an inventory of natural and human-made sources of radioactive materials. Monitoring of radon at HMC's fenceline monitoring stations should be done concurrently with air monitoring in the residential areas.

(iv) EPA-6 consider hiring a community member to serve as a liaison between the community and EPA and its contractors during field studies associated with the assessment and at the time results of the risk assessment are presented to the community.

(v) EPA Region 6 review and reconsider the findings, conclusions and recommendations of the 1989 Record of Decision of the Radon Operable Unit in light of the findings of new environmental monitoring conducted as part of the planned risk assessment and by HMC under its routine and expanded monitoring program.

(vi) HMC comply with NRC Regulatory Guide 4.14 and immediately begin monitoring Pb-210 in particulates measured at its eight air monitoring stations.

(vii) HMC establish at least one air monitoring station in the residential area southwest of the site, including consultation with BVDA, EPA and NRC before selecting a suitable residential monitoring location. Consideration should be given to establishing more than one air monitoring station in the residential area to provide an appropriate geographic distribution that takes into account local wind speeds and directions, and possible contributions to radiation releases from HMC's two irrigation plots located west of Valle Verde Estates.

(viii) HMC compile and report all previous meteorological data, and commit to including all future meteorological data in its Semi-annual Environmental Monitoring Reports. The DRSE Report should further recommend that HMC undertake a study of localized wind patterns to determine if the tailings piles or other land features contribute to a channeling of currents into the adjacent community.

(ix) HMC establish a meteorological station in the residential area. The residential air monitoring station recommended in Section 5.1(vii) above could be co-located at a new residential meteorological station. The residential meteorological station should be capable of measuring wind speeds and directions and ambient temperature and pressure.

5.2 Effluent Spraying:

The DRSE Report should be revised to recommend that —

(i) Homestake conduct and submit to NMED, NRC and EPA radiochemical analyses of precipitates deposited by the sprayers on the berms of the evaporation ponds as soon as possible.

(ii) Data on particulates detected at the seven perimeter air monitors be analyzed to determine if radionuclide levels are correlated with wind patterns (velocities and directions) and/or spraying events.

(iii) DP-725 and SUA-1471 be amended to prohibit spraying when weather conditions would cause mists and precipitates to be deposited outside of the perimeters of the ponds.

(iv) An assessment be conducted on whether existing monitoring data are adequate to determine if effluent spraying is protective of public health. If the RSE Team finds that existing monitoring data are not adequate to determine if effluent spraying is protective of pubic health, the final report should identify the scope of a data-gathering program needed to make such a determination.

5.3 Dose Calculations. The DRSE Report should recommend that HMC reassess all input parameters to the calculation of the Total Effective Dose Equivalent (TEDE), including and especially the occupancy factor and the radon-radon daughter equilibrium factor. The DRSE Report should further recommend that the NRC staff review all assumptions and rationales presented by HMC in the annual TEDE calculation provided in the semi-annual environmental monitoring reports.

5.4 Public Health Risks. The DRSE Report should review the public health risks associated with chronic exposure to levels of radon observed in the community. The planned EPA risk assessment should include a summary of historic and current radon levels around the HMC site and in the community, and calculate doses and respiratory risks using those data. All management alternatives to mitigate or eliminate exposures from anthropogenic sources of radiation, heavy metals and other contaminants should be fully and fairly considered.

5.5 Public Health Studies. The DRSE Report should recommend that HMC, EPA, NRC and NMED identify funding for health studies in the communities, and work with BVDA to identify uninvolved third-party organizations with appropriate credentials to design and implement health studies in the affected community. The RSE Advisory Committee, which includes BVDA members, may be an appropriate vehicle in which to begin these discussions to ensure that all stakeholders have a part in identifying funding sources and recommending health study providers.

6.0 TASC Contact Information

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Table 1.
Major Radon Monitoring Studies in the Grants Mineral Belt and Surrounding the Homestake Mining Company Grants Superfund Site, 1972-2009

Period	Organization(s)/ Reference(s)	Content	Monitors
1972-1973	New Mexico Environmental Institute (NMEI, 1974) for Gulf Minerals Resources	Radon baseline study with aircraft-based investigation of effects of temperature inversions on radon levels in San Mateo, New Mexico; part of environmental baseline study for proposed Mt. Taylor Uranium Mine	Taplex high-volume air samplers with discharge to scintillation cell (p. 68)
1975 (November)	EPA Office of Radiation Programs, Las Vegas, Nev. (Eadie et al., 1976)	Study of outdoor radon and indoor radon progeny levels at 10 sites in the Grants Mineral Belt	48-hr bag collection with discharge of air to scintillation cell
1978-1980	New Mexico Environmental Improvement Division (Buhl et al., 1985)	Study of outdoor radon levels at 27 sites, 21 sites in the Ambrosia Lake-Milan-Bluewater region and six sites in places where uranium mining and milling had not previously occurred	Outdoor radon: 48-hr bag collection with discharge of air to scintillation cell; Indoor radon progeny: Radon Progeny Integrating Sampling Units provided by EPA
1983-1984	NMEID (Millard and Baggett, 1984)	Radiological assessment of residential areas southwest of the HMC site with monitors located in Murray and Broadview Acres and villages of San Mateo and Bluewater	PERMs (Passive Environmental Radon Monitors) provided by EPA
1987-1988	Homestake Mining Co. (Carter 1988, HMC 1989, USEPA, 1989)	Subdivisions Radon Study conducted in 59 homes and at 28 outdoor stations	Initial screening: three-day charcoal canisters; long-term monitoring with Terradex Track-Etch monitors
1999-2009	Homestake Mining Co. (HMC, 2000-2009)	Radon data from HMC's seven perimeter air monitoring sites and one background monitor station, extracted from HMC's SAEMRs	Terradex Track-Etch monitors

Table 2.
Summary of Average Annual Radon Levels at Background and Non-Background Locations in Ambrosia Lake-Milan Uranium Mining District, 1972-2009
(all concentrations in picocuries per liter-air)

Year / Period	Study Area	Background: # monitors (# samples)	Background: Average Rn (range)	Non-background: # monitors (# samples)	Non-background: Average Rn[a] (range)	References
1972-73	San Mateo, NM	3 (135)	**0.19** (0.08-.59)	None	None	GMR: **NMEI, 1974**
Nov. 1975	Ambrosia Lake-Milan	5 (5)	**0.71±0.47** (0.11-1.2)	5 (5)	2.58±0.73 (1.9-3.6)	USEPA: **Eadie et al., 1976**
1978-79	Ambrosia Lake-Milan	9 (122)	**0.57±0.69** (0.10-1.12)	AL: 6 (110)	***3.20±2.53*** (2.01—4.23)	NMEID: **Buhl et al., 1985 (17)**
				HMC: 3 (53)	***1.83±1.24*** (1.55—2.01)	
				AC: 2 (38)	***1.06±0.75*** (0.76-1.37)	
1979-80	Ambrosia Lake-Milan	10 (187)	**0.50±0.58** (0.14-0.81)	AL: 6 (136)	***4.66±2.89*** (3.23-6.40)	NMEID: **Buhl et al., 1985 (18, 28)**
1978-80	Bluewater Lake, Cebolleta, Crownpoint, Gulf Mill Site, Nose Rock, San Mateo	6 (115)	**0.19±0.02** (0.13-0.25)	HMC: 3 (67)	***1.51±1.02*** (1.51—1.89)	
				AC: 2 (42)	***0.87±0.64*** (0.78-0.95)	
1983-84	San Mateo and Bluewater Village	2 (52)	**0.35±0.02** (no range)	MA and BA: 5 (130)	**1.62** (no sd or range given)	NMEID: **Millard & Baggett, 1984**
1987-88 (15 mo.)	Residential area south and southwest of HMC site	28 (112)	**1.9±0.4**[b] (range of corrected Rn values, 1.2-2.7) (range of maximum Rn values, 2.8-8.2)			HMC: **EPA, 1989**
1999-2009*	Perimeter of HMC-licensed area	HMC #16 (21)	**1.16±0.36** (0.8-2.5)	HMC #4 (20)	**1.80±0.33** (1.1-2.4)	**HMC, 2000-2009**
				HMC #5 (20)	**1.63±0.32** (1.2-2.2)	
				HMC #1,2,3,6,7[d] (100)	**1.38±.0.35** (0.8-2.8)	
2010	United States	Not given	**0.4 (average outdoor Rn)**	n/a	n/a	**EPA 2010**

Abbreviations: AC = Anaconda Co.; AL = Ambrosia Lake Mill (Kerr-McGee Corp./Quivira Mining Co.); BA = Broadview Acres; GMR = Gulf Mineral Resources; HMC = Homestake Mining Co.; MA = Murray Acres; NMEID = New Mexico Environmental Improvement Division; sd = standard deviation; EPA = U.S. Environmental Protection Agency

Table 3a.
Ambient Radon-222 Concentrations at HMC Perimeter Air Monitoring Stations, 1999-2009
(all concentrations in picocuries per liter air)

Year	Period	HMC #1	HMC #2	HMC #3	HMC #4	HMC #5	HMC #6	HMC #7	HMC #16	Reference
1999	2nd half	2.0	1.6	1.1	1.7	1.6	1.7	1.2	1.1	HMC-SAEMR, 2/24/00
2000	1st half	1.4	1.5	1.2	1.9	1.2	1.1	1.0	0.9	HMC-SAEMR, 8/8/00
2000	2nd half	2.2	1.6	1.2	2.0	1.8	1.1	1.1	1.1	EPA, 2001 (Table 4)
2001	1st half	1.5	2.2	1.2	1.8	2.0	1.4	1.7	1.1	HMC-SAEMR, 8/15/2001
2001	2nd half	1.1	1.3	0.7	1.4	1.4	1.1	1.1	1.1	HMC-SAEMR, 2/21/02
2002	1st half	1.3	1.6	1.1	1.6	1.3	1.5	1.1	0.9	HMC-SAEMR, 8/28/02
2002	2nd half	1.5	1.3	1.1	1.5	1.3	1.2	1.1	0.9	HMC-SAEMR, 2/26/03
2003	1st half	1.6	2.3	1.2	1.2	1.5	0.9	1.2	0.9	HMC-SAEMR, 8/27/03
2003	2nd half	1.7	1.5	1.1	2.3	1.5	1.6	1.4	1.0	HMC-SAEMR, 2/24/04
2004	1st half	1.1	0.9	0.6	1.1	1.2	1.7	0.8	1.5	HMC-SAEMR, 8/30/04
2004	2nd half	1.6	1.4	1.2	1.8	1.7	1.6	1.2	1.0	HMC-SAEMR, 2/24/05
2005	1st half	1.2	1.8	0.9	1.8	1.4	1.4	1.3	1.2	EPA, 2006 (Table 4)
2005	2nd half	1.5	1.5	1.2	2.0	1.7	1.6	1.3	1.1	HMC-SAEMR, 2/24/06
2006	1st half	1.2	1.7	1.1	2.2	2.1	1.1	1.2	1.0	HMC-SAEMR, 8/30/06
2006	2nd half	1.7	2.0	1.0	2.1	1.8	1.4	1.3	1.0	HMC-SAEMR, 2/20/07
2007	1st half	1.5	1.0	0.7	1.8	1.3	1.3	0.9	0.8	HMC-SAEMR, 8/20/07
2007	2nd half	1.9	1.7	1.6	2.4	1.8	1.7	1.6	1.6	HMC-SAEMR, 2/25/08
2008	1st half	1.4	1.6	1.4	1.8	2.2	1.6	1.3	1.3	HMC-SAEMR, 8/20/08
2008	2nd half	1.3	1.6	1.2	1.7	2.2	2.8	1.2	1.2	HMC-SAEMR, 2/25/09
2009	1st half								1.2	HMC-SAEMR, 12/31/09
2009	2nd half	1.6	1.8	1.4	1.8	1.5	1.4	1.2	2.5	HMC-SAEMR, 12/31/09

Table 3b.
Results of t-Test* of Two Samples Assuming Unequal Variance
for Radon Levels in HMC Perimeter Air Monitors
(all concentrations in pCi/l-air)

Station	N	Mean	Std. Dev.	Median	Max	Min	*p*-value**
HMC #1	20	1.52	0.29	1.50	2.2	1.1	*<0.002*
HMC #2	20	1.60	0.34	1.60	2.3	0.9	*<0.0004*
HMC #3	20	1.11	0.24	1.15	1.6	0.6	0.59
HMC #4	20	1.80	0.33	1.80	2.4	1.1	*<0.0000001*
HMC #5	20	1.63	0.32	1.55	2.2	1.2	*<0.0002*
HMC #6	20	1.46	0.40	1.40	2.8	0.9	*<0.02*
HMC #7	20	1.21	0.21	1.20	1.7	0.8	0.605
HMC #16	21	1.16	0.36	1.10	2.5	0.8	n/a

*Normal distribution of Rn values assumed, based on examination of differences in calculated mean and median values.

***p* is the probability that radon levels at HMC air monitors are significantly different than radon levels in HMC #16 at $\alpha \leq 0.05$. *p*-values in *italic* signify a significant difference in average radon levels.

Table 4.
Radon-Radon Daughter Equilibrium Estimates in Regional Studies

Study (Reference)	Technical Basis	EF Estimate(s)
1975 EPA Study (Eadie et al., 1976, p. 9)	“Percent Equilibrium” was calculated for each of the 10 monitoring stations in the study	Range of EF: 40% - 129%; average of all EFs: 73.7% (0.737)
1978-1980 NMEID Study (Buhl et al., 1985, p. 42)	Outdoor radon was correlated with indoor radon progeny concentration	EF = 50% (0.50)
1983-84 NMEID Radiological Assessment (Millard and Baggett, 1984, p. 2)	Calculated EF from average wind speed from HMC tailings to residences, distance from tailings to homes, travel time from source to target for in-growth of radon daughters	EF = 28% (0.28) Also cited study by George and Breslin (1978) in which an EF of 83% was calculated from outdoor radon and radon daughter levels.

Table 5.
Comparison of HMC-Calculated Total Effective Dose Equivalent (TEDE)
at Nearest-Residence Air Monitoring Station (HMC #4) with Doses Calculated Using
Different Background Radon Values and Different Assumptions
for Occupancy Factor (OF) and Radon-Radon Daughter Equilibrium Factor (EF)
(doses in *italics* exceed NRC's 10 CFR 20.1301(a)(1) limit of 100-mrem/y to member of the public)

Nearest Residence Radon HMC #4 (2009)	Back-ground Radon	Background Station(s) (Year)	HMC Base Case: OF = 0.75 EF = 0.2	OF = 1.0 EF = 0.2	OF = 0.75 EF = 0.5	OF = 1.0 EF = 0.5
pCi/l	pCi/l		mrem/y			
1.8	1.3	HMC #16 (2009)	46.3	58.8	*102.6*	*133.8*
1.8	1.12	NMEID #201 (1979) (comparable with ave. Rn level of 1.16 in HMC #16)	59.8	76.8	*136.3*	*178.8*
1.8	0.81	NMEID #201 (1980)	83.1	*107.8*	*194.4*	*256.3*
1.8	0.53	NMEID #211, #212, #219, #220, #316, #415 (1983)	*104.1*	*135.8*	*246.9*	*326.3*
1.8	0.19	San Mateo (1972-73); Bluewater Lake, Crownpoint, Gulf Mill Site, San Mateo (1978-80)	*129.6*	*169.8*	*310.7*	*411.3*

Table 6.
Lifetime Risk of Lung Cancer from Indoor Radon Exposure – Non-smoking and Smoking
(Source: EPA, 2010)

Radon Level (pCi/l*)	Lifetime Cancer Risk Among Non-smokers	Lifetime Cancer Risk Among Smokers	Remediation Recommendations
20	36 in 1,000 (3.6×10^{-2})	260 in 1,000 (2.6×10^{-1})	Ventilate your home
10	18 in 1,000 (1.8×10^{-2})	150 in 1,000 (1.5×10^{-1})	Ventilate your home
8	15 in 1,000 (1.5×10^{-2})	120 in 1,000 (1.2×10^{-1})	Ventilate your home
4**	7 in 1,000 (7×10^{-3})	62 in 1,000 (6.2×10^{-2})	Ventilate your home
2	4 in 1,000 (4×10^{-3})	32 in 1,000 (3.2×10^{-2})	Consider ventilating or fixing your home
1.3***	2 in 1,000 (2×10^{-3})	20 in 1,000 (2×10^{-2})	Consider fixing your home, but may be difficult
0.4	No risk estimated	No risk estimated	None recommended

*pCi/l = picocuries per liter air
**EPA "action level" for indoor radon
***Average indoor radon level in United States., according to EPA

Figure 1
Air Monitoring Stations at the Homestake Mining Company Superfund Site
(Source: Baker, 2010b)

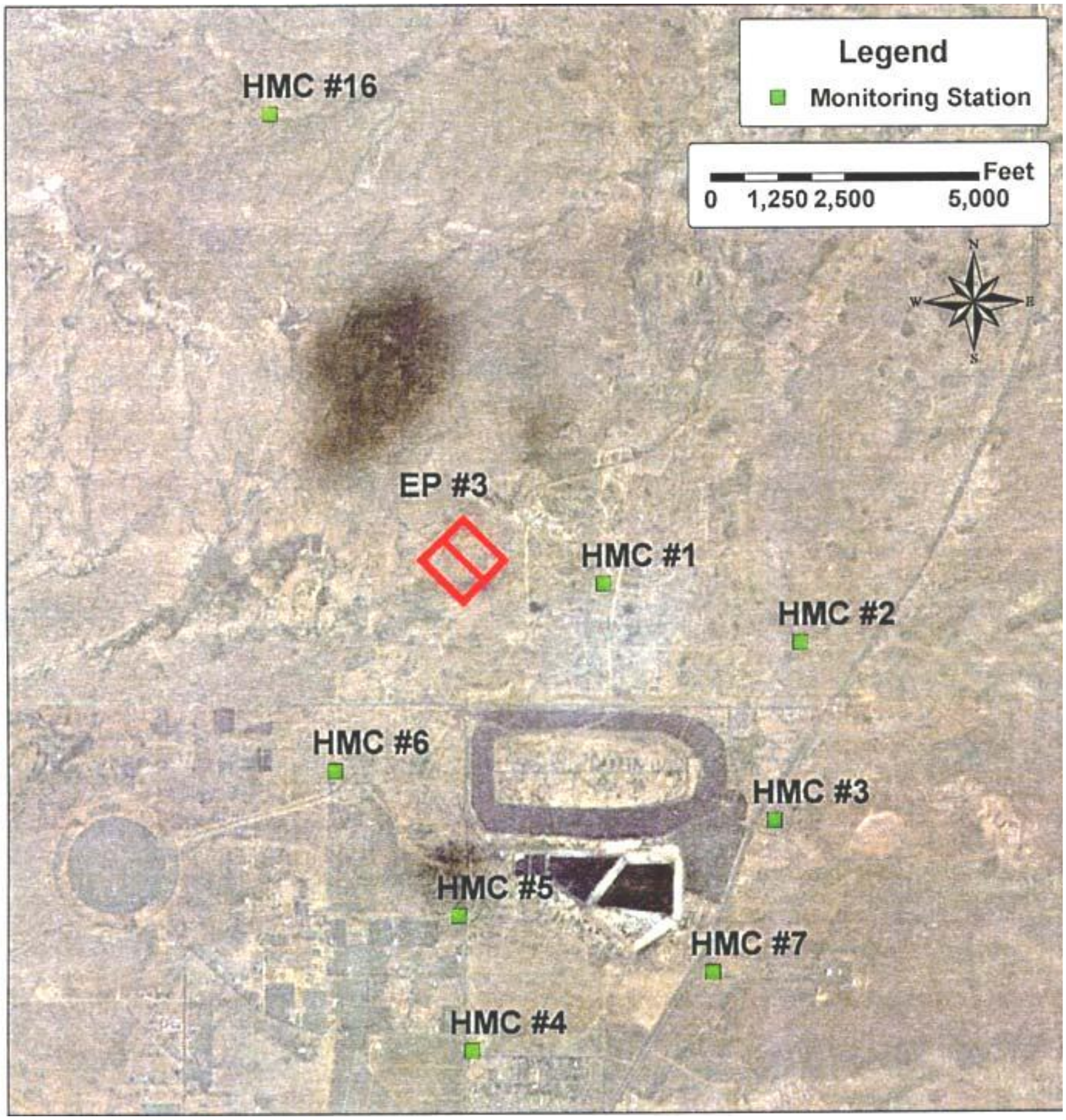


Figure 2.
Average Annual Outdoor Radon Concentrations*
at Background Stations, BVDA Residential Area, and
Nearest-residence Monitor (HMC #4), 1972-2009

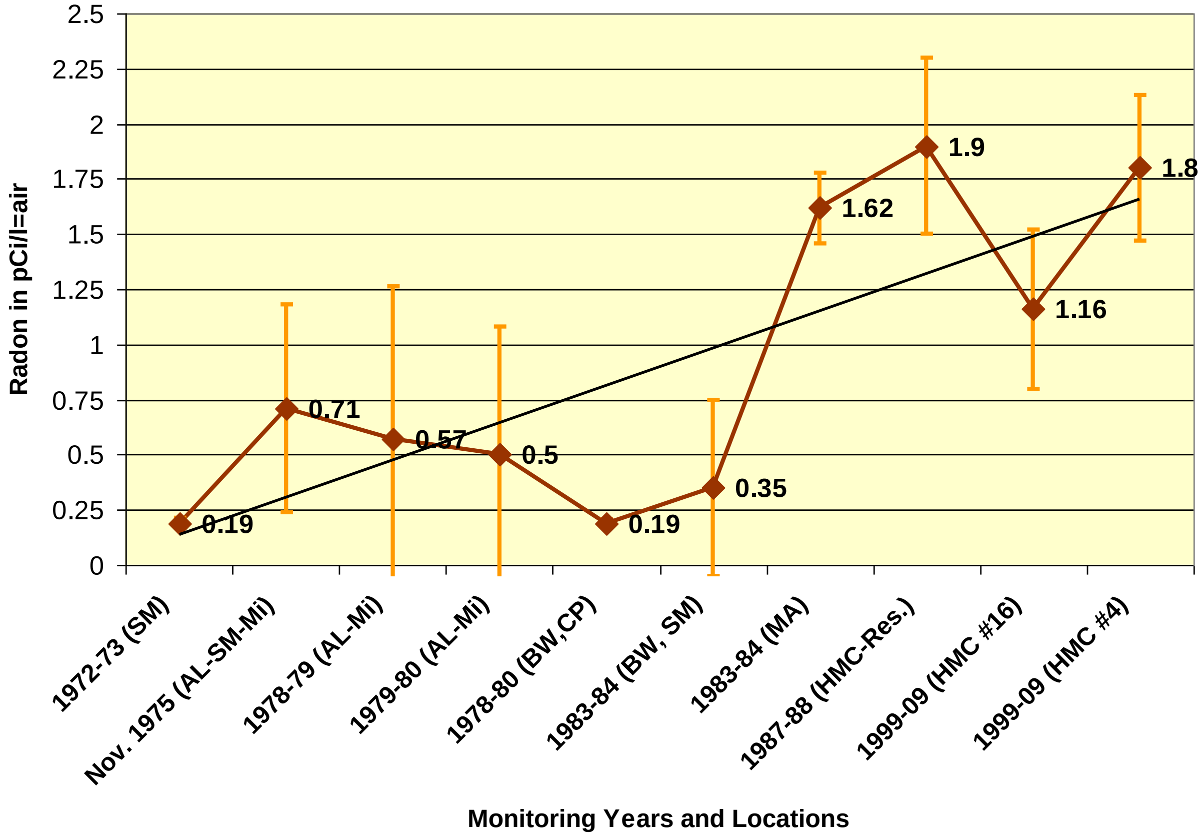


Figure 3. Mean Radon Levels of HMC Air Samplers, 1999-2009

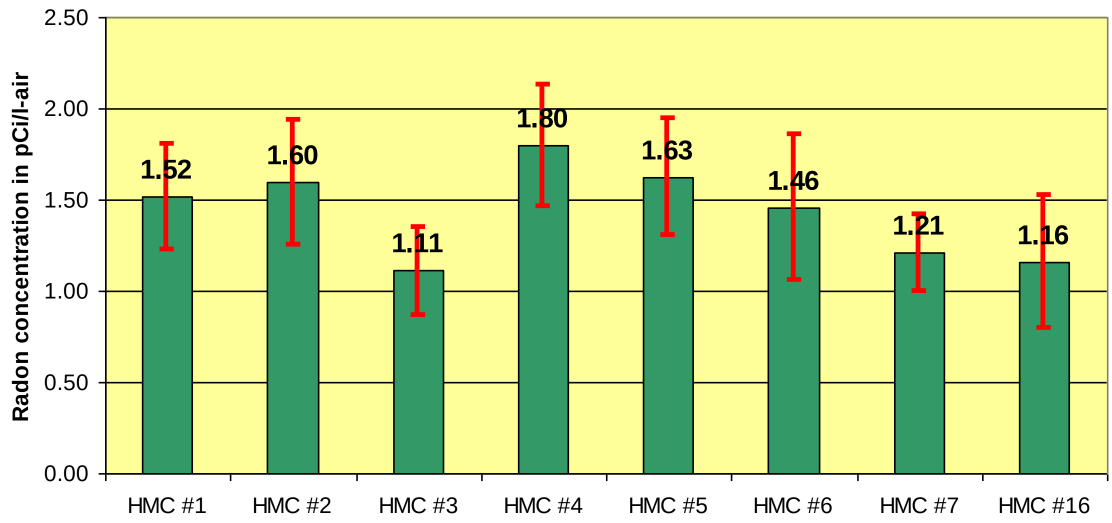


Figure 4.
Soil Assessment Sample Results, Uranium and Ra-226
(Source: Baker, 2010c)

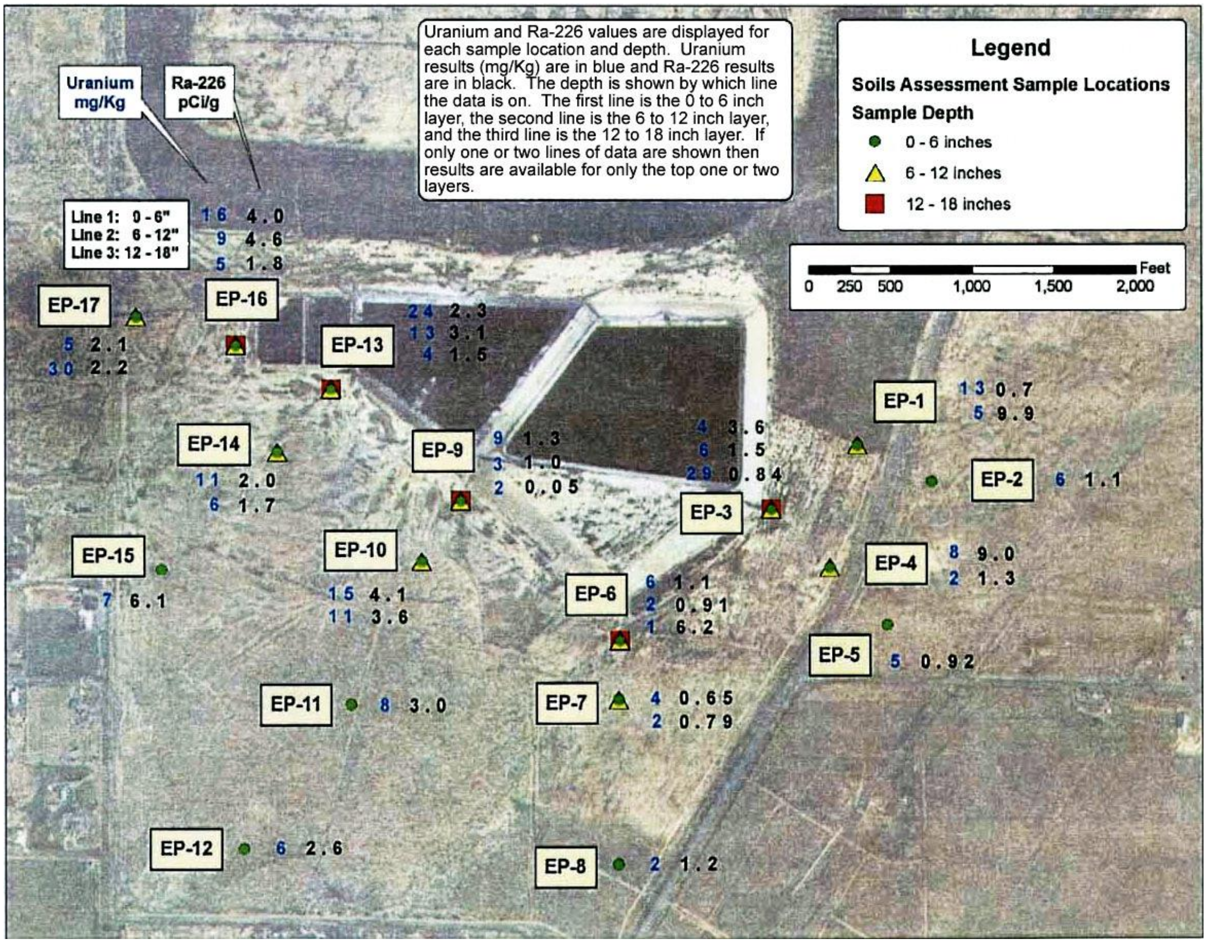
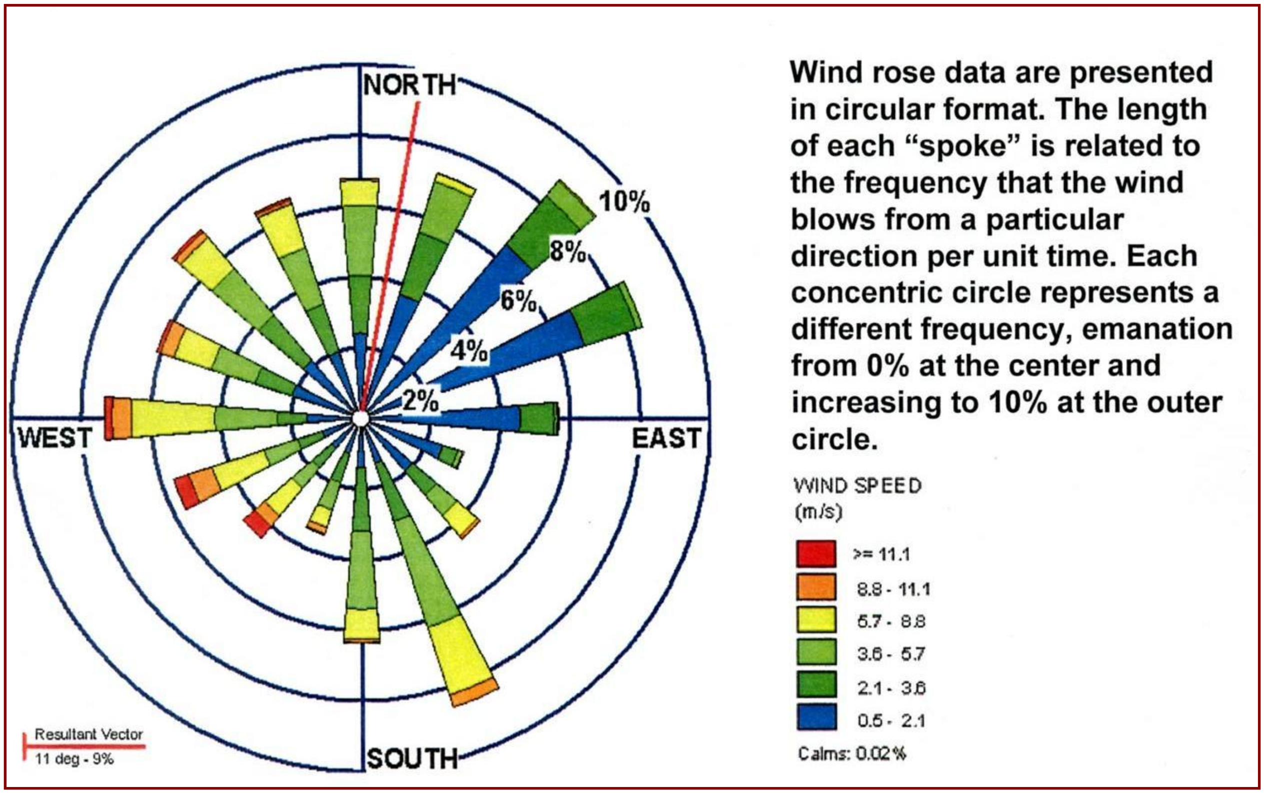
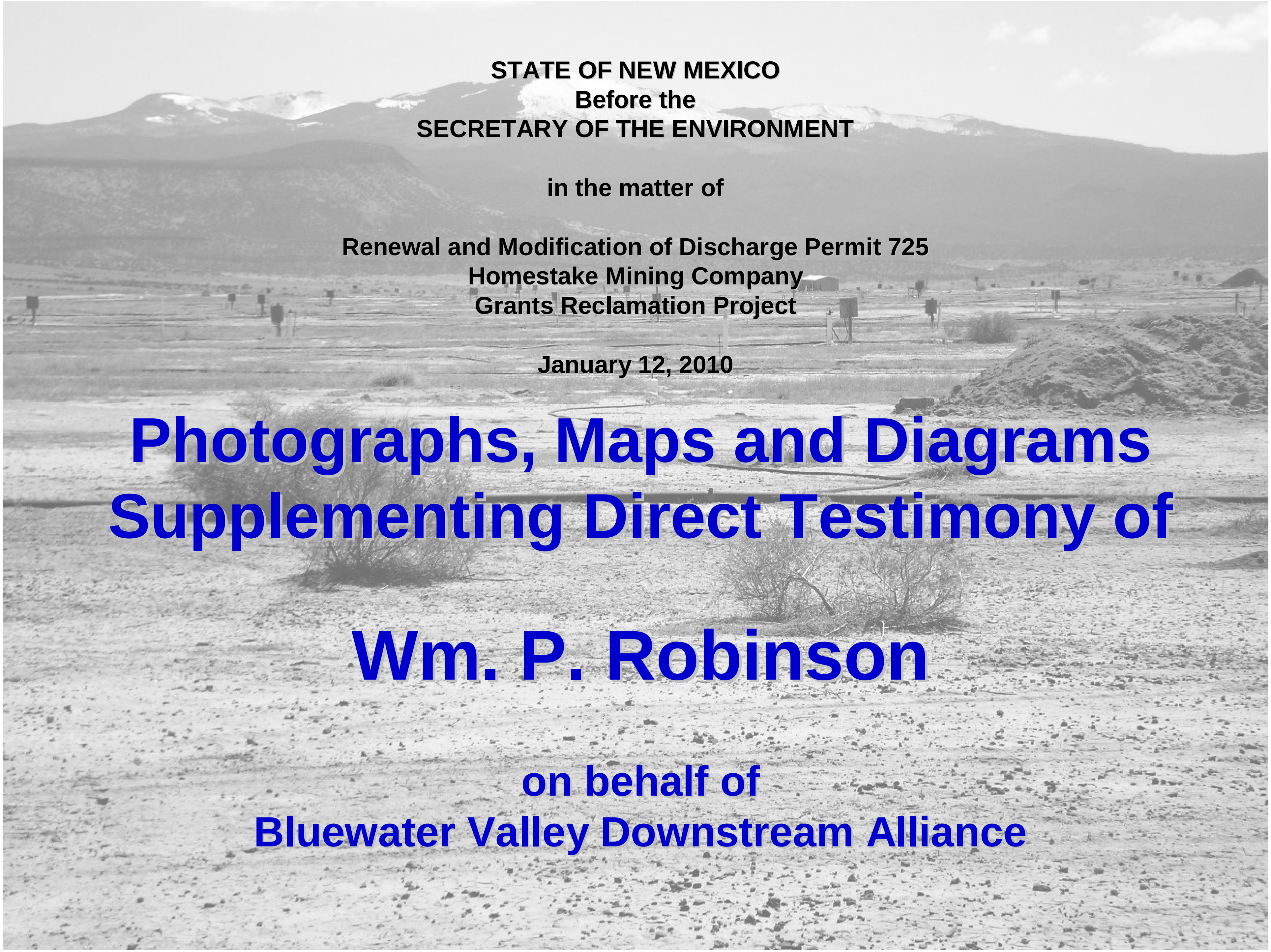


Figure 5.
Meteorological Data Wind Rose
For Homestake Mining Company Superfund Site
(Source: Baker, 2010a)



Appendix A

"Photographs, Maps and Diagrams Supplementing Direct Testimony of Wm. Paul Robinson on behalf of Bluewater Valley Downstream Alliance," in the Matter of the Application of Homestake Mining Company for Groundwater Discharge Permit, DP-725, Renewal and Modification January 12, 2010



STATE OF NEW MEXICO
Before the
SECRETARY OF THE ENVIRONMENT

in the matter of

Renewal and Modification of Discharge Permit 725
Homestake Mining Company
Grants Reclamation Project

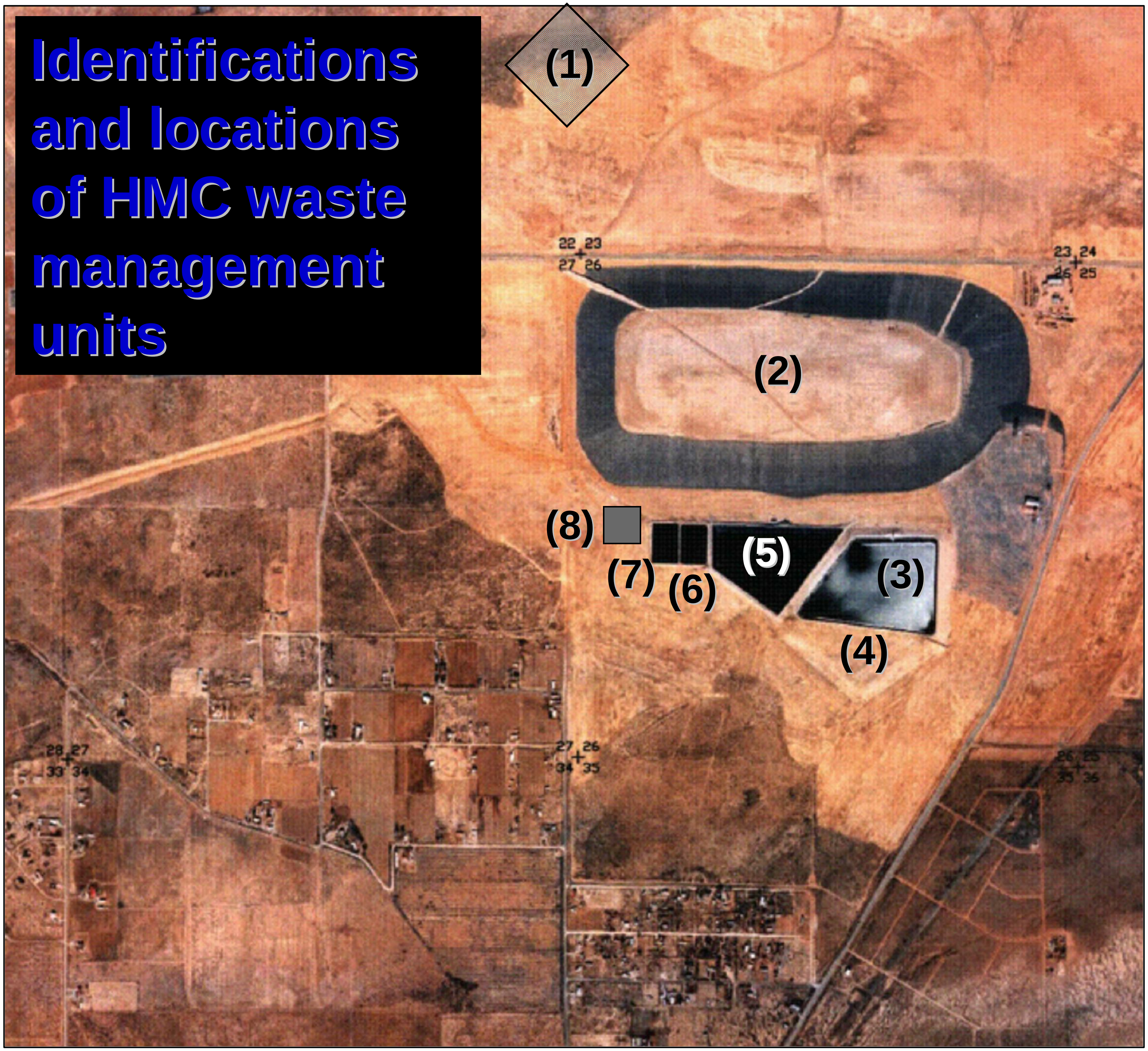
January 12, 2010

Photographs, Maps and Diagrams Supplementing Direct Testimony of

Wm. P. Robinson

on behalf of
Bluewater Valley Downstream Alliance

Identifications and locations of HMC waste management units



(1) Proposed Evaporation Pond 3 (size and location approximate)

(2) Large Tailings Pile

(3) Evaporation Pond 1

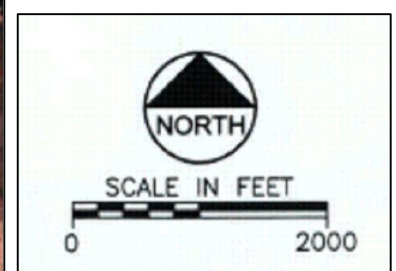
(4) Small Tailings Pile

(5) Evaporation Pond 2

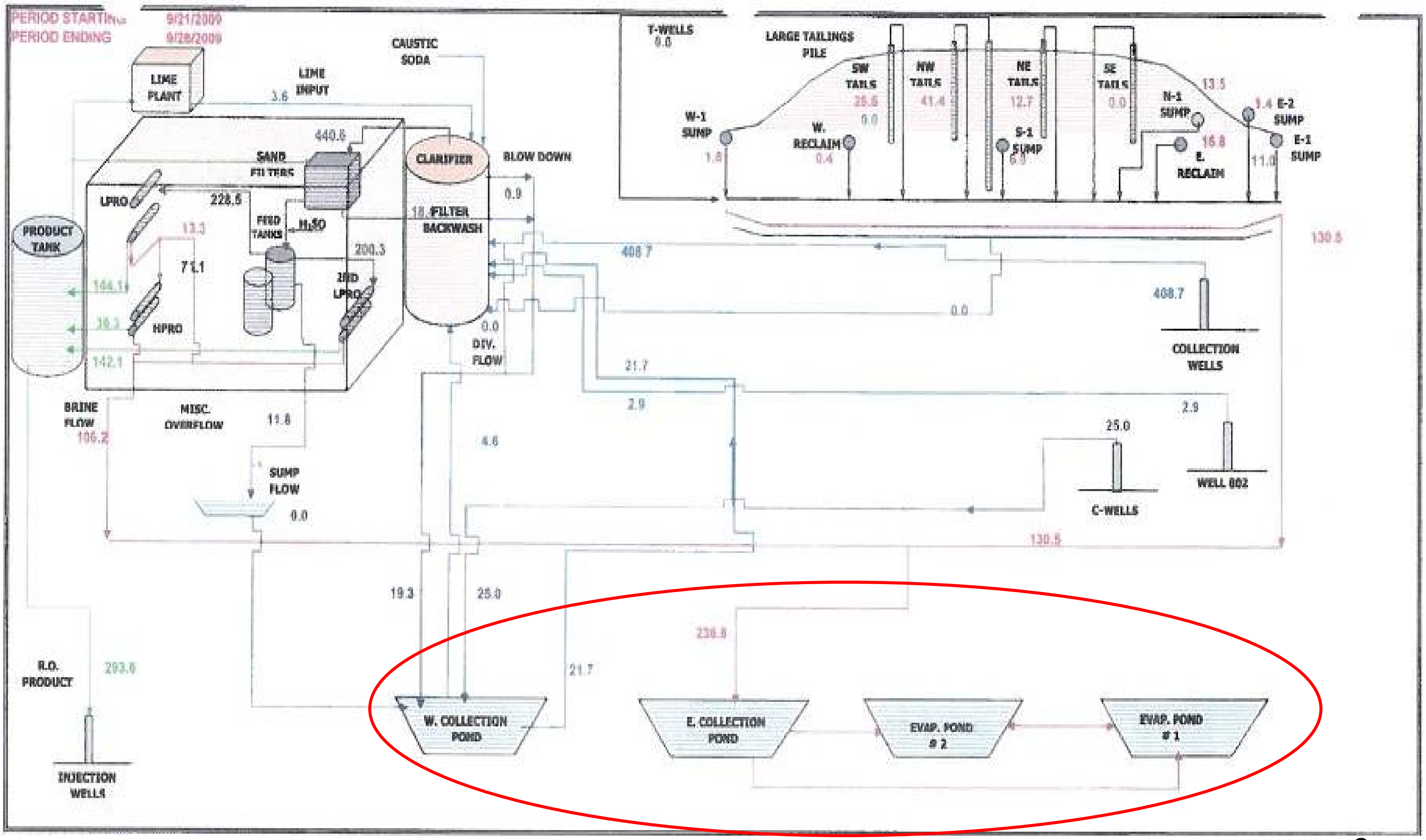
(6) East Collection Pond

(7) West Collection Pond

(8) Reverse Osmosis Plant



Schematic Diagram Summarizing Flows of Liquids and Reverse Osmosis Plant Residues to HMC Waste Management Units for week ending Sept. 28, 2009



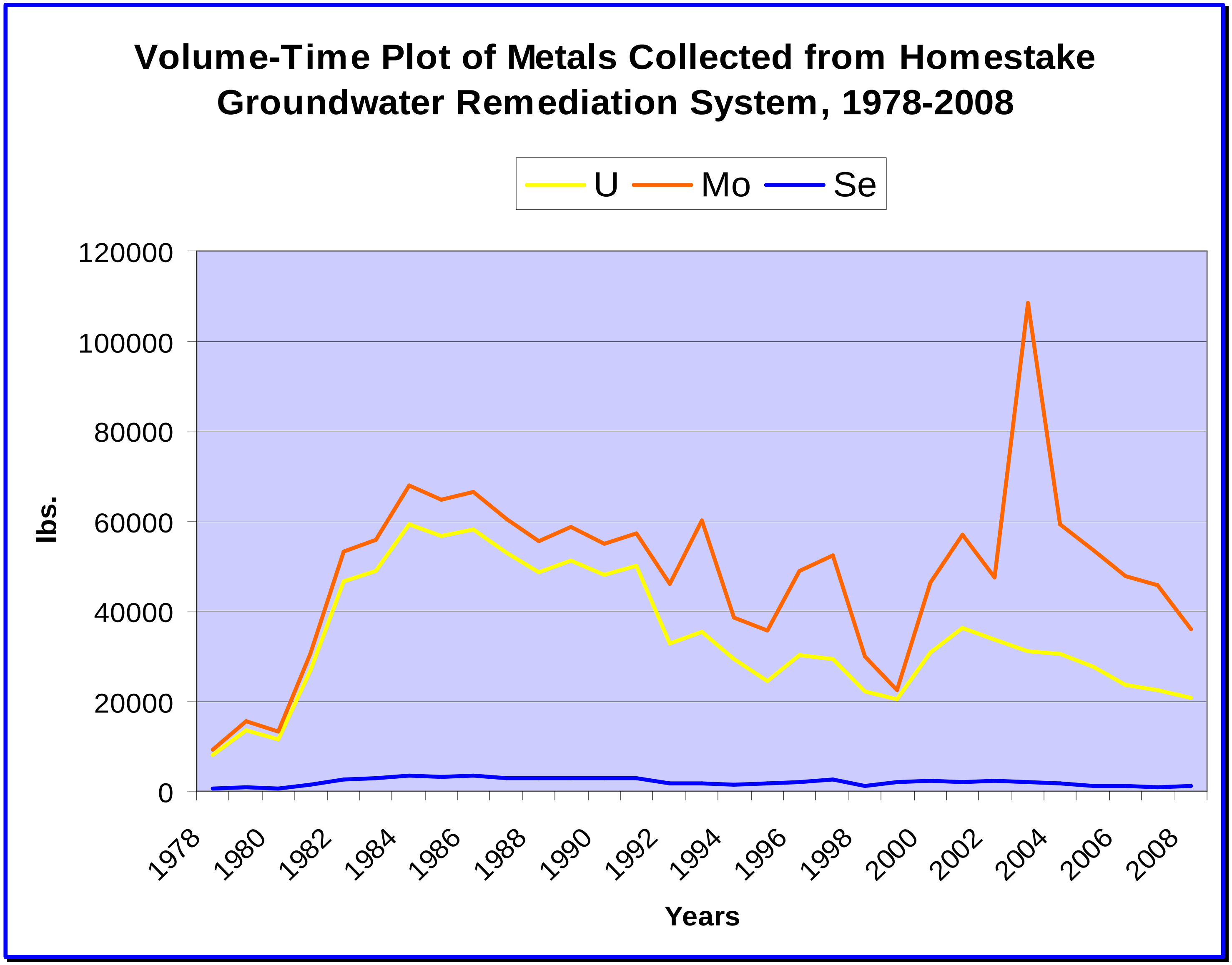
Source: "Example Weekly Report.pdf" provided by Homestake to RSE QuickPlace website

Homestake Mining Co.
DP-725

Effluent Management Facilities

Waste Characterization and Monitoring Issues

Chart 1



Volume-Time Plot of Metals Collected from Homestake Groundwater Remediation System, 1978-2008
U
Mo
Se
120000
100000
80000
60000
40000
20000
0
lbs.
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Years

Chart 2

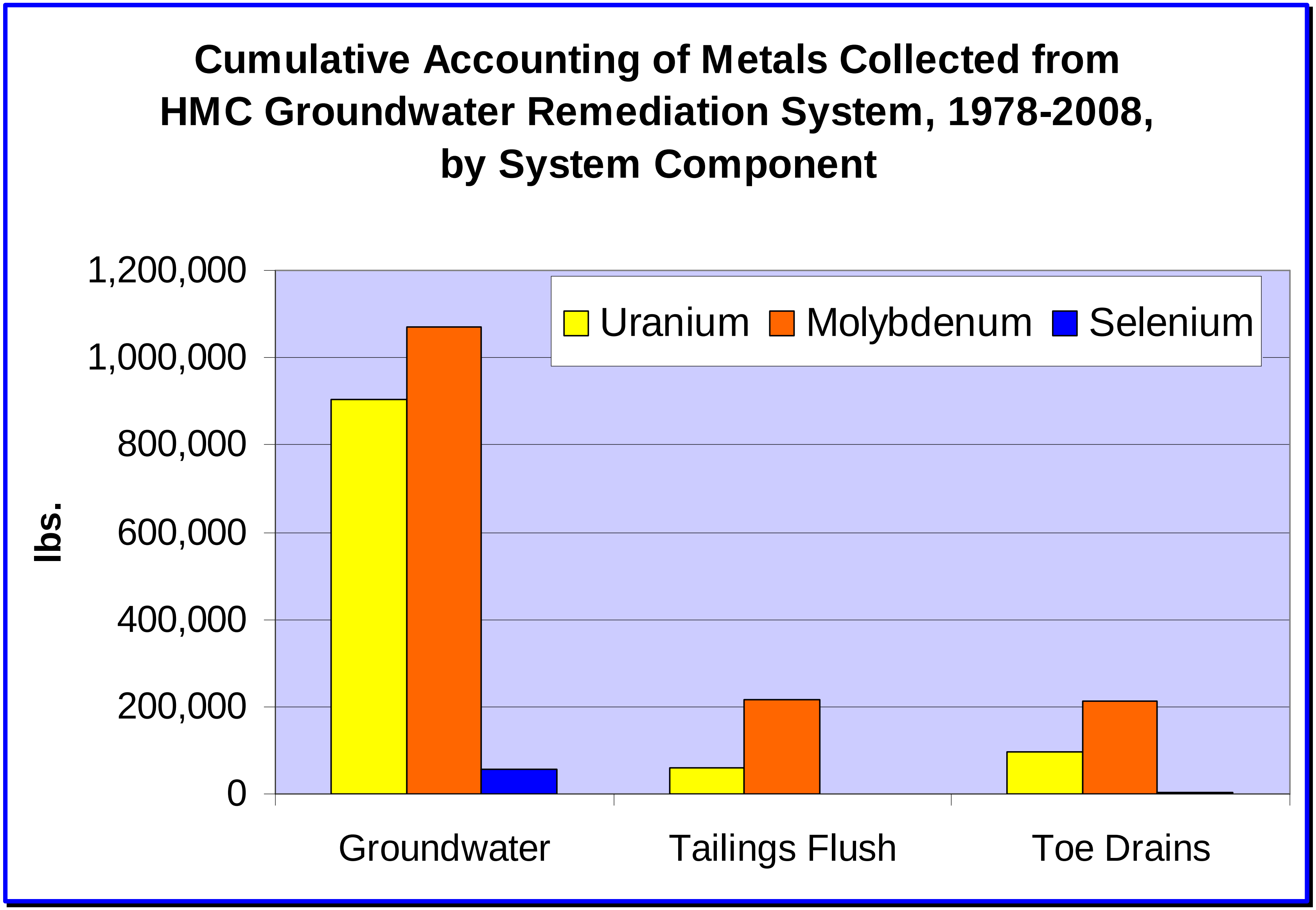
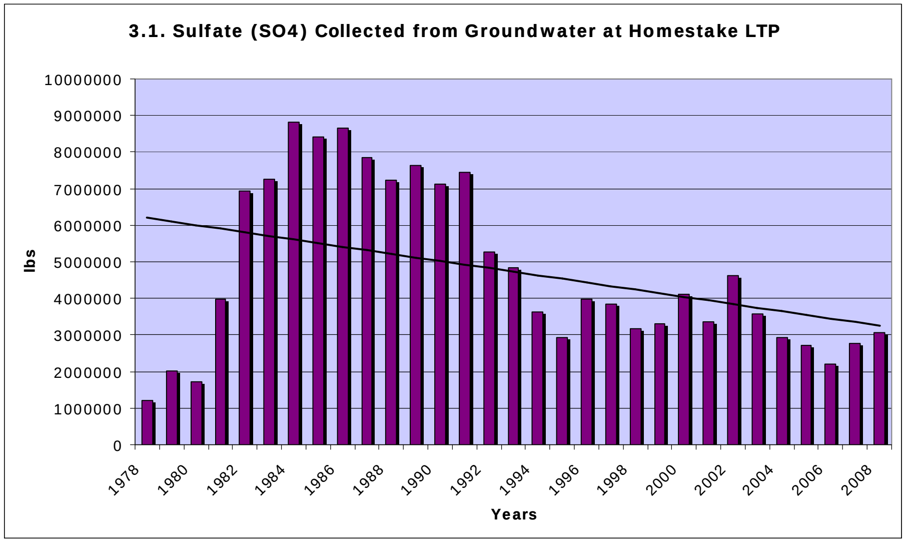
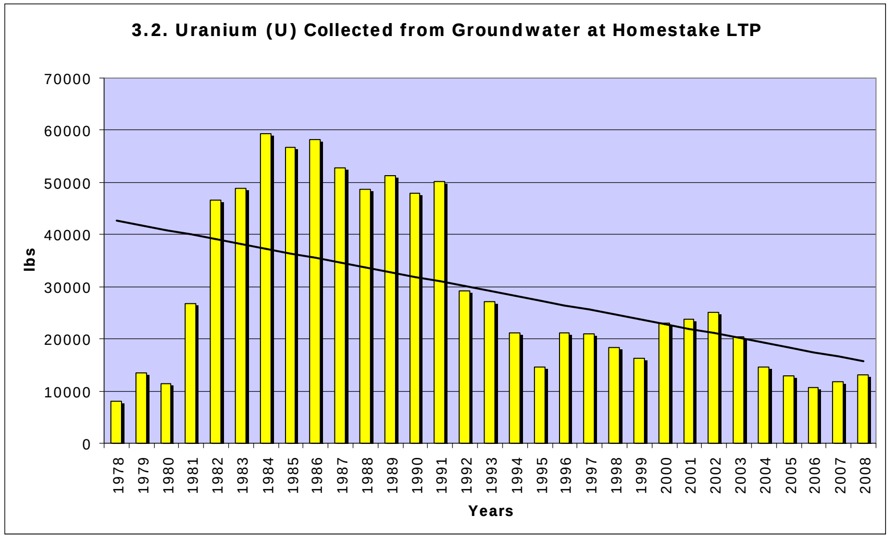
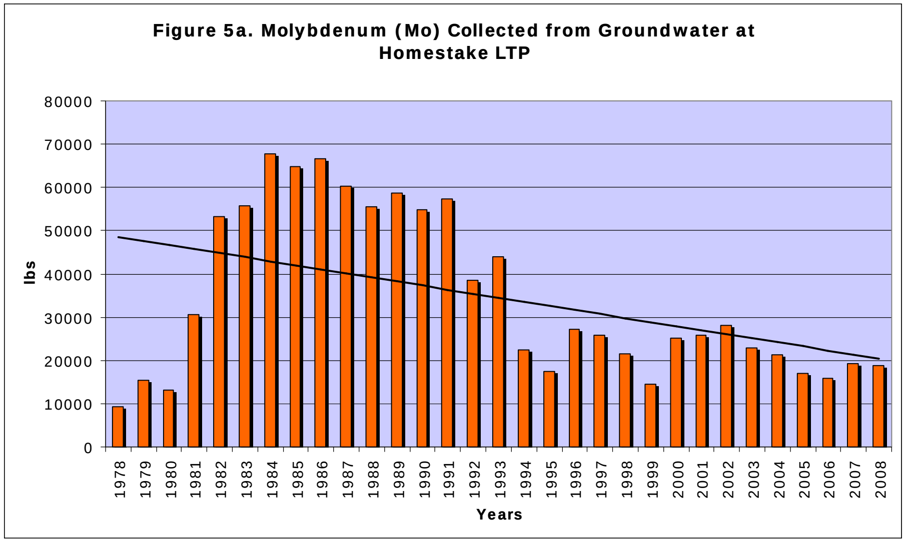

Cumulative Accounting of Metals Collected from
HMC Groundwater Remediation System, 1978-2008,
by System Component
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
lbs.
Uranium
Molybdenum
Selenium
Groundwater
Tailings Flush
Toe Drains

Chart 3:
Constituents Collected from Groundwater







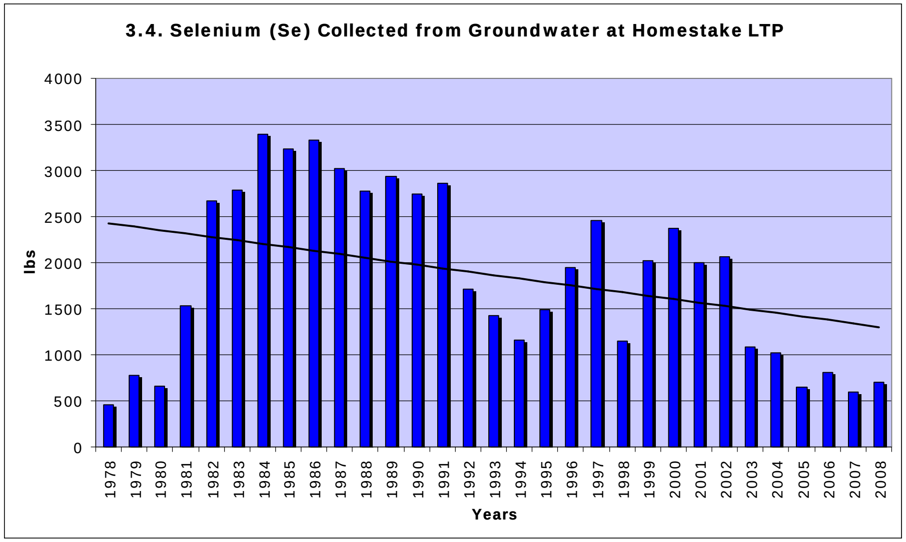
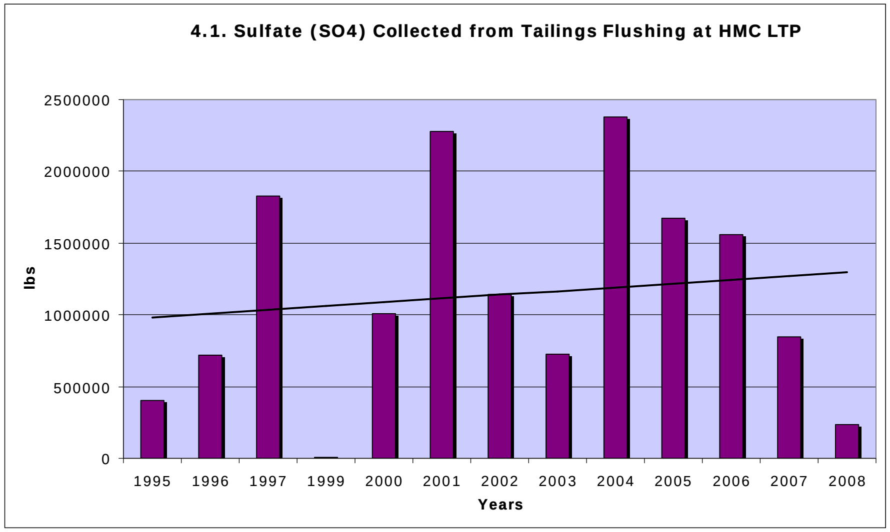
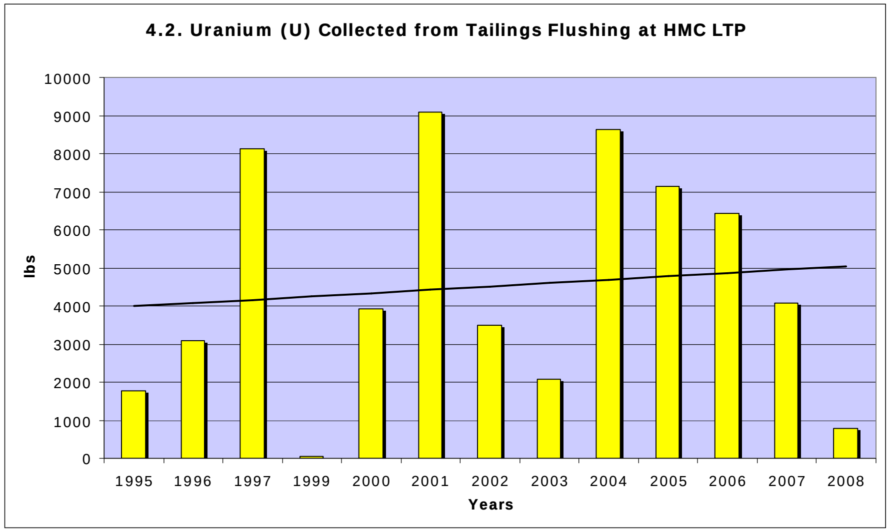
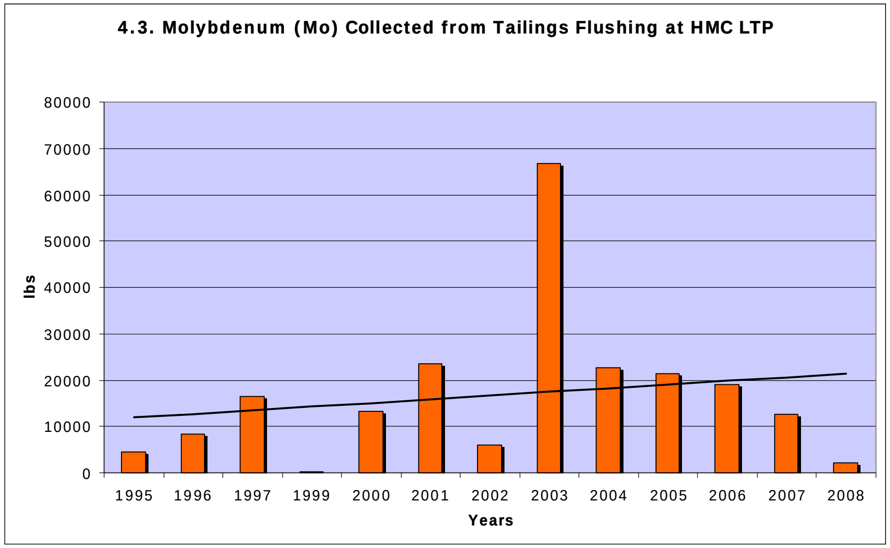


Chart 4:
Constituents Collected from Tailings Flushing







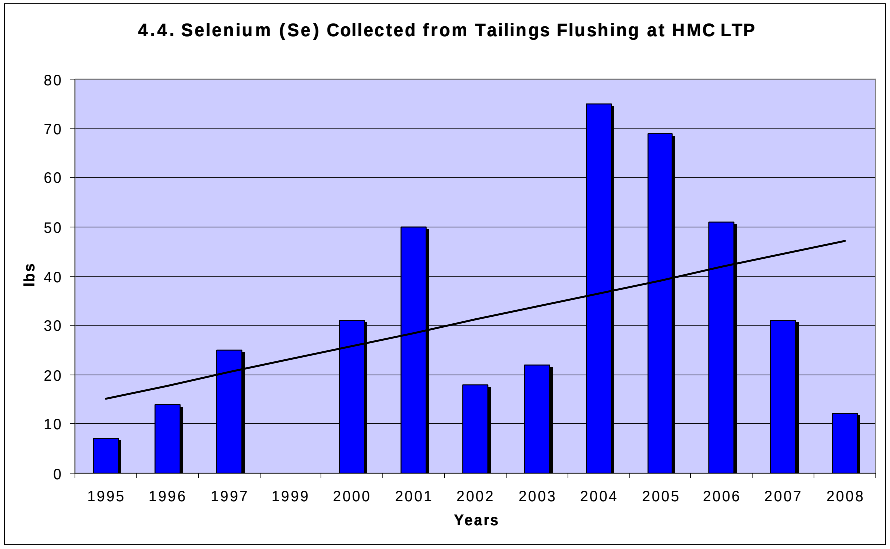
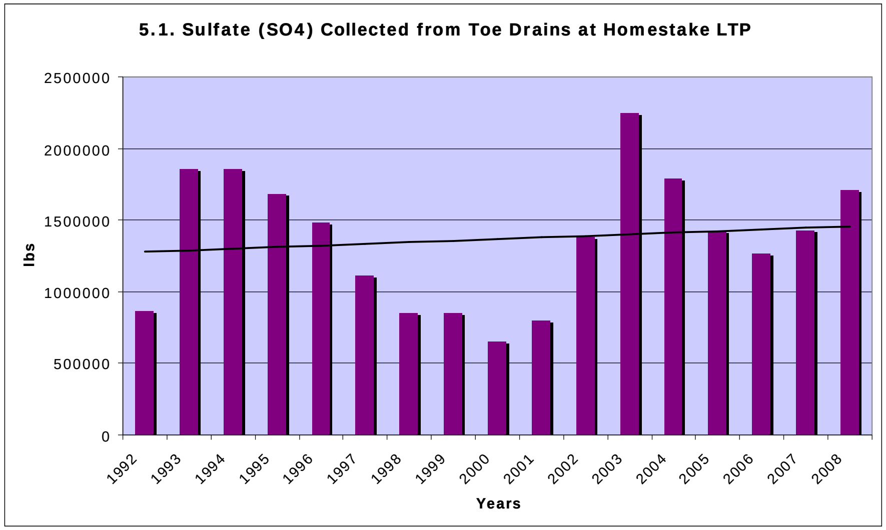
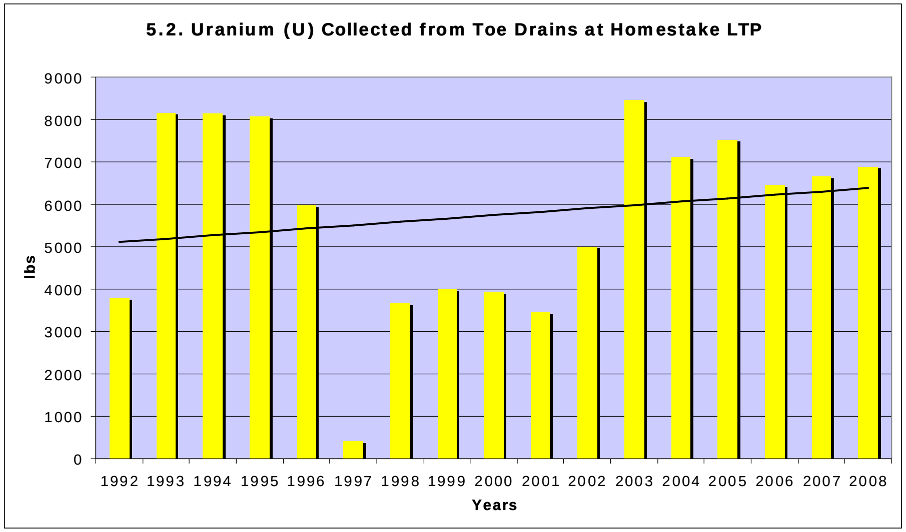
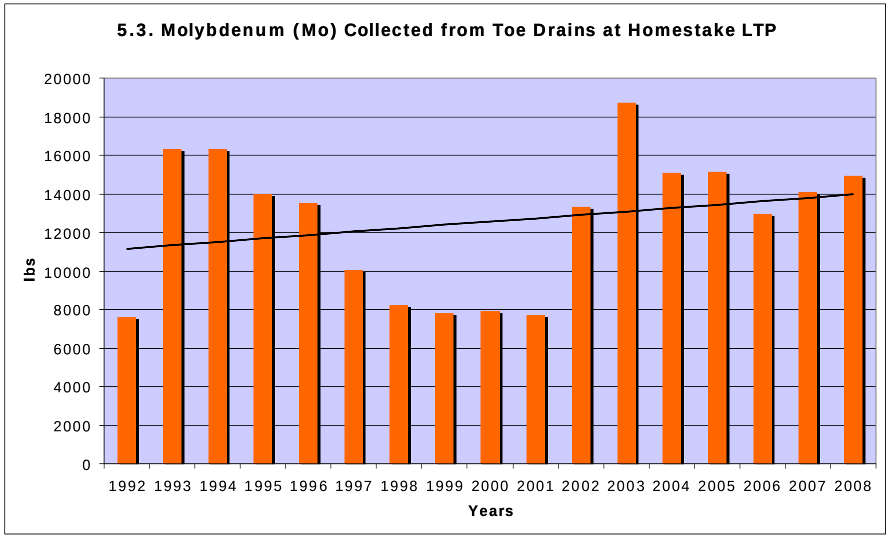
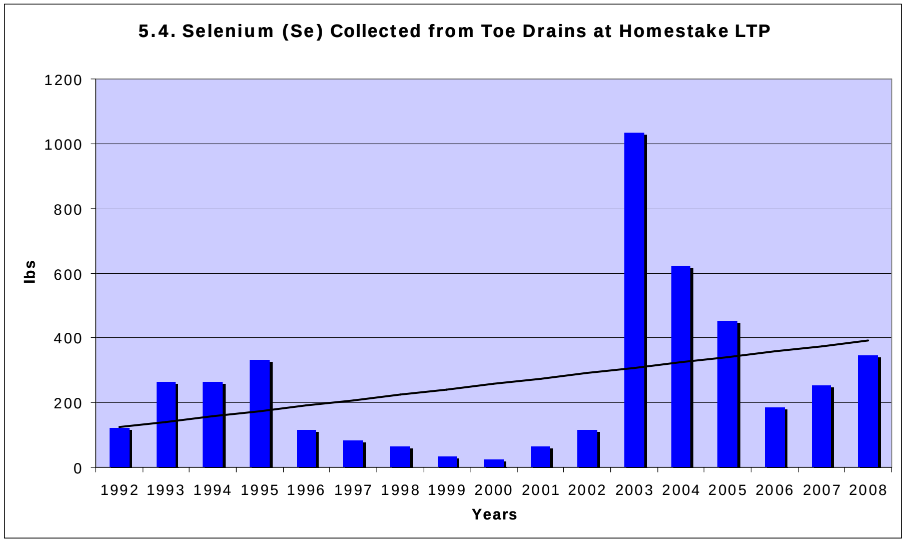


Chart 5:
Constituents Collected from Toe Drains









NMEID Radon Monitoring Stations, 1979-1981

(from Buhl, et al., 1985, p. 13)

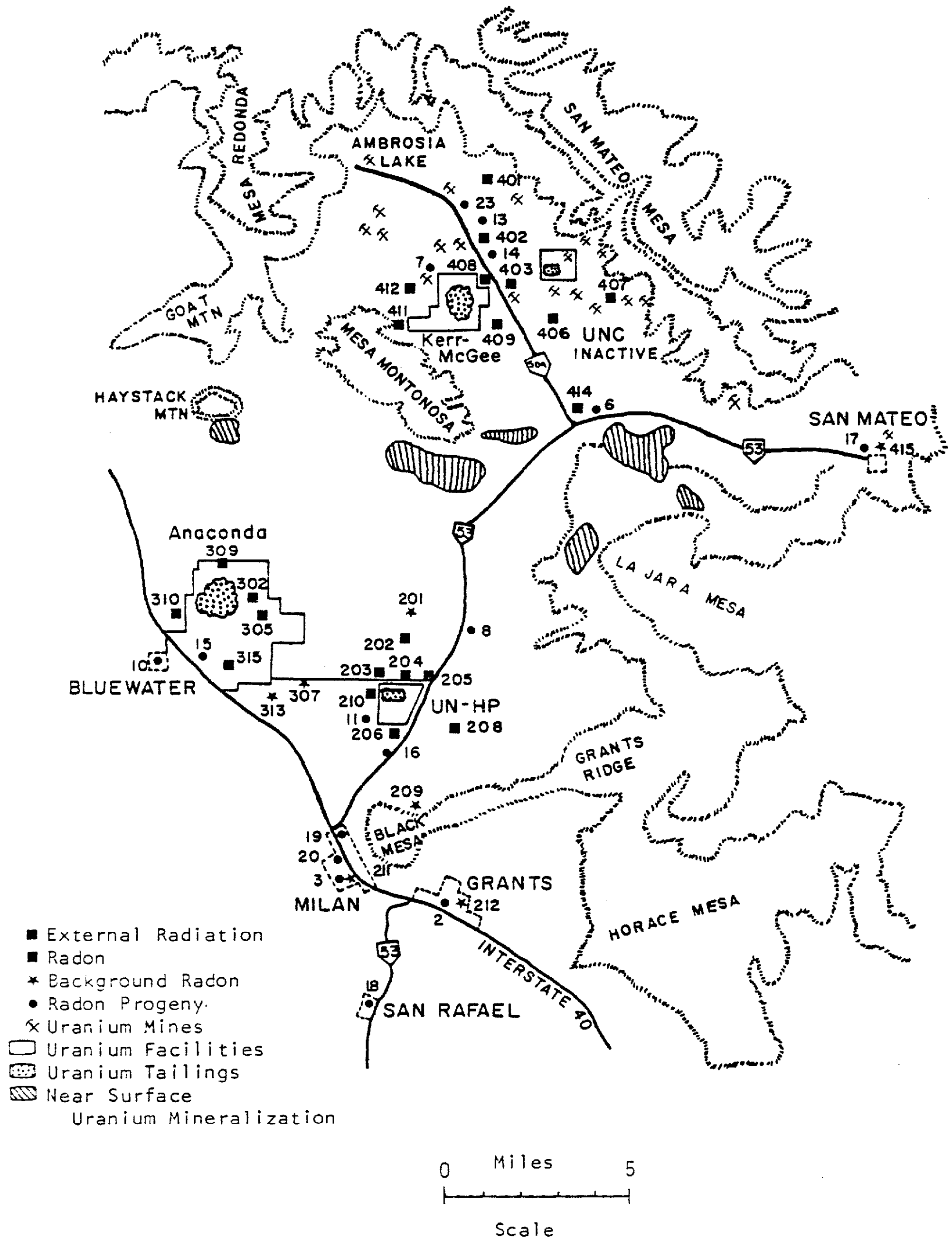


Figure 3.1 Sampling Locations and Station Numbers

NMEID Ambient Rn-222 Levels, 1979-1981

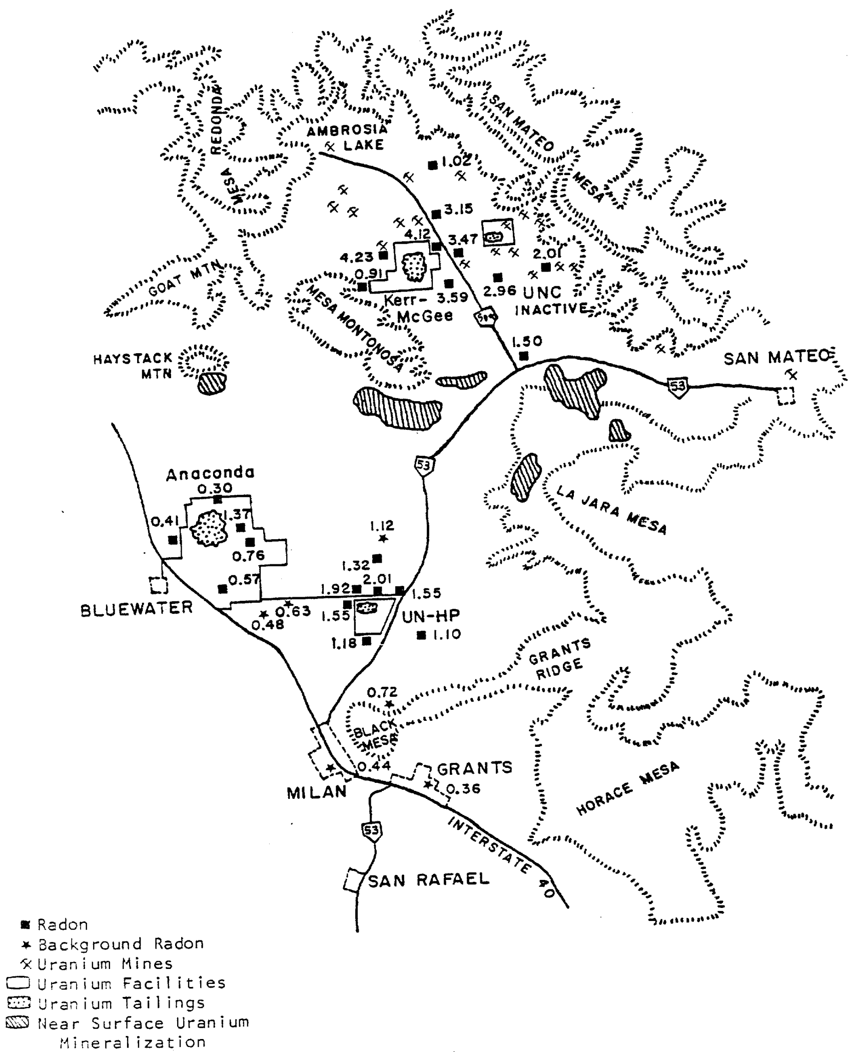


Figure 3.2 First Year Radon Averages By Station

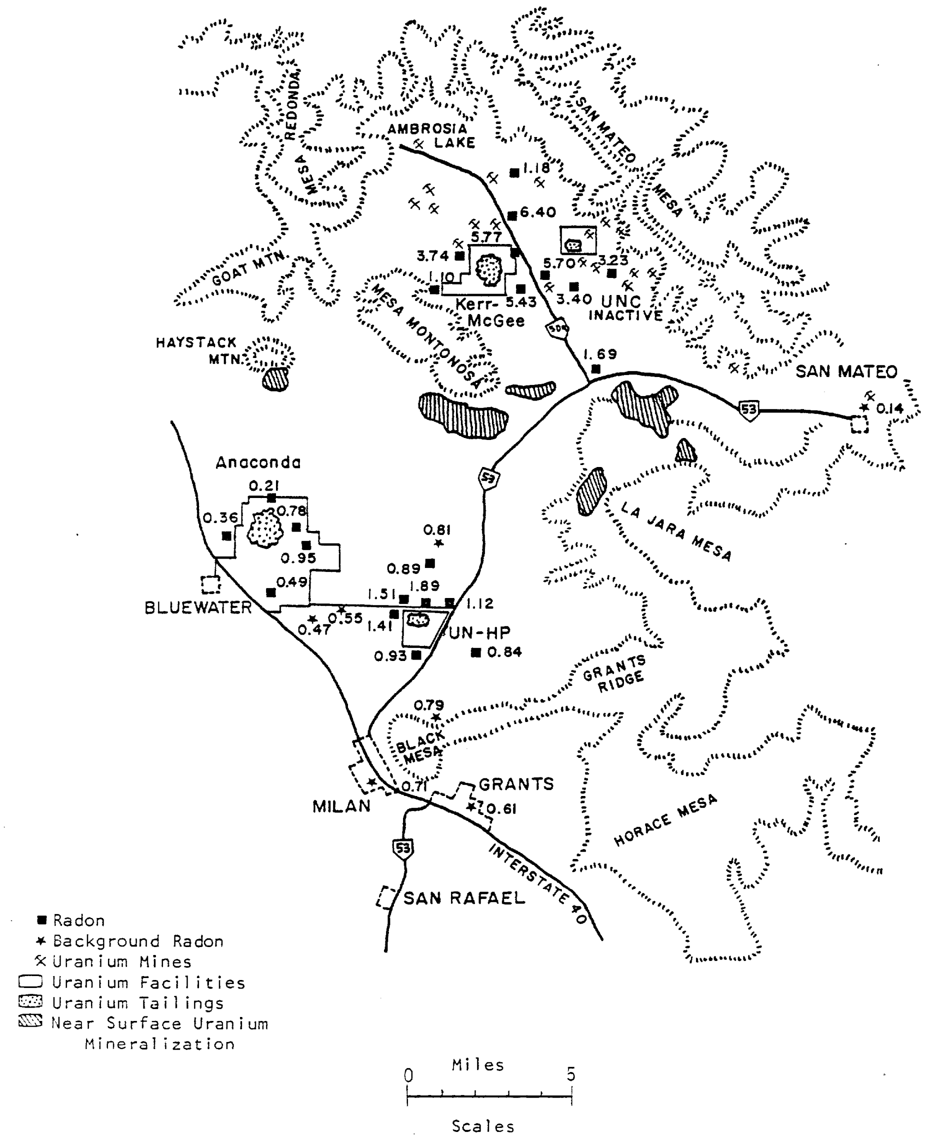


Figure 3.3 Second Year Radon Averages By Station

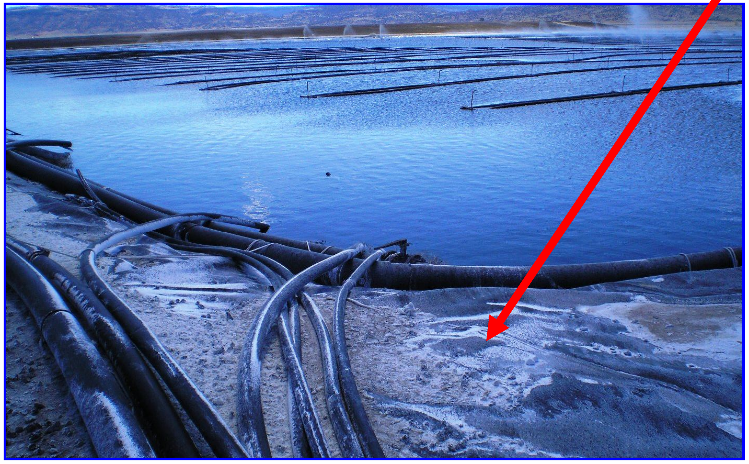
Homestake Mining Co.
DP-725

Effluent Management Facilities

Waste Management Concerns:

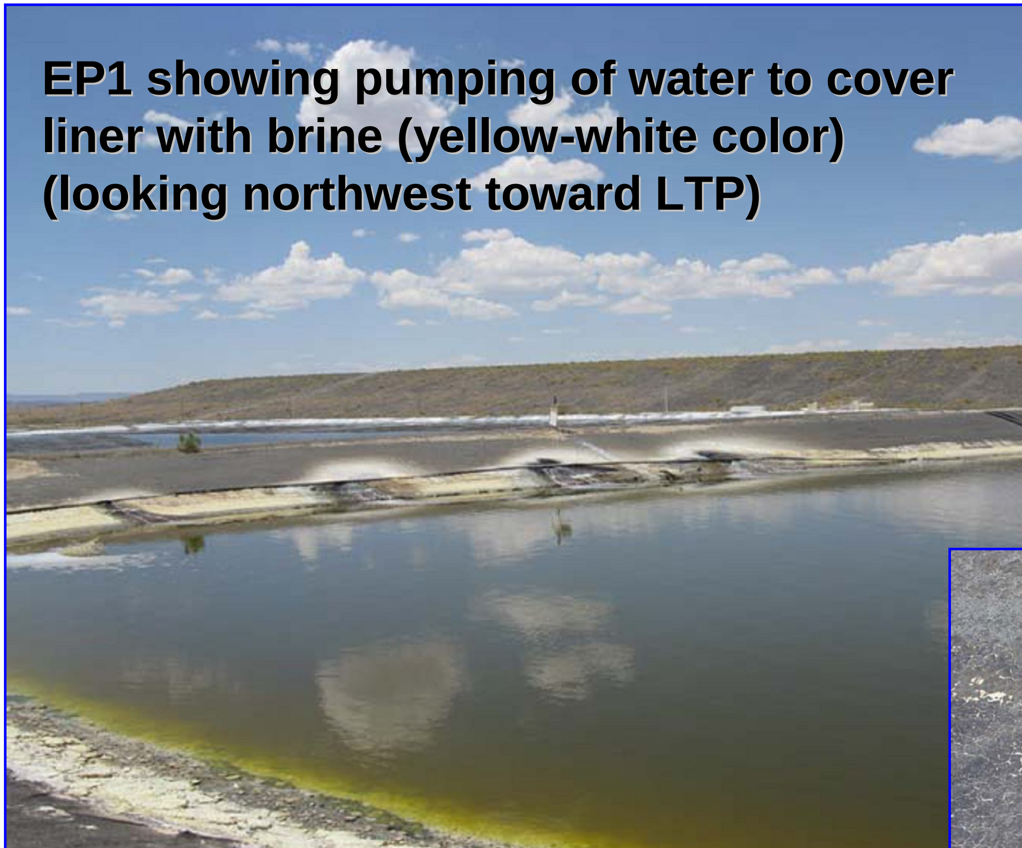
Liner Integrity

Liner exposure to weather and sludge
(April 2007)

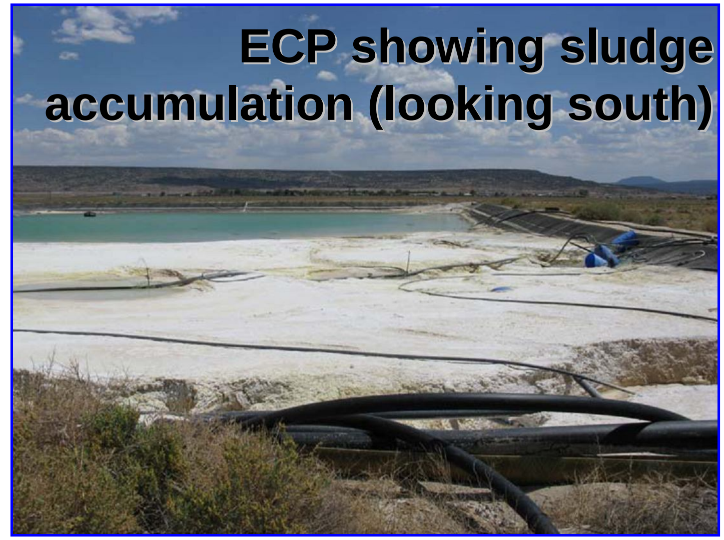


Liner exposure to salinity and weathering, June 2008

(from USEPA RSE-I Report, Dec. 2008)



EP1 showing pumping of water to cover liner with brine (yellow-white color) (looking northwest toward LTP)



ECP showing sludge accumulation (looking south)

Right: EP2 liner showing effects of exposure to air and sun

Homestake Mining Co.
DP-725

Effluent Management Facilities

Waste Management Concerns:

Effluent Spraying

Effluent Spray on EP1, April 2004

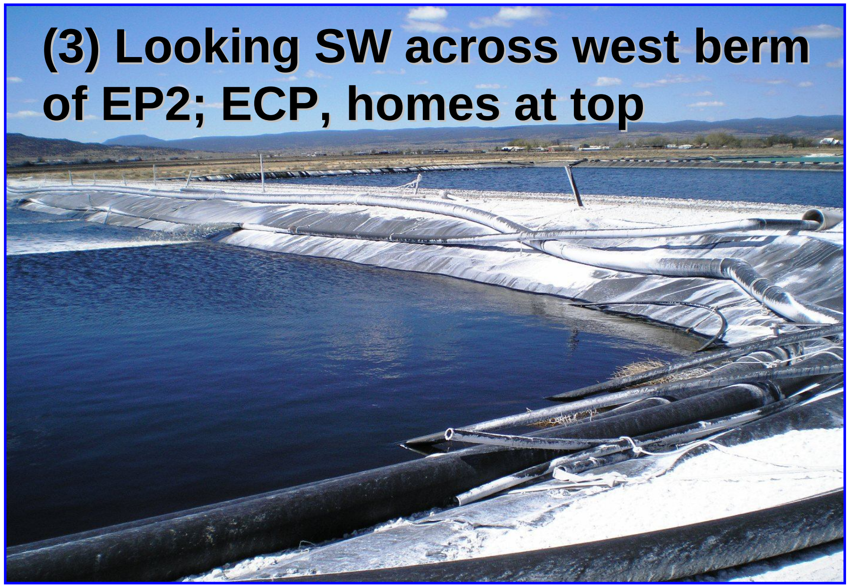
(Large Tailings Pile, center-right)

Spraying effects, April 2007:

White salt deposits on berms of EP2


(1) Looking SE across EP2

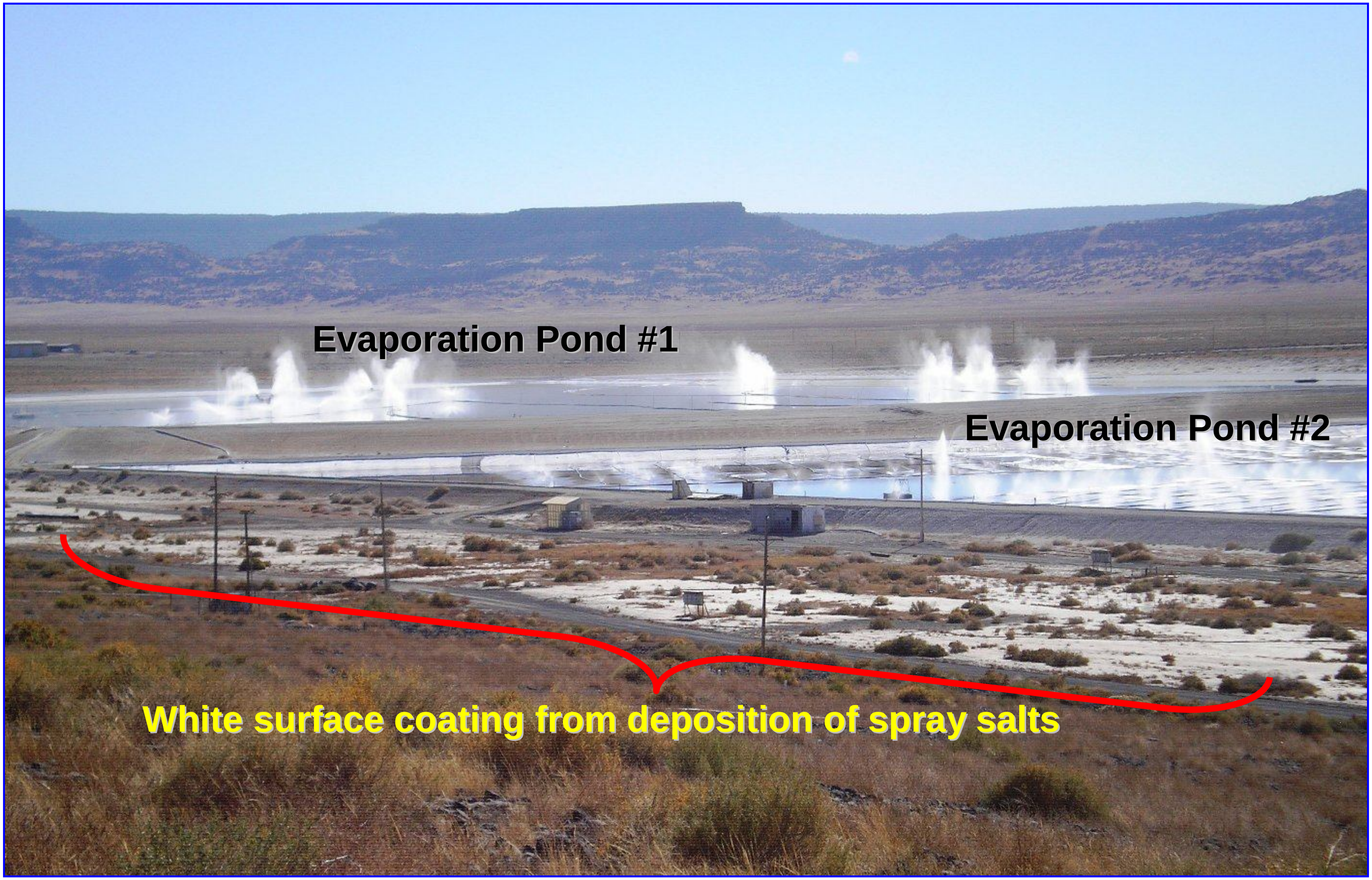

(2) Looking E on north berm of EP2


(3) Looking SW across west berm of EP2; ECP, homes at top


(4) Looking W on EP2 toward ECP

Sprayers on EP1, EP2

October 2007



Effluent Spray over EP1, April 2009

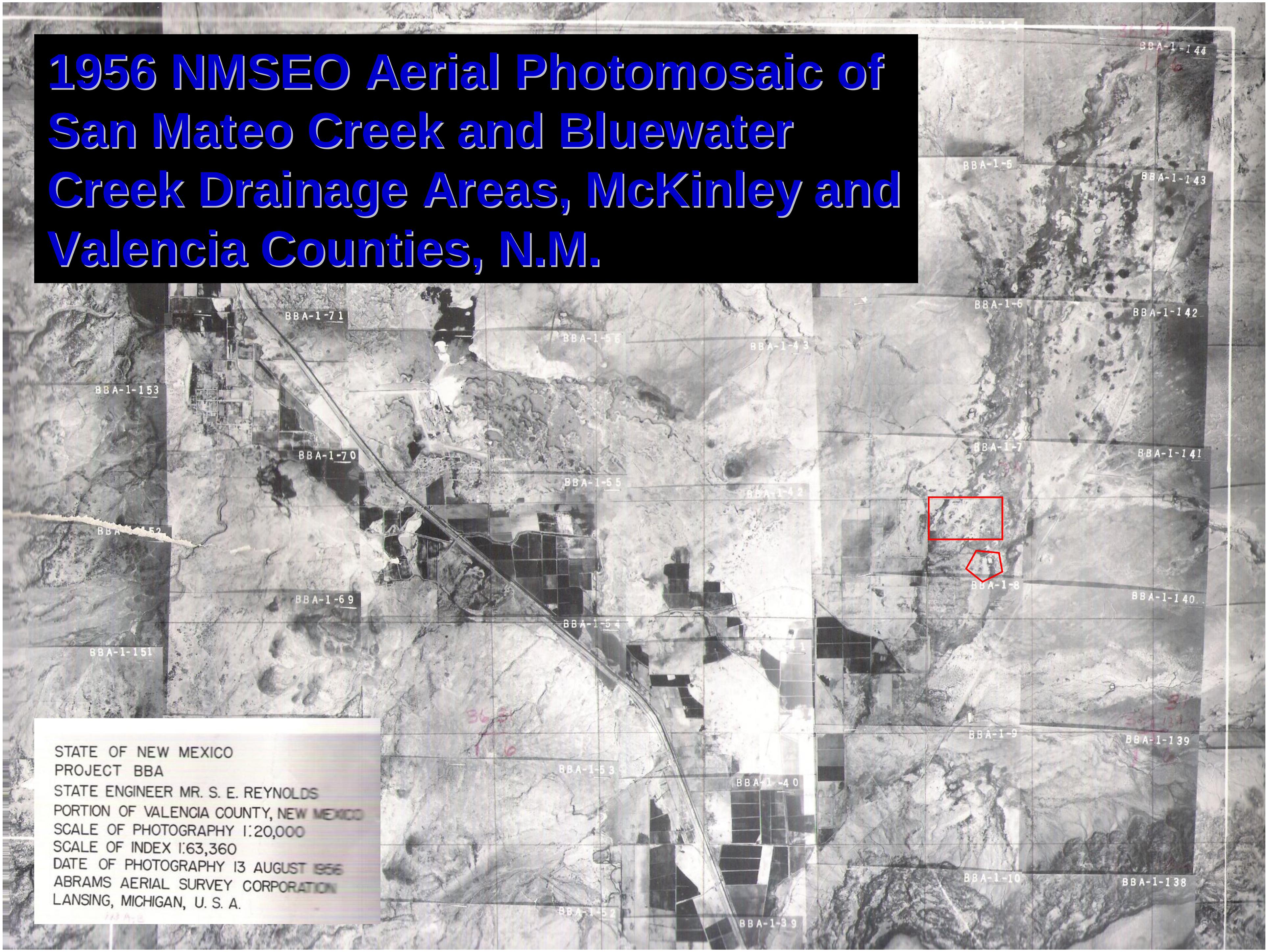
(showing eastern fence line and eastern berm of Small Tailings Pile)

Homestake Mining Co.
DP-725

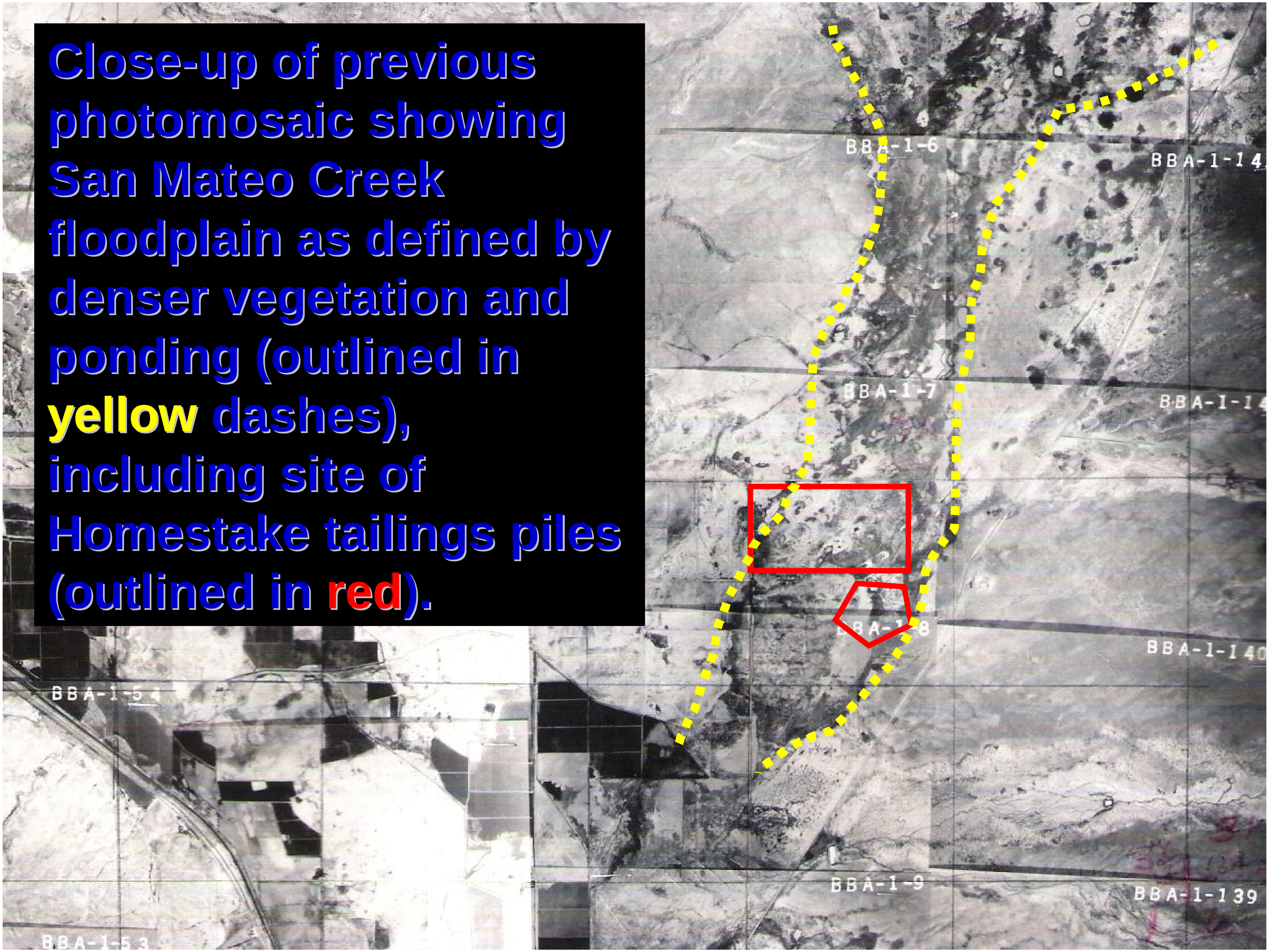
Effluent Management Facilities

Facility Siting Concerns

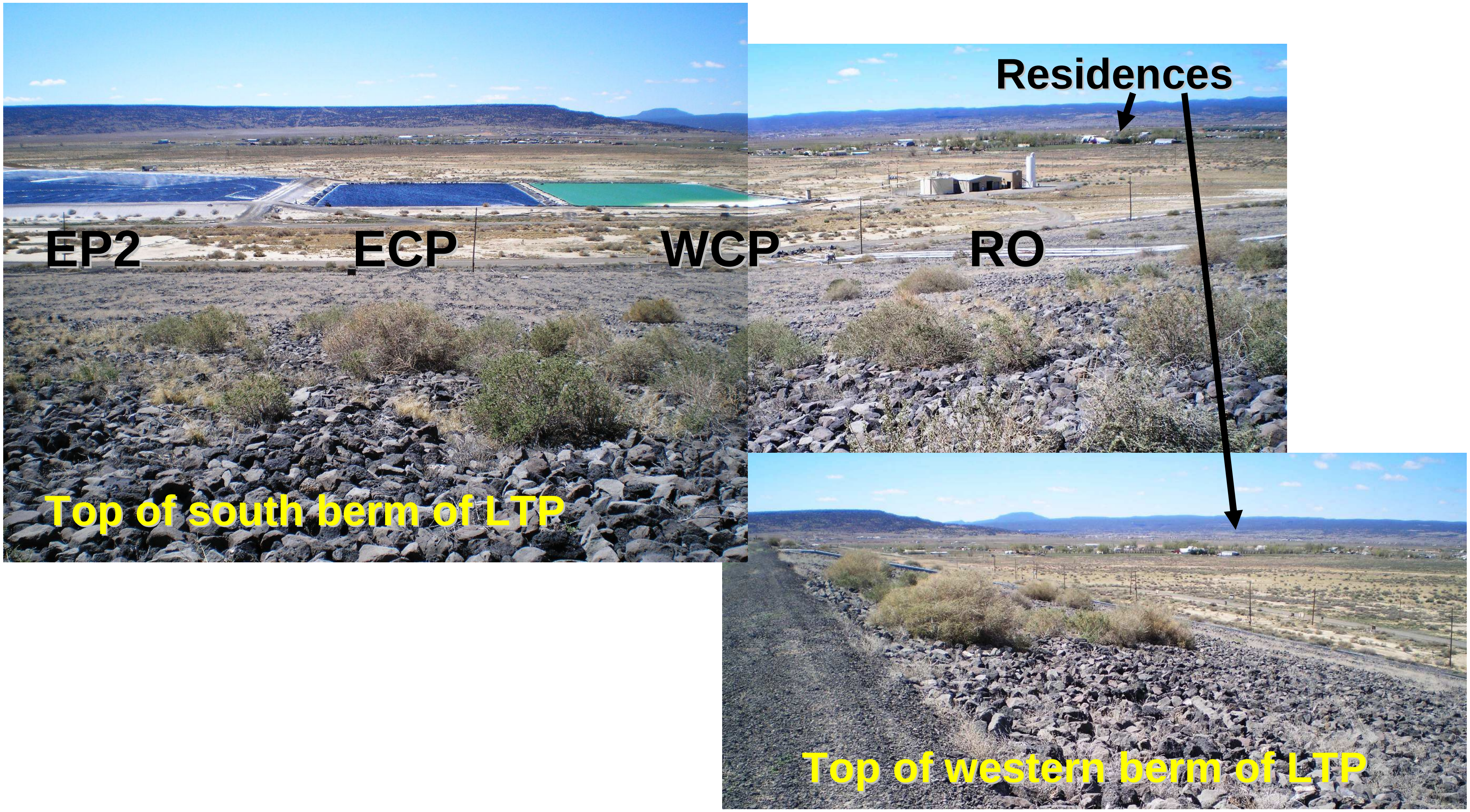
1956 NMSEO Aerial Photomosaic of San Mateo Creek and Bluewater Creek Drainage Areas, McKinley and Valencia Counties, N.M.



Close-up of previous photomosaic showing San Mateo Creek floodplain as defined by denser vegetation and ponding (outlined in yellow dashes), including site of Homestake tailings piles (outlined in red).



Proximity of Waste Management Units to Residential Areas



View of Homestake Mill Tailings Site and Residential Areas, April 2009

(Mt. Taylor in right background)