ENTERED

Allen, Pam, NMENV

From: Oba Vincent <oba.vincent@cbfo.doe.gov>
Sent: Friday, February 28, 2014 12:52 PM
To: Kliphuis, Trais, NMENV; 'peake.tom@epa.gov'; 'Edwards, Jonathan'; 'Walsh, Jonathan'; 'Perrin, Alan'; 'Bob.Kehrman@wipp.ws'; 'Rick.Chavez@wipp.ws'; 'Stone.Nick@epa.gov'; Smith, Coleman, NMENV
Cc: George Basabilvazo - WIPPNet; 'Reynolds, Tammy - NWP (Tammy.Reynolds@wipp.ws)'; 'Pace, Berry (Berry.Pace@wipp.ws)'; 'Alton.Harris@em.doe.gov'; 'Joe Harvill (jharvill@portageinc.com)'; 'Kennedy, Scott - NWP (Scott.Kennedy@wipp.ws)'; 'Jones, Stewart - RES'
Subject: RE: Information for todays call
Attachments: Feb 14 Release Calculation Rev 1Rev1 - Draft - In Review.pdf

Follow Up Flag: Follow up
Flag Status: Completed

Please be advised that the file entitled "Feb 14 Release Calculation Rev1" in my previous email indicates that the information is FOUO on several of the pages. That is not the case. Please use the attached file instead.

Sorry for any confusion.

Oba

From: Oba Vincent
Sent: Friday, February 28, 2014 12:37 PM
To: 'Kliphuis, Trais'; 'peake.tom@epa.gov'; 'Edwards, Jonathan'; 'Walsh, Jonathan'; 'Perrin, Alan'; 'Bob.Kehrman@wipp.ws'; 'Rick.Chavez@wipp.ws'; 'Stone.Nick@epa.gov'; 'coleman.smith@state.nm.us'
Cc: George Basabilvazo - WIPPNet; 'Reynolds, Tammy - NWP (Tammy.Reynolds@wipp.ws)'; 'Pace, Berry (Berry.Pace@wipp.ws)'; 'Alton.Harris@em.doe.gov'; 'Joe Harvill (jharvill@portageinc.com)'; 'Kennedy, Scott - NWP (Scott.Kennedy@wipp.ws)'; 'Jones, Stewart - RES'
Subject: Information for todays call

Attached are sampling results, a list of the questions from yesterday and other requested information (including Rev 1 of the offsite dose estimate).

Thanks

Oba

140270.5

Revision 1

The purpose of this revision is to incorporate comments obtained on the initial calculation and to include additional measurement and modeling information which has become available in the interim. The most significant updates were the revised timeline from Table 1[1] and the incorporation of new measurement data on air sample filters.

Air Monitoring of TRU Data

The source terms used for the values reported in Table 1 below are provided in the attachments and represent a simple conversion of gross alpha activity on the Station B filters into total source term released into the atmosphere up to the time the sample was pulled. The pull time in the sample is also presented in Table 1. These source terms are assumed to have been uniformly distributed throughout the time the sample was being taken so that the integrated activity per time is assumed to have a constant release rate over each interval. The true release rate as a function of time is not known to any greater resolution than that provided in Table 1 and so it should be recognized this is simply the best measurement based estimates available on the temporal distribution of activity released. The data in Table 1 does not include radon because the air comes through the mine first which does not have a radium source term allowing intake radon to decay and plate out in the mine as it is pulled through to the sampling locations. Generally, radon will only contribute around 10 dpm alpha or less at Station B and so the contribution to a source term having 3 orders of magnitude higher levels of activity is considered negligible. Measured values were in dpm and converted to Ci for the NARAC models.

Table 1. Source terms used for NARAC models based on gross alpha beta values not having radon

Date and time	Station B activity (dpm)	Release duration (hrs:min)	Calculated released activity (Ci)
2/14/14 23:54	0	0	0
2/15/14 8:35	2.8E+04	8:41	3.8E-04
2/15/14 14:45	3.6E+04	6:10	4.9E-04
2/15/14 23:05	6.7E+02	8:20	9.1E-06
2/16/14 9:04	3.0E+02	9:59	4.1E-06
2/16/14 17:05	1.4E+02	8:01	1.9E-06
2/17/14 0:30	7.2E+01	7:25	9.7E-07
2/17/14 8:05	4.3E+01	7:35	5.8E-07
2/17/14 16:00	7.8E+01	7:55	1.1E-06

[1] It appears that sample pull times for Station A and Station B were juxtaposed on the initial war room data board.

4. Calculations cont.

To convert a Station B source term into a release value, the unit conversion of 2.22e12 dpm per Ci is used along with a ratio of the flow rates. The Station B flow rate is 2 cfm and the Station B exhaust is kept around 60e3 cfm. These factors combine to give a total conversion coefficient of 1.4E-8 Ci/dpm as given in Equation 1 for the Curie release from Station B based on an assay of the filter activity in dpm.

$$60 \times 10^3\ cfm/\left(2\ cfm\ \times 2.22 \times 10^{12}\ \frac{dpm}{Ci}\right) = 1.4 \times 10^{-8}\ \frac{Ci}{dpm} \qquad \text{Eqn. 1}$$

Using the source terms from Table 1, the resultant plume projections for dose offsite are provided as attachments with representative figures also provided in this calculation. The plumes used in this calculation are not the same as those generated during the initial response to the event as they use different time intervals to reflect current best estimates of the time release as shown in Figure 1. This release profile simply assumes a uniform release rate between each measurement value provided from Station B gross assay results.

What can be seen from Figure 1 is not only that a second event appears to have occurred between 8:35 AM and 2:45 PM but the values steadily decrease after this and also seem to become a constant rate under 100 nCi per hour.

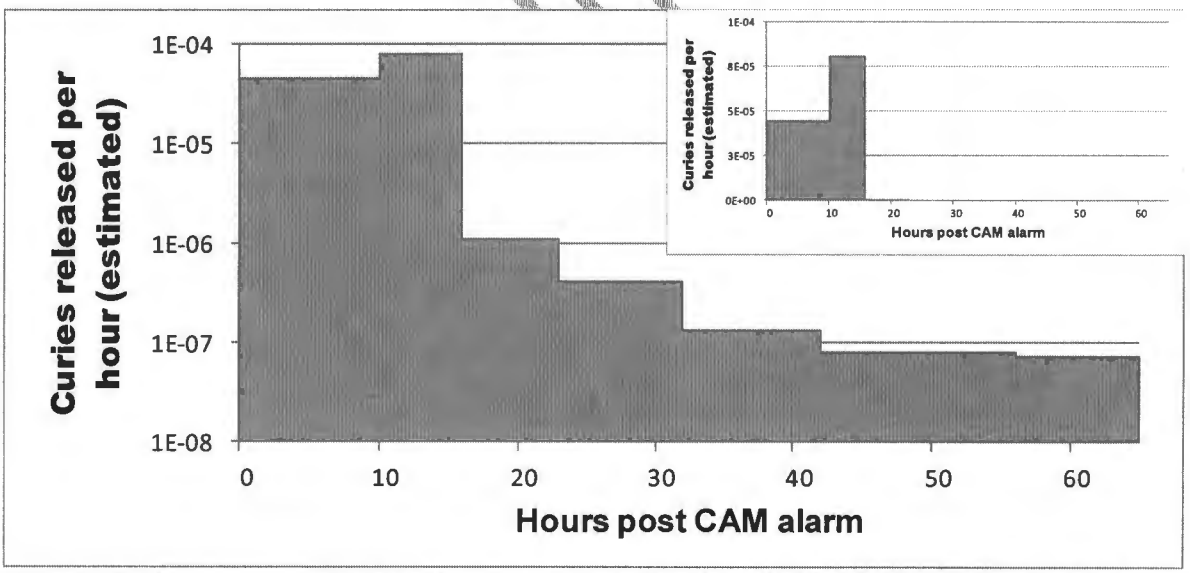


Figure 1. Station B release rates as a function of time after the initial CAM alarm. Note that the axes are presented in a semilog plot so that the vertical axis is not linear but logarithmic. The inset on the upper right is exactly the same plot reproduced on a linear scale for comparison. The linear scale basically shows the first 2 time intervals listed as being the dominant release components of the event.

5. Rev No. 1	6. CE or Author Date	7. Checked By Date	8. CM Approval Date

4. Calculations cont.

By utilizing an informal CM home team from Sandia and the actual NARAC staff out of LLNL, an integral plume using site meteorological data was generated on 2/20/14. This option was not available in the initial stages as the NARAC models using the web application only allow protracted releases to be generated using interpolated data from nearby airport meteorological data such as that used by the National Weather Service. The result of this integrated plume using the WIPP meteorological data is shown in Figure 2. This plume gives a first estimate of the dose consequence to workers and potential members of the public which show the values to be quite low.

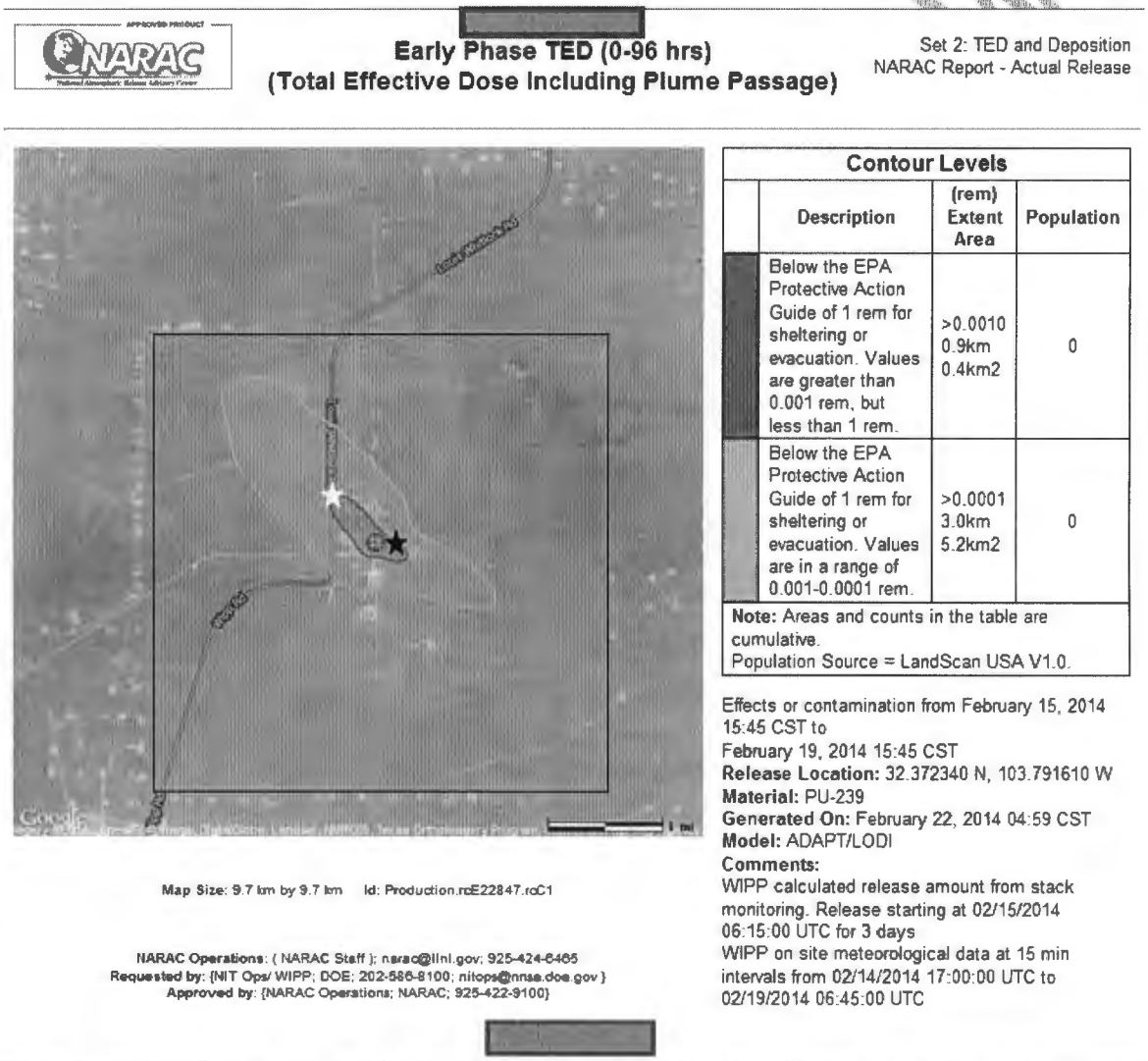


Figure 2. Station B estimate for the isodose contours assuming a uniform release duration over each time period given in Table 1 as shown in Figure 1. Far Field Station is labeled with a white star, South Station is labeled with an orange star and East Station is labeled with a black star.

Highlighted by black outline is the approximate area of the 16 sections comprising the Land Withdrawal Area for WIPP. Closer in but still outside of the barbed wire fence area of the property protection area are the Far Field, South and East sampling stations represented by white, orange and black stars respectively.

Figure 3 shows the same plume closer up. Here the specific location of the air samplers relative to the resultant plume can be seen. The Far Field sample (white star) is outside the 1 mrem contour as is South Station (orange star) but East Station is within the 1 mrem contour boundary.

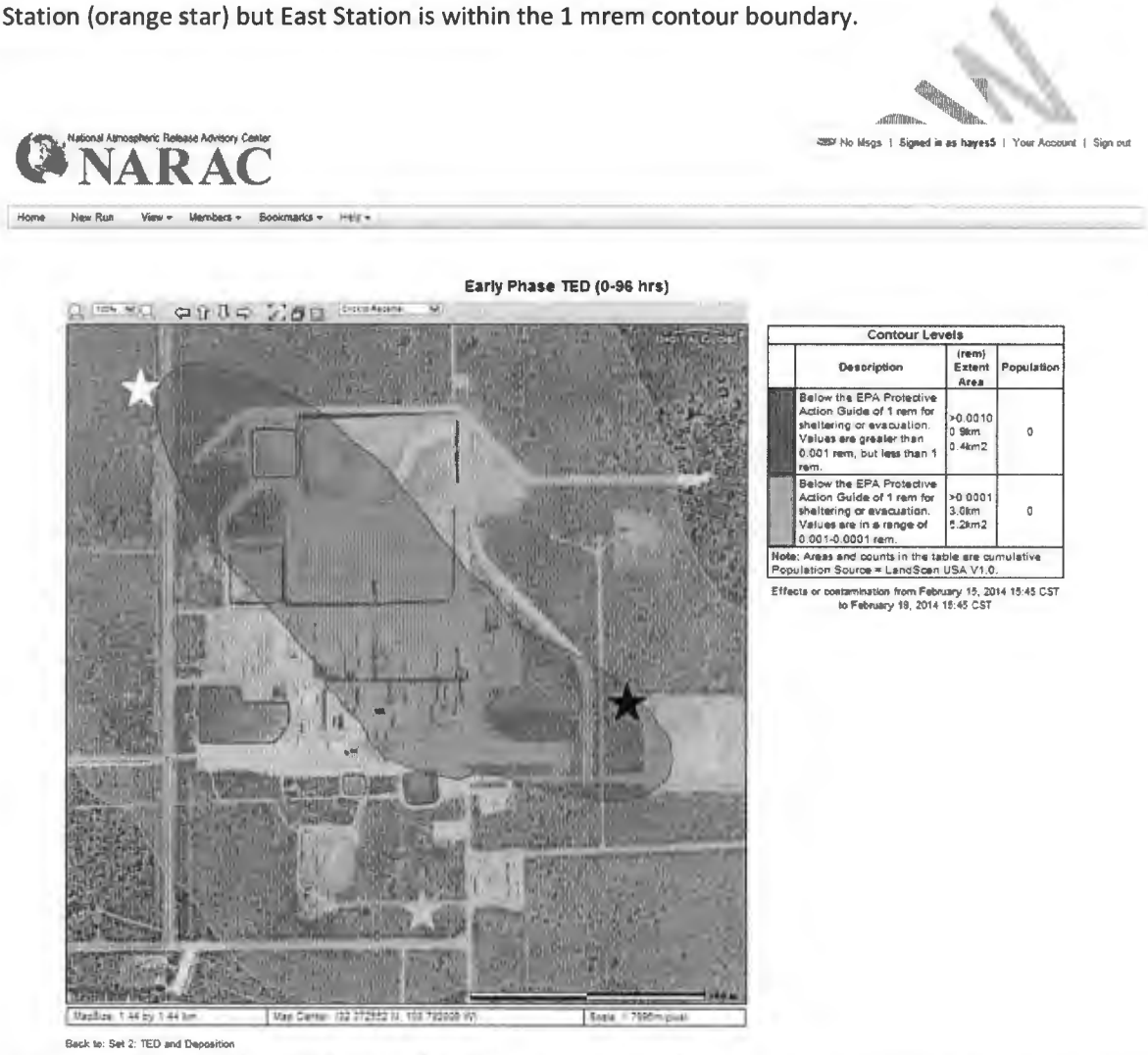


Figure 3. Close up view of Station B estimate for the isodose contours assuming a uniform release duration over each time period given in Table 1 as shown in Figure 1. Far Field Station is labeled with a white star, South Station is labeled with an orange star and East Station is labeled with a black star.

What has been found to date is the Far Field station read 36 dpm TRU activity using alpha spectrometry after a 72 hour decay and 43 dpm Am241 activity using gamma spectrometry (assumed uncertainties are in the range of 20%). The air sampler was running 2 cfm, and although it had a total volume sampled of 103 ft^3 when removed, it was only sampling for approximately 15 hours after the CAM alarmed in the underground. Using Figure 1, it can be inferred that the majority of the plume was being generated for approximately 15 hrs. Using Figure 4, it can be seen that the wind was only blowing from the ESE (from approximately 135 degrees clockwise from the north) for 8.5 hours.

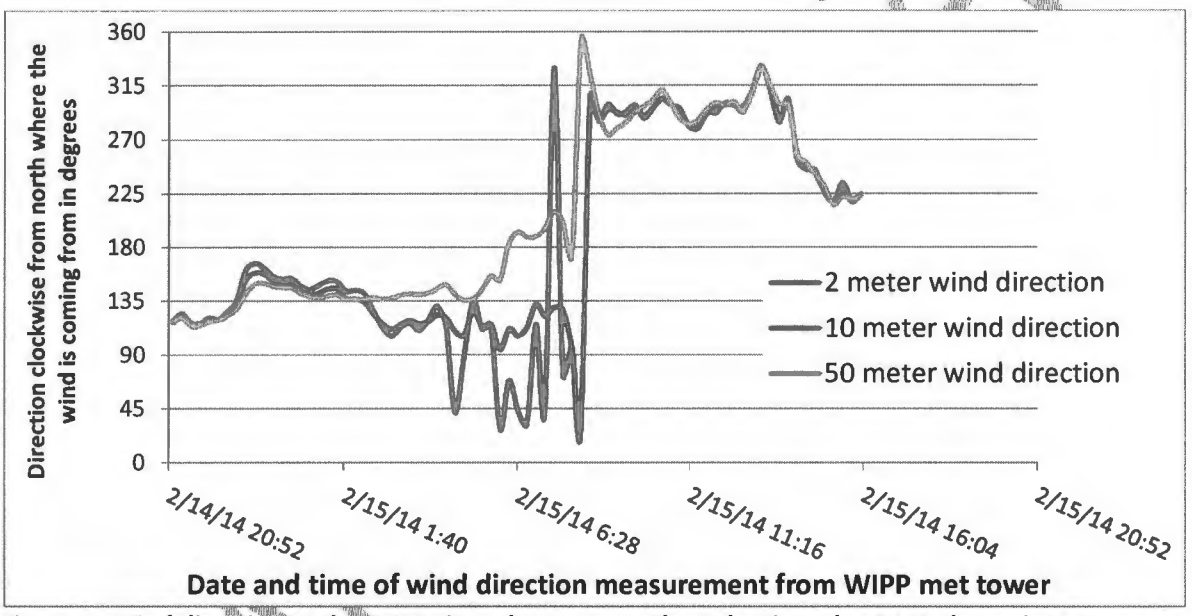


Figure 4. Wind direction at the WIPP site subsequent to the Valentines day CAM alarm given at heights of 2 m, 10 m and 50 m. The CAM alarm took place starting on 2/14/14 at 23:15 and according to Figure 1 continued up to around 2/15/14 14:45. A large shift in wind direction can be seen to occur around 8:30 AM on 2/15/14.

Using these values, an air concentration can be estimated with Equation 2 which would generate 0.03 Bq/m^3 as the measurement value from the air sample.

$$40\ dpm \times \frac{1\ Bq}{60\ dpm} \Big/ \left(2\frac{ft^3}{min} \times 8.5\ hrs \times \frac{60\ min}{hr} \times \frac{1\ m^3}{35.31\ ft^3}\right) \approx 0.02\frac{Bq}{m^3} \qquad \text{Eqn. 2}$$

Using further that according to 10 CFR 835 Appendix A, for Pu239 the most conservative value for a single DAC is 0.2 Bq/m^3. This value is based on 1 ALI being a 5 rem TED assuming a 2000 hr exposure such that 1 DAC = 2.5 mrem/hr. From these, a dose estimate of 2 mrem for a person standing next to the air sampler can then also be estimated using Equation 3.

4. Calculations cont.

$$2\ mrem \approx\ 0.02\,\frac{Bq}{m^3} \times \frac{2.5\ mrem/hr}{1\ DAC} \times \frac{1\ DAC}{0.2\frac{Bq}{m^3}} \times 8.5\ hrs \qquad \text{Eqn. 3}$$

This number assumes of course that the person is standing next to the air sampler for the duration of the release (the full 8.5 hrs).

Current activity measurement results of South and East Stations provided by alpha spectrometry assay post 72 hr decay are 4 and 5 dpm respectively. Using the same approach with Equations 2 and 3, this places the worst case dose estimate around 0.3 mrem at each location. According to Figure 3, this is consistent with the South Station sampler (orange star) which is located between the 0.1 and the 1 mrem contour but shows the East Station location being lower than estimated by the plume model. The plume model in Figure 3 shows East Station being very near the 1 mrem contour line but the sample result is closer to the 0.1 mrem level by measurement.

It is important to understand the context of plume models and air sample correlation. 10 CFR 835[i] requires that dose from inhalation be determined using bioassay rather than air monitoring data due to the extremely large variations inherent to these kinds of measurements. Using laboratory conditions, the correlation between a lapel sampler and a general room area fixed air sampler will indeed give a linear correlation but the typical variation between the two is a full order of magnitude[ii]. This is partially attributed to the large variation in particle activity[iii] as a fixed specific activity will increase as the cube of the particle radius with different particle sizes. Being able to estimate dose based on air concentration measurements from a plume model is considered to be exceptionally well done if they are within a factor of 2 to 5 with a factor of 10 accuracy generally a reasonable value without iteratively perturbing and rerunning the plume models to interpolate measurement results.

Figure 5 shows general locations of more distance offsite sample filters including Mills Ranch, Smith Ranch, Southeast Control and Carlsbad samples with red squares. Also shown as an inset in the lower right are the Far Field, South and East sampling stations located just outside the Property Protection area. The resulting iSolo assay and dose estimate consequences from each of these samples is provided in Table 2 below.

Table 2. Dose estimates using 8 hour exposure times

	Far Field	South	East	Southeast Control	Mills Ranch	Smith Ranch	Carlsbad
iSolo Assay (dpm)	40	3.7	4.4	1.3	2.7	4.2	1.6
dose estimate (mrem)	2	0.2	0.3	0.1	0.2	0.3	0.1

A useful comparison is the internal dose a person receives from having natural potassium in their blood. Potassium is naturally radioactive and essential to life (a person would die if they had no potassium) and this emits a high energy gamma and high energy beta radiation. This dose range goes from a minimum

of 10 mrem/yr for a small person and as high as 40 mrem/yr for a large muscular male[iv]. Similarly, just breathing unfiltered mountain fresh air will give a person over 200 mrem per year (around 0.6 mrem per day) due to natural radon in the air. The legal limit for exposure to a standard adult member of the population is 100 mrem/yr.

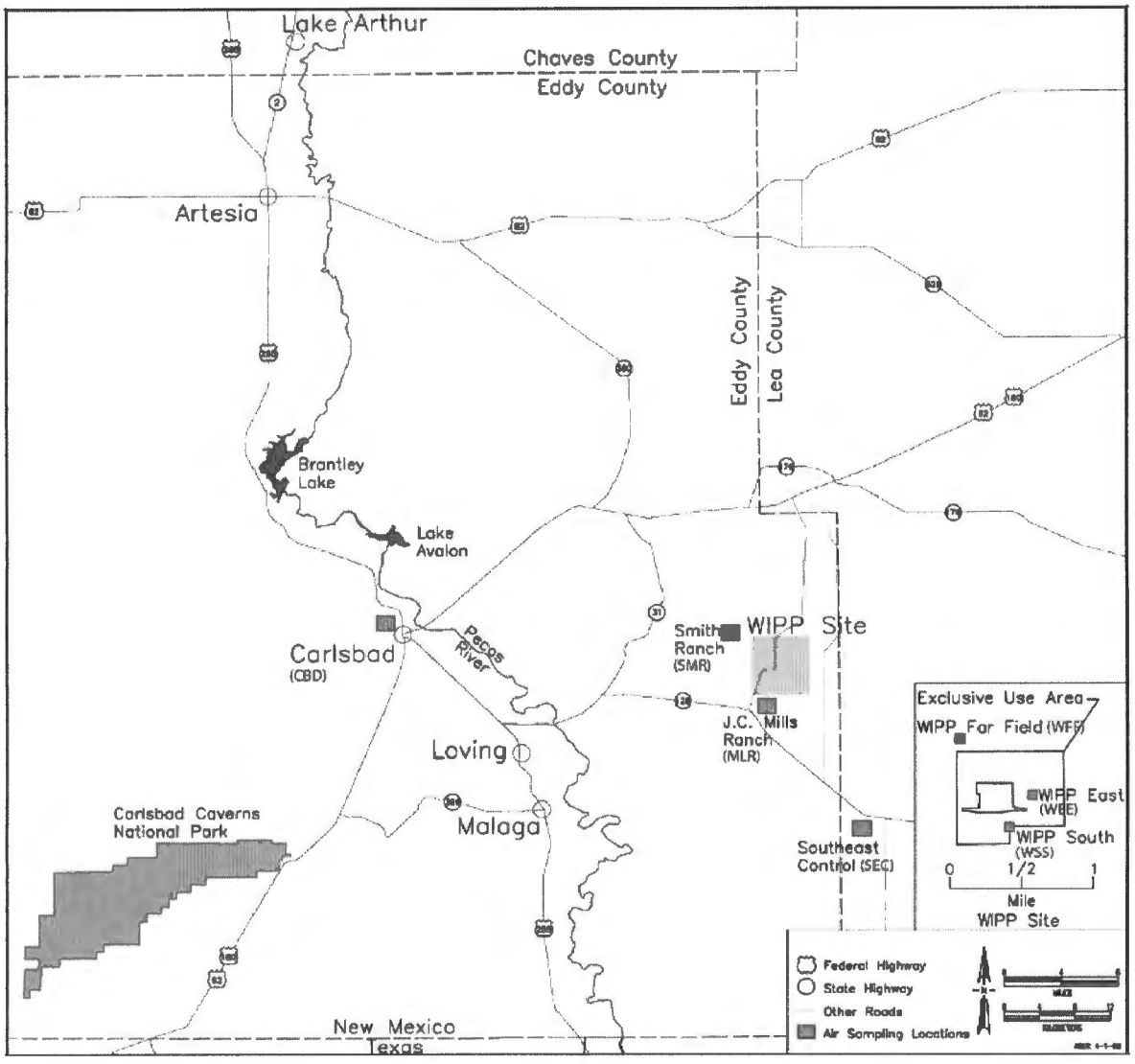


Figure 4.1 – Air Sampling Locations On and Near the WIPP Site

Figure 5. WIPP offsite air sampling locations as marked by red squares. The inset in the lower right shows roughly the same area shown in Figure 2. The upper scale in the lower right corner of the figure is in units of 4 miles. The bottom scale in the lower right is in units of 4 km. This figure was taken from the 2011 ASER (DOE/WIPP-12-3489).

Table 3. A relative comparison of dose consequences from the WIPP release assuming an annual average dose to a US citizen of 620 mrem.

	Far Field	South Station	East Station	Southeast Control	Mills Ranch	Smith Ranch	Carlsbad
Dose estimate (mrem)	2	0.2	0.3	0.1	0.2	0.3	0.1
Fraction of annual average exposure in the US	0.004	0.0004	0.0004	0.0001	0.0003	0.0004	0.0002
Percent of annual average exposure in the US	0.4%	0.04%	0.04%	0.01%	0.03%	0.04%	0.02%

Another parameter of potential interest is the 100 mrem/yr boundary estimated by the plume model generated by the NARAC staff at LLNL. This information is presented in Figure 5 which shows the contour to be completely within the fence line and limited very close to Station B itself.

Surface Contamination

The estimates of surface contamination coming from Station B are presented in Figures 4 and 5 using the same interval releases shown in Figures 2 and 3 respectively. These values are shown with surface contamination units of dpm/100 cm^2. Radioactive contamination is defined as being a removable value of greater than 20 dpm/100 cm^2 or a total (fixed plus removable) of greater than 500 dpm/100 cm^2. The values predicted from the plume show contamination levels on site generally greater than 1 dpm/100 cm^2 with levels near the property protection area being between 0.1 and 1 dpm/100 cm^2. Currently the entire site has been extensively surveyed for contamination and none found which is consistent with the plume modeling.

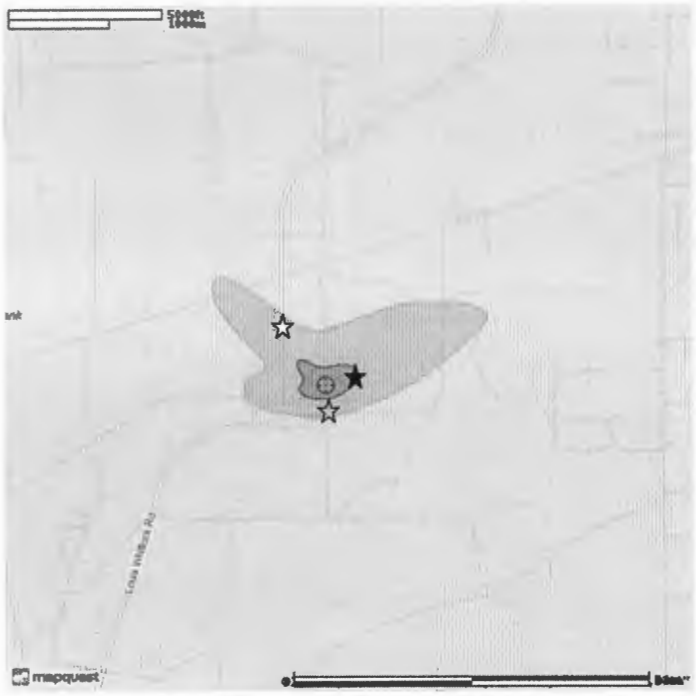
Currently, plume estimates appear consistent with site survey measurements to date which have aggressively searched for contamination both onsite and offsite near the air sampling locations marked in Figures 2 and 3 by the stars. There was contamination found inside of the Station A building which is where the source term air sampling filter to the HEPA banks is located where an air sample of assayed by WIPP labs to have 8 million dpm was pulled on 2/15/14. Note that this filter is just the source term to the HEPA banks and Table 3 shows the most current air sample results from radioactivity released through Station B as measured at the WIPP using gross alpha beta counters.

4. Calculations cont.

NOT APPROVED BY NARAC

Deposition at 96 hrs
(Surface Contamination from Deposited Radionuclides)

Set 1 Deposition for WIPP
Automated Report - Assessment



Map Size: 9.7 km by 9.7 km Id: Production.rcE22847.rcC1

NARAC Operations: (NARAC Staff); narac@llnl.gov; 925-424-6465
Requested by: {onDuty Assessor; NARAC; 925-424-6465; narac@llnl.gov }
Not approved for further distribution

Contour Levels			
	Description	(dpm/100cm2) Extent Area	Population
	Below health effect guidelines. Possibly contaminated area. Use to confirm with monitoring surveys.	>1 0.5km 0.3km2	0
	Below health effect guidelines. Possibly contaminated area. Use to confirm with monitoring surveys.	>0.10 2.5km 3.9km2	0

Note: Areas and counts in the table are cumulative.
Population Source = LandScan USA V1.0.

Effects or contamination at February 19, 2014 15:45 CST
Release Location: 32.372340 N, 103.791610 W
Material: PU-239
Generated On: February 21, 2014 08:47 CST
Model: ADAPT/LODI
Comments:
Hypothetical release starting at 02/15/2014 06:15:00 UTC for 3 day
gridded met at
02/14/2014 06:00:00 UTC;02/14/2014 07:00:00 UTC;02/14/2014 08:00:00 UTC;
02/14/2014 09:00:00 UTC;02/14/2014 10:00:00 UTC;02/14/2014 11:00:00 UTC;
02/14/2014 12:00:00 UTC;02/14/2014 13:00:00 UTC;02/14/2014 14:00:00 UTC;
(additional times truncated)

Figure 4. Station B surface contamination estimate for 1st time interval as sampled assuming a uniform release duration. The inner contour level is at the 1 dpm/100 cm^2 level of surface activity.

The formal survey map of onsite measurements is not available at this writing as it has yet to go through the quality assessments and reviews but outside of the Station A surveys, no contamination has been found onsite or offsite even though it has been aggressively sought. Fiddler measurements having a detection capability of approximately 1 uCi/m^2 have also been employed also showing no detectable TRU activity. The conversion to more familiar units of dpm/100 cm^2 is given by Equation 4 which shows the detection limits are orders of magnitude above expected contamination levels and so not detecting contamination was fully expected.

$$1\frac{dpm}{100\ cm^2} = 1\frac{dpm}{100\ cm^2} \times \frac{1\ Bq}{60\ dpm} \times \frac{uCi}{37{,}000\ Bq} \times \left(\frac{100\ cm}{m}\right)^2 = 4.5 \times 10^{-5}\frac{uCi}{m^2} \qquad \text{Eqn. 4}$$

4. Calculations cont.

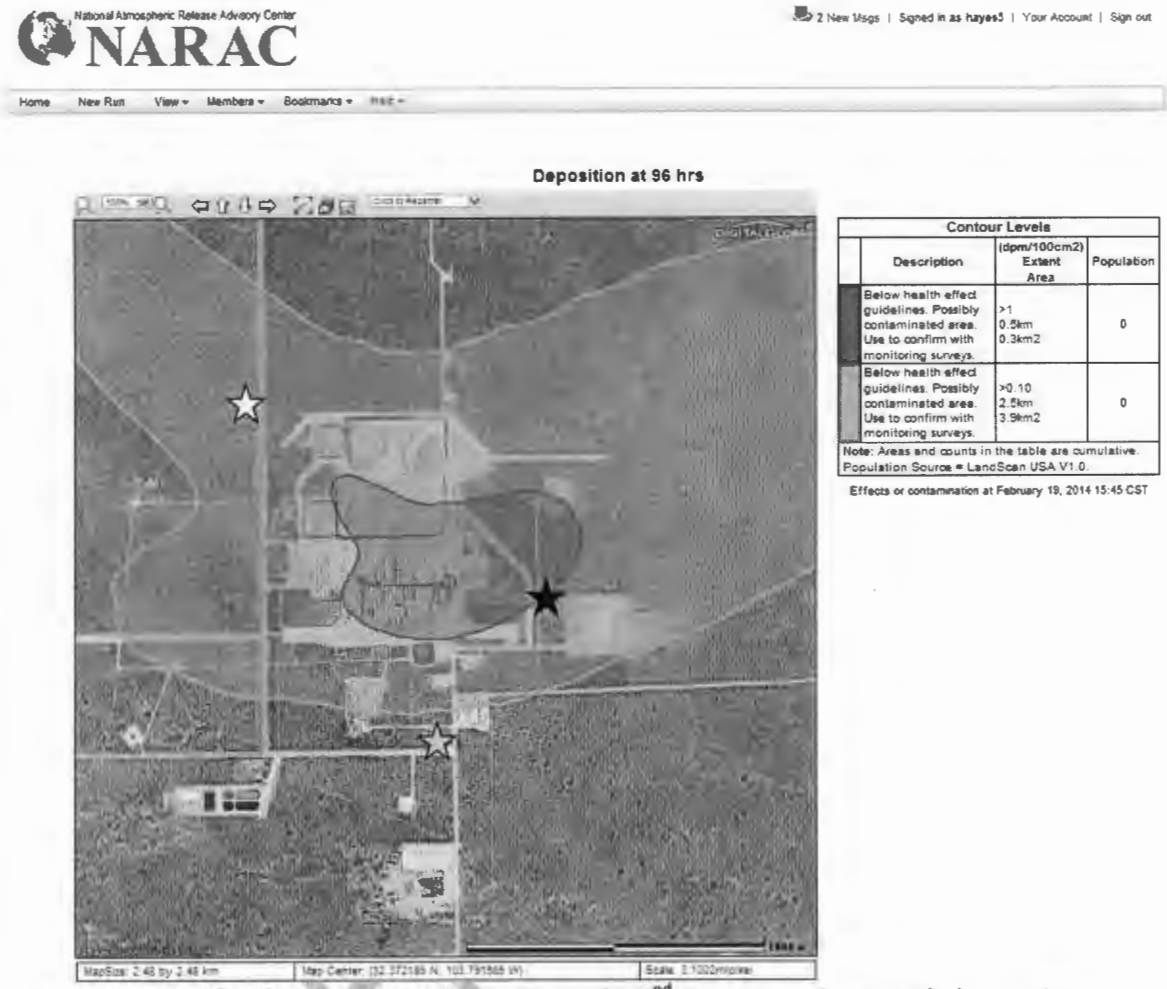


Figure 5. Station B surface contamination estimate for 2nd time interval as sampled assuming a uniform release duration. The inner contour level is at the 1 dpm/100 cm^2 level of surface activity.

As this release will increase the TRU activity both on-site and offsite over and above that already occurring due to the ubiquitous anthropogenic background (from historic atmospheric weapons testing resulting in global fallout), a comparison to these levels is of significance. The Centers for Disease Control (CDC, which is a branch of the National Institutes of Health) conducted a study to determine what the cumulative fallout deposition is across the United States resulting from the global fallout term. These values are graphically displayed in Figure 6.

From Equation 4 it can be seen that 1E-4 uCi/m^2 is comparable to 1 dpm/100 cm^2 (a useful reference value to consider when comparing to the plume plot). This is significant because the highest contour levels shown are 1E-4 uCi/m^2. A useful comparison for onsite measurement is that anything under 20 dpm / 100 cm^2 is by definition, not contaminated for surface deposition considerations. This means that

projected surface deposition levels of TRU activity are expected to be an order of magnitude lower than contamination levels.

Figure 3.28. Cesium-137 deposition density (Bq/m^2) due to NTS and global fallout.

Figure 6. CDC estimates of Cs137 ground deposition from atmospheric nuclear weapons testing. Note that in the region of southeast New Mexico where the WIPP site is located the estimate is in the range of 1000 to 3000 Bq/m^2.

To date there has been no Cs137 detected in any of the released activity from the Station B stack but the historically ubiquitous anthropogenic Pu deposition can be estimated from Figure 6 using the established WIPP region ratio[v] of Cs/Pu=30 approximation. In other words, the Cs-137 content present in the WIPP area prior to constructing or operating the WIPP was about 30 times larger than the Pu content. Using the values shown in Figure 6 for Cs, the Pu values would then be 30 times lower in surface deposition from global fallout placing the WIPP area at an estimate of 30 to 100 Bq/m^2. Converting this to more familiar units of dpm/ 100 cm^2 is done in Equation 5 resulting in a historic TRU surface deposition concentration estimate of 0.4 dpm/100 cm^2.

$$70\ \frac{Bq}{m^2} = 70\ \frac{Bq}{m^2} \times \frac{60\ dpm}{Bq} \times \left(\frac{1\ m}{100\ cm}\right)^2 = 0.4\ \frac{dpm}{100\ cm^2} \qquad \text{Eqn. 5}$$

With the ubiquitous background being on the order of 1 dpm /100 cm^2 and the deposition projections from the release being on the same order, it seems reasonable to expect a roughly doubling of the offsite background levels for this nuclide. Similarly the estimates onsite for historical levels can be

expected to increase by an order of magnitude over the background levels based solely on the plume projections.

Neither of these levels (onsite or offsite) are detectable and are subsequently consistent will all measurements carried out to date.

It is important to note that a large number of assumptions go into the plume projections and only the source term is really a quality value. The time profile shown in Figure 1 and the projected wind directions shown in Figures 2 through 5 show how largely different the plume distribution is sensitive to the time profile alone. The meteorological data came from NARAC interpolation from data used by the National Weather Service and so incorporates measurements from nearby airports as well as any other available quality measurement data they are able to incorporate.

Conclusions

Plume projections and assessed data measured to date are consistent with conservatively estimating offsite doses to be lower than 10 mrem, likely closer to the 1 mrem range with surface contamination levels being below detection limits.

[i] 10 CFR 835 Occupational Radiation Protection,

[ii] Alvarez JL, Bennet WS, Davidson TL. Design of an airborne plutonium survey program for personnel protection. *HealthPhys.* **66**, 634-642 (1994).

[iii] Munyon WJ, Lee MB. Summary of stationary and personal air sampling measurements made during a plutonium glovebox decommissioning project. *Health Phys.* **82**, 244-253 (2002)

[iv] NCRP Report No. 94, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, National Council on Radiation Protection Measurements, Bethesda, MD 1992

[v] WIPP TBD 2012-01 Using Isotopic Ratios for Discrimination of Environmental Anthropogenic Radioactivity.