DOE Oversight Bureau, New Mexico Environment Department

Direct Penetrating Radiation Monitoring Report at the Waste Isolation Pilot Plant

Conducted by the
New Mexico Environment Department DOE Oversight Bureau
for Calendar Year 2017 Q-4

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The purpose of this communication is to transmit direct penetrating radiation (DPR) dose levels collected at the Waste Isolation Pilot Plant during the fourth quarter of calendar year 2017. The data measurements were obtained using the E-PERM® electret ionization chamber system from Rad Elec Inc.

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Acronyms

CFR	Code of Federal Regulations
CY	Calendar Year
DOE	Department of Energy
DPR	Direct Penetrating Radiation
EDE	Effective Dose Equivalent
EPA	Environmental Protection Agency
mrad	Millirad
mrem	Millirem
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMED	New Mexico Environment Department
OB	Oversight Bureau
Q-4	Fourth Quarter
SD	Standard Deviation
WIPP	Waste Isolation Pilot Plant
WOS	WIPP Oversight Section

Introduction

The U.S. Department of Energy (DOE) has provided grant funding to the New Mexico Environment Department (NMED) DOE Oversight Bureau (DOE-OB or the Bureau) to conduct environmental surveillance and monitoring at the Waste Isolation Pilot Plant (WIPP) since 2005. Monitoring programs include ambient air sampling, exhaust air sampling, general environmental sampling and measuring direct penetrating radiation.

The purpose of the Direct Penetrating Radiation (DPR) Monitoring Program is to monitor gamma radiation (or direct penetrating radiation) at the WIPP facility, in the area immediately surrounding, and along the local WIPP transportation routes.

There are no Federal or State standards for gamma radiation in the environment. To verify that activities at the WIPP are protective of public health and the environment, the NMED WIPP Oversight Section (WOS) gamma radiation dosage results are compared to average naturally occurring background gamma radiation dosages and with historical NMED DPR data.

On average, Americans receive a radiation dose of about 620 mrem each year. Half of this dose (310 mrem) comes from natural background radiation: radon in the air, cosmic rays and the Earth itself. The other half comes from man-made sources of radiation: medical, commercial, and industrial sources (Doses in our Daily Lives, U.S. Nuclear Regulatory Commission website http://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html, accessed August 4, 2017).

The environmental dose standard for the WIPP facility is established in Title 40 Code of Federal Regulations (CFR) Part 191, Subpart A, “Environmental Standards for Management and Storage.” The standard sets the regulatory limit for external radiation to a member of the public outside the exclusive use area boundary at 25 mrem per year to the whole body and 75 mrem to any critical organ.

In a 1995 memorandum of understanding between the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE), the DOE agreed that the WIPP facility would comply with 40 CFR Part 61, Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities.” The NESHAP standard for radionuclides requires that the emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent (EDE) of 10 mrem per year. (US Environmental Protection Agency 1995)

The NMED WOS has measured and compiled DPR dose levels at NMED DOE OB monitoring sites during the fourth quarter (Q-4) of the calendar year (CY) 2017. During CY2017, the DOE OB maintained a total of fourteen (14) monitoring sites located in the Exclusive Use Area at WIPP and ten (10) sites at off-site locations in the region surrounding WIPP. DPR dose data are collected quarterly (See Table 1, Figure 1; Appendix 1).

Table 1. Location and operational details of Direct Penetrating Radiation monitoring stations located inside the WIPP Exclusive Use Area and in the WIPP vicinity.

DPR Number	Location Name	Operational History
DPR 01	Parking lot, WIPP Exclusive Use Area	CY2006 Q-3 to present
DPR 02	Railroad Entrance, WIPP Exclusive Use Area	CY2006 Q-3 to present
DPR 03	Southwest Fence Corner, WIPP Exclusive Use Area	CY2007 Q-1 to present
DPR 04	South Fence Center, WIPP Exclusive Use Area	CY2007 Q-1 to present
DPR 05	Near Southeast Fence Corner, WIPP Exclusive Use Area	CY2006 Q-3 to present
DPR 06	Far Southeast Fence Corner, WIPP Exclusive Use Area	CY2006 Q-3 to present
DPR 07	East Fence Middle, WIPP Exclusive Use Area	CY2007 Q-1 to present
DPR 08	Northeast Fence Corner, WIPP Exclusive Use Area	CY2007 Q-1 to present
DPR 09	North Northeast Fence Corner, WIPP Exclusive Use Area	CY2007 Q-1 to present
DPR 10	North Fence Salt Pile WIPP Exclusive Use Area	CY2007 Q-1 to present
DPR 11	Northwest Fence Corner, WIPP Exclusive Use Area	CY2006 Q-3 to present
DPR 12	Waste Handling Building Loading Dock West, WIPP Exclusive Use Area	CY2006 Q-3 to present
DPR 13	Waste Handling Building Loading Dock Center, WIPP Exclusive Use Area	CY2006 Q-3 to present
DPR 14	Waste Handling Building Loading Dock East, WIPP Exclusive Use Area	CY2006 Q-3 to present
DPR 15[1]	Carlsbad, NM - Canal St.(inactive)	CY2006 Q-3 to CY2012 Q-2
DPR 16	Loving Weigh Station	CY2007 Q-3, CY2009 Q-3 to present
DPR 17	Malaga Volunteer Fire Department	CY2008 Q-1 to present
DPR 17a[2]	Gnome Site	CY 2007 Q-3
DPR 18	Hobbs Highway / North Access Road Intersection	CY2009 Q-1 to present
DPR 19	Southeast Control Tower	CY2011 Q-4 to present
DPR 20	Carlsbad, NM – NMED Office. (interior)	CY2012 Q-3 to present
DPR 21	Carlsbad, NM – NMED Office (exterior)	CY2012 Q-3 to present
DPR 22	Seven Rivers Highway / Brantley (formerly “Artesia”)	CY2017 Q-2 to present
DPR 23	North Loop Road	CY2016 Q-3 to present
DPR 24	South Access Road / NM 128 Intersection	CY2016 Q-3 to present
DPR 25	Jal Highway MM49	CY2016 Q-3 to present

[1] Monitoring at DPR 15 was discontinued after CY2012 Q-2 when NMED moved their office from the Canal Street location to 406 N Guadalupe Street.
[2] Monitoring at DPR 17a was completed for Q-3 CY 2007 then discontinued.

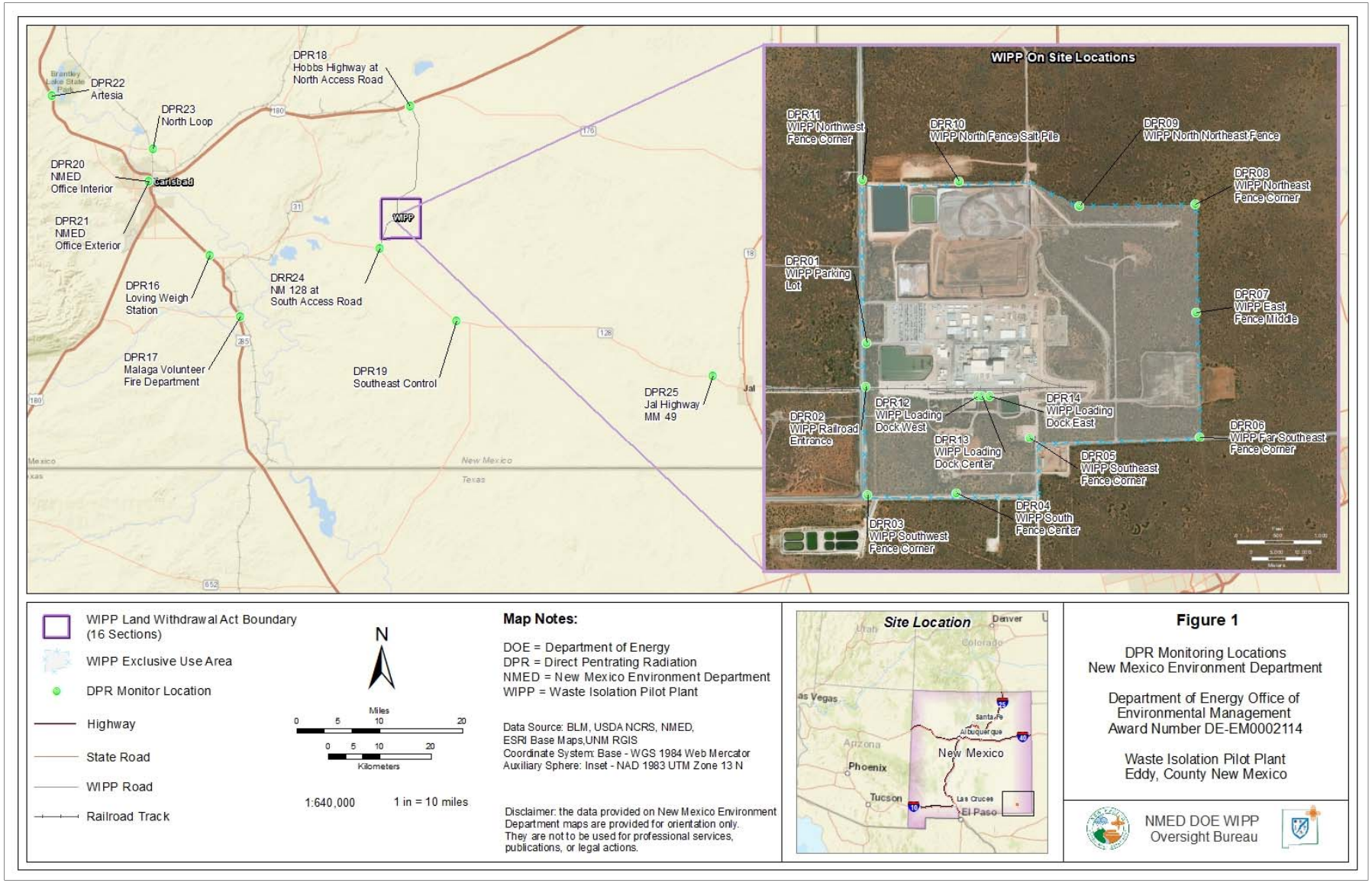

Figure 1. Location of NMED DOE-OB DPR monitors at WIPP and in the area surrounding WIPP

The data were obtained using the E-PERM® electret ionization chamber system from Rad Elec Inc. The electret passive ion chamber uses the principle of ion pair production resulting from gamma photons interacting with air molecules to reduce the voltage of a charged Teflon™ disk. (Rad Elec Inc. 2011) The chambers are housed in aluminum canisters designed to block gamma radiation from radon. Using a predetermined formula, the voltage drop indicates the amount of radiation passing through the chamber. (Rad Elec Inc. 2011) The WOS monitoring program reads electret passive ion chambers at the end of each quarter, readings are converted into quarterly dose values presented in units of millirads (mrad).

A rad is a unit of absorbed radiation dose, regardless of its source. The rem (Roentgen equivalent man) is a commonly used unit of ionizing radiation dose that uses a quality factor based on the source of radiation as it interacts with human body tissue. In the case of gamma radiation, the quality factor is one, and thus one rad is equal to one rem.

The quarterly dose rates have been normalized to reflect an actual quarter of 91.25 days. Normalized quarterly dose rates are summed for an estimated annual dose rate.

Results

The complete data set for Q-4 is presented in Appendix 1. The average quarterly dose measured at each station during Q-4 is provided in Table 2, Figures 2 and 3. The average quarterly dose of all DPR monitoring locations was 22.5 ± 5.3 standard deviation (SD).

DPR results at the WIPP ranged from a minimum average quarterly dose of 17.9 mrad at the WIPP Loading Dock East (DPR14), to a maximum average quarterly dose of 28.6 mrad at the WIPP North East Fence Corner (DPR08). The average of all measurements at the WIPP site during Q-4 was 20.6 mrad ± 2.7 SD.

DPR results off-site ranged from a minimum average quarterly dose of 18.4 mrad at the NMED Office Interior (DPR 20), to a maximum average quarterly dose of 43.5 mrad at the NMED Office Exterior (DPR21). The average of all measurements off-site was 25.2 mrad ± 7.0 SD.

A review of the historical DPR data collected at WIPP and in the surrounding region identified several potential outliers in the dataset. In these instances, one of the three electrets at a location had a voltage drop that was significantly higher or lower than the other electrets. Potential outliers were compared to the quarterly average across all stations, and data that exceeded 2 and 3 SD from the mean are identified in Table 2. Potential outliers have not been excluded from the results reported or analyzed.

Table 2. NMED DOE OB DPR Results for CY2017 Q-4, Average Quarterly Dose (mrad). No data is reported if the data were disqualified (DQ)[3]. One asterisk (*) indicates that one of the three electrets' calculated dose exceeds two SD of the mean quarterly average for all stations without a disqualifying event listed in the field notes. Two asterisks (**) indicates that one of three electrets' calculated dose exceeds three SD of the mean quarterly average for all stations without a disqualifying event in the field notes.

DPR Number	Location Name	2017 Q-4 Average Dose (mrad)
DPR 01	Parking lot, WIPP Exclusive Use Area	21.1
DPR 02	Railroad Entrance, WIPP Exclusive Use Area	20.0
DPR 03	Southwest Fence Corner, WIPP Exclusive Use Area	20.6
DPR 04	South Fence Center, WIPP Exclusive Use Area	22.1
DPR 05	Near Southeast Fence Corner, WIPP Exclusive Use Area	20.1
DPR 06	Far Southeast Fence Corner, WIPP Exclusive Use Area	21.2
DPR 07	East Fence Middle, WIPP Exclusive Use Area	18.0
DPR 08	Northeast Fence Corner, WIPP Exclusive Use Area	28.6
DPR 09	North Northeast Fence Corner, WIPP Exclusive Use Area	21.4
DPR 10	North Fence Salt Pile WIPP Exclusive Use Area	21.7
DPR 11	Northwest Fence Corner, WIPP Exclusive Use Area	18.2
DPR 12	Waste Handling Building Loading Dock West, WIPP Exclusive Use Area	18.7
DPR 13	Waste Handling Building Loading Dock Center, WIPP Exclusive Use Area	18.9
DPR 14	Waste Handling Building Loading Dock East, WIPP Exclusive Use Area	17.9
DPR 16	Loving Weigh Station	25.4
DPR 17	Malaga Volunteer Fire Department	24.8
DPR 18	Hobbs Highway / North Access Road Intersection	25.0
DPR 19	Southeast Control Tower	18.9
DPR 20	Carlsbad, NM – NMED Office. (interior)	18.4
DPR 21	Carlsbad, NM – NMED Office (exterior)	43.5**
DPR 22	Seven Rivers Highway / Brantley (formerly "Artesia")	23.5
DPR 23	North Loop Road	20.6
DPR 24	South Access Road / NM 128 Intersection	25.8
DPR 25	Jal Highway MM49	26.0

[3] Data is disqualified if the canisters or electrets have been tampered with in any way. Details of the conditions for disqualification are provided in Appendix 1. Disqualified data are not included in any further analysis.

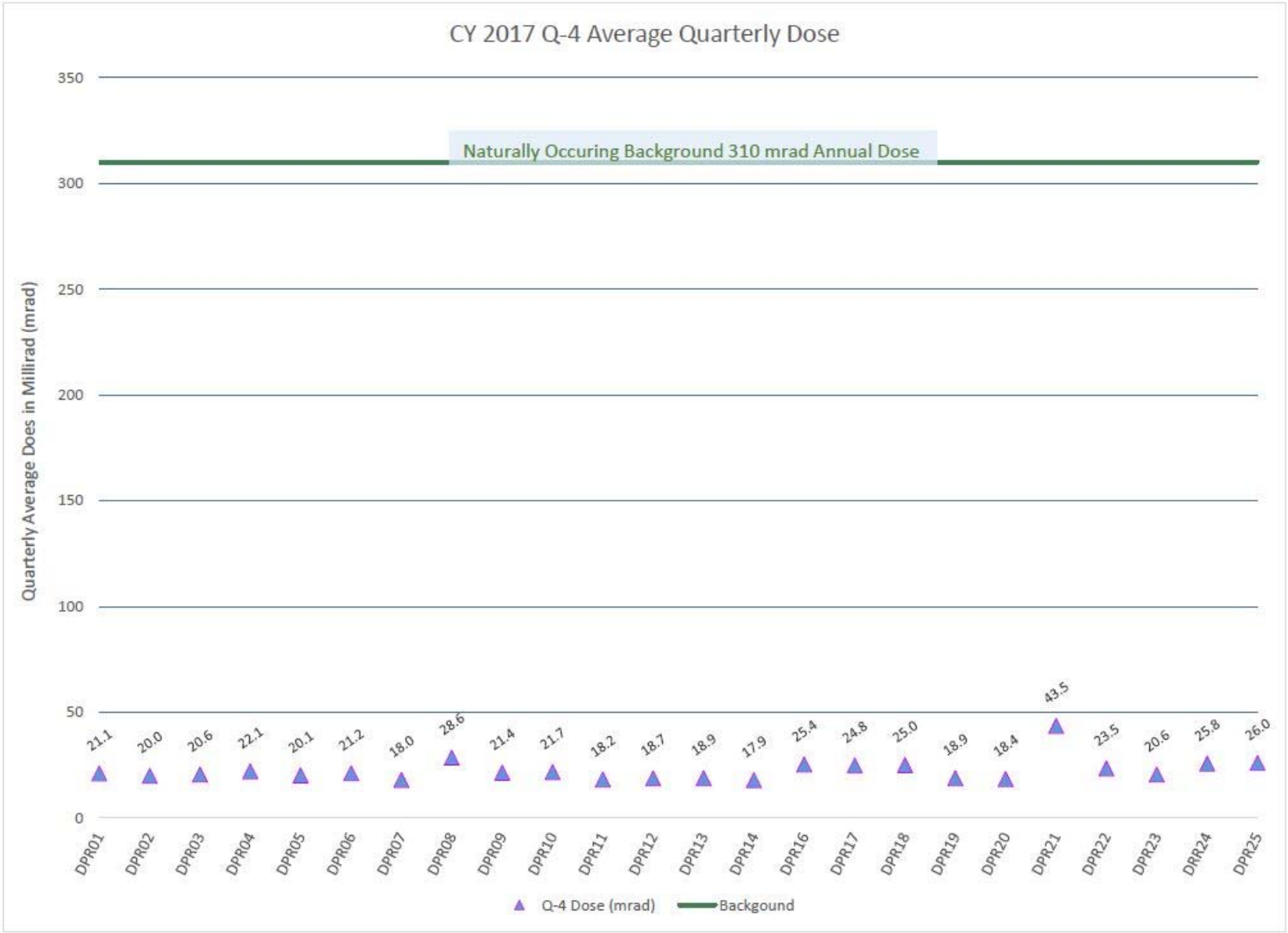

Figure 2. NMED DOE-OB DPR Results for CY2017 Q-4, Average Quarterly Dose (mrad)

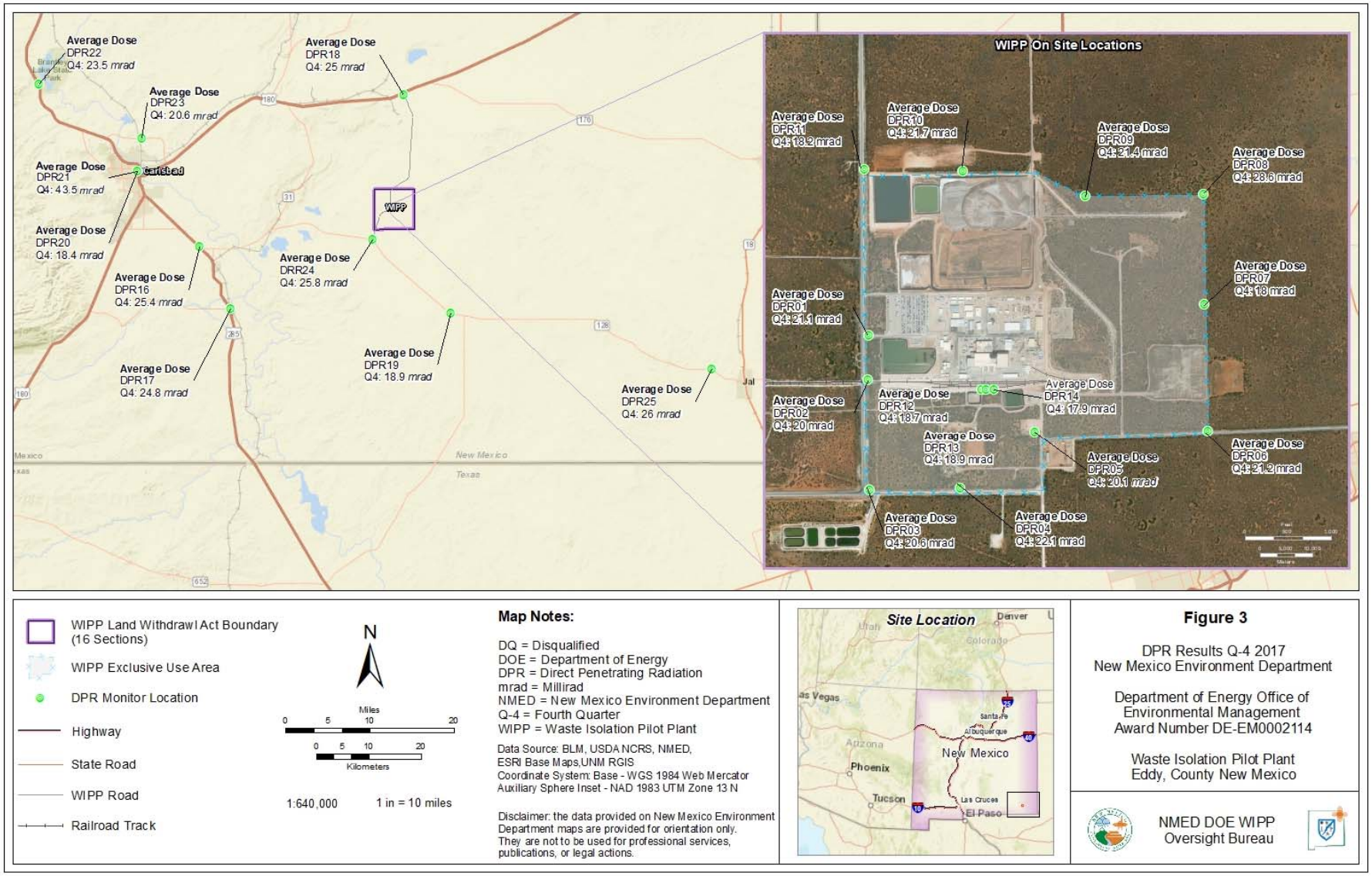

Figure 3. NMED DOE-OB DPR Results for CY2017 Q-4, Average Quarterly Dose (mrad) mapped by sampling location

Conclusions

The doses calculated from the NMED DOE-OB DPR sites located at WIPP and in the surrounding region during CY 2017 Q-4 are comparable with historical results obtained by the Bureau since 2006. Overall the 2017 Q-4 data fall within the range of expected doses.

The average quarterly DPR dosages for Q-4 measured by the NMED DOE-OB at WIPP and in the region surrounding Carlsbad range from 17.9 to 43.5 mrad. If you extrapolate these quarterly doses for an entire year, the annual DPR dosages would range from 71.6 to 174.0 mrad. In the case of gamma radiation, the quality factor is one, and thus one rad is equal to one rem. These observed dose rates are less than the average U.S. natural background annual dose of 310 mrem which is the equivalent to 310 mrad.

References

Rad Elec Inc. 2011. "Environmental Gamma Radiation Measurements, Part II." *Rad Elect Manual E-Perm System Users Manual-2 321.* Rad Elec Inc.

United States Nuclear Regulatroy Commission. 2017. *USNRC Protecting People and the Environment.* July 6. Accessed August 14, 2017. https://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html.

US Environmental Protection Agency. 1995. "Memorandum of Understanding Between the U.S. Environmental Protection Agency and the U.S. Department of Energy concering The Clean Air Act Emission Standards for Radionuclides 40 CFR part 61 Including Subparts H, I, Q and T." Departmental MOU.

Appendix 1

Direct Penetrating Radiation Quarterly Dose Rates for CY 2017 Q-4. One asterisk (*) next to a value, indicates that the calculated dose exceeds two standard deviations of the mean quarterly average for all stations without a disqualifying event listed in the field notes. Two asterisks (**) next to a value, indicates that the calculated dose exceeds three standard deviations of the mean quarterly average for all stations without a disqualifying event listed in the field notes.

Location	Electret ID	Start Date and Time	Stop Date and Time	Voltage Drop	Quarterly Dose Normalized (mrad)	Avg Quarterly Dose (mrad)
DPR01 WIPP Parking Lot	SIR 717	10/2/17 14:46	12/29/17 14:01	63	29.4	**21.1**
	SHC 659	10/2/17 14:46	12/29/17 14:01	33	16.7	
	SIR 704	10/2/17 14:46	12/29/17 14:01	37	17.1	
DPR02 WIPP Railroad Entrance	SIR 626	10/2/17 14:52	12/29/17 14:10	52	24.3	**20.0**
	SIR 662	10/2/17 14:52	12/29/17 14:10	35	16.2	
	SIR 711	10/2/17 14:52	12/29/17 14:14	42	19.5	
DPR03 WIPP SW Fence Corner	SHD 931	10/2/17 14:58	12/29/17 14:17	42	20.2	**20.6**
	SHV 185	10/2/17 14:58	12/29/17 14:17	39	18.9	
	SHD 960	10/2/17 14:58	12/29/17 14:18	46	22.6	
DPR04 WIPP SW Fence Center	SIR 550	10/2/17 15:03	12/29/17 14:20	40	18.9	**22.1**
	SIR 562	10/2/17 15:03	12/29/17 14:20	51	24.0	
	SHC 771	10/2/17 15:03	12/29/17 14:20	46	23.5	
DPR05 WIPP Near SE Fence Corner	SIR 583	10/2/17 15:05	12/29/17 14:27	40	18.8	**20.1**
	SIR 569	10/2/17 15:05	12/29/17 14:28	44	20.7	
	SIR 754	10/2/17 15:05	12/29/17 14:28	45	21.0	
DPR06 WIPP Far SE Fence Corner	SHC 761	10/2/17 15:09	12/29/17 14:30	42	21.0	**21.2**
	SHC 821	10/2/17 15:09	12/29/17 14:33	45	21.7	
	SHD 912	10/2/17 15:09	12/29/17 14:32	43	20.8	
DPR07 WIPP East Fence Mid	SHC 694	10/2/17 15:11	12/29/17 14:33	38	18.3	**18.0**
	SHC 853	10/2/17 15:11	12/29/17 14:36	37	18.0	
	SHD 962	10/2/17 15:11	12/29/17 14:37	37	17.8	
DPR08 WIPP NE Fence Corner	SIR 579	10/2/17 15:14	12/29/17 14:49	82	38.5	**28.6**
	SHD 942	10/2/17 15:14	12/29/17 14:51	48	23.2	
	SHV 211	10/2/17 15:14	12/29/17 14:51	48	24.1	
DPR09 WIPP NNE Fence	SHC 830	10/2/17 15:15	12/29/17 14:52	43	21.0	**21.4**
	SHD 939	10/2/17 15:15	12/29/17 14:52	42	20.5	
	SHD 954	10/2/17 15:15	12/29/17 14:53	47	22.7	
DPR10 WIPP North Fence Salt Pile	SIR 516	10/2/17 15:18	12/29/17 14:55	50	23.6	**21.7**
	SIR 473	10/2/17 15:18	12/29/17 14:56	64	30.1	
	SIR 459	10/2/17 15:18	12/29/17 14:57	25	11.6	

Location	Electret ID	Start Date and Time	Stop Date and Time	Voltage Drop	Quarterly Dose Normalized (mrad)	Avg Quarterly Dose (mrad)
DPR11 WIPP NW Fence Corner	SIR 702	10/2/17 15:19	12/29/17 14:58	37	17.5	**18.2**
	SIR 722	10/2/17 15:19	12/29/17 14:58	40	18.6	
	SIR 670	10/2/17 15:19	12/29/17 14:59	39	18.6	
DPR12 WIPP West Loading Dock	SHC 644	10/2/17 15:20	12/29/17 15:02	37	18.7	**18.7**
	SIR 721	10/2/17 15:20	12/29/17 15:00	39	18.0	
	SIR 444	10/2/17 15:20	12/29/17 15:01	42	19.5	
DPR13 WIPP Center Loading Dock	SIR 485	10/2/17 15:23	12/29/17 15:04	38	17.6	**18.9**
	SHC 799	10/2/17 15:23	12/29/17 15:04	35	17.6	
	SHC 863	10/2/17 15:23	12/29/17 15:04	42	21.4	
DPR14 WIPP East Loading Dock	SHC 645	10/2/17 15:26	12/29/17 15:05	35	17.3	**17.9**
	SHC 715	10/2/17 15:26	12/29/17 15:05	34	16.9	
	SHC 849	10/2/17 15:26	12/29/17 15:07	39	19.5	
DPR16 Loving Weigh Station	SHC 724	10/2/17 15:28	12/29/17 15:09	52	25.8	**25.4**
	SIR 707	10/2/17 15:28	12/29/17 15:09	56	25.9	
	SHV 169	10/2/17 15:28	12/29/17 15:10	50	24.4	
DPR17 Malaga VFD	SHD 893	10/2/17 15:29	12/29/17 15:12	48	23.0	**24.8**
	SHD 895	10/2/17 15:29	12/29/17 15:12	50	24.5	
	SHD 916	10/2/17 15:29	12/29/17 15:13	56	27.0	
DPR18 North Access Road	SHC 744	10/2/17 15:31	12/29/17 15:15	50	24.4	**25.0**
	SHD 928	10/2/17 15:31	12/29/17 15:15	50	24.3	
	SHD 983	10/2/17 15:31	12/29/17 15:15	53	26.5	
DPR19 Southeast Control	SIR 715	10/2/17 15:33	12/29/17 15:17	40	19.1	**18.9**
	SIR 753	10/2/17 15:33	12/29/17 15:17	41	19.4	
	SIR 588	10/2/17 15:33	12/29/17 15:18	38	18.1	
DPR20 NMED Office Interior	SIR 632	10/4/17 13:15	12/29/17 15:20	36	16.9	**18.4**
	SIR 471	10/4/17 13:15	12/29/17 15:21	46	21.7	
	SIR 549	10/4/17 13:15	12/29/17 15:21	35	16.6	
DPR21 NMED Office Exterior	SIR 543	10/4/17 12:56	12/29/17 15:22	85	41.9	**43.5**
	SHD 692	10/4/17 12:56	12/29/17 15:22	135	70.0**	
	SHD 979	10/4/17 12:56	12/29/17 15:22	36	18.5	
DPR22 Brantley	SIR 756	10/2/17 15:34	12/29/17 15:26	53	25.1	**23.5**
	SIR 757	10/2/17 15:34	12/29/17 15:26	48	23.0	
	SIR 691	10/2/17 15:34	12/29/17 15:26	47	22.4	
DPR23 Carlsbad Bypass	SIR 628	10/2/17 15:36	12/29/17 15:29	42	19.6	**20.6**
	SIR 551	10/2/17 15:36	12/29/17 15:29	41	19.2	
	SIR 735	10/2/17 15:36	12/29/17 15:29	49	23.0	
DPR24 South Access Rd	SIR 450	10/2/17 15:38	12/29/17 15:30	71	33.8	**25.8**
	SIR 710	10/2/17 15:38	12/29/17 15:30	45	21.2	
	SIR 438	10/2/17 15:38	12/29/17 15:30	47	22.2	

Location	Electret ID	Start Date and Time	Stop Date and Time	Voltage Drop	Quarterly Dose Normalized (mrad)	Avg Quarterly Dose (mrad)
DPR25 Jal Hwy	SIR 648	10/2/17 15:39	1/5/18 15:30	71	30.8	**26.0**
	SIR 639	10/2/17 15:39	1/5/18 15:30	59	25.8	
	SIR 451	10/2/17 15:39	1/5/18 15:30	50	21.5	