Responses to July 9, 1984 DNR comments on the noise reports. October 31, 1984

RESPONSES TO JULY 9, 1984 DNR COMMENTS ON THE NOISE REPORTS

EXXON MINERALS COMPANY
CRANDON PROJECT

OCTOBER 31, 1984

III.A.2. Ambient Noise Monitoring Data

Comment No. A1

The discussion of sound propagation is more appropriately addressed in the section on Model Evaluation.

Response:

Comment acknowledged.

Comment No. A2

The equipment used was a GenRad 1-inch microphone with windscreen, a GenRad 1933 and a GenRad 1982 sound level meter and Nagra 4.2L magnetic tape recorders. The data was analyzed with a GenRad Realtime Analyzer and a Digital PDP8/e computer. The utilization of this equipment is acceptable.

Response:

Comment acknowledged.

Comment No. A3

The microphone was located 4-5 feet above the ground and at least 12 feet from any reflective surface (such as walls, cars, etc.). This is a standard operating procedure.

Response:

Comment acknowledged.

Comment No. A4

If wind speeds were greater than 12 mph, monitoring was discontinued. This is also standard operating procedure. Section 2.8.1.1 states that certain meteorological parameters were collected. If the report states they were collected, then the data should be included in an appendix to the report.

Response:

Comment acknowledged.

The meteorological data collected during the 1977 and 1983 sampling periods are presented in EIR Appendices 2.8A, Table A-37 and 2.8B, Table B-48, respectively.

Comment No. A5

The position of the observer/operator can not be determined from the data presented. Improper location of the operator/observer can influence the noise levels measured. Exact location of the operator/observer is not needed. However, a statement that he was not adjacent to the mike or the mike was remotely operated at the recorder would be appropriate.

Response:

Comment acknowledged.

A statement has been added to the revised EIR indicating that the microphone was removed from the sound level meter and connected to it by a 30-m (100-foot) cable so that the observer and the tape recording system would have no effect upon the sound data received. The system was calibrated with the 30-m cable attached.

Comment No. A6

The equipment was calibrated before each measurement period with a GenRad 1562A calibrator at 1,000 Hz (114 dBA). Calibration procedures were acceptable.

Response:

Comment acknowledged.

Comment No. A7

Since the noise levels were recorded and analyzed in the consultant's office, readings were not done in the field.

Response:

Comment acknowledged. Linear and A-weighted sound level data were noted on the field data sheets as a later check on the analyzed data. Also, see response to comment No. A9.

Comment No. A8

The noise levels were recorded at each of the ten sites at three different times of the day, both winter and summer, for a period of time ranging from 16 to 21 minutes. This procedure is standard and allows for the development of 24-hour L_{dn} noise levels when the noise sources in the area are typical of what can be expected to occur on a daily basis. The seasonal monitoring accounts for variations in noise levels due to change in foliage and local activities.

Response:

Comment acknowledged.

Comment No. A9

A field log was kept, recording instrument settings and accounts of unusual sounds. This log was reviewed during the analysis procedures to ensure that data printed out was representative of what was measured in the field.

Response:

Comment acknowledged.

Comment No. A10

The 1977 field measurements were taken at six locations. These locations included three residences, Exxon's Field Office, a school, and a community center. No measurements were taken northeast, east, or southeast of the mine site. Exxon's 1983 field measurements present four additional noise sites which satisfactorily cover the areas in question. These four sites include two residences, a park, and a site on Sand Lake Road.

Response:

Comment acknowledged.

Comment No. A11

The majority of the noise data is acceptable and representative of the acoustical environment. Some of the data seems skewed by one loud noise event. One instance is Site 5, March 5, 1977, starting at 2350 hours. Site 5 had L_{90}, L_{50} and L_{10} levels of 22, 24 and 29 dBA, respectively. The resulting L_{eq} was 50.5 dBA, which is extremely high. The L_{10}, L_{50} and L_{90} indicates that the L_{eq} should be about 28-31 dBA. Table A-17 indicate that an event, possibly one passing car, severely skewed the data. The 50.5 L_{eq} is not representative of the L_{eq} in that area at night. The L_{eq} under these circumstances is only representative of the monitoring period. Only if that same event occurs every night at the same time is the L_{eq} truly representative of the environment. The 50.5 L_{eq} should be either averaged over the hour period (instead of the 20-minute monitoring period) which would result in a lower L_{eq} or the single event should be removed from the data and a new L_{eq} developed. Data from various other sites appear questionable and not truly representative of the surrounding area. It is not recommended to remonitor, but to review the data and develop new L_{eq}'s. These will result in different L_{dn}'s at some sites. The adjusted L_{eq}'s should be footnoted to mention that they were developed from the measured data. The other data which appear questionable are Site 3, 7/16/77 - 1905; Site 4, 3/5/77 - 1900; Site 5, 7/16/77 - 2130; and Site 6, 3/5/77 - 1617. The remaining 1977 data and all 1983 data is acceptable.

The seasonal variations do not seem consistent for the 1977 data. General reasons for variations are provided in the text, but specific reason for each site would be more appropriate.

Response:

The baseline noise data obtained in the 1977 sampling periods are representative of the acoustical environment during the period sampled. The A-weighted values for the five periods in question (Tables A-6 [Location 6, 1617 hours, March 5, 1977], A-10 [Location 4, 1900 hours, March 5, 1977], A-17 [Location 5, 2350 hours, March 5, 1977], A-27 [Location 3, 1905 hours, July 16, 1977], and A-29 [Location 5, 2130 hours, July 16, 1977]) were influenced by a small number of short-duration, high-frequency events. The probability of such events occurring during the sampling periods was not under the control of the individuals acquiring the data because the sampling times were selected on a random basis.

The noise sources during the five sampling periods in question are described below:

1) Table A-6, Location 6, 3/5/77, 1617 hours - the presence of snowmobiles.

2) Table A-10, Location 4, 3/5/77, 1900 hours - Snowmobiles and cars passing the monitor location.

3) Table A-17, Location 5, 3/5/77, 2350 hours - Dogs barking and wind rustling fallen leaves.

4) Table A-27, Location 3, 7/16/77, 1905 hours - Cars passing the monitor location and insect, and bird sounds.

5) Table A-29, Location 5, 7/16/77, 2130 hours - TV and human voices at a nearby residence, insect sounds, aircraft overflight, and dog barking.

The occurrence of noise from these sources is variable but likely representative so long as the vegetation and land use remain unchanged. However, in accordance with the DNR's recommendation to review the data and develop new L_{eq}'s, the noise data recorded during the five sampling periods in question were modified by referencing similar sampling periods at the same or a representative location. EMC proposes the adjustments below to show the effect of eliminating the higher decibel, short duration events which skewed the data and affected the L_{eq}. However, since it is believed that these events do constitute a representative environment, both the calculated measured and adjusted values will be reported.

Each of the tables was modified as follows:

1) Table A-6, Location 6, 3/5/77, 1617 Hours

A-weighted sound levels ranging from 22 to 77 dB were truncated at 66 dB (values greater than 66 dB were deleted) and the remaining "% time exceeded" values were adjusted to equal 100%. The equivalent sound level was then adjusted to be 43.4 dB (original L_{eq} value = 53 dB). Selection of 66 dB as the cut-off was based on the maximum A-weighted value presented in Table A-5, Location 5, 3/5/77, 1555 hours, which was sampled at a similar time, had a similar land use, and was acceptable to the DNR's reviewers as representative of baseline conditions.

2) Table A-10, Location 4, 3/5/77, 1900 Hours

A-weighted sound levels ranging from 20 to 65 dB were truncated at 56 dB (values greater than 56 dB were deleted) and the remaining "% time exceeded" values were adjusted to equal 100%. The equivalent sound level was then adjusted to be 33.3 dB (original L_{eq} value = 39.8 dB). Selection of 56 dB as the cut-off was based on the maximum A-weighted value presented in Table A-16, Location 4, 3/5/77, 2215 hours, which was sampled at what should be a quieter time at the same location, and was acceptable to the DNR's reviewers as representative of baseline conditions.

3) Table A-17, Location 5, 3/5/77, 2350 Hours

A-weighted sound levels ranging from 20 to 70 dB were truncated at 58 dB (values greater than 58 dB were deleted) and the remaining "% time exceeded" values were adjusted to equal 100%. The equivalent sound level was then adjusted to be 37.7 dB (original L_{eq} value = 50.5 dB). Selection of 58 dB as the cut-off was based on the second highest A-weighted value presented in Table A-5, Location 5, 3/5/77, 1555 hours, which was sampled at an earlier time at the same location, and was acceptable to the DNR's reviewers as representative of baseline conditions.

4) Table A-27, Location 3, 7/16/77, 1905 Hours

A-weighted sound levels ranging from 29 to 75 dBA were truncated at 56 dB (values greater than 56 dB were deleted) and the remaining "% time exceeded" values were adjusted to equal 100%. The equivalent sound level was then adjusted to be 39.7 dB (original L_{eq} value = 50.1 dB). Selection of 56 dB as the cut-off was based on the highest consistent value from Table A-21, Location 3, 7/16/77, 1525 hours, which was sampled at the same location during an earlier time period, and was acceptable to the DNR's reviewers as representative of baseline conditions. The resultant 39.7 dBA in Table A-27 compares well with the L_{50} value (39 dBA) in Table A-21.

5. Table A-29, Location 5, 7/16/77, 2130 Hours

A-weighted sound levels ranging from 20 to 68 dB were truncated at 63 dB (values greater than 63 dB were deleted) and the remaining "% time exceeded" values were adjusted to equal 100%. The equivalent sound level was then adjusted to be 36.8 dB (original L_{eq} value = 42.7 dB). Selection of 63 dB as the cut-off was based on the maximum A-weighted value presented in Table A-30, Location 6, 7/16/77, 2050 hours, which was sampled at a similar time, had similar land use, and was acceptable to the DNR and its reviewers as representative of baseline conditions.

The comment relating to seasonal variations of the 1977 data, as stated in the 8/9/84 meeting between EMC, DNR, HNTB, and Warzyn Engineering, is not of consequence since the five tables in question are now adjusted. No additional reasons for the seasonal variations are available other than those presented in subsection 2.8.2 of the EIR.

Comment No. A12

The presentation of the summarized noise data in the initial noise report was given for the six sites as the daytime noise level, L_d, for winter and summer. The second noise report presents the data by listing L_d and L_{dn}, the 24-hour noise level, for both summer and winter. The data presentation should be uniform for both data sets presenting the daytime (L_d), night time (L_n), and 24-hour (L_{dn}) noise levels for all sites. The evaluation of the impacts is based on these three noise levels and, therefore, the tables should summarize all the noise levels.

Response:

The format for presenting the 1977 and 1983 data sets has been standardized in Section 2.8 of the revised EIR. Also, the adjusted values are included in the revised EIR and footnoted accordingly in the attached table.

<u>III.A.3. Projected Noise Levels and Model Evaluation</u>

Comment No. A13

The projected noise impact due to operation and construction of the mine and related activities was evaluated at the monitoring sites. Since they are representative of receptors throughout the study area, the impact on these ten receivers defines the noise impact for the surrounding area.

To avoid future questions from the public, it would be advantageous to estimate existing noise levels and impact at other areas based on the data at the ten monitoring sites. Even though impact is clearly identified and represents the impact for the whole area, questions will most likely arise why some areas were not assessed for impact.

Areas of concern would most likely be residences around the north side of Little Sand Lake, the east side of Ground Hemlock Lake, and near the intersection of the Soo Line and Keith Siding Road.

One residence in particular should be assessed. It is located on Keith Siding Road west of the Soo Line Railroad. Exxon's railroad property surrounds the residence.

Response:

The additional locations of interest for estimation of noise levels are: (1) Location A, north shore of Little Sand Lake, (2) Location B, east shore of Ground Hemlock Lake, and (3) Location C, approximate intersection of the Soo Line Railroad and Keith Siding Road. Ambient winter and summer sound levels at these locations are expected to be in the same range as those recorded at the ten locations sampled. As presented below, values were estimated for each of the three locations by using measured values from other locations where land use was similar.

1) Location A, North Shore of Little Sand Lake - Ambient sound levels at this location should be similar to those recorded at Location 6, the Webb residence on Little Sand Lake Road. Winter sound levels during the

(TABLE FOR RESPONSE TO COMMENT NO. A12)

A-Weighted Daytime and Day-Night Equivalent Sound Levels (dB)

Location	Winter			Summer		
	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}
1. School	42.8	29.8	41.9	46.6	42.7	49.9
2. Community Center	37.9	28.5	38.1	42.1	39.7	46.5
3. Mihalko Residence	39.3	23.9	37.9	47.1 (44.4)*	44.1	51.0 (50.5)*
4. Residence 3712	43.7 (43.4)*	35.1	44.2 (44.1)*	63.8	47.0	62.2
5. Exxon Field Office	42.4	50.5 (37.7)*	56.4 (45.2)*	56.8 (56.8)*	26.5	54.7 (54.7)*
6. Webb Residence	51.6 (42.1)*	19.6	49.5 (40.2)*	38.0	38.6	44.9
7. Lake Metonga	44.8	41.8	48.8	47.5	41.3	49.3
8. Rolling Stone Lake	34.2	30.8	37.9	40.7	39.6	46.2
9. Ground Hemlock Lake	33.4	30.0	37.1	42.7	27.4	41.4
10. St. John's Lake	33.4	31.0	37.8	38.6	28.1	38.4

*Values were adjusted to reduce the contribution from short duration, high sound pressure level sources. The procedure for calculating L_d, L_n, and L_{dn} is described in Section 2.8 of the EIR.

1977 sampling periods at this location were dominated by distant traffic, dogs barking, wind moving through the trees, and distant snowmobiles.

Summer sound levels were dominated by traffic on Little Sand Lake Road, resident activities, motorboats, and occasional passing traffic. Estimated ambient values for L_d, L_n, and L_{dn} are summarized at the end of this response.

2) Location B, East Shore of Ground Hemlock Lake - Ambient sound levels at this location should be similar but less than those recorded at Location 9, the west shore of Ground Hemlock Lake which is closer to the Project activities. The sources of winter sound levels during the 1983 sampling period were wind moving fallen tree leaves, bird sounds, and occasional car traffic. The sources of summer sound levels were wind moving tree leaves, bird and insect sounds, car traffic, and distant aircraft. Estimated ambient values for L_d, L_n, and L_{dn} are summarized at the end of this response.

3) Location C, Residence West of the Soo Line Near the Intersection With Keith Siding Road - Ambient sound levels at this location should be similar to those recorded at Locations 3 (Mihalko residence on Airport Road) or 7 (South shore of Lake Metonga in the parking lot of Forest County Veterans Memorial Park). The sources of winter sound levels during the 1977 sampling period at Location 3 were wind moving through the trees and distant traffic. Location 7, sampled in the winter of 1983, was observed to have sound sources resulting from water flowing over a small dam and wind moving fallen tree leaves. The sources of summer sound levels during the 1977 sampling period at Location 3 were traffic on Airport Road, distant traffic, bird and insect sounds, and rustling foliage. The sources of summer noise levels at Location 7 were human activities associated with the picnic area and campground.

With the exception of summer activities at the Forest County Veterans Memorial Park, sound sources at Location C should be similar to those at Locations 3 and 7. However, Location C is approximately 385 m (1265 feet) from the Soo Line and 250 m (800 feet) from the Keith Siding Road which contribute to the acoustical environment. Therefore, ambient sound levels at Location C were determined by logarithmically averaging each L_d, L_n, and L_{dn} sound level from Locations 3 and 7. The resultant values are presented below:

Summary of Equivalent Sound Levels (dBA) at Three Additional Baseline Locations

Location	Winter L_d	Winter L_n	Winter L_{dn}	Summer L_d	Summer L_n	Summer L_{dn}
A. North Shore, Little Sand Lake	51.6 (42.1)*	19.6	49.5 (40.2)*	38.0	38.6	44.9
B. East Shore, Ground Hemlock Lake	33.4	30.0	37.1	42.7	27.4	41.4
C. Keith Siding Road, just West of Soo Line Railroad	42.9	38.9	46.1	46.2	42.9	49.9

*Values were adjusted to reduce the contribution from short duration, high sound pressure level sources. The procedure for calculating L_d, L_n, and L_{dn} is described in Section 2.8 of the EIR.

Estimated noise levels from construction and operation activities at the ten original sampling locations (1-10), the three additional locations (A-C), and at other undefined locations in the environmental study area are presented in the attached Figures 1 through 3. These figures illustrate the property boundary site and area with isopleths of A-weighted equivalent (L_{eq}) sound pressure levels. Existing (ambient) noise levels are not included in these figures. The modeling basis for these estimates is described in the response to comment No. A17.

Comment A14

The noise impact assessment from the five above areas were based on a single noise level. This noise level is a combination of various noise sources for each area. The noise levels at the ten monitoring sites were developed from an equation accounting for distance and various excess attenuation from natural sources.

Response:

Comment acknowledged.

Comment No. A15

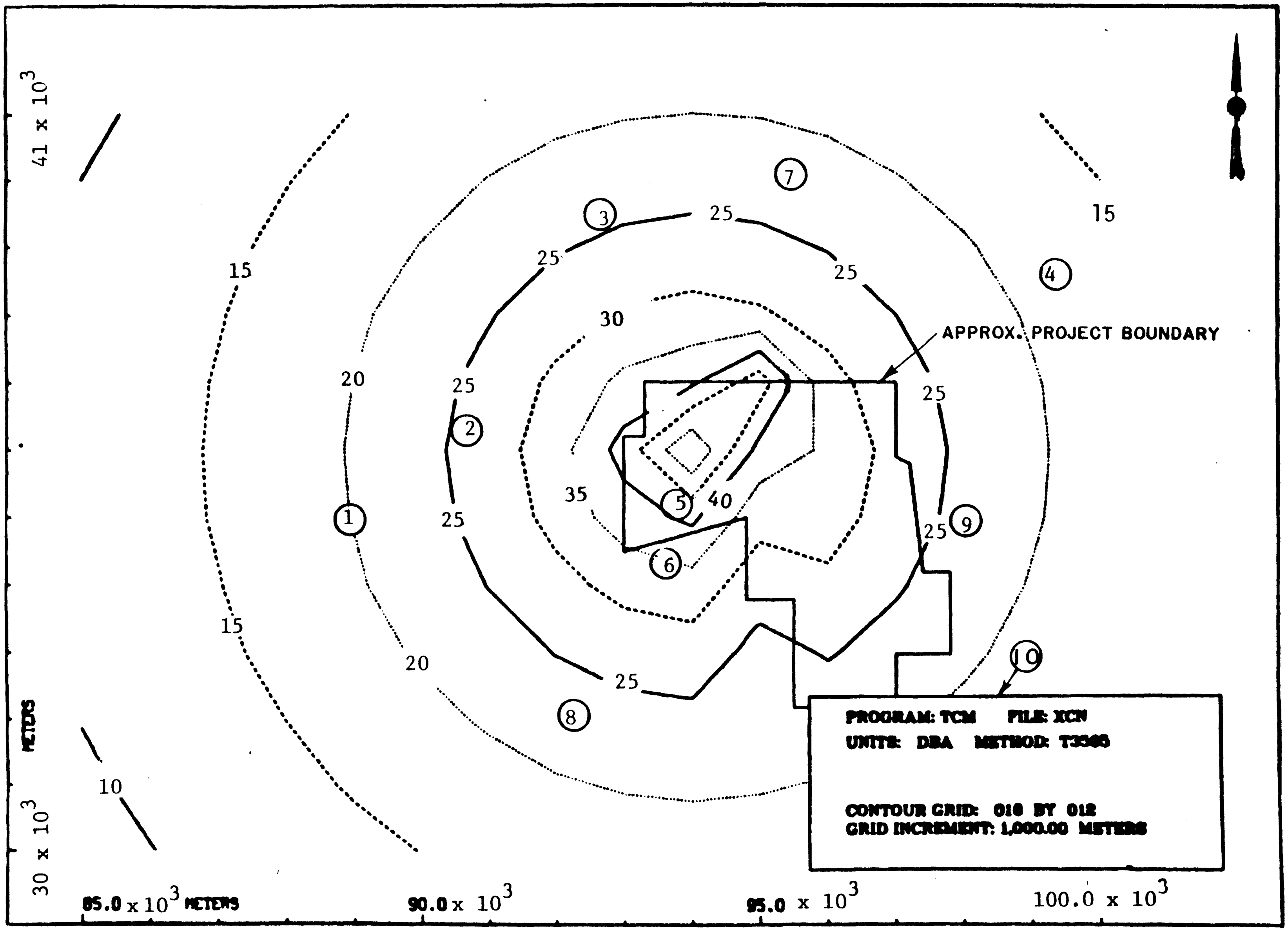
The location and the distance attenuation utilized in projecting future sound levels from the Mine/Mill, Mine Waste Disposal Facility, Access Road, Railroad Spur and Haul Road is valid.

Response:

Comment acknowledged.

(FIGURE 1 FOR THE RESPONSE TO COMMENT NO. A13)

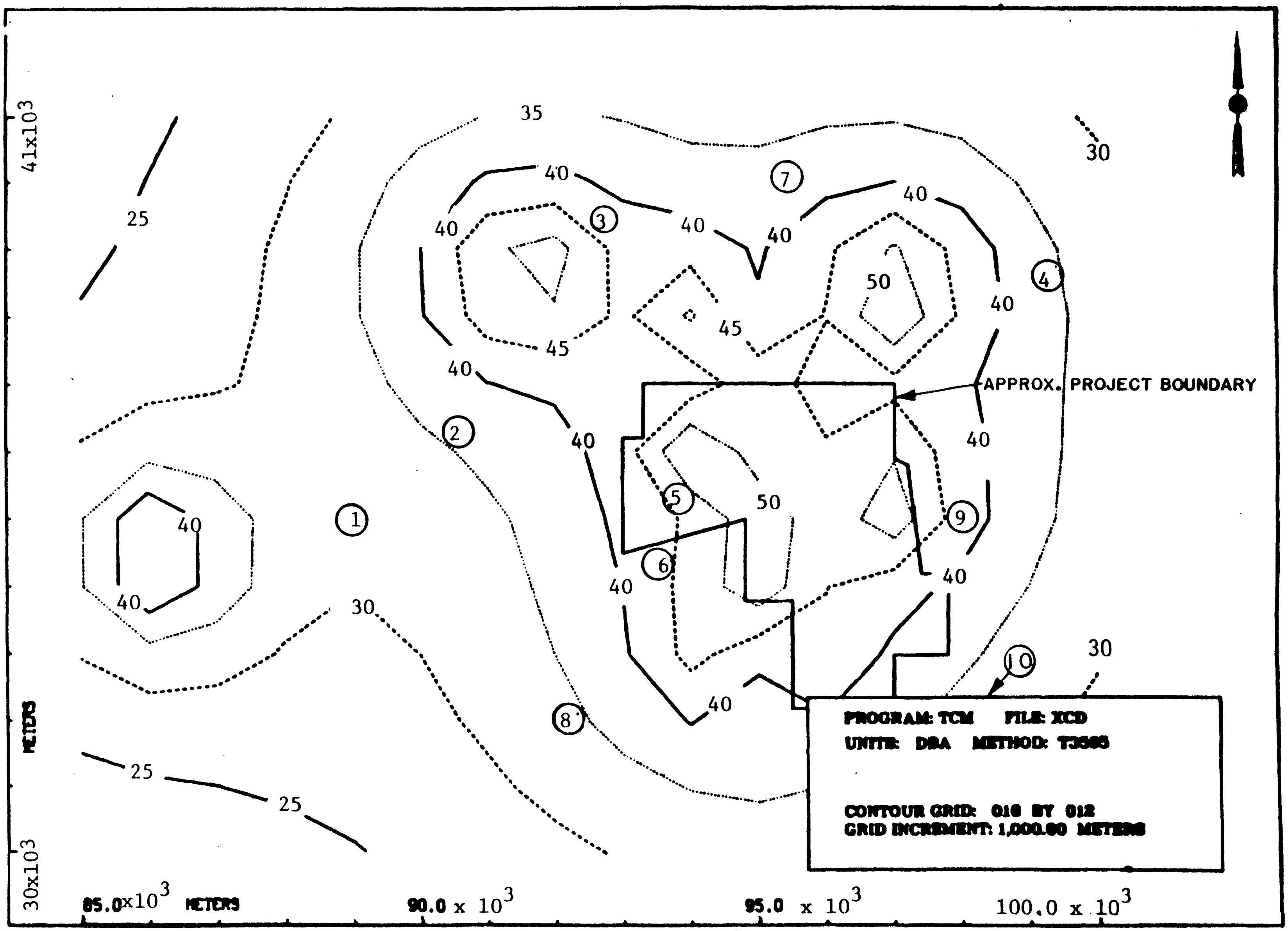
NOISE LEVEL ESTIMATES FOR NIGHT CONSTRUCTION ACTIVITIES



Notes:
1) Contours indicate equal noise levels (dBA, re 20 μPa) as a result of estimated Project activities.
2) Includes hemispherical diversion, attenuation from trees, and molecular air absorption.
3) These sound levels do not include the existing ambient noise within the site area.
4) (1) - indicate site area measurement locations defined in the EIR.

(FIGURE 2 FOR THE RESPONSE TO COMMENT NO. A13)

NOISE LEVEL ESTIMATES FOR DAY CONSTRUCTION ACTIVITIES



Notes: 1) Contours indicate equal noise levels (dBA, re 20 μPa) as a result of estimated Project activities.

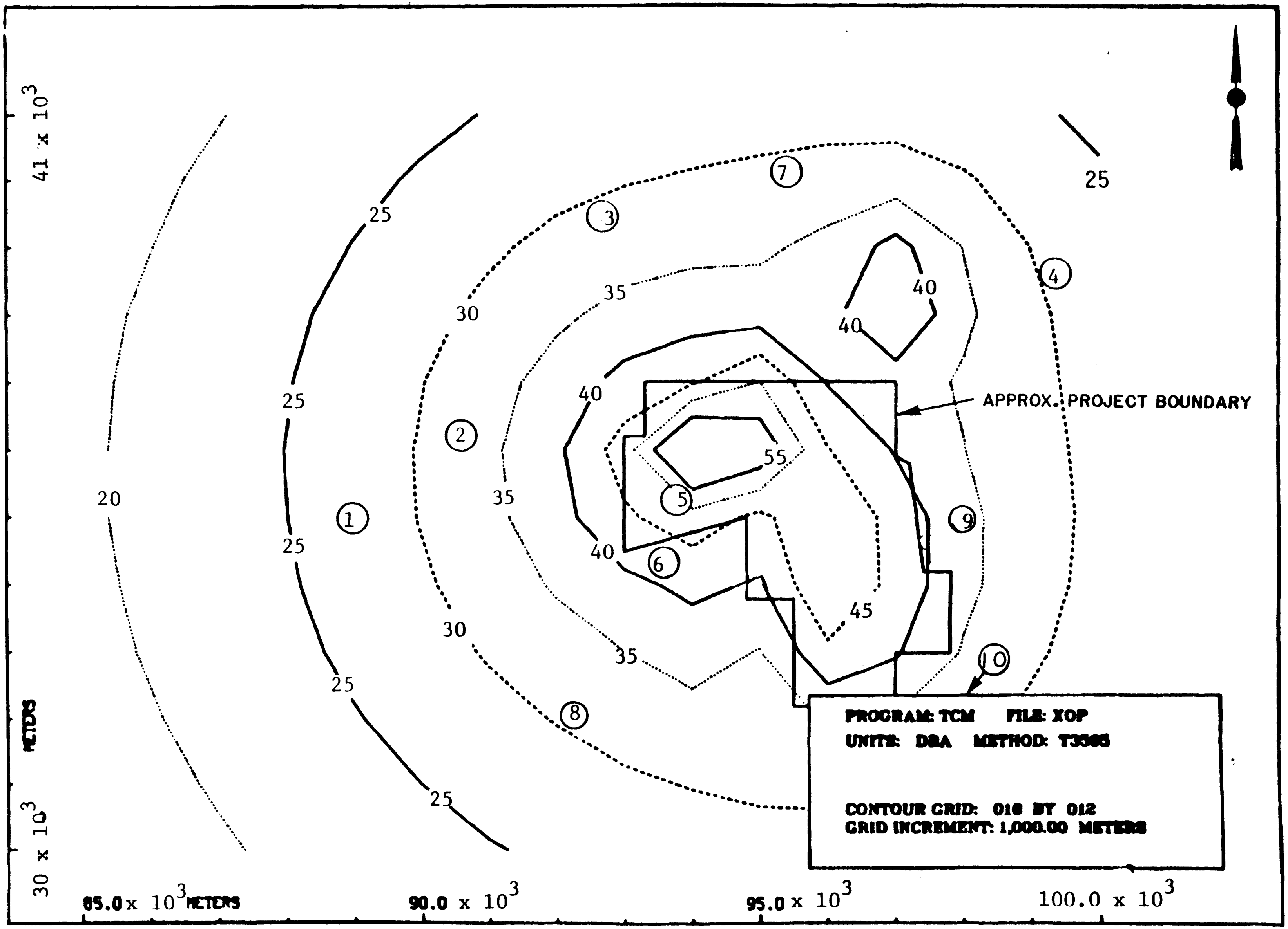
2) Includes hemispherical diversion, attenuation from trees, and molecular air absorption.

3) These sound levels do not include the existing ambient noise within the site area.

4) (1) - indicate site area measurement locations defined in the EIR.

(FIGURE 3 FOR THE RESPONSE TO COMMENT NO. A13)

NOISE LEVEL ESTIMATES FOR OPERATIONS ACTIVITIES



Notes: 1) Contours indicate equal noise levels (dBA, re 20 μPa) as a result of estimated Project activities.
2) Includes hemispherical diversion, attenuation from trees, and molecular air absorption.
3) These sound levels do not include the existing ambient noise within the site area.
4) (1)- indicate site area measurement locations defined in the EIR.

Comment No. A16

Assumptions used for excess attenuation is too simplistic. The noise levels for the mine air heaters at the mine/mill appear to be low. The operating noise spectrum for the mine air heaters is desired.

Response:

The assumptions used for excess attenuation are discussed in detail in the response to comment No. A17.

The fans selected for use on the mine air heaters at the mine/mill site were specified because of their low acoustical emanations. One of the primary design criteria used in fan selection was that the equipment had to have low sound power levels. Sound power levels were determined by using the fan manufacturer's procedure as presented in the attached literature. Using this procedure, the following sound power levels for each heater installation were determined:

Octave Band Center Frequency Hz	63	125	250	500	1000	2000	4000	8000
Sound Power Level, dB re 10^{-12} W	113	109	105	100	95	90	89	89

At present, the detailed design does not permit exact specification of the actual fans that will be used. However, the A-weighted sound pressure level of 68 dBA (at 50 feet) for each heater installation includes fans produced by many manufacturers. Actual fan selection will probably include a fan with lower A-weighting than what was modeled.

Comment No. A17

The excess attenuation rates used are not exact or continuous throughout the day. They may be acceptable for an average daily L_{eq}, but do not allow for proper projections of short-term noise levels. Although the methods used to calculate excess attenuation are somewhat simplistic; more in-depth analysis shows that the total attenuation would remain similar. A more in-depth analysis takes into account foliage and ground cover losses, distance losses, atmospheric absorption losses based on relative humidity and temperature, upwind/downwind losses, and barrier losses. The measured attenuation rates provide reasonable decibel losses at the various sites but do not account for extreme cases of solar heating, inversions, and tunnelling of acoustic energy caused by meteorological and topographical phenomena which can cause short-term noise levels to be 10 to 20 dB greater than those presented in the reports. Exxon must acknowledge this in its documents.

Response:

The excess attenuation rates were used to provide quantification of the effect of the ambient environment on noise emanations during construction and operation activities. The impact projections were directed specifically

Noise Emission from Champion Blower and Forge, Inc., Literature

Equipment - as per current engineering design.

4 ea. Dravo LDF 90 direct fired heaters @ 24 M btu/hr. ea.
Minimum air flow - 46,000 cfm
Maximum air flow - 184,000 cfm
Use average 115,000 cfm $\pm$ @ 1" w.g.

Fan - Champion 660 DIDW

99,200 cfm @ 1" sp operate at 354 rpm 2.72 bhp
Ref. Page 9 - Champion Blower and Forge, Inc.
OV = 2200 fpm, VP = .303", SP = 1.0" SP/VP = 3.31"
Page 12 - sound power levels in octave bands

Center Frequency Hz @ SP/VP = 3	63	125	250	500	1000	2000	4000	8000	OA
@ 400 rpm	73	66	59	51	43	35	31	28	
Factor A	+38	+38	+38	+38	+38	+38	+38	+38	
Factor B	+17	+20	+23	+26	+29	+32	+35	+38	
Factor C	-18	-18	-18	-18	-18	-18	-18	-18	
Two Fan Corr.	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	+ 3	
A-Weight Corr.	-26	-16	- 9	- 3	0	+ 1	+ 1	- 1	
SPL Corr. @ 15.24 m (50 ft)	-31.6	-31.6	-31.6	-31.6	-31.6	-31.6	-31.6	-31.6	
SPL @ 15.24 m (50 ft)	52	58	61	62	60	56	55	53	68dB

*Sound power inside fan inlet and outlet @ 10^{-12} watts.

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CENTRIFUGAL AIRFOIL FANS

CERTIFIED RATINGS
air performance

CERTIFIED RATINGS
sound

CERTIFICATION SOUND & AIR

Champion Blower & Forge, Inc., certifies that the Design-11 Centrifugal Airfoil Fans shown herein, are licensed to bear the AMCA Seal. The ratings shown are based on tests made in accordance with AMCA Standard 210 and AMCA Standard 300 and comply with the requirements of the AMCA Certified Ratings Program.

Air performance shown is for Design-11 Centrifugal Airfoil Fans with outlet ducts. Brake horsepower does not include belt drive losses.

The sound power levels shown are decible levels (referred to 10^{-12} watts) and were obtained in accordance with AMCA Standard 300, Test Setup No. 2. Values shown are total of inlet and outlet internal to ducts and are based on octave band Series 2.

PROCEDURE FOR APPLYING SOUND POWER LEVEL RATINGS TO CHAMPION CENTRIFUGAL AIRFOIL FANS DESIGN-11

1. Find the static pressure/velocity pressure ratio (SP/VP) from page 9 based on known outlet velocity and static pressure.
2. Find the base sound power levels in each octave band from the tables on pages 10,11 or 12, depending on fan size. Enter the appropriate table using RPM and SP/VP, interpolating when required.
3. Find Factor A, the application factor for fan size, from page 8. This factor is constant for all octave bands.
4. Find Factor B from page 8. This factor is a function of the octave bands and will vary between the individual bands as shown.
5. Find Factor C, the application factor for fan RPM, from page ~~8~~ 10. This factor is constant for all octave bands.
6. Total the four values in each octave band. The results are total sound power levels in decibels (referred to 10-12 watts) and are internal to inlet and outlet ducts.
7. The example below illustrates the above procedure.

FAN SIZE	122	135	150	165	182	200	222	245
FACTOR A	-13	-10	-7	-4	-1	+5	+5	+8
FAN SIZE	270	300	330	365	402	445	490	542
FACTOR A	+11	+14	+17	+20	+23	+26	+29	+32
FAN SIZE	600	660	730	807	890	982	1087	
FACTOR A	+35	+38	+41	+44	+47	+50	+53	

OCTAVE BAND	1	2	3	4	5	6	7	8
FACTOR B	+17	+20	+23	+26	+29	+32	+35	+38

EXAMPLE		PAGE NO.
FAN SIZE	— 270 SISW	21
CFM	— 11732	21
STATIC PRESSURE	— 4"	21
OUTLET VELOCITY	— 2800 FT./MIN	21
RPM	— 1399	21
SP/VP	— 8.16	9
BASE SOUND POWER RATINGS — SIZES 270 SISW — 330 SISW		11
FACTOR A FOR SIZE 70 = +11		8
FACTOR B		8
FACTOR C FOR 1399 RPM = +6		10

Octave Band No.	1	2	3	4	5	6	7	8
Band Limits—HZ	45/90	90/180	180/355	355/710	710/1400	1400/2800	2800/5600	5600/11200
Center Frequency—HZ	63	125	250	500	1000	2000	4000	8000
Base Sound Power	76	62	59	50	46	45	37	32
Factor A	+11	+11	+11	+11	+11	+11	+11	+11
Factor B	+17	+20	+23	+26	+29	+32	+35	+38
Factor C	+6	+6	+6	+6	+6	+6	+6	+6
Sound Power Ratings	110	99	99	93	92	94	89	87

The Sound Power Ratings shown in the examples above are total Sound Power Decibel Levels (Referred to 10-12 Watts) and are internal to inlet and outlet ducts.

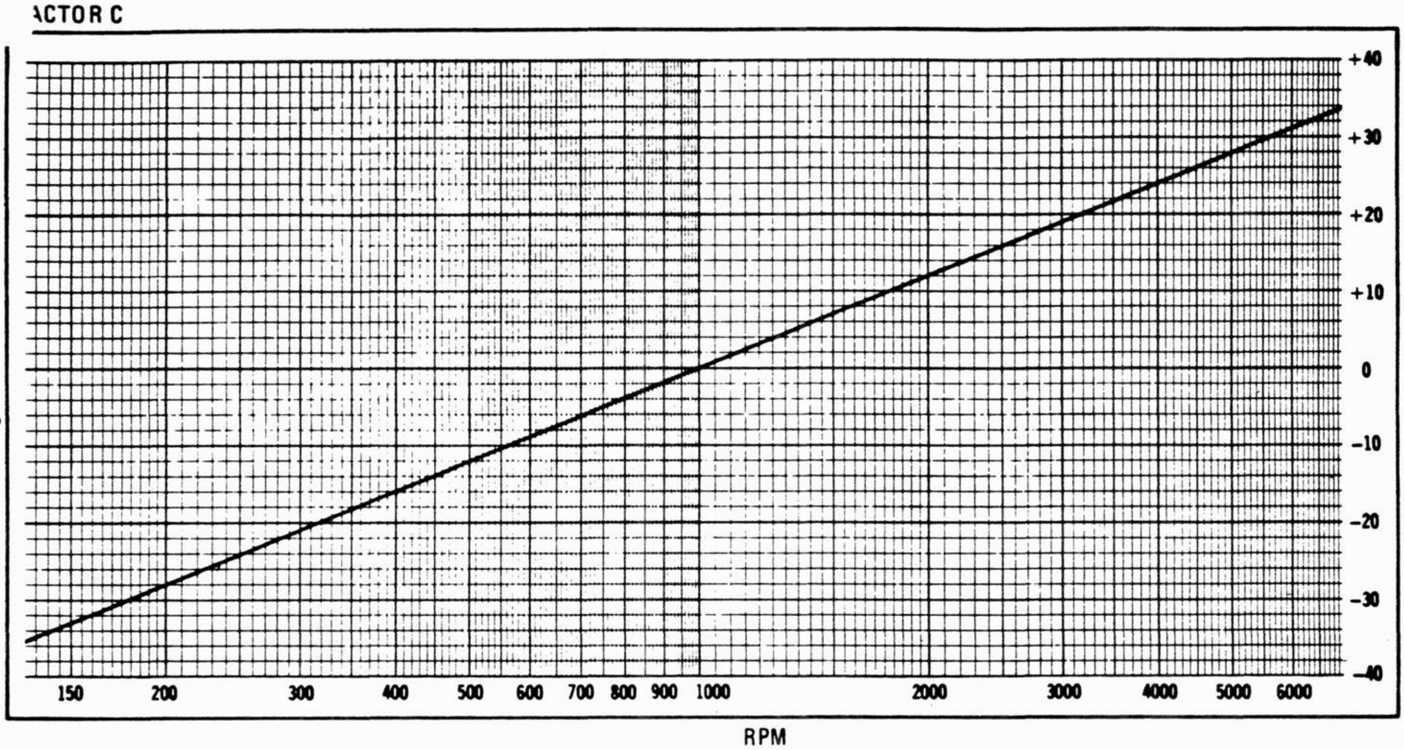
SP/VP RATIOS FOR CENTRIFUGAL AIRFOIL FANS

EQUIVALENT STATIC PRESSURES

OV	VP	1/4	3/8	1/2	5/8	3/4	7/8	1	1¼	1½	1¾	2	2½	3	3½	4	4½	5	5½
800	.0400	6.25	9.37	12.5	15.6	18.8	21.9												
900	.0506	4.93	7.41	9.86	12.4	14.8	17.3	19.7											
1000	.0625	4.00	6.00	8.00	10.0	12.0	14.0	16.0	20.0										
1100	.0756	3.30	4.96	6.60	8.26	9.90	11.6	13.2	16.5	19.8									
1200	.0900	2.78	4.16	5.56	6.94	8.34	9.72	11.1	13.8	16.7	19.4								
1300	.105	2.37	3.57	4.74	5.95	7.12	8.33	9.48	11.9	14.2	16.7	19.0							
1400	.123	2.03	3.05	4.06	5.08	6.09	7.11	8.12	10.2	12.2	14.2	16.2	20.3						
1500	.141	1.77	2.66	3.54	4.43	5.32	6.21	7.09	8.86	10.6	12.4	14.2	17.7	21.3					
1600	.160	1.56	2.34	3.12	3.91	4.68	5.47	6.24	7.81	9.37	10.9	12.5	15.6	18.7	21.8				
1700	.181	1.38	2.07	2.76	3.45	4.14	4.83	5.52	6.90	8.30	9.68	11.0	13.8	16.5	19.3				
1800	.202	1.23	1.86	2.46	3.09	3.69	4.33	4.92	6.18	7.38	8.66	9.85	12.3	14.8	17.2	19.7			
1900	.226	1.11	1.66	2.21	2.77	3.32	3.87	4.43	5.53	6.63	7.74	8.84	11.1	13.3	15.5	17.7	19.9		
2000	.250	1.00	1.50	2.00	2.50	3.00	3.50	4.00	5.00	6.00	7.00	8.00	10.0	12.0	14.0	16.0	18.0	20.0	
2200	.303	.824	1.24	1.66	2.06	2.48	2.89	3.31	4.12	4.97	5.78	6.62	8.28	9.94	11.6	13.3	14.9	16.6	18.2
2400	.360	.695	1.04	1.39	1.74	2.09	2.43	2.78	3.47	4.17	4.86	5.56	6.93	8.33	9.72	11.1	12.5	13.9	15.3
2600	.423	.592	.886	1.18	1.48	1.78	2.07	2.37	2.95	3.55	4.14	4.73	5.92	7.10	8.30	9.50	10.6	11.8	13.0
2800	.490	.510	.765	1.02	1.28	1.53	1.79	2.03	2.55	3.06	3.57	4.08	5.09	6.10	7.15	8.16	9.18	10.2	11.2
3000	.563	.444	.666	.890	1.11	1.34	1.55	1.78	2.22	2.66	3.11	3.55	4.44	5.33	6.22	7.11	7.99	8.88	9.76
3200	.640	.391	.586	.780	.976	1.17	1.37	1.56	1.95	2.35	2.73	3.12	3.90	4.67	5.47	6.24	7.03	7.82	8.59
3400	.722		.519	.693	.865	1.04	1.21	1.38	1.73	2.08	2.42	2.77	3.46	4.15	4.84	5.53	6.23	6.92	7.61
3600	.810		.453	.617	.771	.925	1.08	1.23	1.54	1.85	2.16	2.46	3.08	3.70	4.31	4.93	5.55	6.16	6.79
3800	.905			.554	.690	.831	.966	1.11	1.38	1.66	1.93	2.22	2.77	3.32	3.88	4.43	4.97	5.54	6.07
4000	1.00			.500	.625	.750	.875	1.00	1.25	1.50	1.75	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50
4200	1.10				.568	.682	.795	.909	1.14	1.36	1.59	1.81	2.27	2.72	3.18	3.63	4.09	4.54	5.00
4400	1.21				.517	.620	.723	.826	1.03	1.24	1.45	1.65	2.07	2.48	2.89	3.30	3.72	4.13	4.55

EQUIVALENT STATIC PRESSURES

OV	VP	6	6½	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2200	.303	19.9	21.5																	
2400	.360	16.7	18.1	19.4																
2600	.423	14.2	15.4	16.5	19.0	21.2														
2800	.490	12.2	13.3	14.2	16.3	18.4	20.4													
3000	.563	10.7	11.5	12.4	14.2	16.0	17.8	19.5	21.3											
3200	.640	9.38	10.2	10.9	12.5	14.1	15.6	17.2	18.8	20.3										
3400	.722	8.30	9.00	9.70	11.1	12.5	13.8	15.2	16.6	18.0	19.4	20.8								
3600	.810	7.40	8.02	8.64	9.88	11.1	12.3	13.6	14.8	16.0	17.3	18.5	19.8	21.0						
3800	.905	6.65	7.18	7.73	8.85	9.94	11.0	12.2	13.3	14.4	15.5	16.6	17.7	18.8	19.9	21.0				
4000	1.00	6.00	6.50	7.00	8.00	9.00	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0		
4200	1.10	5.45	5.91	6.36	7.27	8.18	9.09	10.0	10.9	11.8	12.7	13.6	14.6	15.5	16.4	17.3	18.2	19.1	20.0	20.9
4400	1.21	4.95	5.37	5.78	6.61	7.44	8.26	9.09	9.90	10.7	11.6	12.4	13.2	14.0	14.9	15.7	16.5	17.4	18.2	19.0
4600	1.32	4.55	4.92	5.30	6.06	6.82	7.58	8.33	9.10	9.85	10.6	11.4	12.1	12.9	13.6	14.4	15.2	15.9	16.7	17.4
4800	1.44	4.17	4.51	4.86	5.55	6.25	6.95	7.64	8.35	9.02	9.73	10.4	11.1	11.8	12.5	13.2	13.9	14.6	15.3	15.9
5000	1.56	3.84	4.17	4.48	5.13	5.77	6.41	7.05	7.70	8.33	8.97	9.62	10.3	10.9	11.5	12.2	12.8	13.5	14.1	14.7
5200	1.69	3.55	3.85	4.14	4.73	5.33	5.92	6.51	7.10	7.69	8.29	8.88	9.47	10.1	10.7	11.2	11.8	12.4	13.0	13.6
5400	1.82	3.30	3.57	3.84	4.40	4.95	5.50	6.04	6.60	7.14	7.70	8.24	8.79	9.34	8.89	10.4	10.9	11.5	12.1	12.6



SIZES 122 SISW THROUGH 182 SISW

RPM	BAND 1 SP/VP 24	14	8	3	.3	BAND 2 SP/VP 24	14	8	3	.3	BAND 3 SP/VP 24	14	8	3	.3	BAND 4 SP/VP 24	14	8	3	.3
500	66	65	65	64	67	61	59	60	61	64	50	50	51	52	58	47	47	48	50	55
600	67	66	66	65	68	64	61	62	63	66	52	50	51	53	58	48	46	49	51	56
700	68	67	67	66	69	65	62	63	63	66	54	53	54	55	60	49	49	50	51	57
800	69	68	68	67	71	65	63	64	64	67	57	55	56	57	62	49	49	50	52	57
900	70	69	68	68	72	66	64	64	64	67	59	57	58	59	63	50	49	50	52	57
1000	71	69	69	69	73	66	65	65	64	67	61	59	60	61	64	50	50	51	52	58
1200	72	71	71	71	75	67	66	66	65	68	64	61	62	63	66	52	50	51	53	58
1400	75	73	72	72	77	68	67	67	66	69	65	62	63	63	66	54	53	54	55	60
1600	77	74	74	74	76	69	68	68	67	71	65	63	64	64	67	57	55	56	57	62
1800	79	76	76	75	80	70	69	69	68	72	66	64	64	64	67	59	57	58	59	63
2000	80	77	77	76	81	71	69	69	69	73	66	65	65	64	67	61	59	60	61	64
2400	83	79	79	78	83	72	71	71	71	75	67	66	66	65	68	64	61	62	63	66
2600	65	61	81	80	85	75	73	73	72	77	68	67	67	66	69	65	62	63	63	66
3200	87	83	83	81	86	77	74	74	74	78	69	68	68	67	71	65	63	64	64	67
3600	89	85	84	83	88	79	76	76	75	80	70	69	69	68	72	66	64	64	64	67
4000	91	86	86	84	89	80	77	77	76	61	71	69	69	69	73	66	65	65	64	67
4400	92	87	87	85	90	82	78	78	77	82	72	70	70	70	74	67	65	65	64	67
4800	94	88	88	86	91	83	80	79	78	63	72	71	71	71	75	67	66	66	65	68

RPM	BAND 5 SP/VP 24	14	8	3	.3	BAND 6 SP/VP 24	14	8	3	.3	BAND 7 SP/VP 24	14	8	3	.3	BAND 8 SP/VP 24	14	8	3	.3
500	43	43	44	46	51	42	42	41	42	46	41	41	39	37	41	40	40	36	33	35
600	44	44	45	47	53	42	42	42	43	47	41	41	39	38	42	40	40	37	34	37
700	45	45	46	48	54	43	43	43	44	49	41	41	40	39	43	40	40	37	35	38
800	46	46	47	49	54	43	43	43	45	50	42	42	40	40	44	40	40	38	36	39
900	46	46	47	49	55	43	43	43	45	51	42	42	41	41	45	41	41	38	36	40
1000	47	47	48	50	55	43	43	44	46	51	42	42	41	42	46	41	41	39	37	41
1200	48	48	49	51	56	44	44	45	47	53	42	42	42	43	47	41	41	39	38	42
1400	49	49	50	51	57	45	45	46	48	54	43	43	43	44	49	41	41	40	39	43
1600	49	49	50	52	57	46	46	47	49	54	43	43	43	45	50	42	42	40	40	44
1800	50	49	50	52	57	46	46	47	49	55	43	43	43	45	51	42	42	41	41	45
2000	50	50	51	52	58	47	47	48	50	55	43	43	44	46	51	42	42	41	42	46
2400	52	50	51	53	58	48	48	49	51	56	44	44	45	47	53	42	42	42	43	47
2600	54	53	54	55	60	49	49	50	51	57	45	45	46	48	54	43	43	43	44	49
3200	57	55	56	57	62	49	49	50	52	57	46	46	47	49	54	43	43	43	45	50
3600	59	57	58	59	63	50	49	50	52	57	46	46	47	49	55	43	43	43	45	51
4000	61	59	60	61	64	50	50	51	52	58	47	47	48	50	55	43	43	44	46	51
4400	63	60	61	62	65	51	50	51	53	58	48	48	49	50	56	43	43	44	47	52
4800	64	61	62	63	66	52	50	51	53	58	48	48	49	51	56	44	44	45	47	53

SIZES 200 SISW THROUGH 245 SISW

RPM	BAND 1 SP/VP 24	14	8	3	.3	BAND 2 SP/VP 24	14	8	3	.3	BAND 3 SP/VP 24	14	8	3	.3	BAND 4 SP/VP 24	14	8	3	.3
400	64	66	66	67	70	55	56	57	58	60	48	47	49	51	53	45	45	47	48	51
500	66	67	66	68	70	58	59	60	61	63	50	50	51	53	56	46	46	47	49	52
600	68	67	67	68	70	60	62	62	64	66	52	52	54	55	57	46	46	48	49	52
700	69	68	67	68	69	62	64	65	66	68	54	54	55	57	59	47	47	48	50	53
800	70	69	68	68	70	64	66	66	67	70	55	56	57	58	60	48	47	49	51	53
900	73	70	69	70	71	65	66	66	68	70	57	58	59	60	62	49	49	50	52	55
1000	75	71	71	71	72	66	67	67	68	70	58	59	60	61	63	50	50	51	53	56
1200	78	74	73	73	75	68	67	67	68	70	60	62	62	64	66	52	52	54	55	57
1400	81	75	75	75	77	69	68	67	68	69	62	64	65	66	68	54	54	55	57	59
1600	84	77	76	76	78	71	69	68	69	70	64	66	66	67	70	55	56	57	58	60
1800	86	78	78	78	80	73	70	69	70	71	65	66	66	68	70	57	58	59	60	62
2000	88	80	79	79	81	75	72	71	71	73	66	67	67	68	70	58	59	60	61	63
2400	91	82	81	81	83	78	74	73	73	75	68	67	67	68	70	60	62	62	64	66
2800	94	84	83	83	85	81	76	75	75	77	69	68	67	68	69	62	64	65	66	68
3200	97	85	85	84	87	84	77	76	76	78	71	69	68	69	70	64	66	66	67	70

RPM	BAND 5 SP/VP 24	14	8	3	.3	BAND 6 SP/VP 24	14	8	3	.3	BAND 7 SP/VP 24	14	8	3	.3	BAND 8 SP/VP 24	14	8	3	.3
400	38	38	38	40	42	32	32	32	32	35	25	26	25	25	28	19	20	19	18	20
500	41	40	41	42	45	34	34	34	35	37	27	28	27	28	30	21	22	21	21	23
600	42	42	43	45	47	36	35	35	37	39	29	29	29	30	32	23	24	23	22	25
700	44	44	45	47	49	37	36	37	38	41	30	31	31	31	34	24	25	24	24	26
800	45	45	47	48	51	38	38	38	40	42	32	32	32	32	35	25	26	25	25	28
900	45	46	47	48	51	39	39	40	41	44	33	33	33	34	36	26	27	27	27	29
1000	46	46	47	49	52	41	40	41	42	45	34	34	34	35	37	27	28	27	28	30
1200	46	46	48	49	52	42	42	43	45	47	36	35	35	37	39	29	29	29	30	32
1400	47	47	48	50	53	44	44	45	47	49	37	36	37	38	41	30	31	31	31	34
1600	48	47	49	51	53	45	45	47	48	51	38	38	38	40	42	32	32	32	32	35
1800	49	49	50	52	55	45	46	47	48	51	39	39	40	41	44	33	33	33	34	36
2000	50	50	51	53	56	46	46	47	49	52	41	40	41	42	45	34	34	34	35	37
2400	52	52	54	55	57	46	46	48	49	52	42	42	43	45	47	36	35	35	37	39
2800	54	54	55	57	59	47	47	48	50	53	44	44	45	47	49	37	36	37	38	41
3200	55	56	57	58	60	48	47	49	51	53	45	45	47	46	51	38	38	38	40	42

SIZES 200 DIDW THROUGH 245 DIDW

RPM	BAND 1 SP/VP 24	14	8	3	.3	BAND 2 SP/VP 24	14	8	3	.3	BAND 3 SP/VP 24	14	8	3	.3	BAND 4 SP/VP 24	14	8	3	.3	BAND 5 SP/VP 24	14	8	3	.3	BAND 6 SP/VP 24	14	8	3	.3	BAND 7 SP/VP 24	14	8	3	.3	BAND 8 SP/VP 24	14	8	3	.3
400	69	70	70	71	74	61	61	62	64	66	54	55	55	57	60	50	50	51	52	55	42	42	43	44	47	36	36	37	37	40	31	31	31	30	33	25	26	26	24	26
500	71	71	71	72	74	64	64	65	67	69	56	57	57	59	62	51	52	52	54	57	45	45	45	47	50	36	38	38	39	42	32	33	33	32	35	27	27	27	26	28
600	73	72	72	72	74	66	67	68	69	71	58	58	59	61	63	52	53	53	55	58	47	47	48	49	52	39	39	40	41	44	34	34	34	34	37	28	29	29	28	30
700	74	73	73	73	75	68	69	70	71	74	59	60	60	62	64	53	54	54	56	59	49	49	50	51	54	40	41	41	42	45	35	35	35	36	38	29	30	30	29	31
800	76	75	75	74	77	69	70	70	71	74	61	61	62	64	66	54	55	55	57	60	50	50	51	52	55	42	42	43	44	47	36	36	37	37	40	31	31	31	30	33
900	78	77	76	76	78	70	71	71	72	74	62	63	64	65	68	55	56	57	58	61	50	51	51	53	56	44	44	44	46	49	37	37	37	38	41	31	32	32	31	34
1000	80	79	78	78	80	71	71	71	72	74	64	64	65	67	69	56	57	57	59	62	51	52	52	54	57	45	45	45	47	50	38	38	38	39	42	32	33	33	32	35
1200	82	81	80	80	83	73	72	72	72	74	66	67	68	69	71	58	58	59	61	63	52	53	53	55	58	47	47	48	49	52	39	39	40	41	44	34	34	34	34	37
1400	85	83	82	83	85	74	73	73	73	75	68	69	70	71	74	59	60	60	62	64	53	54	54	56	59	49	49	50	51	54	40	41	41	42	45	35	35	35	36	38
1600	87	85	84	85	87	76	75	75	75	77	69	70	70	71	74	61	61	62	64	66	54	55	55	57	60	50	50	51	52	55	42	42	43	44	47	36	36	37	37	40
1800	89	87	86	86	89	78	77	76	76	78	70	71	71	72	74	62	63	64	65	68	55	56	57	58	61	50	51	51	53	56	44	44	44	46	49	37	37	37	38	41
2000	91	89	87	88	90	80	79	78	78	80	71	71	71	72	74	64	64	65	67	69	56	57	57	59	62	51	52	52	54	57	45	45	45	47	50	38	38	38	39	42
2400	94	91	89	91	93	83	81	80	81	83	73	72	72	72	74	66	67	68	69	71	58	58	59	61	63	52	53	53	55	58	47	47	48	49	52	39	39	40	41	44
2800	96	94	91	93	95	85	84	82	83	85	74	73	73	73	75	68	69	70	71	74	59	60	60	62	64	53	54	54	56	59	49	49	50	51	54	40	41	41	42	45
3200	98	95	93	95	97	87	85	84	85	87	76	75	75	75	77	69	70	70	71	74	61	61	62	64	66	54	55	55	57	60	50	50	51	52	55	42	42	43	44	47

SIZES 270 DIDW THROUGH 330 DIDW

RPM	BAND 1 SP/VP 24	14	8	3	.3	BAND 2 SP/VP 24	14	8	3	.3	BAND 3 SP/VP 24	14	8	3	.3	BAND 4 SP/VP 24	14	8	3	.3	BAND 5 SP/VP 24	14	8	3	.3	BAND 6 SP/VP 24	14	8	3	.3	BAND 7 SP/VP 24	14	8	3	.3	BAND 8 SP/VP 24	14	8	3	.3
300	61	62	63	66	67	49	49	49	53	56	44	44	45	47	50	39	39	39	44	43	33	34	36	36	38	32	34	35	35	38	31	33	34	34	37	30	33	34	33	36
400	62	63	63	65	68	54	54	55	58	61	46	46	47	50	53	41	41	42	45	46	36	36	37	39	40	33	34	35	36	38	32	33	35	35	37	31	33	34	34	36
500	64	63	63	65	68	56	58	59	62	64	47	48	48	52	55	42	43	44	46	46	38	38	38	42	42	33	34	36	36	38	32	34	35	35	37	31	33	34	34	37
600	64	63	62	64	68	61	62	63	66	67	49	49	49	53	56	44	44	45	47	50	39	39	39	44	43	33	34	36	36	38	32	34	35	35	38	31	33	34	34	37
700	67	66	64	66	70	62	62	63	66	68	51	52	52	56	59	45	45	46	49	51	40	40	41	45	44	35	35	36	38	39	33	34	35	36	38	32	33	35	35	37
800	69	68	66	68	72	63	63	63	65	68	54	54	55	58	61	46	46	47	50	53	41	41	42	45	46	36	36	37	39	40	33	34	35	36	38	32	33	35	35	37
900	71	70	68	70	74	63	63	63	65	68	56	56	57	61	63	47	47	47	51	54	42	42	43	46	47	37	37	38	41	41	33	34	35	36	38	32	34	35	35	37
1000	73	72	70	72	75	64	63	63	65	68	58	58	59	62	64	47	48	48	52	55	42	43	44	46	48	38	38	38	42	42	33	34	36	36	38	32	34	35	35	37
1200	77	75	73	74	78	64	63	62	64	68	61	62	63	66	67	49	49	49	53	56	44	44	45	47	50	39	39	39	44	43	33	34	36	36	38	32	34	35	35	38
1400	79	77	75	77	80	67	66	65	66	70	62	62	63	66	68	51	52	52	56	59	45	45	46	49	51	40	40	41	45	44	35	35	36	38	39	33	34	35	36	38
1600	82	80	77	79	82	69	68	67	68	72	63	63	63	65	68	54	54	55	58	61	46	46	47	50	53	41	41	42	45	46	36	36	37	39	40	33	34	35	36	38
1800	84	81	79	80	84	72	70	68	70	74	63	63	63	65	68	56	56	57	61	63	47	47	47	51	54	42	42	43	46	47	37	37	38	41	41	33	34	35	36	38
2000	86	83	80	82	86	73	72	70	72	75	64	63	63	65	68	58	58	59	62	64	47	48	48	52	55	42	43	44	46	48	38	38	38	42	42	33	34	36	36	38
2400	89	86	83	85	88	77	75	73	74	78	64	63	62	64	68	61	62	63	66	67	49	49	49	53	56	44	44	45	47	50	39	39	39	44	43	33	34	36	36	38
2800	92	89	85	87	91	79	77	75	77	80	67	66	65	66	70	62	62	63	66	68	51	52	52	56	59	45	45	46	49	51	40	40	41	45	44	35	35	36	38	39
3200	94	91	88	89	93	82	80	77	79	82	69	68	67	68	72	63	63	63	65	68	54	54	55	58	61	46	46	47	50	53	41	41	42	45	46	36	36	37	39	40

SIZES 365 DIDW THROUGH 1087 DIDW

RPM	BAND 1 SP/VP 24	14	8	3	.3	BAND 2 SP/VP 24	14	8	3	.3	BAND 3 SP/VP 24	14	8	3	.3	BAND 4 SP/VP 24	14	8	3	.3	BAND 5 SP/VP 24	14	8	3	.3	BAND 6 SP/VP 24	14	8	3	.3	BAND 7 SP/VP 24	14	8	3	.3	BAND 8 SP/VP 24	14	8	3	.3
100	58	58	59	61	65	51	51	51	53	57	42	42	42	45	49	33	33	34	37	42	28	28	29	32	37	25	25	26	29	32	22	22	23	26	28	19	19	20	23	23
200	63	63	64	67	72	58	58	59	61	65	51	51	51	53	57	42	42	42	45	49	33	33	34	37	42	28	28	29	32	37	25	25	26	29	32	22	22	23	26	28
300	66	66	68	72	76	61	61	62	65	69	56	56	56	58	62	47	47	48	50	54	38	38	38	41	46	31	31	32	34	40	27	27	28	31	35	24	24	25	28	30
400	69	69	72	75	80	63	63	64	67	72	58	58	59	61	65	51	51	51	53	57	42	42	42	45	49	33	33	34	37	42	28	28	29	32	37	25	25	26	29	32
500	72	72	75	78	83	64	64	65	69	74	60	60	61	63	68	54	54	54	56	60	45	45	45	48	52	35	35	35	39	44	29	29	30	33	38	26	26	27	30	34
[illegible]	74	74	77	81	85	66	66	68	72	76	61	61	62	65	69	56	56	56	58	62	47	47	48	50	54	38	38	38	41	46	31	31	32	34	40	27	27	28	31	35
[illegible]	76	76	79	83	86	68	68	70	74	79	62	62	63	66	71	57	57	57	59	64	49	49	50	52	56	40	40	40	43	48	32	32	33	36	41	28	28	29	31	36
800	77	77	81	65	89	69	69	72	76	60	63	63	64	67	72	58	58	59	61	65	51	51	51	53	57	42	42	42	45	49	33	33	34	37	42	28	28	29	32	37
900	79	79	82	86	91	71	71	73	77	82	63	63	65	68	73	59	59	60	62	66	53	53	53	55	59	44	44	44	46	50	34	34	35	38	43	29	29	30	32	37
1000	80	80	84	88	92	72	72	75	79	83	64	64	65	69	74	60	60	61	63	68	54	54	54	56	60	45	45	45	48	52	35	35	35	39	44	29	29	30	33	38
1200	82	82	86	90	95	74	74	77	81	86	66	66	68	72	76	61	61	62	65	69	56	56	56	58	62	47	47	48	50	54	38	38	38	41	46	31	31	32	34	40
1400	84	84	88	92	97	76	76	79	83	88	68	68	70	74	79	62	62	63	66	71	57	57	57	59	64	49	49	50	52	56	40	40	40	43	48	32	32	33	36	41
1600	86	86	90	94	98	78	78	81	85	89	69	69	72	76	80	63	63	64	67	72	58	58	59	61	65	51	51	51	53	57	42	42	42	45	49	33	33	34	37	42
1800	87	87	92	95	100	79	79	83	86	91	71	71	73	77	82	63	63	65	68	73	59	59	60	62	66	53	53	53	55	59	44	44	44	46	50	34	34	35	38	43
2000	88	88	93	97	101	80	80	84	88	92	72	72	75	79	83	64	64	65	69	74	60	60	61	63	68	54	54	54	56	60	45	45	45	48	52	35	35	35	39	44
2400	90	90	95	99	104	82	82	86	90	95	74	74	77	81	86	66	66	68	72	76	61	61	62	65	69	56	56	56	58	62	47	47	48	50	54	38	38	38	41	46

SIZE **807**

DIDW
DOUBLE CAMBER

WHEEL DIA. - 86-19/32"	CLASS	I	II	III	IV	V
TIP SPEED (FPM) - 22.66xRPM	MAX TIP SPEED	10,000	14,000	17,500	20,000	22,500
INLET AREA - 85.40 Sq. Ft.						
OUTLET AREA - 67.48 Sq. Ft.						
MAX. BHP - 1930 $\left(\frac{RPM}{1000}\right)^3$	MAX RPM	441	618	772	883	993

CFM	OV	¼ SP RPM	¼ SP BHP	½ SP RPM	½ SP BHP	¾ SP RPM	¾ SP BHP	1 SP RPM	1 SP BHP	1¼ SP RPM	1¼ SP BHP	1½ SP RPM	1½ SP BHP	1¾ SP RPM	1¾ SP BHP	2 SP RPM	2 SP BHP	2½ SP RPM	2½ SP BHP
54009	800	117	2.97	140	5.23	166	8.06												
67511	1000	135	4.29	154	6.98	172	9.81	193	13.2										
81014	1200	154	6.03	171	9.21	187	12.4	201	15.7	218	19.7	236	23.9	253	28.4	270	33.1		
94516	1400	173	8.18	190	11.9	204	15.7	217	19.4	229	23.2	243	27.4	257	32.2	272	37.2	302	47.8
108018	1600	193	10.9	209	15.2	222	19.5	234	23.8	245	28.0	256	32.3	267	35.8	280	41.9	305	52.9
121521	1800	214	14.4	228	19.2	241	23.9	252	28.8	263	33.5	273	38.3	282	43.2	292	48.0	313	58.9
135023	2000	235	18.7	247	23.6	260	29.0	270	34.3	281	39.8	290	45.0	299	50.4	308	55.8	326	66.6
148525	2200	256	23.9	267	29.0	279	35.1	289	40.8	299	46.6	309	52.7	317	58.4	326	64.5	342	76.4
162028	2400	277	29.9	288	35.4	298	41.6	309	48.2	318	54.6	327	60.8	336	67.5	343	73.7	359	86.6
175530	2600	298	36.9	308	42.9	318	49.2	328	56.5	337	63.3	346	70.4	354	77.0	362	84.2	376	98.0
189033	2800	320	45.0	329	51.7	338	58.1	347	65.4	357	73.6	365	80.6	373	88.3	380	95.4	395	110
202535	3000	341	54.3	351	61.7	359	68.3	367	75.7	376	84.0	384	92.4	391	100	399	108	413	123
216037	3200	363	64.9	372	72.7	379	79.9	387	87.4	395	95.7	403	104	411	113	418	121	432	138
229540	3400	385	76.8	393	84.9	400	92.9	407	100	415	109	422	118	430	128	437	137	[illegible]	155
243042	3600	406	90.2	414	98.7	422	107	428	115	435	124	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	469	172

CFM	OV	3 SP RPM	3 SP BHP	3½ SP RPM	3½ SP BHP	4 SP RPM	4 SP BHP	4½ SP RPM	4½ SP BHP	5 SP RPM	5 SP BHP	5½ SP RPM	5½ SP BHP	6 SP RPM	6 SP BHP	6½ SP RPM	6½ SP BHP	7 SP RPM	7 SP BHP
108018	1600	332	64.5																
121521	1800	336	71.4	360	84.2	383	97.7												
135023	2000	345	78.5	365	92.0	386	106	407	120	428	136								
148525	2200	358	88.0	375	100	393	115	412	130	431	146	[illegible]	162	[illegible]	179				
162028	2400	374	99.9	388	112	403	126	420	141	437	157	[illegible]	174	472	191	[illegible]	[illegible]	[illegible]	227
175530	2600	390	111	404	126	418	139	431	154	[illegible]	[illegible]	[illegible]	187	477	205	493	223	510	242
189033	2800	408	125	421	140	434	155	[illegible]	[illegible]	459	186	472	202	486	219	501	238	515	258
202535	3000	426	140	439	156	[illegible]	[illegible]	463	188	474	204	486	220	498	237	511	255	524	274
216037	3200	[illegible]	[illegible]	[illegible]	[illegible]	469	190	480	207	491	224	502	242	513	258	524	276	535	294
229540	3400	[illegible]	172	475	191	486	209	498	227	508	245	518	263	529	283	539	300	549	318
243042	3600	[illegible]	191	493	210	505	230	515	248	526	268	536	287	546	306	556	326	565	346
256544	3800	[illegible]	211	512	231	523	251	534	272	544	291	554	312	564	333	573	353	582	373
270047	4000	[illegible]	[illegible]	[illegible]	[illegible]	541	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	572	[illegible]	[illegible]	360	591	[illegible]	599	403
283549	4200	[illegible]	256	550	277	561	301	570	322	580	344	590	368	599	389	608	412	617	436
297051	4400	[illegible]	[illegible]	[illegible]	303	579	326	[illegible]	[illegible]	599	373	[illegible]	[illegible]	[illegible]	421	626	443	635	467

CFM	OV	8 SP RPM	8 SP BHP	9 SP RPM	9 SP BHP	11 SP RPM	11 SP BHP	13 SP RPM	13 SP BHP	15 SP RPM	15 SP BHP	17 SP RPM	17 SP BHP	19 SP RPM	19 SP BHP	21 SP RPM	21 SP BHP	23 SP RPM	23 SP BHP
175530	2600	[illegible]	280																
189033	2800	[illegible]	[illegible]	[illegible]	[illegible]														
202535	3000	[illegible]	[illegible]	[illegible]	358	635	446												
216037	3200	[illegible]	[illegible]	[illegible]	378	638	470	690	568										
229540	3400	[illegible]	[illegible]	[illegible]	400	642	494	692	591										
243042	3600	[illegible]	[illegible]	[illegible]	425	650	520	696	621	742	724								
256544	3800	[illegible]	414	619	455	659	547	702	651	746	758	790	869						
270047	4000	[illegible]	[illegible]	634	489	671	579	710	681	751	793	794	907	835	1023				
283549	4200	634	479	651	526	684	615	720	714	759	827	798	945	839	1066	878	1188		
297051	4400	652	516	668	561	700	656	732	755	768	864	805	983	842	1108	882	1235	918	1363
310554	4600	669	551	685	601	716	702	746	798	779	905	813	1024	849	1151	885	1281	923	1415
324056	4800	687	589	703	643	733	744	762	847	792	955	823	1068	857	1195	891	1330	926	1465
337558	5000	706	631	721	683	750	791	779	902	806	1005	835	1120	866	1243	899	1377	932	1520
351061	5200	724	674	739	728	768	843	795	951	822	1063	849	1177	878	1297	908	1429	939	1570
364563	5400	742	716	758	777	786	891	812	1006	839	1126	864	1237	891	1360	919	1486	948	1626

PERFORMANCE SHOWN IS FOR DESIGN ELEVEN CENTRIFUGAL AIRFOIL FANS WITH OUTLET DUCT.
BHP DOES NOT INCLUDE DRIVE LOSSES.

at the average daily L_{eq} values to assess the potential effects on identified noise sensitive areas in the environmental study area. Representatives of the Towns of Lincoln and Nashville have been informed during public meetings that our estimates of noise effects address the general environment and that for certain meteorological conditions some noise sources could have a greater or lesser sound level perception than what was determined by the model. Also, it has been stated at the Town meetings that detectability of all sources is a function of the masking provided by background sound levels.

We disagree that a more in-depth analysis would show total attenuation to remain similar to that originally presented in the EIR. The modeling results presented in the response to comment No. A13 include the following three components of attenuation: sound reduction because of (1) distance effects, (2) atmospheric absorption effects (for conservative cases), and (3) absorption effects from trees and vegetative ground cover.

The following mathematical model for estimating noise levels at receiver locations distant from a noise source has been used (consistent with Beranek, 1971):

$$L_p(f) = L_w(f) - 10 \log 2\pi r^2 - A_1(f,t,h) - A_2(f) - A_3(f) - A_4(f) - A_5(f)$$

where:

L_p = sound pressure level, dB re 20 μPa, at receiver location.

F = frequency, Hz

L_w = source sound power level, dB re 10^{-12} W. If the source is other than omnidirectional, the sound power may be adjusted to account for source directivity.

r = distance between source and receiver, m

A_1 = molecular air absorption attenuation, dB as a function of air temperature, t, and relative humidity, h. Values are obtained from Beranek, L., Noise and Vibration Control, 1971 (for the figures in the response to comment No. A13, t = 0°C, h = 55%).

A_2 = shielding attenuation from manmade structures. Except where specified otherwise, A2 has been set to 0 for this study.

A_3 = shielding attenuation from land contours, manmade or existing. Except where specified otherwise, A_3 has been set to 0 for this study.

A_4 = shielding attenuation from trees and other vegetative ground cover. See discussion below.

A_5 = meteorological effects, can be positive or negative. A_5 has been set to 0 for this study. See discussion below.

The model is implemented for multiple noise sources by logarithmically summing the results within each octave band from all sources at the receiver location. After the octave band totals at the receiver location have been computed, they are A-weighted and summed to yield the total A-weighted sound pressure level at the receiver location. The contour plots included in the response to comment No. A13 were generated by repeating the above process over a grid of 192 receiver locations. Attached Table 1 lists the source sound power levels used to generate the contour plots. These source sound power levels are consistent with the A-weighted sound pressure levels and usage factors described in the EIR according to the following:

$$L_{wa} = L_{pa} + 10\log 2\pi ro^2 + 10\log UF$$

where:

L_{wa} = The A-weighted source sound power level, dB (Note: the source sound power levels in the attached tables are not A-weighted).

L_{pa} = A-weighted source sound pressure level, dB, at distance ro, m as specified in subsection 4.1.8 of the EIR.

U.F.= Usage Factor for the source (percentage of time equipment operates in its noisiest mode) listed in subsection 4.1.8 of the EIR.

Attached revised EIR Tables 4.1-19 and 4.2-17 show the results of applying the model at the 10 receptor locations.

The modeling results indicate that losses for distance and atmospheric absorption equal or exceed the winter values determined in the initial modeling, i.e., most recent modeling shows less impact when tree/foliage attenuation is minimal (winter).

The following information on forest attenuation, refractive focusing and barrier effects has been summarized from technical reports and other literature provided to EMC and the DNR by HNTB.

Sound Pressure Level Variations

The extreme fluctuations of sound pressure levels (refractive focusing or defocusing) predicted by Thomson (1981) (in the order of 10 to 20 dB) were estimated in complex terrain with the presence of mountain tops and air mass drainage effects which are not present in the environmental study area. Nevertheless, refractive focusing (or defocusing) may occur in the area surrounding the Project site area. As described below, the magnitude of any enhancement or decrement will be less than 20 dB because of the filtering (attenuation) effects of the forest.

The attenuation effects associated with forests reduce the sound level variations (A_5 of the previous equation) associated with thermal plumes which are characteristic of an open field environment (Roth, 1983). Roth attributed forest attenuation effects to the micrometeorological climate produced by the shading from tree foliage and limbs and their interaction as windbreaks which serve to diffuse thermal air currents within the forest.

NOISE SOURCES DURING DAYTIME CONSTRUCTION, NIGHTTIME CONSTRUCTION, AND OPERATION, LOCATIONS AND SOUND POWER LEVELS

						FREQUENCY (Hz)									
N	TYPE	CODE	X	Y	Z	31	63	125	250	500	1000	2000	4000	8000	16000
CONSTRUCTION - DAYTIME SOURCES															
1	SCRP	SCRAPER	96800.0	35400.0	1.0	0.0	110.0	109.0	108.0	107.0	106.0	100.0	94.0	89.0	0.0
2	DOZR	CAT D9	96800.0	35400.0	1.0	0.0	112.0	110.0	109.0	108.0	107.0	102.0	96.0	91.0	0.0
3	DOZR	CAT D8	96800.0	35400.0	1.0	0.0	112.0	111.0	110.0	109.0	108.0	102.0	96.0	91.0	0.0
4	DOZR	CAT D6	96800.0	35400.0	1.0	0.0	111.0	110.0	109.0	108.0	107.0	101.0	95.0	90.0	0.0
5	FEL	CAT 988	96800.0	35400.0	1.0	0.0	113.0	112.0	111.0	110.0	109.0	103.0	97.0	91.0	0.0
6	FEL	CAT 966	96800.0	35400.0	1.0	0.0	115.0	114.0	113.0	112.0	111.0	105.0	99.0	95.0	0.0
7	MDGR	GRAD 16G	96800.0	35400.0	1.0	0.0	112.0	111.0	110.0	109.0	108.0	102.0	96.0	91.0	0.0
8	MDGR	GRAD 14G	96800.0	35400.0	1.0	0.0	106.0	105.0	104.0	103.0	102.0	96.0	90.0	85.0	0.0
9	EXCV	EXCA 235	96800.0	35400.0	1.0	0.0	113.0	112.0	111.0	110.0	109.0	103.0	97.0	92.0	0.0
10	BKHE	BKHJD410	96800.0	35400.0	1.0	0.0	105.0	104.0	103.0	102.0	101.0	95.0	89.0	84.0	0.0
11	DPTK	FRD-9001	96800.0	35400.0	1.0	0.0	121.0	120.0	119.0	118.0	117.0	111.0	105.0	100.0	0.0
12	BDTK	FRD-9002	96800.0	35400.0	1.0	0.0	121.0	120.0	119.0	118.0	117.0	111.0	105.0	100.0	0.0
13	DOZR	CAT D7-1	94850.0	35500.0	1.0	0.0	111.0	110.0	109.0	108.0	107.0	101.0	95.0	90.0	0.0
14	BKHE	BKHOE235	94850.0	35500.0	1.0	0.0	106.0	105.0	104.0	103.0	102.0	96.0	90.0	85.0	0.0
15	FEL	CAT 988B	94850.0	35500.0	1.0	0.0	109.0	108.0	107.0	106.0	105.0	99.0	93.0	88.0	0.0
16	DPTK	5 YARD	94850.0	35500.0	1.0	0.0	114.0	113.0	112.0	111.0	110.0	104.0	98.0	93.0	0.0
17	FTBD	TRK 8TON	94850.0	35500.0	1.0	0.0	105.0	104.0	103.0	102.0	101.0	95.0	89.0	84.0	0.0
18	SPCL	TRENCHER	94850.0	35500.0	1.0	0.0	115.0	114.0	113.0	112.0	111.0	105.0	99.0	94.0	0.0
19	DOZR	CAT D7-2	86200.0	34500.0	1.0	0.0	111.0	110.0	109.0	108.0	107.0	101.0	95.0	90.0	0.0
20	BHOE	BHOE2352	86200.0	34500.0	1.0	0.0	106.0	105.0	104.0	103.0	102.0	96.0	90.0	85.0	0.0
21	FEL	CAT988B2	86200.0	34500.0	1.0	0.0	109.0	108.0	107.0	106.0	105.0	99.0	93.0	88.0	0.0
22	DTRK	5 YARD-2	86200.0	34500.0	1.0	0.0	114.0	113.0	112.0	111.0	110.0	104.0	98.0	93.0	0.0
23	FBTK	TRK 8T-2	86200.0	34500.0	1.0	0.0	105.0	104.0	103.0	102.0	101.0	95.0	89.0	84.0	0.0
24	SPCL	TRENCH-2	86200.0	34500.0	1.0	0.0	115.0	114.0	113.0	112.0	111.0	105.0	99.0	94.0	0.0
25	CSAW	SAW - 2	96950.0	38400.0	1.0	0.0	123.0	122.0	121.0	120.0	119.0	113.0	107.0	102.0	0.0

26	FEL	C 988B-3	96950.0	38400.0	1.0	0.0	109.0	108.0	107.0	106.0	105.0	99.0	93.0	88.0	0.0
27	FEL	CAT 992C	96950.0	38400.0	1.0	0.0	109.0	108.0	107.0	106.0	105.0	99.0	93.0	88.0	0.0
28	DOZR	CAT D9-2	96950.0	38400.0	1.0	0.0	112.0	111.0	110.0	109.0	108.0	102.0	96.0	91.0	0.0
29	DOZR	CAT D6-2	96950.0	38400.0	1.0	0.0	114.0	113.0	112.0	111.0	110.0	104.0	98.0	93.0	0.0
30	BHOE	(COMB)	96950.0	38400.0	1.0	0.0	108.0	107.0	106.0	105.0	104.0	98.0	92.0	87.0	0.0
31	MRGR	GRADER16	96950.0	38400.0	1.0	0.0	108.0	107.0	106.0	105.0	104.0	98.0	92.0	87.0	0.0
32	DTRK	5 YARD-3	96950.0	38400.0	1.0	0.0	123.0	122.0	121.0	120.0	119.0	113.0	107.0	102.0	0.0
33	SPCL	COMPACTR	96950.0	38400.0	1.0	0.0	108.0	107.0	106.0	105.0	104.0	98.0	92.0	87.0	0.0
34	CSAW	SAW - 3	91600.0	38600.0	1.0	0.0	123.0	122.0	121.0	120.0	119.0	113.0	107.0	102.0	0.0
35	FEL	C 988B-4	92500.0	38400.0	1.0	0.0	109.0	108.0	107.0	106.0	105.0	99.0	93.0	88.0	0.0
36	FEL	CAT 977B	93900.0	38200.0	1.0	0.0	112.0	111.0	110.0	109.0	108.0	102.0	96.0	91.0	0.0
37	MGRD	GRDR16-2	94000.0	35700.0	1.0	0.0	111.0	110.0	109.0	108.0	107.0	101.0	95.0	90.0	0.0
38	SPCL	GRADALL	91600.0	38600.0	1.0	0.0	108.0	107.0	106.0	105.0	104.0	98.0	92.0	87.0	0.0
39	DOZR	CAT D9-3	92500.0	38400.0	1.0	0.0	112.0	111.0	110.0	109.0	108.0	102.0	96.0	91.0	0.0
40	DOZR	CAT D6-3	93900.0	38200.0	1.0	0.0	114.0	113.0	112.0	111.0	110.0	104.0	98.0	93.0	0.0
41	BHOE	(COMB)-2	94000.0	38700.0	1.0	0.0	108.0	107.0	106.0	105.0	104.0	98.0	92.0	87.0	0.0
42	DTRK	5 YARD-4	91600.0	38600.0	1.0	0.0	125.0	124.0	123.0	122.0	121.0	115.0	109.0	104.0	0.0
43	SPCL	COMPR-2	92500.0	38400.0	1.0	0.0	109.0	108.0	107.0	106.0	105.0	99.0	93.0	88.0	0.0
44	SPCL	CRANE	93900.0	38200.0	1.0	0.0	107.0	106.0	105.0	104.0	103.0	97.0	91.0	86.0	0.0
45	CSAW	SAW - 4	94850.0	33500.0	1.0	0.0	123.0	122.0	121.0	120.0	119.0	113.0	107.0	102.0	0.0
46	FEL	C 988B-5	94850.0	33500.0	1.0	0.0	109.0	108.0	107.0	106.0	105.0	99.0	93.0	88.0	0.0
47	FEL	C 977B-2	94850.0	33500.0	1.0	0.0	112.0	111.0	110.0	109.0	108.0	102.0	96.0	91.0	0.0
48	MRGR	GRAD16-3	94850.0	33500.0	1.0	0.0	111.0	110.0	109.0	108.0	107.0	101.0	95.0	90.0	0.0
49	GRDR	GRADALL2	94850.0	33500.0	1.0	0.0	108.0	107.0	106.0	105.0	104.0	98.0	92.0	87.0	0.0
50	DOZR	CAT D9-4	94850.0	33500.0	1.0	0.0	112.0	111.0	110.0	109.0	108.0	102.0	96.0	91.0	0.0
51	DOZR	CAT D6-4	94850.0	33500.0	1.0	0.0	114.0	113.0	112.0	111.0	110.0	104.0	98.0	93.0	0.0
52	BHOE	(COMB)-3	94840.0	33500.0	1.0	0.0	108.0	107.0	106.0	105.0	104.0	98.0	92.0	87.0	0.0
53	DTRK	5 YARD-5	94850.0	33500.0	1.0	0.0	125.0	124.0	123.0	122.0	121.0	115.0	109.0	104.0	0.0

54	SPCL	COMPR -3	94850.0	33500.0	1.0	0.0	109.0	108.0	107.0	106.0	105.0	99.0	93.0	88.0	0.0
55	SPCL	CRANE -2	94850.0	33500.0	1.0	0.0	107.0	106.0	105.0	104.0	103.0	97.0	91.0	86.0	0.0
56	M/M	MINE/M S	93900.0	35800.0	1.0	0.0	121.0	120.0	119.0	118.0	117.0	111.0	105.0	100.0	0.0
57	M/M	MINE/MS2	94600.0	35700.0	1.0	0.0	117.0	116.0	115.0	114.0	113.0	107.0	103.0	98.0	0.0

CONSTRUCTION - NIGHTTIME SOURCES

1	MNML	SHAFT-S1	93800.0	35900.0	1.0	0.0	121.0	120.0	119.0	118.0	117.0	111.0	105.0	100.0	0.0
2	FEL	SHAFT-S2	94700.0	35900.0	1.0	0.0	117.0	116.0	115.0	114.0	113.0	107.0	103.0	98.0	0.0

OPERATION

1	MWDF	T2 1	95200.0	35300.0	1.0	0.0	118.0	117.0	116.0	115.0	114.0	108.0	102.0	97.0	0.0
2	MWDF	T2 2	95900.0	35400.0	1.0	0.0	118.0	117.0	116.0	115.0	114.0	108.0	102.0	97.0	0.0
3	MWDF	T2 3	95100.0	34950.0	1.0	0.0	118.0	117.0	116.0	115.0	114.0	108.0	102.0	97.0	0.0
4	MWDF	T2 4	95900.0	33700.0	1.0	0.0	118.0	117.0	116.0	115.0	114.0	108.0	102.0	97.0	0.0
5	MWDF	T2 5	96400.0	34700.0	1.0	0.0	118.0	117.0	116.0	115.0	114.0	108.0	102.0	97.0	0.0
6	MWDF	T2 6	96400.0	33600.0	1.0	0.0	118.0	117.0	116.0	115.0	114.0	108.0	102.0	97.0	0.0
7	MNML	SWITCHER	93900.0	35925.0	1.0	0.0	111.0	130.0	119.0	124.0	120.0	117.0	110.0	104.0	0.0
8	TRAN	TRANSFOM	94120.0	35730.0	1.0	0.0	0.0	93.0	96.0	100.0	100.0	97.0	90.0	0.0	0.0
9	MNML	CRUSHER	94200.0	35775.0	1.0	0.0	116.0	98.0	85.0	73.0	66.0	62.0	58.0	55.0	0.0
10	MNML	BATCHPT	94500.0	35600.0	1.0	0.0	0.0	88.0	91.0	95.0	95.0	92.0	85.0	0.0	0.0
11	MNML	HTRS MS	94450.0	35670.0	1.0	0.0	113.0	109.0	105.0	100.0	95.0	90.0	89.0	89.0	0.0
12	MNML	HTRS IAS	94390.0	35585.0	1.0	0.0	113.0	109.0	105.0	100.0	95.0	90.0	89.0	89.0	0.0
13	MNML	COMPRESS	94370.0	35725.0	1.0	0.0	104.0	104.0	84.0	77.0	77.0	74.0	69.0	69.0	0.0
14	FAN	EAST E R	94625.0	35460.0	1.0	0.0	106.0	120.0	118.0	111.0	108.0	102.0	98.0	96.0	0.0
15	FAN	WEST E R	93240.0	35590.0	1.0	0.0	106.0	120.0	118.0	111.0	108.0	102.0	98.0	96.0	0.0
16	ROAD	ACCESS-1	91600.0	38600.0	1.0	0.0	81.0	83.0	86.0	80.0	77.0	73.0	65.0	56.0	0.0
17	ROAD	ACCESS-2	92500.0	38400.0	1.0	0.0	81.0	83.0	86.0	80.0	77.0	73.0	65.0	56.0	0.0
18	ROAD	ACCESS-3	93900.0	38200.0	1.0	0.0	81.0	83.0	86.0	80.0	77.0	73.0	65.0	56.0	0.0
19	ROAD	ACCESS-4	94000.0	35700.0	1.0	0.0	81.0	83.0	86.0	80.0	77.0	73.0	65.0	56.0	0.0

20	RAIL	RR SPUR	96950.0	38400.0	1.0	0.0	104.0	123.0	112.0	114.0	113.0	110.0	103.0	97.0	0.0
21	MNML	GENERAT	94160.0	35710.0	1.0	0.0	0.0	105.0	104.0	105.0	105.0	102.0	94.0	88.0	0.0
22	ROAD	HAULROAD	94850.0	35500.0	1.0	0.0	122.0	121.0	120.0	119.0	118.0	112.0	106.0	101.0	0.0

NOTES:

1. Tailing pond T1 noise sources (1-12).
2. Slurry pipeline noise sources (13-18).
3. Water discharge pipeline noise sources (19-24)
4. Railroad spur noise sources (25-33).
5. Access road noise sources (34-44).
6. Haul road noise sources (45-55).
7. The six tailing pond T2 noise sources listed for the operation phase modeling are based upon the equipment specified in items 1-12 of the construction-daytime analyses. The total sound power level of these six noise sources is equal to that of the 12 sources used in the construction-daytime modeling. However, these six operation phase noise sources (1-6) were simulated for several locations along the edge of tailing pond T2.

(TABLE 4.1-19 FOR THE RESPONSE TO COMMENT NO. A17 AND A25)

CONSTRUCTION PHASE EFFECT ON AMBIENT SOUND LEVELS[a]

LOCATION	BASELINE L_d	BASELINE L_n	BASELINE L_{dn}	CONSTRUCTION NOISE L_A	TOTAL[b] NOISE DURING CONSTRUCTION L_d	TOTAL[b] NOISE DURING CONSTRUCTION L_n	TOTAL[b] NOISE DURING CONSTRUCTION L_{dn}	CHANGE L_d	CHANGE L_n	CHANGE L_{dn}
WINTER										
1	42.8	29.8	41.9	31.0 (20.1)[c]	43.1	30.2	42.2	0.3	0.4	0.3
2	37.9	28.5	38.1	36.0 (27.4)[c]	40.1	31.0	40.5	2.2	1.5	2.4
3	39.3	23.9	37.9	43.1 (26.1)[c]	44.6	28.1	43.4	5.3	4.2	5.5
4	43.7 (43.4)[d]	35.1	44.2 (44.1)[d]	36.7 (18.2)[c]	44.5 (44.2)[e]	35.2	44.8 (44.6)[e]	0.8 (1.1)[e]	0.1	0.5
5	42.4	50.5 (37.7)[d]	56.4 (45.2)[d]	45.9 (41.0)[c]	47.5	51.0 (42.7)[e]	51.1 (50.2)[e]	5.1	0.5 (5.0)[e]	0.7 (5.0)[e]
6	51.6 (42.1)[d]	19.0	49.5 (40.2)[d]	46.8 (32.8)[c]	52.8 (48.1)[e]	38.2	51.6 (48.1)[e]	1.2 (6.0)[e]	19.2	2.1 (7.9)[e]
7	44.8	41.8	48.8	36.6 (22.7)[c]	45.5	41.9	49.0	0.7	0.1	0.2
8	34.2	30.8	37.9	33.3 (22.1)[c]	36.8	31.3	39.0	2.6	0.5	1.1
9	33.4	30.0	37.1	42.1 (23.6)[c]	42.6	30.9	42.0	8.7	0.9	2.9
10	33.4	31.0	37.8	30.4 (18.9)[c]	35.4	31.3	38.9	3.0	0.3	1.1
SUMMER										
1	46.6	42.7	49.9	31.0 (20.1)[c]	46.7	42.7	50.0	0.0	0.0	0.1
2	42.1	39.7	46.5	36.0 (27.4)[c]	43.0	39.9	47.0	0.9	0.2	0.5
3	47.1 (44.4)[d]	44.1	51.0 (50.5)[d]	43.1 (26.1)[c]	48.6 (46.8)[e]	44.2	51.6 (51.1)[e]	1.5 (2.4)[e]	0.1	0.6 (1.6)[e]
4	63.8	47.0	62.3	36.7 (18.2)[c]	63.8	47.0	62.3	0.0	0.0	0.0
5	58.6 (58.6)[d]	26.5	56.6 (56.6)[d]	45.9 (41.0)[c]	58.8 (58.8)[e]	41.2	57.2 (57.2)[e]	5.2	14.7	0.6 (0.6)[e]
6	38.0	38.6	44.9	46.8 (32.8)[c]	47.3	39.6	48.3	9.3	1.0	3.4
7	47.5	41.3	49.3	36.6 (22.7)[c]	47.9	41.4	49.6	2.1	0.1	0.3
8	40.7	39.6	46.2	33.3 (22.1)[c]	41.4	39.7	46.4	0.7	0.1	0.2
9	42.7	27.4	41.4	42.1 (23.6)[c]	45.4	28.9	43.9	1.2	1.5	2.5
10	38.6	28.1	38.4	30.4 (18.9)[c]	39.2	28.6	39.0	0.4	0.5	0.6

[a]All sound levels are A-weighted in dB.

[b]Ambient plus construction phase noise.

[c]Nighttime mine/mill contribution during shaft sinking.

[d]Measured ambient values were adjusted to reduce the contribution from short duration, high sound pressure level sources (see response to comment No. A11).

[e]Construction phase change in values based on adjusted ambient data.

(TABLE 4.2-17 FOR THE RESPONSE TO COMMENT NO. A17)

OPERATION PHASE EFFECT ON AMBIENT SOUND LEVELS[a]

LOCATION	BASELINE L_d	BASELINE L_n	BASELINE L_{dn}	OPERATION NOISE L_A	TOTAL[b] NOISE DURING OPERATIONS L_d	TOTAL[b] NOISE DURING OPERATIONS L_n	TOTAL[b] NOISE DURING OPERATIONS L_{dn}	CHANGE L_d	CHANGE L_n	CHANGE L_{dn}
WINTER										
1	42.8	29.8	41.9	27.3	42.9	31.7	42.5	0.1	1.9	0.6
2	37.9	28.5	38.1	34.0	39.4	35.1	42.4	1.5	6.6	4.3
3	39.3	23.9	37.9	32.7	40.2	33.2	41.6	0.9	9.9	3.7
4	43.7 (43.4)[c]	35.1	44.2 (44.1)[c]	29.9	43.9 (43.6)[d]	36.2	44.9 (44.8)[d]	0.2 (0.2)[d]	1.1	0.7 (0.7)[d]
5	42.4	50.5 (37.7)[c]	56.4 (45.2)[c]	47.8	48.9	52.4 (48.2)[d]	58.5 (54.7)[d]	6.5	1.9 (10.5)[d]	2.1 (9.5)[d]
6	51.6 (42.1)[c]	19.0	49.5 (40.2)[c]	41.2	52.0 (44.7)[d]	41.2	51.7 (48.3)[d]	0.4 (2.6)[d]	22.2	2.2 (8.1)[d]
7	44.8	41.8	48.8	31.0	45.0	42.1	49.1	0.2	0.3	0.3
8	34.2	30.8	37.9	30.2	35.7	33.5	40.3	1.5	2.7	2.4
9	33.4	30.0	37.1	36.2	38.0	37.1	43.7	4.6	7.1	6.6
10	33.4	31.0	37.8	31.8	35.7	34.4	41.0	2.3	3.4	3.1
SUMMER										
1	46.6	42.7	49.9	27.3	46.7	42.8	50.0	0.1	0.1	0.1
2	42.1	39.7	46.5	34.0	42.7	40.7	47.5	0.6	1.0	1.0
3	47.1 (44.4)[c]	44.1	51.0 (50.5)[c]	32.7	47.3 (44.7)[d]	44.4	51.4 (50.9)[d]	0.2 (0.3)[d]	0.3	0.4 (0.4)[d]
4	63.8	47.0	62.3	29.9	63.8	47.1	62.3	0.0	0.1	0.0
5	58.6 (58.6)[c]	26.5	56.6 (56.6)[c]	47.8	58.9 (58.9)[d]	47.8	58.5 (58.5)[d]	0.3 (0.3)[d]	21.3	1.9 (1.9)[d]
6	38.0	38.6	44.9	41.2	42.9	43.1	49.5	4.9	4.5	4.6
7	47.5	41.3	49.3	31.0	47.6	41.7	49.6	0.1	0.4	0.3
8	40.7	39.6	46.2	30.2	41.1	40.1	46.7	0.4	0.5	0.5
9	42.7	27.4	41.4	36.2	43.6	36.7	45.2	0.9	9.3	3.8
10	38.6	28.1	38.4	31.8	39.4	33.3	41.3	0.8	5.2	2.9

[a]All sound levels are A-weighted in dB.

[b]Ambient plus operation phase noise.

[c]Measured ambient values were adjusted to reduce the contribution from short duration high sound pressure level sources (see response to comment No. A11).

[d]Operation phase change in values based on adjusted ambient data.

His report indicates that as a direct result of forests, a decrease in sound pressure level variations would occur with a reduction in the variations of approximately 12 dB. This reduction in both fluctuations and large peaks of noise levels lessened annoyance to listeners. Figure V-33 of the same report indicates that noise in the 400 Hz- 4 KHz region was attenuated 10 - 12 dB more through a forest than across an open field. In general, peak sound levels resulted across open fields on days when ground level to the height of the convective boundary layer thermal gradients was high, which occurs on hot, sunny days. Therefore, maximum variations of peak levels would be expected primarily during summer when foliage provides maximum shading, thus creating a favorable attenuation environment.

Attenuation of Forests

Several other studies contain documentation on the excess attenuation effects (A_4 in the previous equation) of forests. Typical forest floors of either decaying leaves or needles are "excellent acoustic absorbers" (Reehof, 1976) when the width of the forested area is a minimum of 60 m (200 feet). Reethof also stated in his conclusions that:

> "Low frequencies, typical of low-speed truck noise, are attenuated to a far lesser degree than the higher frequencies characteristic of high-speed traffic and industrial noise sources. However, low frequency truck noise is in a frequency range in which the human ear is quite insensitive to sound. A thick litter layer is an important element in the sound absorption process of forests."
>
> "Natural forests should be 200 to 300 feet wide to provide significant noise reduction from traffic."

Heisler (1977) stated that "trees are useful for noise control primarily because they scatter sound waves, which are then absorbed by the ground" and that "trees used for noise abatement also influence climate."

Cook and Van Haverbeke (1971) stated that:

> "Diesel truck noise was reduced to the acceptable level (60 dBa) at 350 feet from a highway with a strip of trees 100 feet wide and 45 feet tall between the highway and the receiver. Without the trees and the sound passing over a field, the noise would have been above the acceptable level out to 450 feet from the highway."

The following statements (cited in Heisler [1977]) support the concept of forests acting as attenuators.

> "Trees themselves apparently do not absorb much sound. Most investigators now agree that trees are effective in reducing noise transmission primarily by reflecting and scattering sound waves" (Aylor 1975; Reethof et al. 1975). "Tree bark absorbs only a small amount of sound--usually less than 10 percent" (Reethof et al. 1976). "Foliage is also effective primarily by scattering sound rather than by absorption" (Aylor 1972a, 1972b, 1975). "The most effective sound absorber is the ground beneath trees" (Reethof et al. 1975). Herrington and Brock (1975) studied the variation of sound reduction in

relation to height in a forest and found that by far the greatest reduction was near ground level, apparently because of the strong absorption of sound by the forest floor following scattering by foliage, branches, and boles. Hence, it is the combination of all forest elements that makes forests effective in sound absorption.

Quantitative results of the attenuation effects of forests are cited in Giesbers (1984) and include:

"Hess [54] compared the attenuation of the sound level of a diesel engine over open terrain with its attenuation through a mixed forest. He found that the forest attenuated 7 dB more over 100 m. This attenuation includes both ground and vegetational absorption....

The Dutch Government has also investigated the influence of forests on the absorption of traffic noise [125]. The results are expressed in an absorption factor of 0.05 - 0.08 dB(A)/m....

Mitscherlich and Scholzke [89] found that at 120 m from the road a pine forest attenuated 7 dB(A), a decidous forest 5 dB(A) and a field 3 dB(A) more than a meadow."

Other work by Harrison (1975) for the USDA indicates that maximum acoustic attenuation provided by trees and rocks, occurs in the first 150 m (500 feet). The resulting octave band attenuation ranged from 14 dB at 250 Hz to 9 dB at 1,000 Hz and 0 dB above 1,000 Hz. Overall attenuation levels reported by Harrison (1975) for foliage and ground cover were 14 dB for conifers and hardwoods at distances greater than 110 m (350 feet). Also, the Federal Highway Administration (Barry, 1978) allows 10 dBA reduction if dense woods are at least 60 m (200 feet) in width between the road source and the receiver.

To account for the effects of the forest surrounding the mine/mill site, A_4 in the above equation has been conservatively set to 10 dB for distances of more than 150 m (492 feet) from the site.

Barrier Effects

The barrier effects of land forms and buildings (A_3 and A_2, respectively, in the above equation) were not included in the noise contour figures (see response to comment No. A13) or in either of the modeling sequences. For example, the hills and the embankments of the MWDF excavation will tend to reduce the noise estimates shown on those figures. To conservatively estimate impact and offset any short-term effects that weather conditions may present, no attenuation from these sources was assumed.

We have, therefore, made a conservative estimation of the noise impact which occurs during identified phases of the Project. It is acknowledged that during short periods of time meteorological conditions could have a greater or lesser effect on the projected noise levels. The magnitude of this temporary change may be as high as 10 dB but for the reasons presented above, it should not exceed this level. Subsection 4.2.8 of the revised EIR will contain a statement acknowledging the possibility of higher or lower noise levels on a short-term basis as a result of extreme meteorological or topographical phenomena.

REFERENCES FOR RESPONSE TO COMMENT NO. A17

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Thompson, D. W., Refractive focusing of sound in complex terrain environments, Proceeding of Acoustic Remote Sensing Atmosphere and Oceans, Calgary, Alberta, 1981.

Comment No. A18

Acoustical abatement measures for various sources should be developed to reduce noise levels, especially at night. Although impacts may be minimal, residents will still hear the mine and related activities. To develop harmony with residences, a noise abatement plan should be developed.

Abatement of the mine waste disposal facility, access road, railroad spur, and haul road noise is difficult due to the transient nature of the source. Operating time restrictions should be developed to limit these noise sources during the nighttime hours when the impact would be the greatest.

Certain sources at the mine/mill lend themselves to the adaptation of abatement measures. The transformer, compressor, and heaters could be acoustically enclosed (if not already enclosed) to reduce their noise levels (The train/concentrator could have restrictions on operations at night.) A plan to reduce the train/concentrator noise levels at night along with enclosing the transformer, compressor, and heaters will minimize the noises reaching the residents. Analysis should be undertaken to determine the effectiveness of the noise reductions. Details of a noise abatement plan should be enclosed with the mining permit.

Response:

Construction and operation activities of the Crandon Project will generate additional sound levels within the local site area. Many of the sounds will be similar to those produced by typical construction projects in which earthwork and structure fabrication are occurring or in which operation of an industrial facility is occurring. The primary objective of the noise abatement measures is to mitigate the construction and operation sounds (noises) within a reasonable distance from the Project site. Abatement of all Project produced noise sources is not possible. Therefore, those sources most likely to affect residential and working areas will be mitigated.

Two types of mitigative controls will be used to manage these activities: Administrative and Engineering.

<u>Administrative Controls</u> are generally modifications to operating procedures or work practices which serve to reduce, eliminate, or shorten the duration of the noise source. This type of control is most effective for transient sources. Operating procedures are often directed at controlling workers' actions, and therefore, controlling the noise produced by those actions.

<u>Engineering Controls</u> are associated with physical changes to the noise source. This type of control may take the form of source relocation, source replacement and source modification (e.g., addition of a muffler to a diesel engine). Engineering Controls are specific to the noise source.

A number of noise abatement measures will be common during the construction, operations, and reclamation phases of the Project. These include:

<u>Administrative</u>

1) Posting of speed limits;

2) Limiting tree removal on the site to only those areas requiring immediate construction;

3) Re-establishment of vegetative species in the site areas soon after construction is completed;

4) Limiting engine idling of mobile equipment during periods of inactivity;

5) Limiting certain activities to daytime hours, where feasible. Such activities will include: surface facility construction (including MWDF), site grading and waste haulage. It must be recognized, however, that certain circumstances may result in periodic nighttime activities; and

6) Movement of trains by the Soo Line on the spur will normally occur during the daytime. However, concentrate loading occurs continuously, so there will be some movement and placing of rail cars within the plant area at night.

Engineering

1) The noise modeling activity begun during the permitting procedures will be continued during the equipment procurement stage. For equipment items that have been identified as potential major noise sources, purchase inquiries and requisitions will include a request for vendors to supply sound power level and sound pressure level data. With this information, the noise model could be periodically updated, if necessary, so that cost-effective alternatives for achieving noise control can be evaluated;

2) Installation and maintenance of mufflers on all internal combustion engines;

3) Maintenance of equipment to assure proper operating conditions thus minimizing noise levels;

4) All ore processing equipment will be contained within buildings or other enclosures;

5) Enclosing other equipment with large noise generation potential in special enclosures. Such equipment will include the air compressors and emergency electrical generators; and

6) Transformers will not be enclosed. The noise modeling results indicate that the contribution to off-site noise levels by the transformers is minimal. Therefore, enclosing them would be of little benefit.

Other specific activities with noise potential will be controlled as follows:

Mine Ventilation Fans

The mine ventilation fans will operate continuously. To mitigate these noise sources the following actions will be taken:

1) Fans will be selected with emphasis placed on the unit exhibiting the lowest overall sound power level; and

2) The discharge structure will be directed vertically.

Mine Air Heaters

Reduction of noise from the mine air heaters will be achieved in the following ways:

1) An air mixing system will be used in which a fraction of the total air is heated to a high level and mixed with unheated air; and

2) Noise output level will be a major factor in selection of the fan.

Shaft Excavations

The noise associated with the shaft collar excavation from surface to bedrock will be similar to that of other construction equipment. When blasting is initiated, sounds will be greatly reduced by closing the shaft doors and because of depth (21-51 m [70-170 feet]). See response to comment No. S2 for a description of the excavation technique.

The above facilities and practices have been reflected in the noise modeling conducted to assess noise impacts.

Comment No. A19

Pipelines and Discharge Structure - The assumption that the slurry pipeline, water discharge pipeline and the water discharge structure would have no operating noise levels because the components are underground or enclosed appears valid.

Response:

Comment acknowledged.

Comment No. A20

East and West Exhaust Raise - The exhaust raises are of particular concern because they will operate 24 hours a day. Therefore, these sources should be analyzed separately using theoretical octave band level for the types of fan and air flow along with published data on atmospheric attenuation for various seasonal weather conditions. Why were the exhaust fans in the initial noise report 89 dBA while the last noise report lists them at 82.5 dBA?

Since the steady noise of the fan would be heard at various monitoring sites, especially at night, attenuation of the fans should be investigated.

Response:

The fan stations located at the east and west exhaust raises (shafts) were remodeled using a corrected octave band spectrum that relates to the specific model of fan required and the fan arrangement according to current design criteria. The actual model of fan installed may vary from that modeled, but the overall sound pressure level will not exceed 82.5 dBA at 50 feet.

In the original modeling presented in EIR subsection 4.2.8 (see also EIR subsection 1.4.2.3), the capacity of the fans at each exhaust raise was 437 m^3/s (9.25×10^5 cfm) of air at 9" w.g. pressure for a total air movement capacity of approximately 873 m^3/s (1.85×10^6 cfm). With the current fan design there is the capacity to move 296 m^3/s (6.3×10^5 cfm) of air at 9" w.g. pressure at each of the two exhaust raises (EER and WER). The total air movement capacity for the current mine design is approximately 592 m^3/s (1.25×10^6 cfm). A corrected octave band spectrum was developed to accurately represent the fan type and installation arrangement currently planned. The estimated noise levels for the type of fan being proposed are presented in the attached table.

The noise emission inventory described in the response to comment No. A17 shows the noise contribution from the east and west exhaust raises limited to less than 1 dBA at distant locations when considered with all other Project noise sources. As described in the noise control measures (response to comment No. A18), the contribution of these fans and all other potential major noise sources will be reevaluated during equipment procurement and detailed engineering.

The effect of atmospheric attenuation on noise levels is addressed in the response to comment No. A17.

OPERATION

Comment No. A21

Other - The impact of increased highway noise levels appears to have been overlooked. All vehicles using the mine/mill access road must use Highway 55. Therefore, properties adjacent to Highway 55 can be expected to experience a change in the acoustical environment. The amount of change should be projected.

Response:

The Federal Highway Authority (FHWA) equation for predicting noise at distances of 15 m (50 feet) or greater was used to estimate current and Project-related noise levels on State Highway 55 north and south of the intersection with the proposed access road. This equation is the same as that used by the State of Wisconsin Department of Transportation. The attached Table 1 presents current and projected vehicle traffic rates. The attached Table 2 presents the calculation method used, and attached Tables 3 and 4 indicate the estimated differences in L_{eq} as a result of increased Project-related traffic during construction and operation activities.

(Table for the Response to Comment No. A20)

Estimated Noise Levels for a Joy M108-58D Fan (Meakin, 1982)

Frequency Hz	63	125	250	500	1000	2000	4000	8000
Specific Noise (10^{-12} watts)	31	45	43	39	36	32	28	26
10 Log_{10} (cfm x pt^2) (310,000 x 9^2)	74	74	74	74	74	74	74	74
Sound Power Level (Fan Only)	105	119	117	113	110	106	102	100
2 Fan Correction (Side by Side)	3	3	3	3	3	3	3	3
Directivity Correction* (Vertical Discharge)	-2	-2	-2	-5	-5	-7	-7	-7
Adjustment to SPL at 15.24 m (50 ft)	-32	-32	-32	-32	-32	-32	-32	-32
A-Weighted Correction	-26	-16	-9	-3	0	1	1	-1
SPL ÷ 15.24 m (50 ft) dBA	48	72	77	76	76	71	67	63

Overall Sound Pressure Level = 82.2 dBA; Use 82.5 dBA

*Stated values are half the allowable level for distances greater than one mile (Thumann and Miller, 1976).

REFERENCES FOR THE RESPONSE TO COMMENT NO. A20

Meakin, 1982: Letter of July 2, 1982 from W. D. Meakin of Joy Industrial Equipment Company to W. A. Sadik, EMC. Subject: Noise levels M108-58D Fan.

Thumann, A. and R. K. Miller. 1976. Secrets of noise control. K. C. Williams, editor. The Fairmont Press, Atlanta, Georgia.

(Table 1 for Response to Comment No. A21)

TABLE 1

SUMMARY OF DATA ON EXISTING AND EXPECTED TRAFFIC FLOW ON STATE HIGHWAY 55 NORTH AND SOUTH OF THE INTERSECTION WITH THE PROPOSED ACCESS ROAD[a]

	VEHICLES/DAY Construction		VEHICLES/DAY Operation	
Vehicle/Location	Existing	Expected[b]	Existing	Expected[b]
Cars - North	846[c]	1620	846[c]	1096
Trucks - North	94[c]	106	94[c]	100
Buses - North	0[c]	24	0[c]	10
Cars - South	477[d]	493	477[d]	577
Trucks - South	53[d]	65	53[d]	59
Buses - South	0[d]	8	0[d]	4

[a]Source: Existing traffic flow - RPC, Inc. 1983, Forecast of future conditions. RPC, Inc., Austin, Texas.

Expected traffic flow - EIR Sections 1.3 and 1.4.

[b]Expected = existing + total (including round trip) increased traffic flow caused by Crandon Project.

[c]Based upon total traffic flow of 940 vehicles/day.
90% assumed cars
10% assumed trucks

[d]Based upon total traffic flow of 530 vehicles/day.
90% assumed cars
10% assumed trucks

TABLE 2

FHWA HIGHWAY TRAFFIC NOISE PREDICTION MODEL

$L_{eq}(h)_i = (\overline{L_o})E_i$	reference energy mean emission level
$+10 \log \left(\frac{N_i \pi D_o}{S_i T}\right)$	traffic flow adjustment
$+10 \log \left(\frac{D_o}{D}\right)^{1+\alpha}$	distance adjustment
$+10 \log \left(\frac{\psi_\alpha(\phi_1, \phi_2)}{\pi}\right)$	finite roadway adjustment
$+\Delta_s$	shielding adjustment

where

$L_{eq}(h)_i$	is the hourly equivalent sound level of the ith class of vehicles.
$(\overline{L_o})E_i$	is the reference energy mean emission level of the ith class of vehicles.
N_i	is the number of vehicles in the ith class passing a specified point during some specified time period (1 hour).
D	is the perpendicular distance, in meters, from the centerline of the traffic lane to the observer.
D_o	is the reference distance at which the emission levels are measured. In the FHWA model, D_o is 15 meters. D_o is a special case of D.
S_i	is the average speed of the ith class of vehicles and is measured in kilometers per hour (km/h).
T	is the time period over which the equivalent sound level is computer (1 hour).
α	is a site parameter whose values depend upon site conditions.
ψ	is a symbol representing a function used for segment adjustments, i.e., an adjustment for finite length roadways.
Δ_s	is the attenuation, in dB, provided by some type of shielding such as barriers, rows of houses, densely wooded areas, etc.

TABLE 2 (continued)

Notes:

1. The speed limit on State Highway 55 where the model is being applied is 88 km/h (55 miles per hour). At that speed

$$(\overline{L_o})E\text{-cars} = 72 \text{ dBA}$$

$$(\overline{L_o})E\text{-Buses} = 82 \text{ dBA}$$

$$(\overline{L_o})E\text{-Trucks} = 86 \text{ dBA}$$

2. For one hour, the traffic flow adjustment term = $10 \log \left(\frac{N_i D_o}{S_i}\right) - 25$ where the units are defined as above.

3. The distance, finite roadway, and shielding adjustments = 0. (Do = 15 m).

TABLE 3

NOISE CALCULATIONS FOR TRAFFIC ON STATE HIGHWAY 55 NORTH
AND SOUTH OF THE INTERSECTION
WITH THE PROPOSED ACCESS ROAD DURING PROJECT CONSTRUCTION

North of site (Existing)	L_{eq}, dBA @ 15 m
Cars: L_{eq} (1 hr) $= 72 + 10 \log \left[\frac{(\frac{846}{24}) \times 15}{88}\right] - 25$	= 54.8
Trucks: L_{eq} (1 hr) $= 86 + 10 \log \left[\frac{(\frac{94}{24}) \times 15}{88}\right] - 25$	= 59.2
L_{eq} (1 hr) total from above at 15 m from centerline of traffic lane	= 60.6

North of site (Expected)

Cars: L_{eq} (1 hr) $= 72 + 10 \log \left[\frac{(\frac{1620}{24}) \times 15}{88}\right] - 25$	= 57.6
Trucks: L_{eq} (1 hr) $= 86 + 10 \log \left[\frac{(\frac{106}{24}) \times 15}{88}\right] - 25$	= 59.8
Buses: L_{eq} (1 hr) $= 82 + 10 \log \left[\frac{(\frac{24}{24}) \times 15}{88}\right] - 25$	= 49.3
L_{eq} (1 hr) total from expected traffic at 15 m from centerline of traffice lane	= 62.1

L_{eq} increase = 1.5 dBA

TABLE 3 (continued)

	L_{eq}, dBA @ 15 m
South of Site (Existing)	
Cars: L_{eq} (1 hr) = $72 + 10 \log \left[\frac{(\frac{477}{24}) \times 15}{88}\right] - 25$	= 52.3
Trucks: L_{eq} (1 hr) = $86 + 10 \log \left[\frac{(\frac{53}{24}) \times 15}{88}\right] - 25$	= 56.8
L_{eq} total from above at 15 m from centerline of traffic lane	= 58.1
South of site (Expected)	
Cars: L_{eq} (1 hr) = $72 + 10 \log \left[\frac{(\frac{493}{24}) \times 15}{88}\right] - 25$	= 52.4
Trucks: L_{eq} (1 hr) = $86 + 10 \log \left[\frac{(\frac{65}{24}) \times 15}{88}\right] - 25$	= 57.6
Buses: L_{eq} (1 hr) = $82 + 10 \log \left[\frac{(\frac{8}{24}) \times 15}{88}\right] - 25$	= 44.5
L_{eq} (1 hr) total from expected traffic at 15 m from centerline of traffic lane	= 58.9

L_{eq} increase = 0.8 dBA

TABLE 4

NOISE CALCULATIONS FOR TRAFFIC ON STATE HIGHWAY 55 NORTH AND SOUTH OF THE INTERSECTION WITH THE PROPOSED ACCESS ROAD DURING PROJECT OPERATION

North of site (Existing) **L_{eq}, dBA @ 15 m**

Cars: $L_{eq}\ (1\ hr) = 72 + 10 \log \left[\frac{(\frac{846}{24}) \times 15}{88}\right] - 25$ = 54.8

Trucks: $L_{eq}\ (1\ hr) = 86 + 10 \log \left[\frac{(\frac{94}{24}) \times 15}{88}\right] - 25$ = 59.2

L_{eq} (1 hr) total from above at 15 m from centerline of.traffic lane = 60.6

North of site (Expected)

Cars: $L_{eq}\ (1\ hr) = 72 + 10 \log \left[\frac{(\frac{1096}{24}) \times 15}{88}\right] - 25$ = 55.9

Trucks: $L_{eq}\ (1\ hr) = 86 + 10 \log \left[\frac{(\frac{100}{24}) \times 15}{88}\right] - 25$ = 59.5

Buses: $L_{eq}\ (1\ hr) = 82 + 10 \log \left[\frac{(\frac{10}{24}) \times 15}{88}\right] - 25$ = 45.5

L_{eq} (1 hr) total from expected traffic at 15 m from centerline of traffic lane = 61.2

L_{eq} increase = 0.6 dBA

TABLE 4 (continued)

	L_{eq}, dBA @ 15 m
South of side (Existing)	
Cars: $L_{eq}\ (1\ hr) = 72 + 10 \log \left[\frac{(\frac{477}{24}) \times 15}{88} \right] - 25$	= 52.3
Trucks: $L_{eq}\ (1\ hr) = 86 + 10 \log \left[\frac{(\frac{53}{24}) \times 15}{88} \right] - 25$	= 56.8
L_{eq} (1 hr) total from above at 15 m from centerline of traffic lane	= 58.1
South of site (Expected)	
Cars: $L_{eq}\ (1\ hr) = 72 + 10 \log \left[\frac{(\frac{577}{24}) \times 15}{88} \right] - 25$	= 53.1
Trucks: $L_{eq}\ (1\ hr) = 86 + 10 \log \left[\frac{(\frac{59}{24}) \times 15}{88} \right] - 25$	= 57.2
Buses: $L_{eq}\ (1\ hr) = 82 + 10 \log \left[\frac{(\frac{4}{24}) \times 15}{88} \right] - 25$	= 41.5
L_{eq} (1 hr) total from expected traffic at 15 m from centerline of traffic lane	= 58.7

L_{eq} increase = 0.6 dBA

The attached computations were completed using an assumption of a uniform traffic flow over the course of a day. Although this assumption is simplistic, it does accurately calculate the change in daily L_{eq} caused by increased traffic flow. The L_{eq} energy change is only a function of the change of vehicle totals per day. Any other comparison would provide a similar answer.

Comment No. A22

The noise levels for construction impacts was based on the type and quantity of equipment needed to complete a specified job. Using the noise level and the usage factor for each type of equipment a source L_{eq} was calculated. The projected noise level at each monitoring site was developed utilizing the same model as for the operations assessment.

Response:

Comment acknowledged.

Comment No. A23

The assumptions to determine the number and type of equipment and their respective noise level appear reasonable. The distance attenuation is valid. The excess attenuation, as stated before, is too simplistic.

Response:

The comments regarding equipment and distance attenuation are acknowledged. The response to comment No. A17 addresses excess attenuation.

Comment No. A24

The usage factors need further explanation. If the factors are based on the 15-hour (L_d) or 24-hour (L_{dn}) period, the factors appear valid. If the factors are based on an 8-hour shift, the usage factors should be higher. Some usage factors do not appear to match the usage factors for similar equipment in the references source.

Response:

The usage factors applied to construction equipment operation were based on operation of that equipment, at maximum noise levels, for a 15-hour work day. Actual work day length will be a direct function of available daylight. Usage factors for equipment used to construct the access road, haul road, railroad spur, slurry pipeline and water discharge pipeline were slightly adjusted from the referenced sources to match the specific type of tasks to be performed. The usage factors applied are the most accurate estimate currently available of actual conditions that will be encountered during peak construction activity.

Comment No. A25

Table 4.1-29 presents the nighttime Mine/Mill noise levels for the sinking of the shafts. Data is presented only for winter. Since the construction schedules in the Mining Permit Application show construction of the shafts could occur in summer months, data for summer should also be included.

Response:

The noise levels associated with shaft sinking relate primarily to near surface activity early in the development phase. Predominant sources expected to produce noise during this period are freezing equipment, and the use of rock drills and blasting in bedrock. All three of these sources will decrease in intensity or cease as the shafts are deepened.

Table 4.1-29 presents daytime and nighttime mine/mill noise levels for winter and summer. Data in Table 4.1-29 were developed using construction noise L_A from Table 4.1-28 in which mine/mill noise was estimated from all sources. Table 4.1-29 includes summer daytime mine/mill L_A but excluded summer nighttime noise. The exclusion of nighttime noise levels during summer was based on the schedule for development activities. When these calculations of potential noise impacts were performed, collar freezing was planned only during the winter. Recent schedule changes may require shaft collar freezing during summer months. Revised Table 4.1-29 (presented in response to comment No. A17) has been updated to reflect shaft construction during summer months and will be included in the revised EIR.

CLOSURE AND RECLAMATION

Comment No. A26

The noise analysis does not include closure and reclamation operations. They do not need to be modeled separately, but their impact should be assessed based upon the projected construction impacts.

Response:

As stated in EIR subsection 4.3.8, the noise effects of closure and reclamation activities are expected to be no greater than those projected during the construction phase. Noise levels associated with activities, such as tailing pond reclamation, will be less than during construction activites because of the time sequencing and absence of strict schedule constraints which are important in tailing pond development.

Activities associated with reclamation of the mine will not have surface evident noises such as those emitted during shaft sinking. Also, many of the mine/mill noise sources will be eliminated, such as the mine heating and exhaust fan installations. These types of operationally produced noises will cease and equipment similar to that used during Project construction for grading and hauling will be used to perform the various tasks associated with reclamation.

Subsection 4.3.8 of the EIR will be revised to include the above information.

OTHER

Comment No. A27

Wildlife - No discussion of the effect of noise on wildlife is presented.

Response:

The literature prior to 1971 contains little substantive information on the effects of noise on wildlife. In 1980, the U.S. EPA published a review report (EPA 550/9-80-100) entitled "Effects of Noise on Wildlife and Other Animals - Review of Research Since 1971," which continues to be the most comprehensive review available, although limited with regard to quantitative information.

In considering a wide variety of wildlife species, the report concludes that startle or fright is the principal reaction to transient and unexpected noise. Wildlife generally flee the noise source temporarily, or for long periods if the noise persists. There is a tendency to adapt to noise that is predictable and unchanging. For example, the observed reactions of birds to high noise levels include fright reactions, altered behavior, and, in some cases, attraction to noisy areas.

Effects on domestic (farm) animals are not well documented, although there are indications that excessive noise may disrupt their behavioral activities. The major effects appear to be initial fright reactions and temporary increases in heart rate. Domestic animals are located a sufficient distance from the planned activities to be unaffected by noise.

Based on the information presented in the referenced U.S. EPA report, it is anticipated that noise impacts on wildlife will be minimal. However, little quantitative data are available to support demonstrated effects of noise on wildlife. In terms of behavioral response, some animals will tolerate increased noise levels whereas others will temporarily avoid such areas. During periods of noise generating activity in the Project area (e.g., periods of heavy equipment use during construction), wildlife may temporarily avoid the area where the activity is occurring. However, any effect should be localized around the area of activity and will decrease in magnitude with increasing distance from the noise source.

Additional discussion of the demonstrated and suspected effects of noise on mammals, birds, fish, and insects and citations to the source of the findings are presented in the above cited U.S. EPA report.

Comment No. A28

Instantaneous Noises - Noise levels for instantaneous noise sources are not presented; i.e., warning horns, blasting.

Response:

The Project will produce some noises that are instantaneous in nature but not unlike those of any similar mining operation. In fact, the short duration of these noise sources is similar to that of intermittent auto, snowmobile, or airplane noise already present in the site area. Examples of the sources capable of emitting instantaneous noise are provided below:

1) Warning Horns - OSHA requirements regulate activities such as blasting. OSHA requires that surface construction blasting be conducted according to 1926.909, Table U-1, which includes the following requirements:

   a. Warning Signal - A one-minute series of horn's sound five minutes prior to Blast Signal.

b. Blast Signal - A series of short horn sounds one minute prior to explosives detonation.

c. All Clear Signal - A prolonged horn sound following the inspection of the area for detonation.

2) Blasting - Surface blasting is not planned as part of the Project construction phase activities for the development of the facilities such as the mill, main office building and MWDF. However, large boulders may be encountered in the glacial till during construction activities and may have to be reduced in size by blasting. When bedrock is encountered during shaft sinking, blasting will be required. Sound pressure levels associated with blasting for both of these circumstances will be highly variable and directly related to the geometry of material blasted and quantity of explosives used. Estimated noise levels generated from a confined shaft blast at different depths (plus 15.2 m [50 feet] from the shaft collar) are presented below based on the following equation*:

$$P = 82\left(\frac{R}{W^{0.33}}\right)^{-1.2}$$

where P = psi (overpressure)
R = feet (distance)
W = pounds (explosives) per delay
SD = feet (scaled distance)

$$SD = \left(\frac{R}{W^{0.33}}\right)$$

Example calculations:

a. For start of main shaft blasting at 34 m (110 feet) depth,
$P = 82\left(\frac{110 + 50}{32^{0.33}}\right)^{-1.2} = 0.73$ psi, $SD = \left(\frac{110 + 50}{32^{0.33}}\right) = 51$ feet

from attached Figure 26-H, SPL = 85; 75 dBA @ 20 H_z peak

b. For middle of main shaft blasting at 435 m (1425 feet) depth,
$P = 82\left(\frac{1425 + 50}{32^{0.33}}\right)^{-1.2} = 0.051$ psi, $SD = \left(\frac{2745 + 50}{32^{0.33}}\right) = 470$ feet

from attached Figure 26-H, SPL = 61; 51 dBA @ 20 H_z peak

c. For bottom of main shaft blasting at 837 m (2745 feet) depth,
$P = 82\left(\frac{2745 + 50}{32^{0.33}}\right)^{-1.2} = 0.24$ psi, $SD = \left(\frac{2745 + 50}{32^{0.33}}\right) = 891$ feet

from attached Figure 26-H, SPL = 57; 47 dBA @ 20 H_z peak

*Source: duPont Company. 1977. Blasters' handbook. Explosives Products Divison, E. I. duPont de Nemours & Co., Inc., Willmington, Delaware.

(FIGURE 26-H FOR THE RESPONSE TO COMMENT NO. A28)

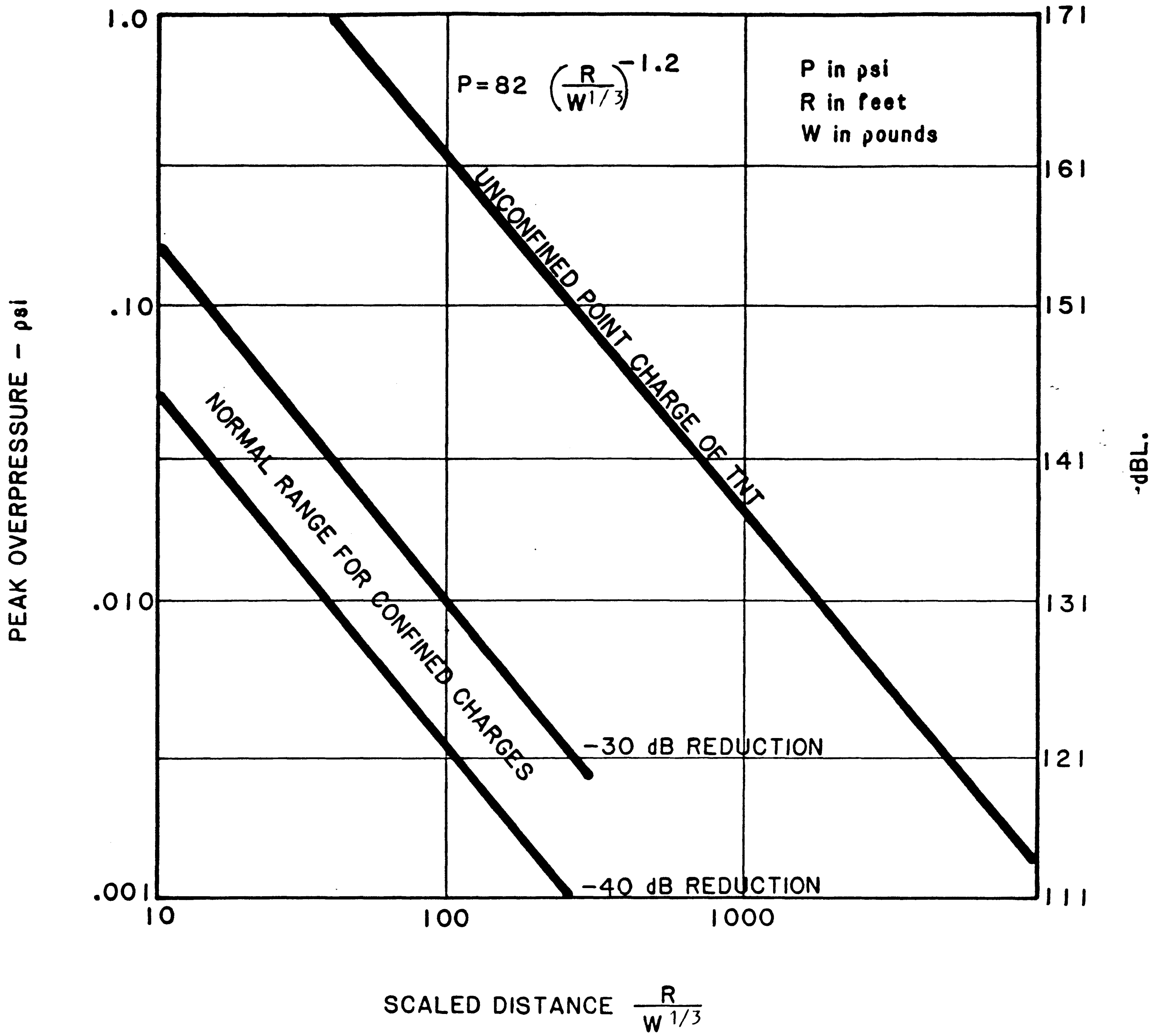


Figure 26-H. Air blast overpressure as a function of distance and charge weight for the unconfined and confined charges. P is expressed in psi, R in feet, and W in pounds.

3) Backup Alarms - OSHA Regulations No. 1926.602(a)(9)(ii).
No employer shall permit earthmoving or compacting equipment which has an obstucted view to the rear to be used in reverse gear unless one of the following conditions is met: (1) the equipment has in operation a reverse signal alarm distinguishable from the surrounding noise level or (2) an employee signals to the operator that it is safe to move in reverse gear.

   Sound pressure levels for excavation equipment range from 80 to 92 dBA and would likely have alarms 5 to 10 dB greater than the A-weighted sound pressure level of the equipment. The exact levels for the construction equipment are not presently available. However, construction and operation excavation activities will likely occur under this category.

4) Startup Alarms - Remotely started and stopped equipment may also require alarms. These types of alarms probably will be operated at the minimum noise level consistent with safe operations.

Most alarm devices are high frequency in nature so that maximum benefit can be achieved from atmospheric absorption. This will lessen annoyance to off-site, noise-sensitive locations. Further, the alarm systems on the trucks and other construction phase mobile equipment will be checked to ensure that their sound levels do not exceed the amount required for safety.

Comment No. A29

In general, 24-hour L_{eq} noise levels, as presented by Exxon, are, in most cases, believable. EPA's guidelines were set to try to create a quieter urban environment. This area is so quiet that it is very questionable to use an L_{dn} level of 55 dBA as a guideline when the existing environment is in the 30 to 40 dBA range. This project is going to raise the ambient noise level in the study area. Additionally, there will be times, with certain meteorological conditions, that noise from the project will travel great distances. These points must be made clear to the local residents. The noise levels will not harm them and the majority of residents will adapt to the new acoustical environment, but the ambient noise environment will increase. This information does not appear to be sufficiently presented in the Noise Impact Chapters.

Response:

When the EPA published their guidelines in 1974, the goal was "to provide information on the levels of noise requisite to protect public health and welfare with an adequate margin of safety" (EPA, 1974). At some locations in the environmental study area, the acoustical environment will change as a result of construction and reclamation activity. These changes will be limited in duration. Noise impacts during operation activities will last for considerably longer periods; however, as presented in the response to comment No. A18, numerous limitations on the operations and plans for the noise controls are included in the Project to limit the potential effects.

The EPA guidelines summary (1978) indicates that the EPA's recommendations are to provide protection for 96 percent of the people. EPA further states, "It is assumed that people with poorer hearing than the 96th percentile are not affected by noise of typical levels . . .so that the recommendations protect virtually the entire population." The L_{dn} EPA guideline value of 55 dBA was also intended to prevent degradation of public health and welfare by environmental noise for activities such as:

"1. Speech communication in conversation and teaching

2. Telephone communication

3. Listening to TV and radio broadcasts

4. Listening to music

5. Concentration during mental activities

6. Relaxation

7. Sleep."

This guideline serves as a reference point for determining a level at which interference will occur.

Field data, acquired during 1977 and 1983 at randomly selected periods in the environmental study area, produced L_{dn} values ranging from 37.1 to 62.2 dBA. The upper range of the recorded noise levels for the existing environment exceed the 30 to 40 dBA range mentioned in the DNR comment. These levels are representative of the ambient noise environment including human activities at the areas sampled and are acceptable to the DNR (see response to comment No. All).

Potential increases in noise levels in areas affected during construction and operation phases of the Project have been identified. A general statement such as "the Project is going to raise the ambient noise level in the study area" might give the impression that all noise sensitive areas will experience an impact, which is inaccurate. The discussion provided in subsections 4.1.8 and 4.2.8 of Chapter 4.0 of the EIR will provide the predicted changes which may occur. Further, the intermittent short duration changes will be distinguished from those which may be audible over the longer term of Project activities. This will present a better approximation of any potential noise effects which will be perceived at various receptors in the site area.

A more complete discussion of the modeling results and the conservative estimations of the noise impacts will be added to subsections 4.1.8 and 4.2.8 of the revised EIR to address the comment that under certain meteorological conditions noise from the Project will travel greater or lesser distances than what was calculated and presented in the EIR. The paragraphs to be added in the revised EIR will be a condensation of the information provided in the response to comment No. A17. We will also clearly state our conclusion that the majority of the residents will not perceive or will easily adapt to the new acoustical environment.

SEISMIC REVIEW

Comment No. S1

A. Exxon EIR Volumes I through X and other documents have been reviewed.

There is very little in the Exxon EIR and other documents that have been reviewed concerning exactly what Exxon expects in the level of vibrations to the residences in the area. What is said to date in available publications is insufficient for DNR to know if there will or will not be a problem from the blasting.

Section 8 (Pre-Blasting Survey) of the Mining Permit Application prepared by Exxon Minerals Company states "since the bedrock which will be blasted is overlain by a minimum of 21m (70 ft) of unconsolidated glacial overburden, seismic effects of blasting will be largely attenuated before reaching ground surface. This is especially true for initial blasting, which will be on a relatively small scale using only a few kilograms of explosives per shot. For these reasons, there are no current plans to conduct a pre-blasting survey of structures."

The above statement may generally be acceptable. However, from an engineering point of view and considering the very sensitive nature of this project, it is not acceptable.

Response:

The plan for conducting the pre-blasting survey required in accordance with NR 132 was presented in EMC's response to DNR comment No. 182 on the Mining Permit Application (letter from B. Hansen, EMC, to G. Reinke, DNR, dated November 11, 1983) and is presented verbatim below:

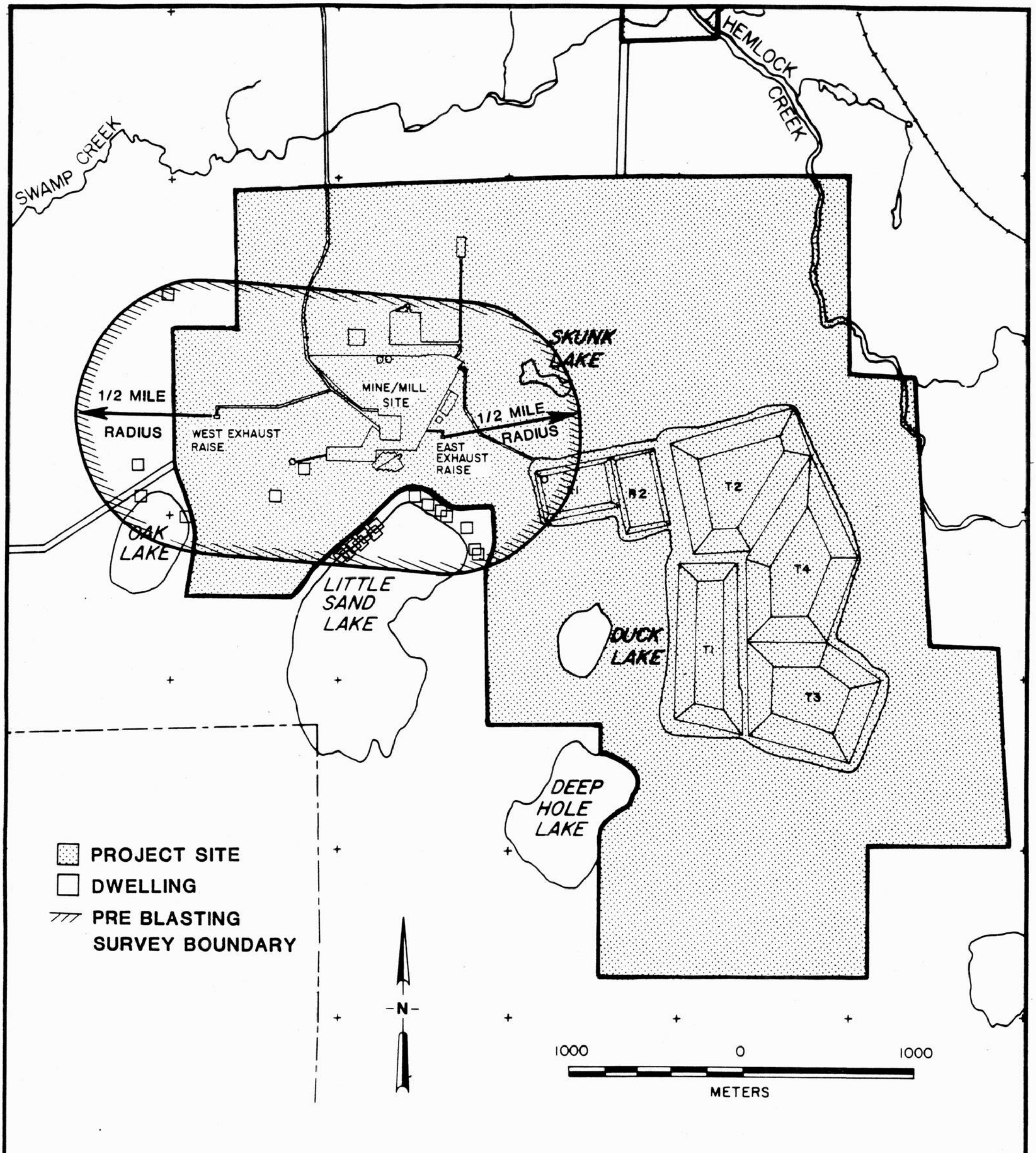
1) All permanent structures within an 0.8-km (0.5-mile) radius of any of the mine access or ventilation shafts (four) will be inspected (see attached figure).

2) Such inspections will be conducted just prior to the start of site blasting, with an appropriate allowance of time for submission of survey results to state agencies prior to commencement.

3) Property inspection elements will include:

- Foundations
- Concrete slabs
- Exterior and interior masonry
- Structural framing
- Exterior and interior wall treatments
- Ceiling and floor treatments
- Windows and doors (framing and glass)
- Visible plumbing
- Exterior utility services
- Exterior structures (i.e. antennas, flag poles)
- Miscellaneous elements as required.

(FIGURE FOR THE RESPONSE TO COMMENT NO. S1)



PRE BLASTING SURVEY BOUNDARY

384-2C-145

Inspected elements will be fully documented, including photographs where appropriate. Element age and state of general maintenance will be noted. Inspections will be conducted by state licensed professionals.

4) Inspections will be conducted with property owner consent and universally in the case of Exxon Minerals Company owned structures.

5) Copies of the pre-blasting survey inspection sheets, photographs, and property condition report will be submitted to each private owner and state agencies. File copies will be retained for use at the mine site.

The nominal 0.8-km (0.5-mile) survey radius planned will likely exceed the limit of any measurable blasting effects. In fact, neither seismic stress nor air blast concussion of a magnitude sufficient to cause structural damage is expected immediately adjacent to the shaft collars.

Seismic motion from bedrock blasting will be dampened by the overlying glacial sands and gravels (minimum 21 m [70 feet] thick). Air blasts will be muffled by the length of the shaft course to the ground surface.

Comment No. S2

The following topics should be addressed and presented to DNR by Exxon to verify the statement from Section 8 (Pre-Blasting Survey) of the Mining Permit Application:

1) Overburden Excavation

   a) The size of the largest anticipated area in the glacial overburden requiring blasting.

   b) Generalized drilling and blasting pattern and number of delays.

   c) Total amount of explosive for each shot, and poundage per delay.

Response:

A discussion of the probable method of excavation of the overburden was included in the response to DNR comment No. 45 on the Mining Permit Application (letter from B. Hansen, EMC, to G. Reinke, DNR, dated July 31, 1984) and is presented below.

The overburden at each of the four vertical mine entryways consists of partially saturated glacial sands and gravels. It is expected that it can be excavated to the bedrock subcrop without conventional drilling and blasting by using one or more of the following methods, after the overburden has been consolidated by ground freezing techniques.

1) Directly mucking unfrozen, unconsolidated material inside the freeze ring with a clamshell or grab operating on a large mobile crane.

2) Loading consolidated material into a mucking bucket on the crane with an air operated crawler mounted overshot loader (EIMCO 630), or a backhoe on the shaft bottom. The backhoe, particularly, would have the ability to rip well consolidated or frozen material from the shaft excavation wall and bottom.

3) Using hand-held pneumatic chipping hammers to enlarge the consolidated or frozen shaft wall and bottom to its neat line.

4) Employing impact breakers to reduce the size of any glacial boulders too large for the shaft excavation loading equipment to handle. Under unusual circumstances blasting may be required to reduce the size of boulders.

Comment No. S3

2) Hard Rock Excavation

a) Generalized drilling and blasting pattern.

b) Total amount of explosive per blasthole, pounds of explosives per delay, and number of delays per shot.

Response:

A general description is presented below on the drilling and blasting pattern during shaft development through hard rock and during production blasting in stopes. This information was previously presented in EMC's response to DNR comment No. 45 on the Mining Permit Application (letter from B. Hansen, EMC, to G. Reinke, DNR, dated July 31, 1984).

1) Shaft Development

Main Shaft and Intake Air Shaft

The attached Figure 20-K from the 175th Anniversary Edition (1977) of duPont's Blasters' Handbook illustrates the type of drilling and blasting planned for bedrock sinking of the Crandon main and intake air shafts. These shafts will be circular and excavated to 7.9 m (26 feet) and 5.8 m (19 feet) rock diameters, respectively. Even though circular, the same general drilling pattern and blasting sequence as illustrated on the referenced figure for a rectangular shaft will apply.

For the main shaft, two bench blasts per day are planned, resulting in a net shaft advance of 2.13 m (7 feet). The smaller intake air shaft will average 2.5 bench blasts per day, resulting in a net shaft advance of 2.65 m (8.7 feet) per day.

Preliminary design for the main shaft drilling and blasting patterns resulted in 44 blastholes per bench. A total of 160 kg (352 pounds) of 40 percent or 60 percent straight gelatin dynamite will be detonated by 44 non-electric delay blasting caps. Fifteen delay periods will be used for an average of three holes per delay period. An average of 3.6 kg (8 pounds) of

(Figure 20-K for the Response to Comment No. S3)

One of the most efficient shaft sinking methods, which is applicable in rectangular shafts, is benching shown in Figure 20-K. In this system drilling is simplified. It is similar to a small quarry face pattern. Failure of a cut to "pull" is practically eliminated as sinking blasts are alternated from one side to the other with good relief provided by the previously removed lower side. Also, the lower "other side" collects the water which tends to cover drill holes once the electric pumps are removed for loading the blast. This provides a good sump during pumping.

The number of holes-per-round is reduced by benching. Explosives and cap consumption is low in relation to all other shaft methods. Hole spacing varies with hole diameter, but can be in the three to four-foot range with good results.

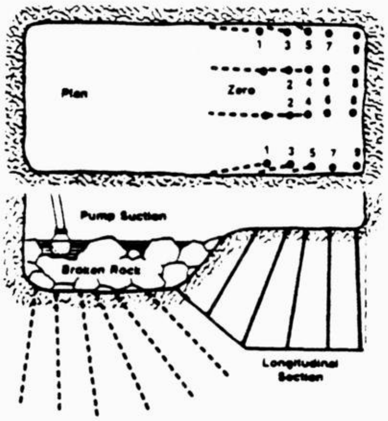


Figure 20-K. Benching illustrated above is a most efficient shaft sinking method.

explosives will be used in each hole, or 10.9 kg (24 pounds) per delay period. A maximum of four holes on one delay will be used for a total explosives weight of 14.5 kg (32 pounds).

Similar design criteria apply to the intake air shaft, where 41 blastholes per bench will be required. A total of 86 kg (189 pounds) of 40 percent or 60 percent straight gelatin dynamite will be detonated by 41 non-electric delay blasting caps. Fifteen delay periods will be used for an average of 2.7 holes per delay period. An average of 2.1 kg (4.6 pounds) of explosives wll be used in each hole, or 5.7 kg (12.5 pounds) per delay period. A maximum of five holes on a single delay will be used with a total explosives weight of 10.5 kg (23.2 pounds).

East and West Exhaust Ventilation Shafts

The east exhaust ventilation shaft will be excavated in the following manner (the bedrock subcrop [21 m deep] to the 230-m level segment will be the largest and require the most explosives):

- A drift will intersect the planned shaft centerline at the 230-m level and provide a breakthrough opening for a pilot hole drilled from the bottom of the overburden shaft collar. A 2.13-m (7-foot) cutter head will then be attached to the drill string on the 230-m level and a raise drill will pull it through to the collar floor, creating a raise to provide relief for slashing the shaft to its full 6.7-m (22-foot) diameter.

- The raise will be enlarged from the top down by drilling and blasting a circular pattern of vertical 3.66-m (12-foot) deep small diameter blastholes, with the broken rock falling through the pilot raise to the 230-m mine level below, where it will be removed by a front-end loader.

The west exhaust ventilation shaft will be excavated in the same manner, with the initial large diameter segment extending from the bedrock subcrop (49-m deep) to the 230-m level.

For the exhaust shafts, two raise slashing blasts per day are planned with each blast advancing 3 m (10 feet).

For a raise slash, approximately 58 holes will be required. A total of 220 kg (485 pounds) of 40 percent or 60 percent straight gelatin dynamite will be detonated by 50 non-electric delay blasting caps. Fifteen delay periods will be used for an average of four holes per delay period. An average of 3.8 kg (8.4 pounds) of explosives will be used in each hole, or 15.2 kg (33.5 pounds) per delay period. A maximum of six holes on one delay will be used, with a total explosives weight of 22.8 kg (50.2 pounds).

2) Production Blasting in Stopes

The largest anticipated production blast in the upper or near surface part of the orebody might occur between the 140 and 95 m mine levels. The mining method in this interval will be vertical crater retreat

(VCR), in which a number of vertical large diameter (150-mm [6-inch]) blastholes are loaded with a charge of explosives located at a critical position in the hole, normally about 3 m (10 feet) from the free face directly below. Charges are detonated with delays between the holes and fragment the ore by the "cratering" effect of the concentrated explosive charge. In the very unlikely probability that all holes in the top sill of a VCR stope blast accidentally detonate simultaneously, as much as 8,000 kg (17,600 pounds) of explosives could be involved. Normally, blasts will be designed so that no more than 250-300 kg (550-660 pounds) are detonated with a single delay.

Below the 140-m level the normal mining method will be blasthole open stoping. A large production blast of two stope rows could require 12 holes blasted in six delay intervals - a planned consumption of about 8,000 kg (17,600 pounds) of explosives or 1,330 kg (2,925 pounds) blasted with any single delay. The simultaneous detonation of all holes in one or two rows would never be planned and could only occur if gross operational errors were made during the charging of the blastholes.

Comment No. S4

3) Evaluation Methods

a) Analytical methods; model and parameters used and computation sheets. Analytical methods attempt to use factual site information, possibly with models to describe the situation. They may be adequate by themselves.

b) Theoretical methods; source and computation sheets with references for levels of vibration acceptable to persons. (The Bureau of Mines criteria for buildings may not be appropriate at this site due to the very low background levels of vibrations. The Bureau of Mines criteria generally is applied to structures and seldom can be used for determining the acceptable level of vibrations for persons.) The theoretical methods that may be considered would use available blast vibration propagation theories, along with estimates of or test results for elasticity, isolation effects, and the like, to predict the level of vibration at distant points from a blast. They may be suitable in themselves to predict the actual site situation, but without at least some form of submittal, with computations, it cannot be determined if they would be adequate for addressing the situation, without other techniques.

c) Experimental plan: location, amount of explosive sensor locations, and results. In the experimental methods, test blasts with measuring devices could be used to predict what full-scale blasts will do. This would be the preferred method, regardless of whether there is any prediction on the basis of other methods. Due to the many unknowns and assumptions that would have to be made in calculations, some sort of proof by experiment is deemed required for dependable DNR evaluation of the submittals.

Response:

The discussion presented below on the evaluation methods used to estimate the blasting induced ground surface peak particle velocity was presented in EMC's response to DNR comment No. 45 on the Mining Permit Application (letter from B. Hansen, EMC, to G. Reinke, DNR, dated July 31, 1984).

An estimate of blasting induced ground surface peak particle velocity (PPV) has been made utilizing an empirical relation as suggested by Ambraseys and Hendron (1968).

Results of the estimate indicate an expected maximum PPV of 0.4 mm/s (0.02 inch per second) at an epicentral distance of 396 m (1,300 feet) for shaft construction. Production blasting is anticipated to produce maximum PPV's on the order of 6.5 mm/s (0.26 inch per second) at an epicentral distance of 762 m (2,500 feet) (see Table I attached).

a) Analytical Methods: Models, Parameters

Peak particle velocities were estimated by utilizing an empirical relation which accounts for the distance from the charge, the weight of charge, and the character of the media through which the stress wave travels (see Figure 1 attached). The assumed material cross section is a two-layer model consisting of 50 m (164 feet) of nonindurated sediments (i.e. sand, gravels, glacial till) and weathered rock which rests on fresh Precambrian volcanics and massive sulfide ore. The weathered rock contact was modeled at a depth of 25 m (82 feet), establishing the location for initial shaft blasting. The materials model was developed by synthesizing available geologic data and site refraction seismic survey data acquired by Geoterrex Ltd. for the Crandon Project.

The mathematical model utilized for the estimate is presented in Hoek and Brown (1980). The peak particle velocity relationship is expressed as:

$$V_p = k \frac{W^{\alpha}}{R^{\beta}}$$

where:

V_p = peak particle velocity (mm/s)
W = explosive charge weight (kg)
R = hypocentral distance to the point of estimated peak particle velocity (m)
k = velocity coefficient (empirical)
= exponent (empirical)
= exponent (empirical)

Examination of the data for the empirical values of the exponents suggests a narrow range for both α and β. As no test blasting has yet been conducted at Crandon, mean values were used for both α and β ($\alpha = 0.73$, $\beta = 1.75$).

The empirical velocity coefficient (k) displays a wide range in values which results from the variation of geologic materials at different test locations. For this study a k value for fresh rock (k_2) was

(TABLE I FOR THE RESPONSE TO COMMENT NO. S4)

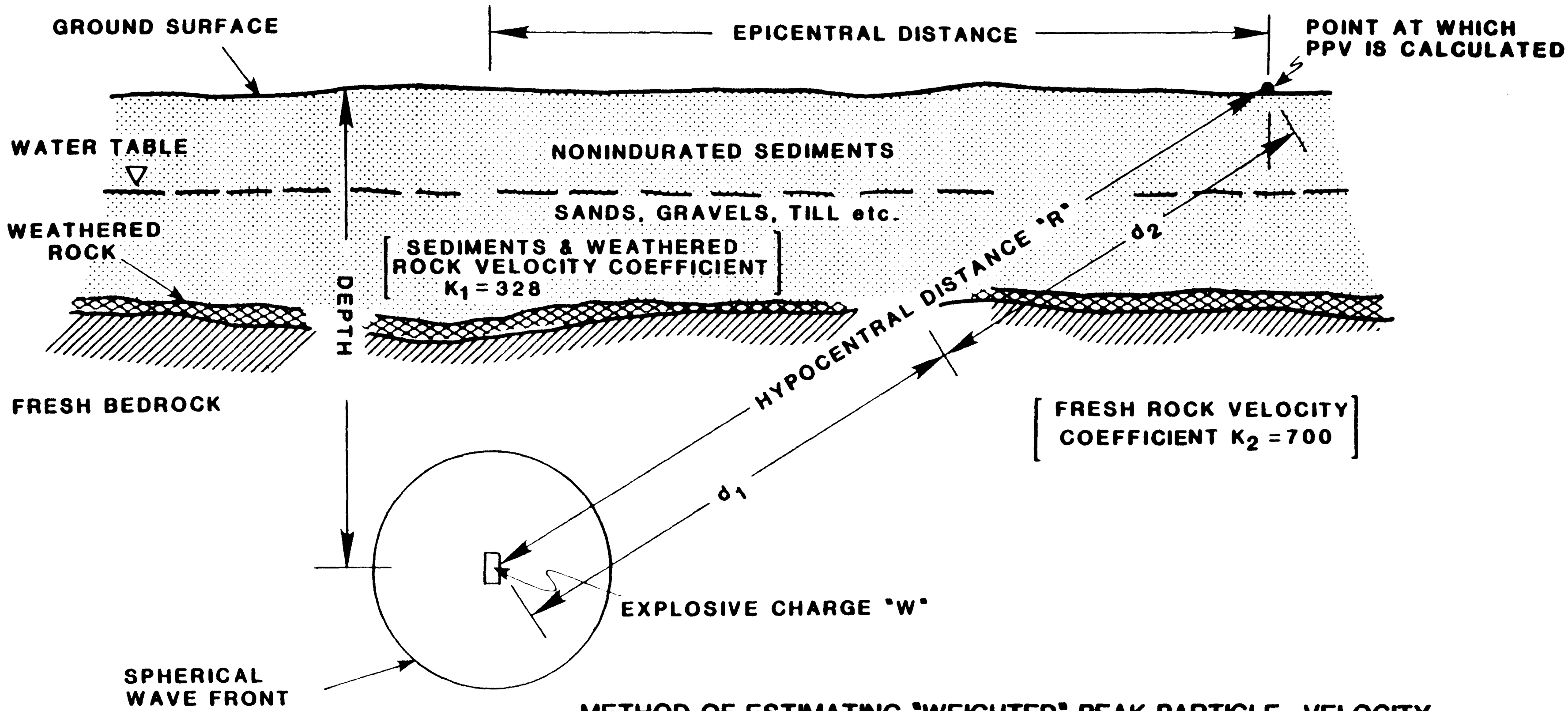
CRANDON BLAST VIBRATION STUDY

POTENTIAL SURFACE PEAK PARTICLE VELOCITY (PPV) GENERATED BY SHAFT SINKING AND PRODUCTION BLASTING

Location	Epicentral Distance	Maximum Charge Weight	Peak Particle Velocity (PPV)
Intake Air Shaft at 25 m	396 m (1,300 feet)	88 kg (194 pounds)	0.4 mm/s (0.02 inch per second)
95 m Production Level	762 m (2,500 feet)	4,000 kg (8,840 pounds)	3.4 mm/s (0.14 inch per second)
140 m Production Level	762 m (2,500 feet)	8,000 kg (17,680 pounds)	6.3 mm/s (0.25 inch per second)
290 m Production Level	762 m (2,500 feet)	8,000 kg (17,680 pounds)	6.5 mm/s (0.26 inch per second)
640 m Production Level	762 m (2,500 feet)	10,000 kg (22,100 pounds)	5.7 mm/s (0.22 inch per second)

(FIGURE 1 FOR THE RESPONSE TO COMMENT NO. S4)

CRANDON BLASTING VIBRATION ESTIMATE
PEAK PARTICLE VELOCITY MODEL



METHOD OF ESTIMATING "WEIGHTED" PEAK PARTICLE VELOCITY

PEAK PARTICLE VELOCITY (PPV)(mm/sec) $= (1.8)\left[\frac{d_1}{R}K_1 + \frac{d_2}{R}K_2\right]\frac{W^{\alpha}}{R^{\beta}}$

WHERE:

K_1 = VELOCITY COEFFICIENT FOR NON-INDURATED SEDIMENTS (328)

K_2 = VELOCITY COEFFICENT FOR FRESH ROCK (700)

d_1 = DISTANCE WAVE FRONT TRAVELS IN NON-INDURATED SEDIMENTS, (m)

d_2 = DISTANCE WAVE FRONT TRAVELS IN FRESH ROCK(m)

R = HYPOCENTRAL DISTANCE (m)

W = CHARGE WEIGHT (kg)

$\alpha = 0.73$ $\beta = 1.75$

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used which is similar to the Precambrian rock encountered in Scandinavia. The velocity coefficient for nonindurated sediments (k_1) was assumed to be similar to that found for heavily weathered and fractured porphyry copper deposits.

- Nonindurated sediments $k_1 = 328$
- Fresh Precambrian rock $k_2 = 700$

The velocity coefficients were then weighted for relative proportion of material through which the seismic wave must travel along the hypocentral distance.

Charge weights selected for evaluation were established from preliminary blasting designs and mining industry conventions for both shaft sinking operations and production blasting. For both cases, the delay sequence and column charge pattern were examined and all closely spaced delays were combined to form a single charge weight. The combined charge weight was then utilized to estimate the ground surface peak particle velocity.

Ground surface peak particle velocity was then determined for various charge weights for both shaft sinking and production blasting (see Figures 2 through 7 attached).

b) Theoretical Methods: Source and Computation Sheets with References for Levels of Vibration Acceptable to Persons

Data on human response to peak particle velocity were compiled from information provided by Vibra-tech (1976). The Vibra-tech data are based on field and laboratory studies conducted by the USBM and other sources (see Figure 8 attached). Combined with the human response information are comments on structural effects as summarized in CANMET (1977).

Results of this study suggest that production blasting at Crandon will be detectable at an epicentral distance of 762 m (2,500 feet) and that shaft sinking operations will be essentially undetectable at the same epicentral distance.

It is unlikely that the peak particle velocity produced by production blasting will be routinely noticed by the general population located near the mine site.

3) Experimental Plan

Blast monitoring will be necessary to optimize blasting efficiency (see McKenzie et al., 1983). Monitoring of peak particle velocity may be necessary during various phases of shaft sinking, mine development, early stope production and during upper mine level production late in the mine life. During the course of the monitoring program, data will be acquired which will allow the development of site-specific empirical parameters and coefficients for estimating peak particle velocity. These data will allow evaluation of blasting effects. It may also be valuable to monitor mine plant structures allowing the development of response spectra as suggested by Walker et al. (1982).

(REFERENCES FOR THE RESPONSE TO COMMENT NO. 84)

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Hendron, A. J. and Dowding, C. H., 1973, "Ground and structural response due to blasting," In: Proc. of the 3rd Int'l. Cong. of the ISRM, Denver, Colorado.

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Calder, P., 1977, "Pit slope manual chapter 7 - perimeter blasting," CANMET Report 77-14.

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Langefors, V. and Kihlstrom, B., 1973, "The modern technique of rock blasting," John Wiley & Sons, New York.

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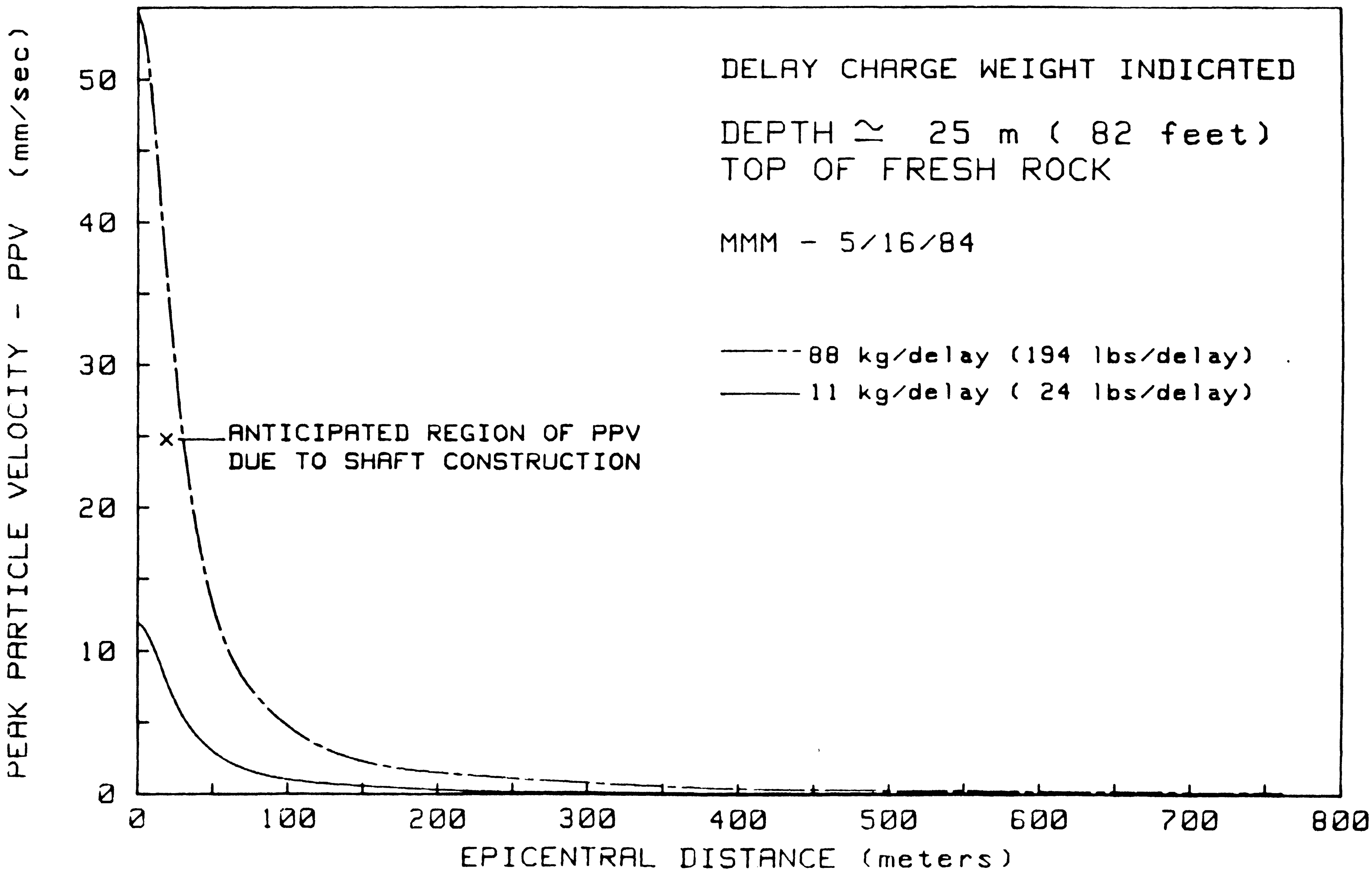
Geoterrex Ltd., 1980, "Logistic report on a refraction seismic survey in Crandon, Wisconsin," prepared for Exxon Minerals Company.

Nicholas, D. E., 1984, Personal communication.

McKenzie, C. K. et al., 1983, "Limit blast design evaluation," In: Proc. of 5th Int'l. Cong. of ISRM, Melbourne, Australia.

(Figure 2 for the Response to Comment No. S4)

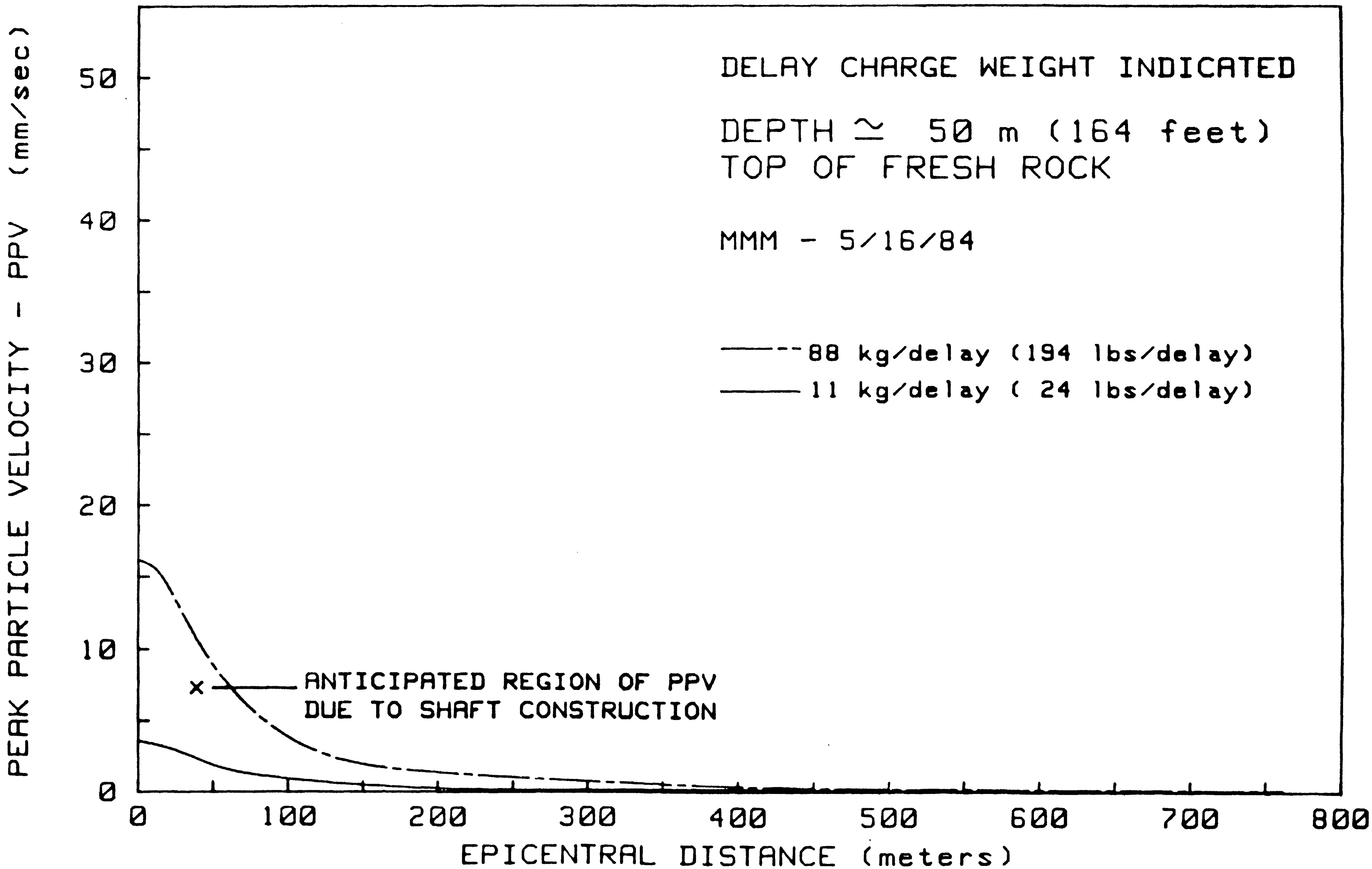
FIGURE 2
CRANDON INTAKE AIR SHAFT
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITY



CDM-2-2

(Figure 3 for the Response to Comment No. S4)

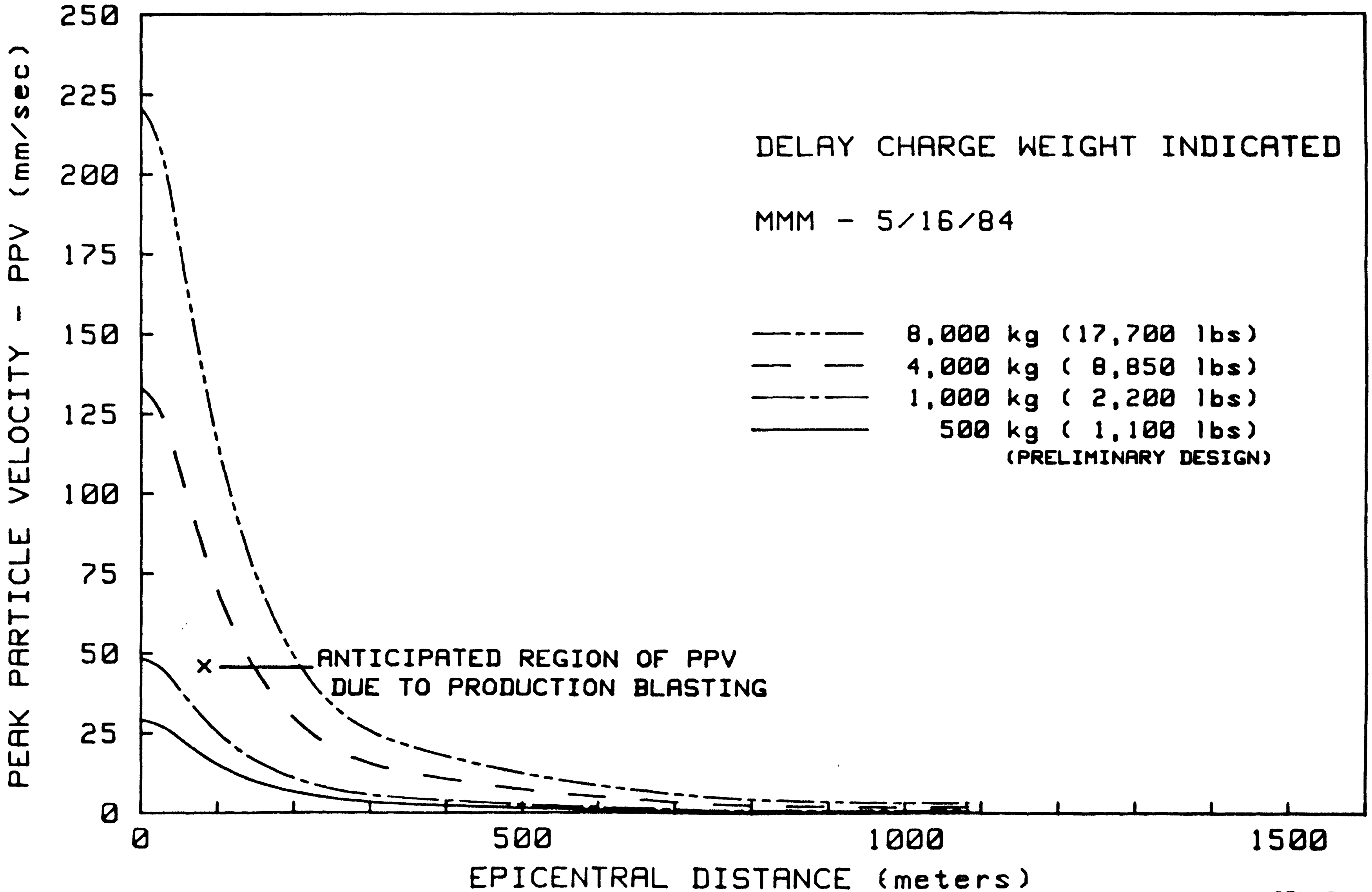
FIGURE 3
CRANDON MAIN SHAFT
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITY



CDM-0-3

(Figure 4 for the Response to Comment No. S4)

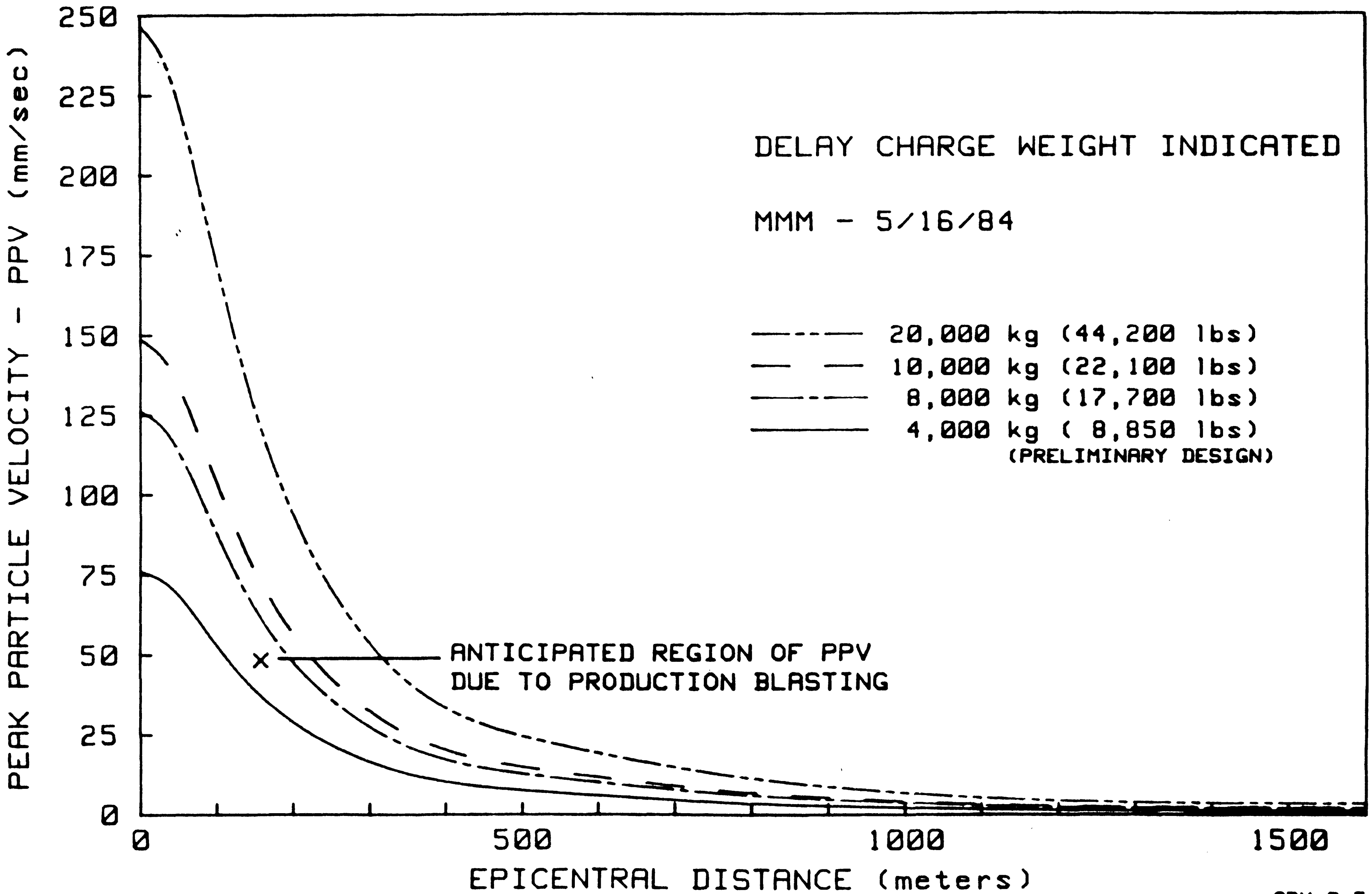
FIGURE 4
CRANDON: 95 m LEVEL PRODUCTION BLASTING
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITY



CDM-0-4

(Figure 5 for the Response to Comment No. S4)

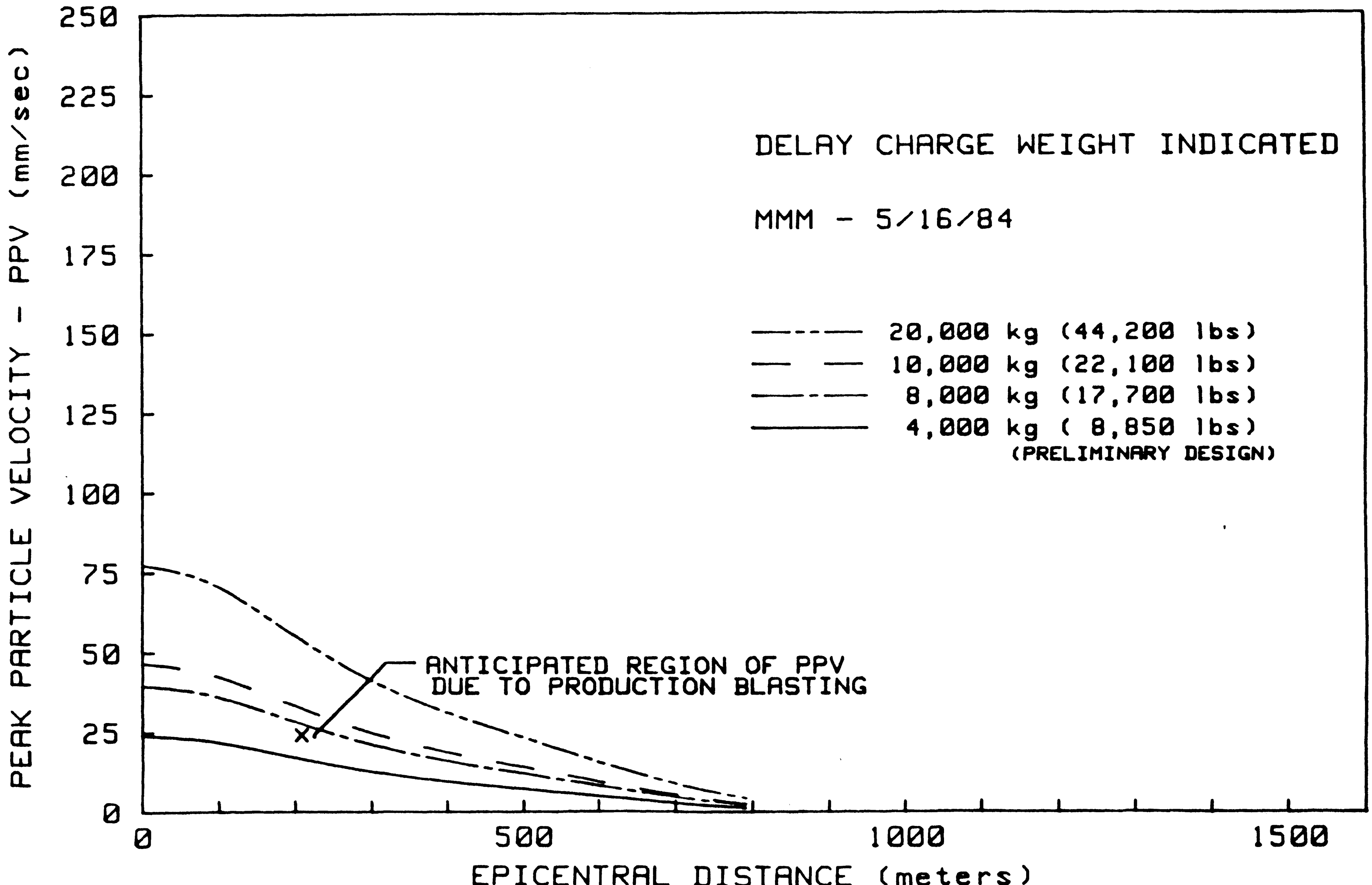
FIGURE 5
CRANDON: 140 m LEVEL PRODUCTION BLASTING
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITY



CDM-0-5

(Figure 6 for the Response to Comment No. S4)

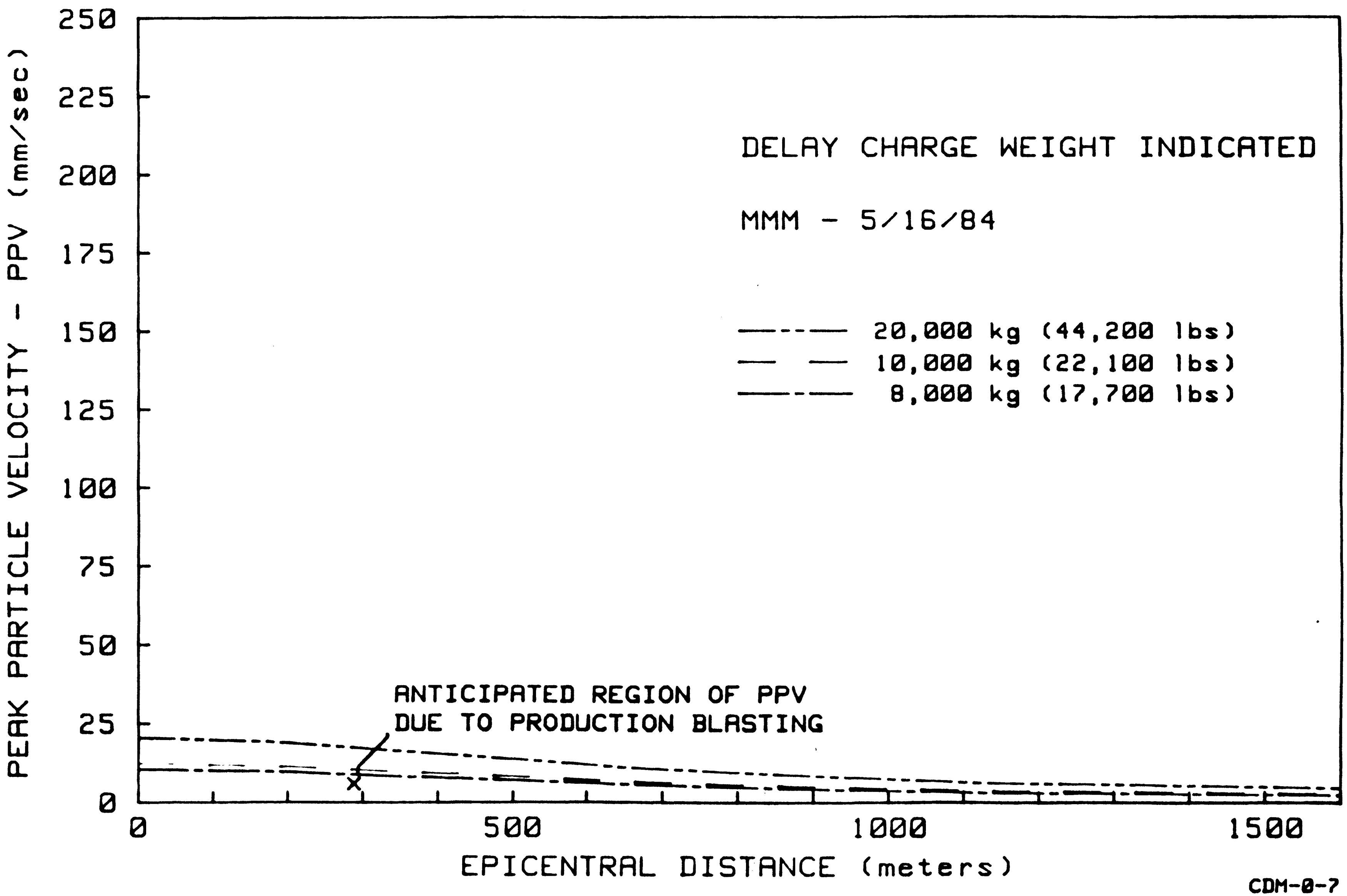
FIGURE 6
CRANDON: 290 m LEVEL PRODUCTION BLASTING
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITY



CDM-0-6

(Figure 7 for the Response to Comment No. S4)

FIGURE 7
CRANDON: 640 m LEVEL PRODUCTION BLASTING
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITY



(Figure 8 for the Response to Comment No. S4)

FIGURE NO. 8

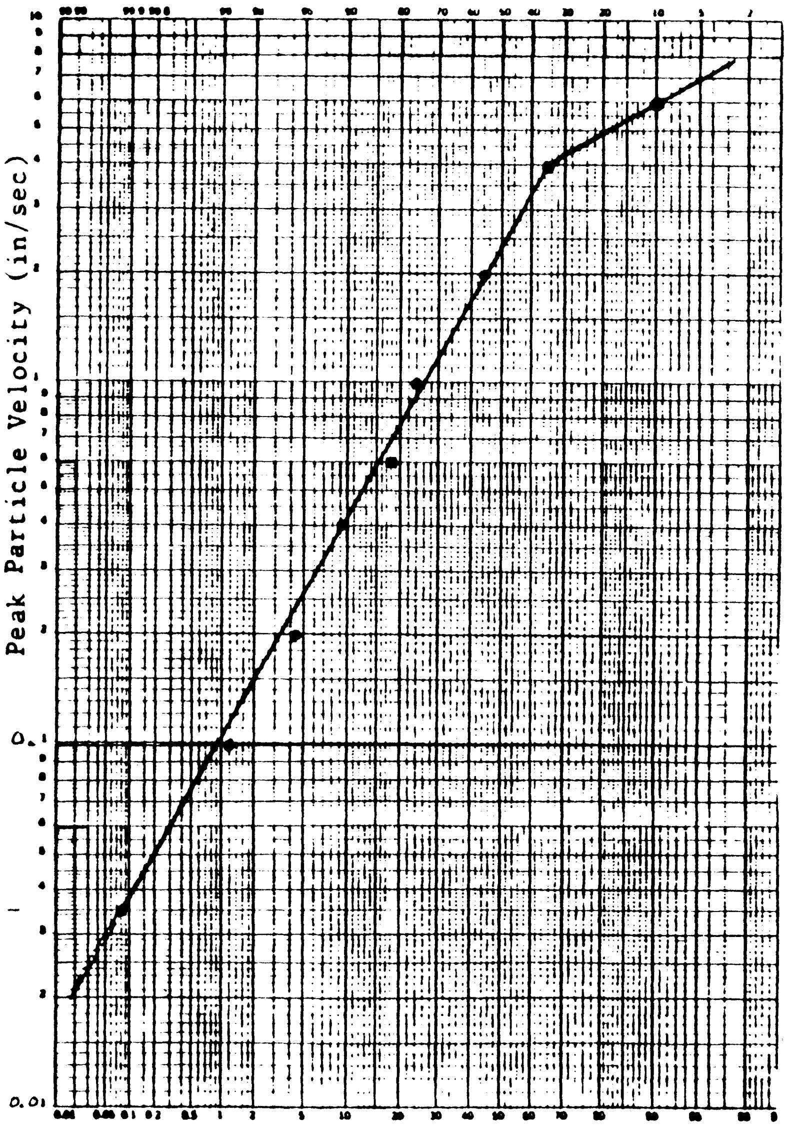
CRANDON BLASTING VIBRATION ESTIMATE

GENERAL HUMAN & STRUCTURAL RESPONSE TO PEAK PARTICLE VELOCITY LEVELS

HUMAN RESPONSE*

- Unbearable
- Insufferable
- Very Unpleasant
- Unpleasant
- Disturbing
- Definitely Detectable
- Detectable
- Barely Detectable
- Can Be Detected
- Detection Limit

PROBABILITY OF NO COMPLAINTS*



PROBABILITY OF COMPLAINTS*

COMMENTS**

- Concrete Block Foundations May Split
- Minor Falls of Plaster; Heavy Cracking of Plaster
- Minor Cracking of Plaster
- Safe Blasting Criterion For Residential Structures. Recommended by U.S. Bureau of Mines.
- Rigidly Mounted Mercury Switches Trip Out
- Threshold of Advising Population of Blasting: Structure Surveys Conducted

*VIBRA-TECH (1976) COMPILED FROM USBM DATA

**CANMET (1977)

Comment No. S5

4) Monitoring Plan

   a) Equipment to be used.

   b) Locations of readings to be taken.

   c) Schedule of monitoring.

   c) Schedule of monitoring.

   d) Review of data and reporting plan.

   e) Test shot plan, if it is proposed.

   There is a good chance that documented results of underground blasting with detailed measurements (not just physical human response) at similar sites could prove useful in evaluation of the potential for problems with seismic vibrations.

   By combining the results of a full-scale measurement, in similar geologic and ground water conditions, with theoretical or analytic computations, it is possible that there would be less need for a detailed experimental on-site measurement of vibrations and subsequent prediction of full-scale effects.

   While the exact mode of presentation of predicting seismic vibrations should not be spelled out, the mere indication of "no problem" on the basis of some opinions will not adequately provide the information needed to determine the human response to the proposed blasting operations.

A complete discussion of the above topics will permit evaluation of the potential seismic effects from the proposed operations.

Response:

Site area blast monitoring will be limited to verification of design parameters during initial construction and mine operation events.

Blasting events for which baseline monitoring will be conducted might logically include:

1) Initial bedrock blasting during shaft sinking.

2) Initial horizontal mine level development blasting adjacent to the shafts.

3) Early stope production shots.

4) Production blasting beneath the mine crown pillar late in the mine life.

Monitoring the surface effects of these unique events would verify blast design parameters and operational performance. Survey equipment might typically include portable velocity seismographs, air wave detectors and sound pressure instruments, in addition to conventional devices for measuring meteorological conditions. Data stations could reasonably be located at:

- Mine main shaft headframe.
- Mine west exhaust raise fan station.
- Plant access road - Swamp Creek bridge.
- Northwest shore of Little Sand Lake.

Results of special surface effects monitoring of construction phase or unique operations blasting events will be kept on file at the site. Where possible, this surface data will also be used to complement the routine underground blast safety and rock mechanics monitoring programs. As described in the response to comment No. S4, the surface impacts of underground development and/or production blasting at the Crandon site will likely be negligible.

Surface blast monitoring programs will be conducted primarily for engineering purposes, being routinely unnecessary for performance documentation.

EXXON MINERALS COMPANY

POST OFFICE BOX 813 • RHINELANDER, WISCONSIN 54501

January 4, 1985

DNR Reference: 1630

Responses to Noise and Seismic
Vibration Comments

Mr. Robert H. Ramharter
Department of Natural Resources
Bureau of Environmental Analysis and Review
EAR/3
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Madison, WI 53707

Dear Mr. Ramharter:

Enclosed are 40 copies of the responses to the DNR's Noise and Seismic Vibration comments contained in S. Druckenmiller's letter to B. Hansen dated December 28, 1984. These responses will be integrated into Chapter 4.0 of the revised EIR prior to printing. Responses to the remaining comments contained in the December 28, 1984 DNR letter will be included in a subsequent letter. A copy of these responses is also being provided to Terry McKnight at the North Central District office in Rhinelander.

Should you have comments on the responses, please contact me or Howard Lewis.

Very truly yours,

EXXON MINERALS COMPANY

Barry J. Hansen
Permitting Manager

BJH:ef

Enclosure (40)

xc/w/enclosure: S. Klafka, DNR-Madison
T. McKnight, DNR-NCD

Noise and Seismic Vibration

Comment No. 1

Our consultants have recently completed their review of your October 31, 1984 letter "Responses to July 9, 1984 DNR comments on the Noise Reports". Their review indicates the responses on noise are adequate for the DEIS. However, additional information is needed for the seismic vibration analyses.

Response: Comment acknowledged.

Comment No. 2

The analysis method is depicted on p. 61 of the October 31, 1984 responses. While the method is correct, its application is not. It is assumed that blast vibrations will travel in a straight line from the point of explosion to the ground level receptor. In fact, vibrations move a greater distance through the bedrock before traveling through the overburden. This causes surface vibrations to be greater than predicted using Exxon's approach. Since off-site vibrations were shown to be detectable, the analysis should be adjusted to account for this phenomenon. This subject is discussed further in "Vibrations of Soils and Foundations" by Ricardi.

Response:

Projected blast vibrations have been recalculated using a bilinear shock wave path as illustrated in the attached Figure 1. The resulting calculated ground surface peak particle velocities (PPV) for four cases of production blasting, on the 95 m, 140 m, 290 m, and 640 m mining levels, are presented on attached Figures 2 through 9 as both linear and log-log relationships. Previously calculated PPV for shaft sinking operations showed values well below the detectable limit of 0.89 mm/s (0.035 inches/second) at distances exceeding 500 m (1,640 feet). These values were confirmed using the bilinear approach for the same distance and are presented below:

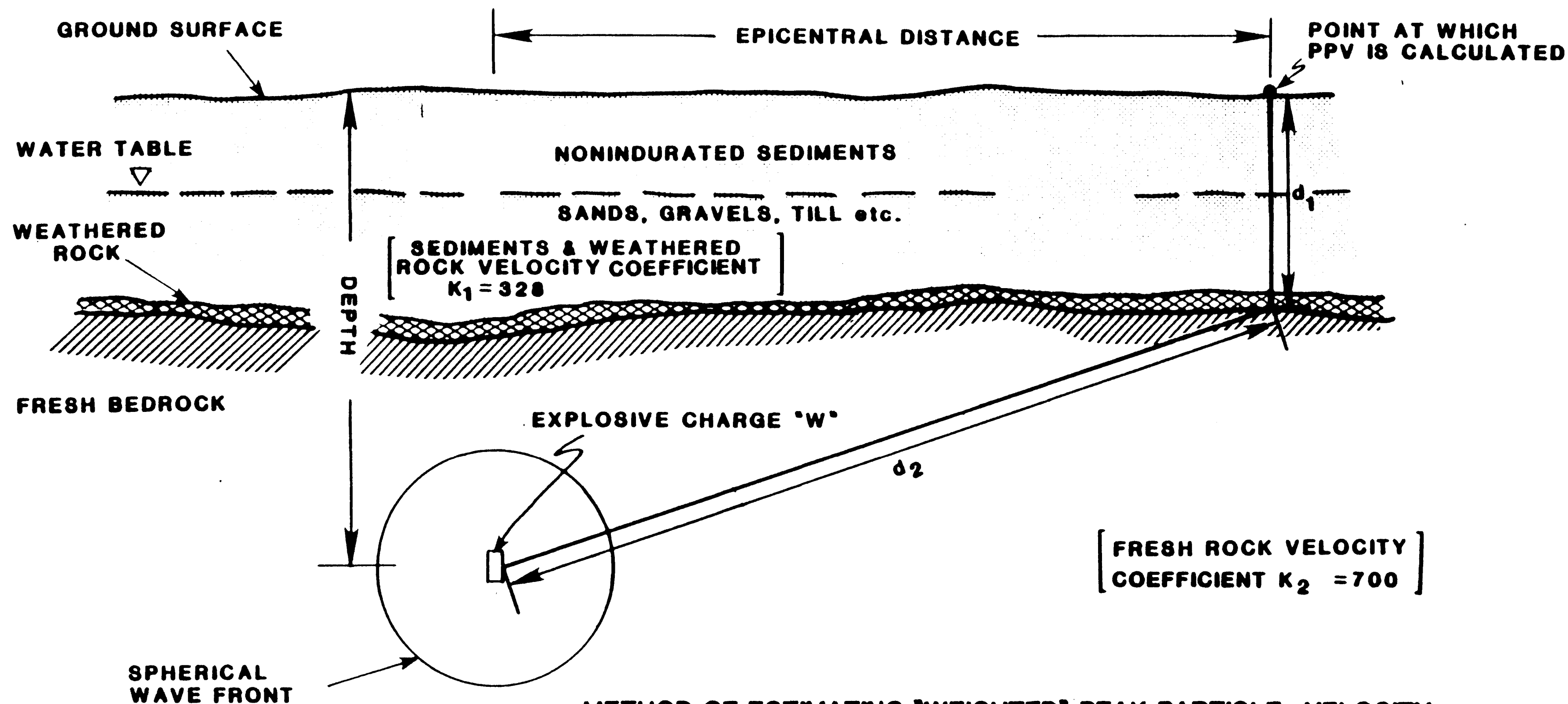
Structure	Delay Charge Wt-Kg.	PPV -mm/s (inches/second)
Intake Air Shaft	Max. - 88	0.503 (0.02)
	Min. - 11	0.11 (0.004)
Main Shaft	Max. - 88	0.501 (0.02)
	Min. - 11	0.109 (0.004)

Comment No. 3

The analysis predicted blasting vibrations within 1/2 mile from the point of the blast. At 2,500 feet from the surface point above the blast, vibrations were predicted to be 0.14 to 0.26 inches per sec (peak particle velocity). This is well above the detection limit of 0.035 in/sec shown in Figure No. 8 on p. 70. Exxon should extend the analysis to a distance where blast vibrations are still detectable, as this may include nearby residences.

(FIGURE 1 FOR THE RESPONSE TO COMMENT NO. 2)

CRANDON BLASTING VIBRATION ESTIMATE
PEAK PARTICLE VELOCITY MODEL



METHOD OF ESTIMATING "WEIGHTED" PEAK PARTICLE VELOCITY

$$\text{PEAK PARTICLE VELOCITY (PPV)(mm/sec)} = (1.8)\left[\frac{d_1}{R}K_1 + \frac{d_2}{R}K_2\right]\frac{W^{\alpha}}{R^{\beta}}$$

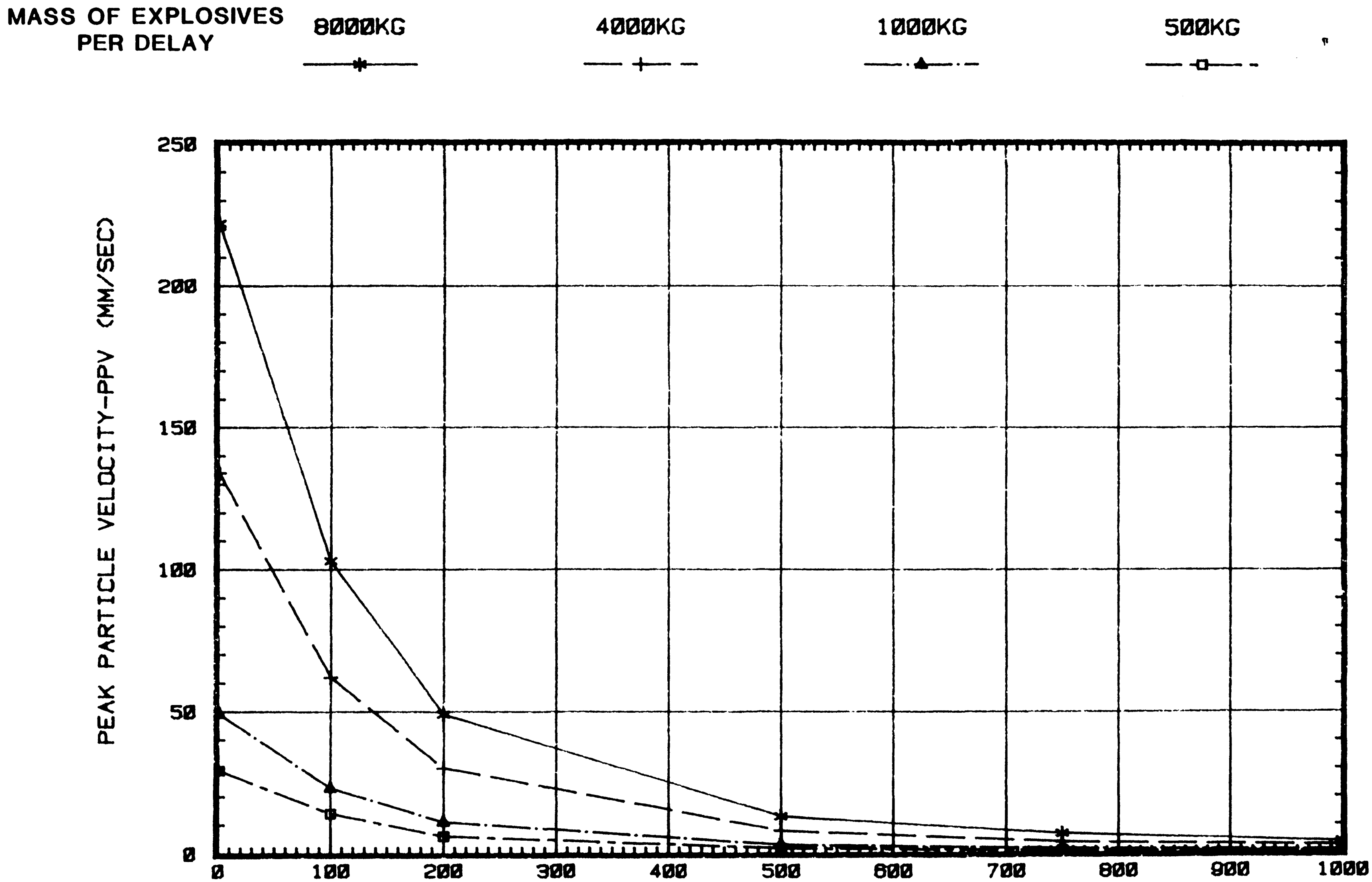
WHERE:

K_1 = VELOCITY COEFFICIENT FOR NON-INDURATED SEDIMENTS (328)
K_2 = VELOCITY COEFFICENT FOR FRESH ROCK (700)
d_1 = DISTANCE WAVE FRONT TRAVELS IN NON-INDURATED SEDIMENTS, (m)
d_2 = DISTANCE WAVE FRONT TRAVELS IN FRESH ROCK(m)
R = $d_1 + d_2$ IN METERS
W = CHARGE WEIGHT (kg)
$\alpha = 0.73$ $\beta = 1.75$

(FIGURE 2 FOR THE RESPONSE TO COMMENT NO. 2)

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES



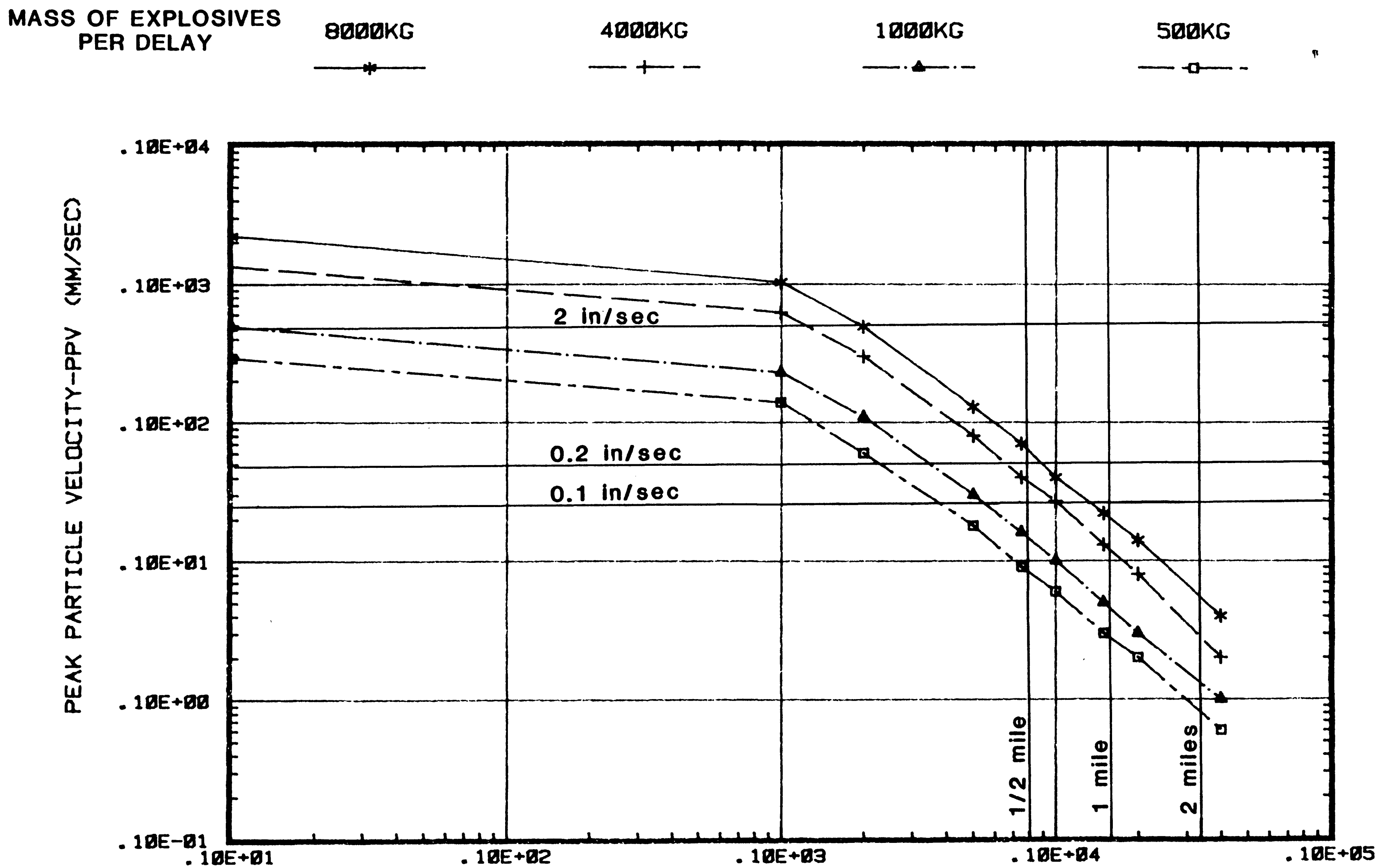
EPICENTRAL DISTANCE FROM BLAST IN METERS

95M LEVEL PRODUCTION BLASTING

(FIGURE 3 FOR THE RESPONSE TO COMMENT NO. 2)

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES

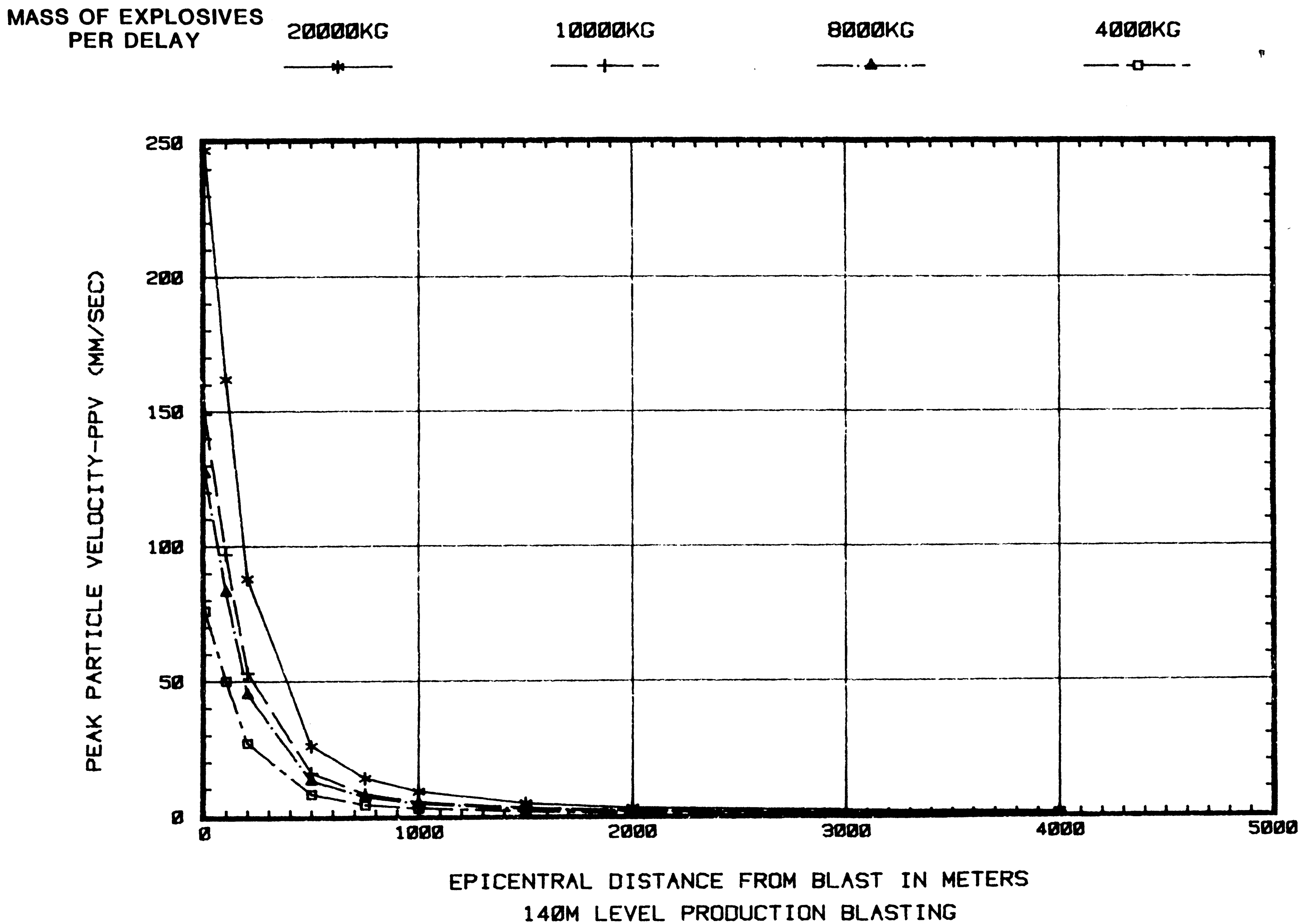


EPICENTRAL DISTANCE FROM BLAST IN METERS
95M LEVEL PRODUCTION BLASTING

(FIGURE 4 FOR THE RESPONSE TO COMMENT NO. 2)

CRANDON PROJECT

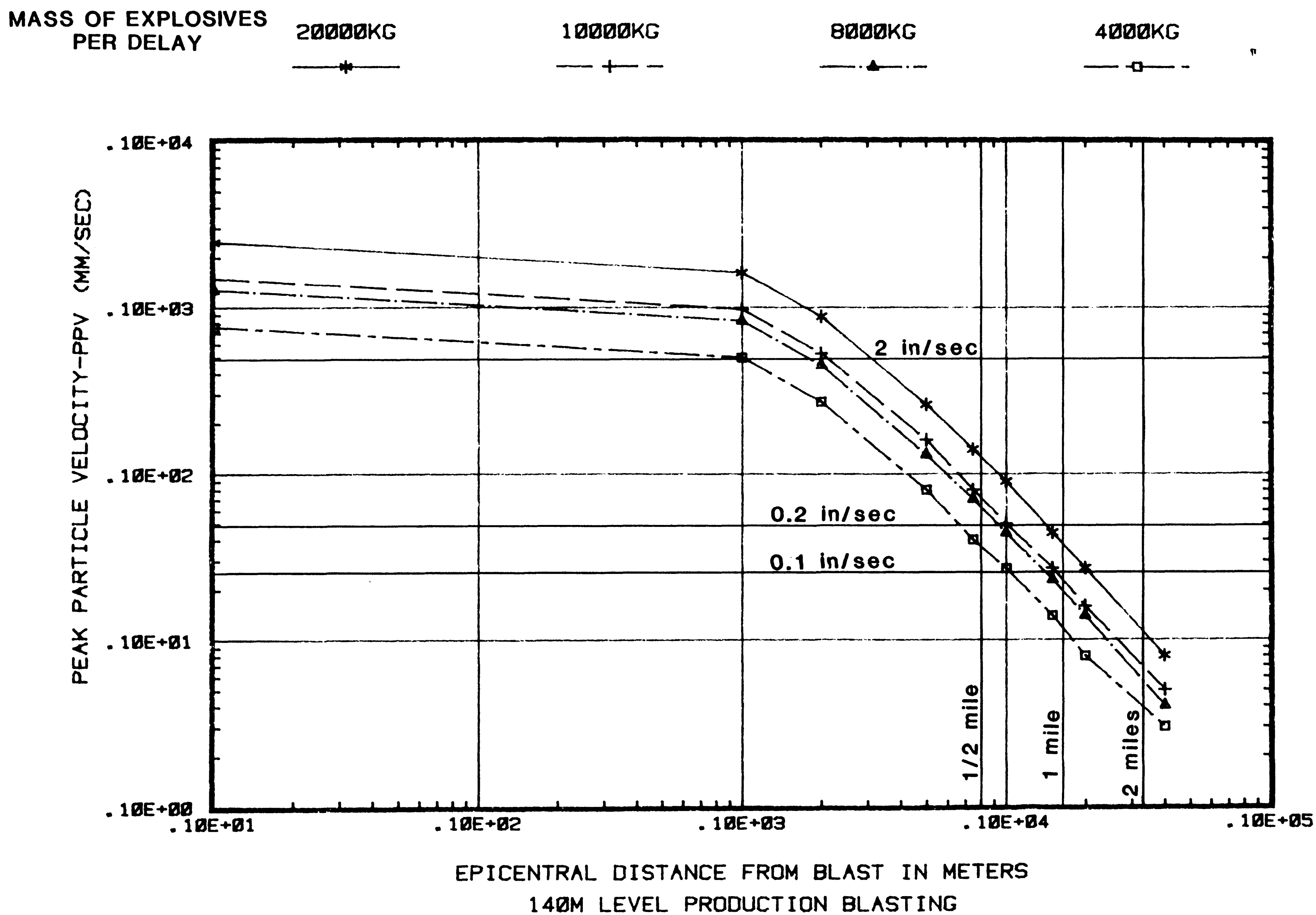
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES



(FIGURE 5 FOR THE RESPONSE TO COMMENT NO. 2)

CRANDON PROJECT

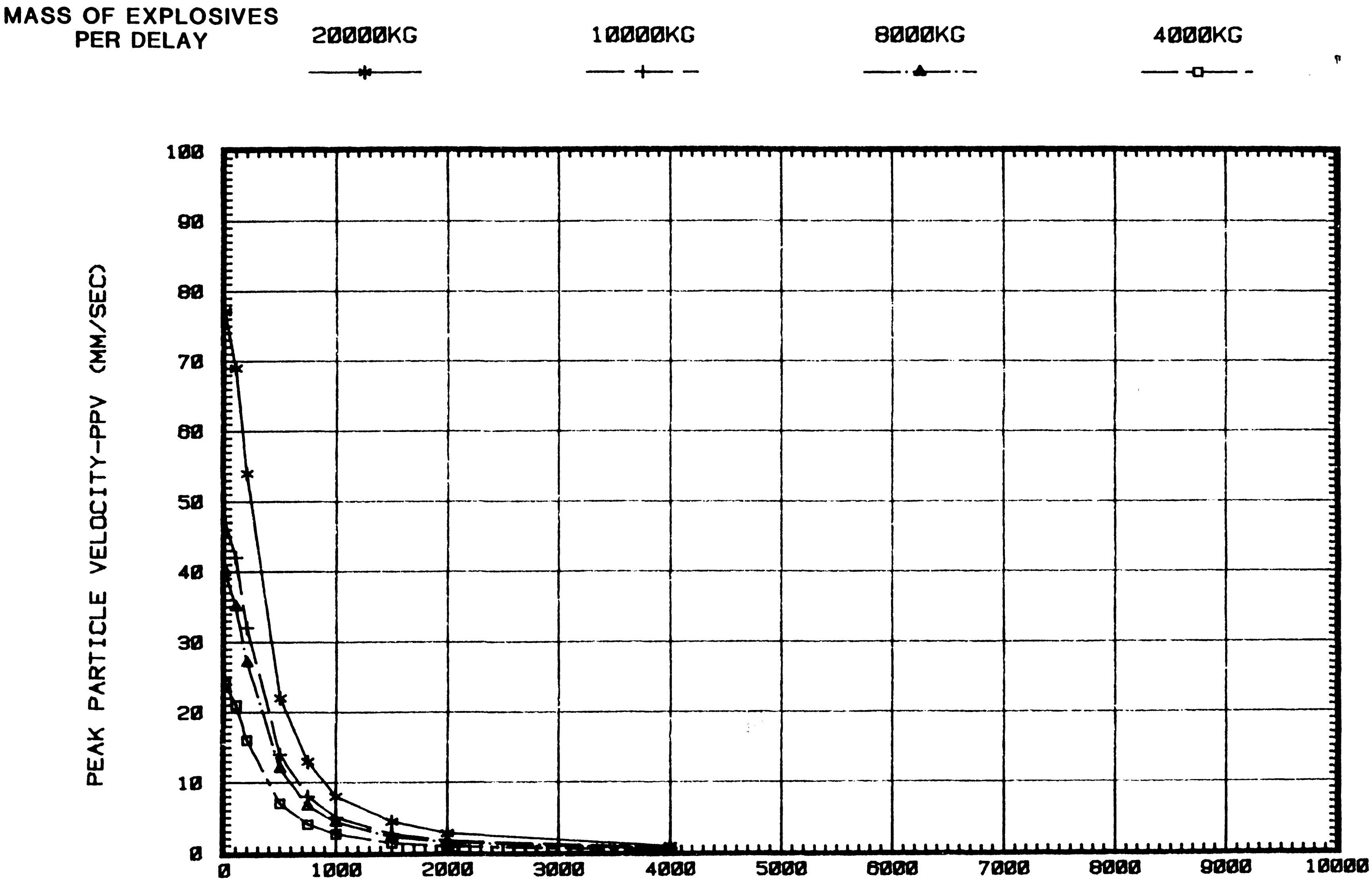
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES



(FIGURE 6 FOR THE RESPONSE TO COMMENT NO. 2)

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES



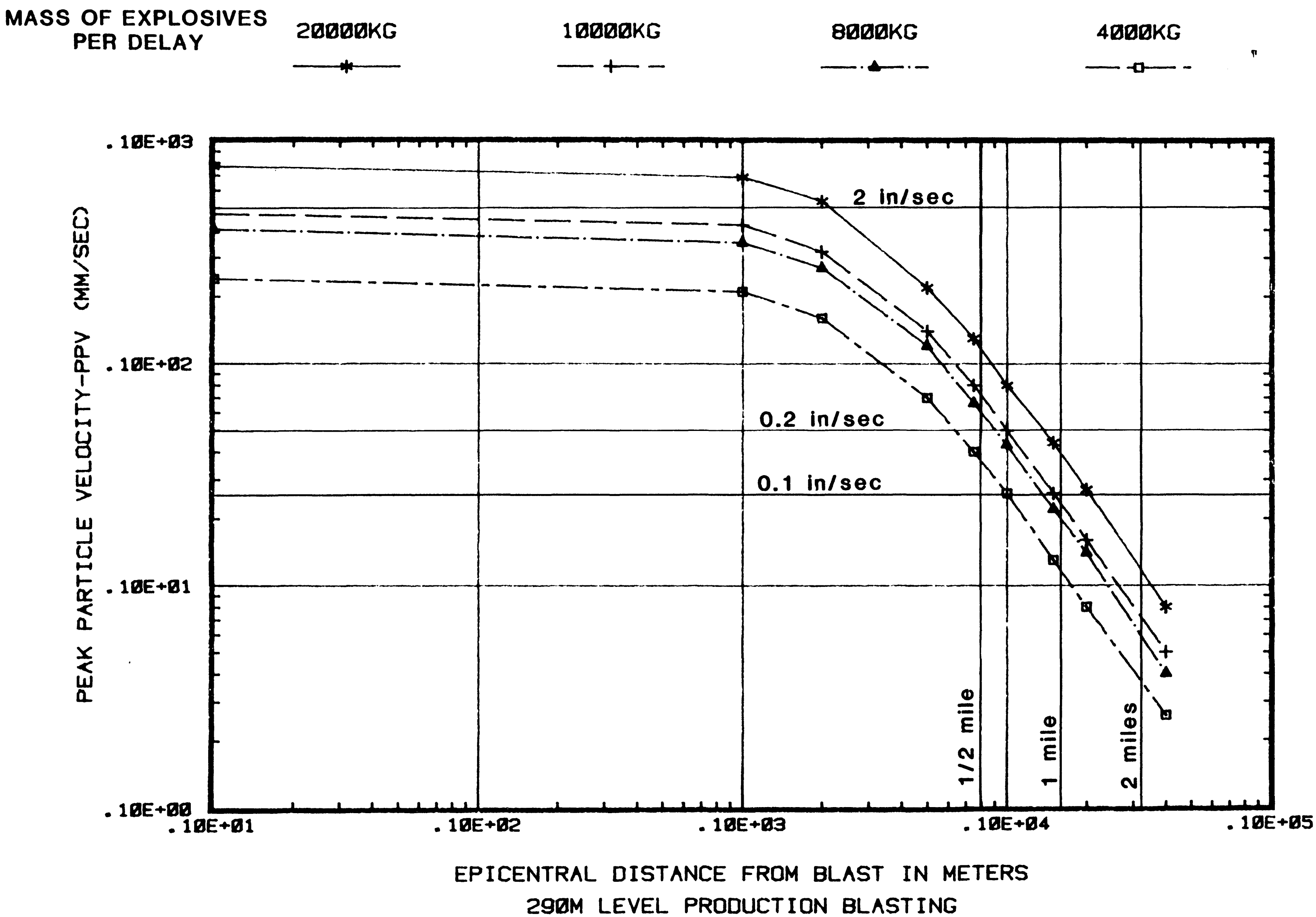
EPICENTRAL DISTANCE FROM BLAST IN METERS

290M LEVEL PRODUCTION BLASTING

(FIGURE 7 FOR THE RESPONSE TO COMMENT NO. 2)

CRANDON PROJECT

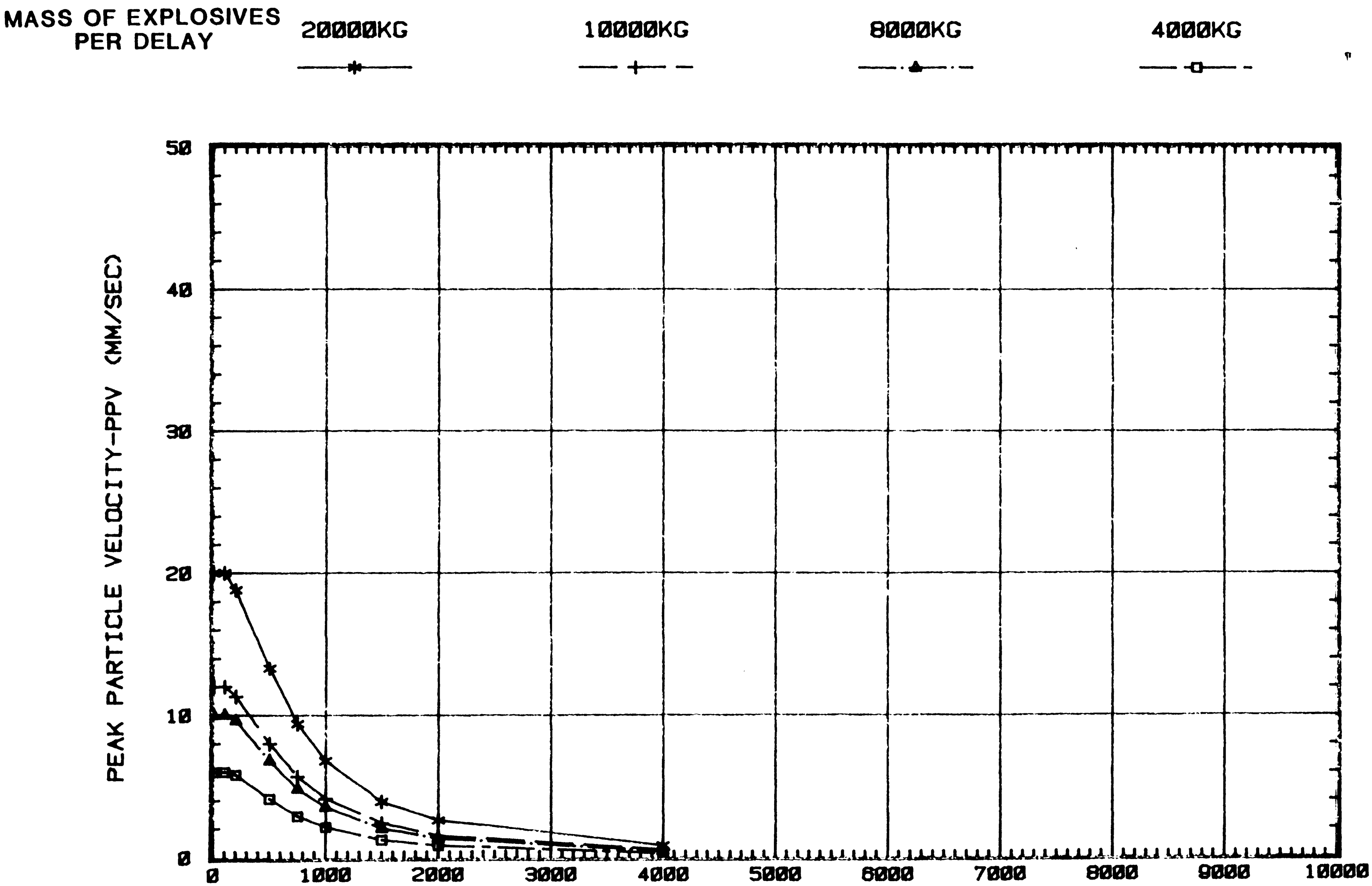
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES



(FIGURE 8 FOR THE RESPONSE TO COMMENT NO. 2)

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES

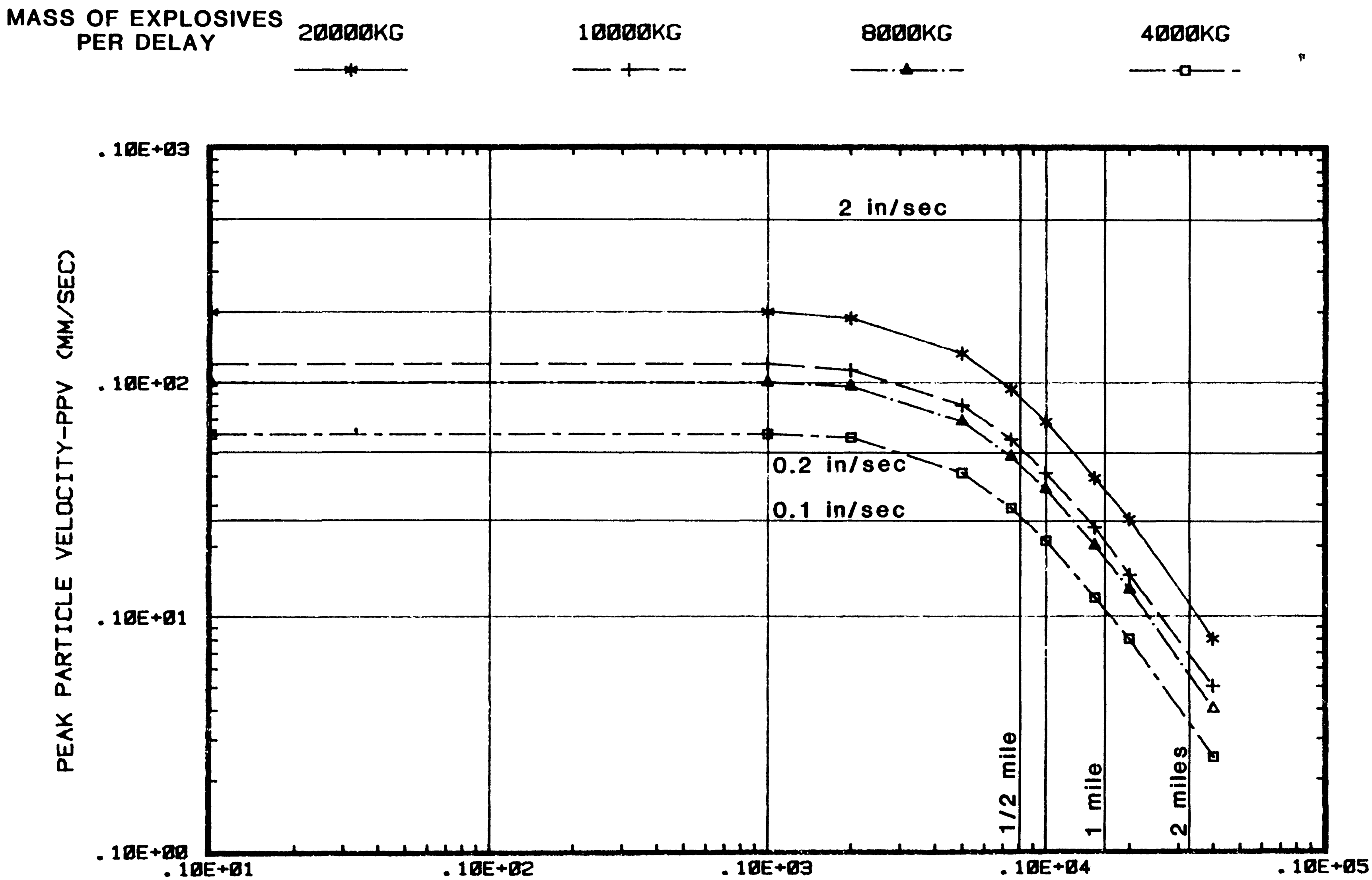


EPICENTRAL DISTANCE FROM BLAST IN METERS
640M LEVEL PRODUCTION BLASTING

(FIGURE 9 FOR THE RESPONSE TO COMMENT NO. 2)

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES



EPICENTRAL DISTANCE FROM BLAST IN METERS
640M LEVEL PRODUCTION BLASTING

Response:

The estimated ground surface peak particle velocities presented on Figures 2 through 9 in the response to comment No. 2 cover a wide range of cases for both blast depth and delay charge weight. Actual mine development or production blast design during operations will be such that the safety of mine surface facilities will be insured. With this in mind, blast design will limit PPV directly over the mine site to less than 50.8 mm/s (2.0 inches/second). As indicated on Figures 2 through 9, the calculated site responses for some of the delay sizes evaluated would result in PPV in excess of the imposed limit of 50.8 mm/s (2.0 inches/second). For the conditions assumed in predicting site response, higher delay charge weights would be unacceptable and not used for an underground blast.

Using the 50.8 mm/s (2.0 inches/second) as a limiting threshold, blast designs producing PPVs directly above the blast exceeding this threshold are meaningless. For acceptably designed blasts/delay, using the 50.8 mm/s (2.0 inches/second) design criteria, PPVs at a radius of 805 m (0.5 mile) or greater are generally less than 5.1 mm/s (0.2 inches/second) (Figures 2 through 9) or in the range defined on attached Figure 1 as between detectable and barely detectable. At a distance of 1,610 m (1 mile), predicted PPVs are below the barely detectable level of 2.5 mm/s (0.1 inches/second).

Comment No. 4

Figures 2 through 7 on pp. 64-69 display the analysis results. The scale of the figures accommodates the high level of vibrations occurring near the point of a blast, obscuring the detectable vibrations that are greater distances away. The scale should be adjusted so the peak particle velocities off-site are clearly visible. This may also be solved by the use of log-log scale figures.

Response:

Curves have been replotted showing recalculated PPVs on both linear and log-log formats (see Figures 2 through 9 in the response to comment No. 2).

Comment No. 5

Figure No. 8 on p. 70 indicates that structure surveys should be conducted when vibrations exceed 0.2 in/sec. Predicted vibrations at 1/2 mile exceed this criteria. Exxon should expand the area of the pre-blast survey beyond the proposed 1/2 mile to include those structures which will experience vibrations above 0.2 in/sec.

Response:

The calculated PPVs presented herein are theoretical using assumed site response parameters. Blast performance monitoring will be conducted during early site development associated with shaft sinking and early mining activities in order to allow the formulation of site specific response parameters. Design of actual production blasts will be based on the actual field data while maintaining the 50.8 mm/s (2.0 inches/second)

(FIGURE 1 FOR THE RESPONSE TO COMMENT NO. 3)

CRANDON BLASTING VIBRATION ESTIMATE

GENERAL HUMAN & STRUCTURAL RESPONSE TO PEAK PARTICLE VELOCITY LEVELS

HUMAN RESPONSE*

nbearable

nsufferable

ery Unpleasant

npleasant

isturbing

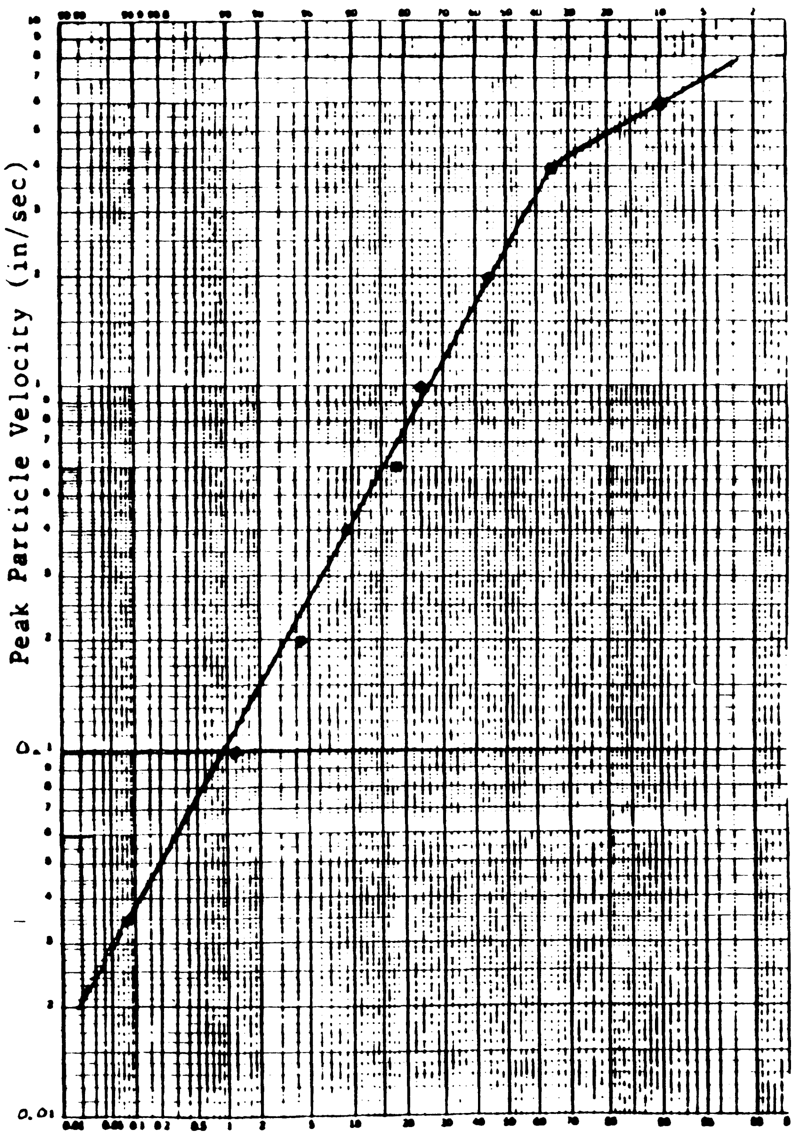
efinitely Detectable

etectable

arely Detectable

an Be Detected
etection Limit

PROBABILITY OF NO COMPLAINTS*



PROBABILITY OF COMPLAINTS*

COMMENTS**

Concrete Block Foundations May Split

Minor Falls of Plaster; Heavy Cracking of Plaster

Minor Cracking of Plaster

Safe Blasting Criterion For Residential Structures. Recommended by U.S. Bureau of Mines.

Rigidly Mounted Mercury Switches Trip Out

Threshold of Advising Population of Blasting: Structure Surveys Conducted

*VIBRA-TECH (1976) COMPILED FROM USBM DATA

**CANMET (1977)

design criteria for protection of the immediate surface facilities. Site response is anticipated to be similar to that shown on Figures 2 through 9 in the response to comment No. 2, such that barely noticeable effects will be produced beyond an 805-m (0.5-mile) radius of any blast.

Comment No. 6

The analysis shows blast vibrations are likely to be detectable off-site. Exxon should discuss alternatives dealing with complaints from nearby residents. This should include alternatives available to reduce off-site vibrations such as increasing the number of delays, decreasing the size of the charges, and changing the time when blasting occurs.

Response:

With consideration to responses to comments No. 1-4 above, the analyses show reduced likelihood of off-site detectable blast vibrations.

Comment No. 7

Has a plan been developed for monitoring surface level vibrations when blasting begins? If so, this should be submitted. Otherwise, a blast vibration monitoring plan should be developed.

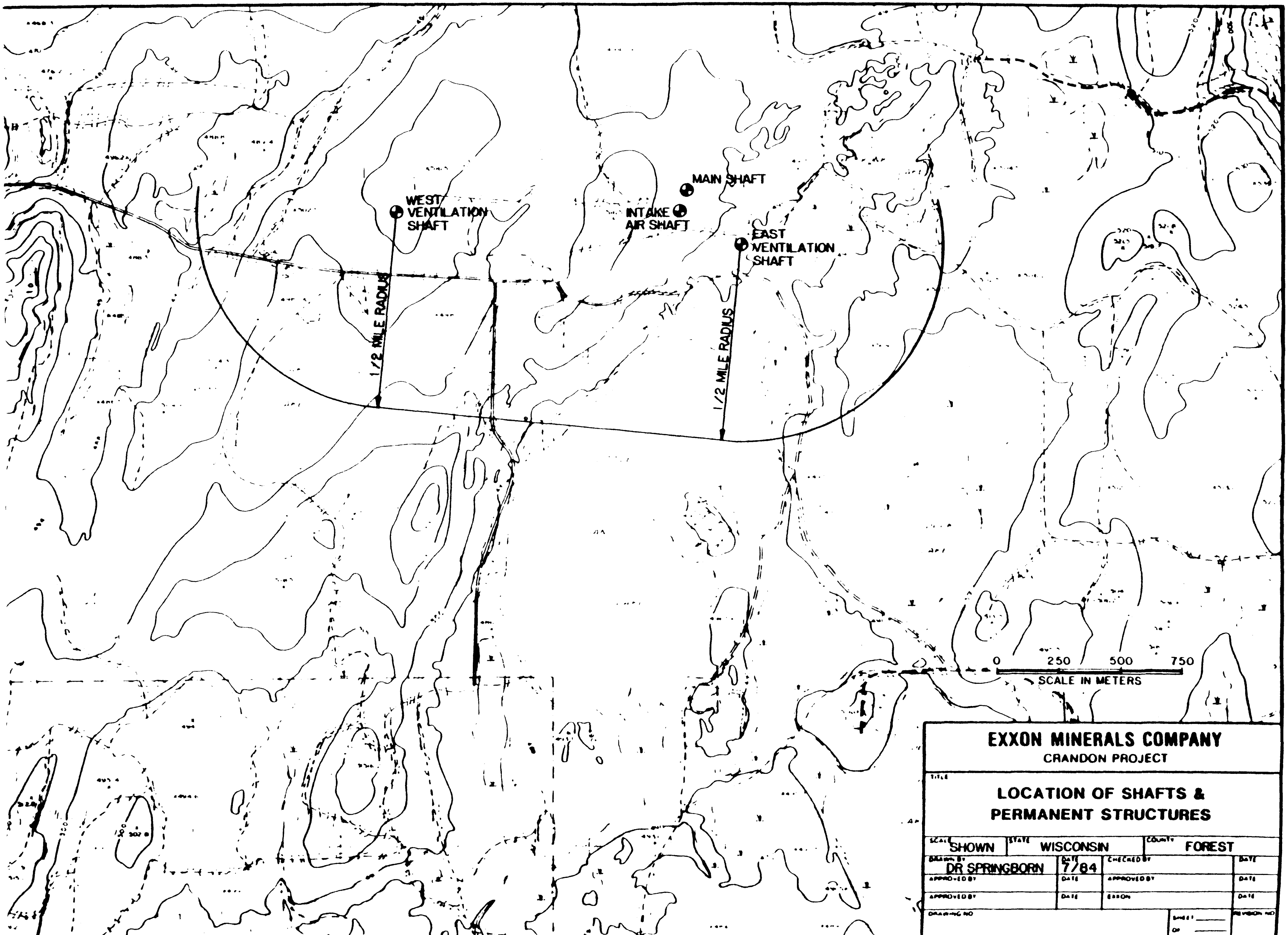
Response:

A description of the proposed blast monitoring plan was previously provided in the response to DNR comment No. 45 on the Mining Permit Application (letter from B. Hansen, EMC, to G. Reinke, DNR, dated July 31, 1984). Also, the blast monitoring plan was described in the response to comment No. S5 on the noise reports (letter from B. Hansen, EMC, to R. Ramharter, DNR, dated October 31, 1984). The proposed blast monitoring plan, as presented in EMC's response to comment No. 45 on the Mining Permit Application, is repeated below.

BLAST MONITORING PLAN

Site blast monitoring will be limited to verification of design parameters during initial construction and mine operation events. Modern blasting agents and delayed initiation techniques will be employed as required by site conditions to control blast vibration and overpressure. All blasts will be designed to preclude damaging seismic, air blast, or noise effects immediately adjacent to all four mine openings to the surface (see attached Figure 1). Such protection of site personnel and physical facilities implies that off-site blast effects will be well below annoyance levels, if not totally imperceptible.

(FIGURE 1 FOR THE RESPONSE TO COMMENT NO. 7)



Blasting events for which baseline monitoring will be conducted might logically include:

- Initial bedrock blasting during shaft sinking.
- Initial horizontal mine level development blasting adjacent to the shafts.
- Early stope production shots.
- Production blasting beneath the mine crown pillar late in the mine life.

Monitoring the surface effects of these unique events would verify blast design parameters and operational performance. Survey equipment might typically include portable velocity seismographs, air wave detectors and sound pressure instruments, in addition to conventional devices for measuring meteorological conditions. Data stations could reasonably be located at:

- Mine main shaft headframe.
- Mine west exhaust raise fan stations.
- Plant access road - Swamp Creek bridge.
- Northwest shore of Little Sand Lake.

Results of special surface effects monitoring of construction period or unique operations blasting events will be kept on file at the site. Where possible, this surface data will also be used to complement the routine underground blast safety and rock mechanics monitoring programs. As described in the previous responses, the surface impacts of underground development and/or production blasting at the Crandon site will likely be negligible. Surface blast monitoring programs will be conducted primarily for engineering purposes, being routinely unnecessary for performance documentation.