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State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

BOX 7921
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April 16, 1984

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Dear Librarian:

Please place the enclosed document (Comments on Prickett's Mine Inflow Model as Documental in "Ground Water Inflow Model for the Proposed Crandon Mine" by Dr. Mary P. Anderson, August 1983, revised February 1984) along with the Exxon Environmental Impact Material (EIR).

Thank you for your assistance.

Sincerely,
Bureau of Environmental Impact

Carol Nelson

Carol Nelson
Environmental Specialist

CN/bjb
Enc.

COMMENTS ON PRICKETT'S MINE INFLOW MODEL AS DOCUMENTED IN "GROUND WATER INFLOW MODEL FOR THE PROPOSED CRANDON MINE"

COMMENTS PREPARED BY

DR. MARY P. ANDERSON

AUGUST 1983

REVISED FEBRUARY 1984

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Prickett's mine inflow model consists of a two-dimensional horizontal flow model of the glacial aquifer linked to a three-dimensional flow model of the orebody. The two-dimensional flow model was constructed so that parameters and boundary conditions are consistent with D'Appolonia's flow model. I have provided comments on D'Appolonia's flow model in a separate report. In reviewing Prickett's mine inflow model attention will focus on:

I. Orebody Model

II. Resistive Layer (the interface between the orebody and the glacial aquifer)

III. Glacial Aquifer Model

IV. Transient Model Calibration

V. Sensitivity Analysis

I. OREBODY MODEL

A. HYDRAULIC CONDUCTIVITY:

1. Estimates of the hydraulic conductivity of the orebody are given in Table 4.2 of Golder's Geohydrologic Characterization Report (p.46). Prickett used the designation of weak to strong zones of hydraulic conductivity that are established in Golder's Table 4.2 to provide a relative ranking of four hydraulic conductivity values for his model. Absolute values for the hydraulic conductivity of the orebody were determined by model calibration.

The final calibrated hydraulic conductivity values used in the mine inflow model (p. 49) are each about an order of magnitude higher than the values listed in Golder's Table 4.2. Hydraulic conductivity values reported in Table 4.2 were obtained from falling head tests (p. 81 of the Geohydrologic

Characterization Report). However, no details are given regarding the way in which the tests were conducted. For example, were these field or laboratory tests? EXXON SHOULD PROVIDE DETAILS REGARDING THE WAY IN WHICH THE FALLING HEAD TESTS WERE CONDUCTED.

2. Because the measured values for hydraulic conductivity of the orebody are point values and therefore have limited usefulness, hydraulic conductivities for use in the modeling effort were estimated by model calibration to pumping tests. Hence, the validity of these values depends on the validity of the model and the model calibration. Moreover, the selection of values of hydraulic conductivity for the orebody depends on the values selected for other model parameters, in particular the hydraulic conductivity of the resistive layer. Therefore, the subject of hydraulic conductivity will be addressed again later in this report under the discussions of the resistive layer and the transient calibration.

B. STORAGE COEFFICIENT: According to the numbers shown in Fig. 3.14, the pumping test analysis for well 210 gives a value of 0.00039 (4E-4) for the storage coefficient of the orebody. This apparently is an error; my calculations show that this value should be 4E-5. The value of storage coefficient determined from calibration of the mine inflow model (1E-5) is in the same order of magnitude.

1. According to Prickett's interpretation (Fig. 4.2), during mining the potentiometric surface in the orebody will drop below the base of the resistive layer, which acts as a leaky confining bed. When this happens the orebody will respond as an unconfined aquifer and there will be an unsaturated zone between the orebody and the resistive layer. When the

orebody converts to unconfined conditions, the storage coefficient is assumed to increase to 0.005. The unconfined storage coefficient was not adjusted during model calibration. THE BASIS FOR THE CHOICE OF 0.005 IS UNCLEAR. According to Prickett (p. 63), there are three sources of mine inflow: the water that drains down from the glacial aquifer, the water released from storage within the confined orebody and "The third source is that water resulting from drainage of the orebody. Presently there are some data on the orebody drainage characteristics. The aforementioned flow estimates are based upon a gravity drainage coefficient of approximately 0.005." EXXON SHOULD PROVIDE THE DATA ON THE "OREBODY DRAINAGE CHARACTERISTICS" AND SHOW HOW A STORAGE COEFFICIENT OF 0.005 FOR UNCONFINED CONDITIONS WAS DERIVED.

2. Storage coefficient values do not affect the steady state solution. However, the magnitude of the storage coefficient does influence the length of time needed to reach steady state. Larger values of storage coefficient would increase the time to steady state. HENCE, CHOICE OF STORAGE COEFFICIENTS COULD SIGNIFICANTLY CHANGE THE PREDICTED FLOW RATES IN THE INITIAL STAGES OF MINING. AN ANALYSIS OF THE SENSITIVITY OF THE PREDICTED FLOW RATES TO CHANGES IN STORAGE COEFFICIENTS IS NEEDED. See the discussion under Section V below.

C. BOUNDARY CONDITIONS: The sides and bottom of the orebody were assumed to be impermeable. The top of the orebody is connected to the glacial aquifer through the so-called "resistive layer". The validity of this top boundary condition will be discussed below under Section II. The side and bottom boundaries are discussed below.

1. The orebody apparently has much more intrinsic permeability than the surrounding bedrock and on this basis the sides and bottom of the orebody were assumed to be impermeable. EXXON SHOULD PROVIDE A DISCUSSION OF THE DATA ON THE HYDRAULIC CONDUCTIVITY AND FRACTURE DENSITY IN THE BEDROCK SURROUNDING THE OREBODY WHICH JUSTIFY THIS ASSUMPTION.

2. Water is held in storage in the orebody and it is unlikely that this water is static. Prickett's Fig. 4.2 suggests that under pre-mining conditions the potentiometric surface in the glacial aquifer is higher than water levels in the orebody. Hence, there is the potential for downward flow of water from the glacial aquifer to the orebody. Presumably this water must flow back upward into the glacial aquifer if the country rock is impermeable. A THREE-DIMENSIONAL MODEL SHOULD BE USED TO SIMULATE THE CURRENT THREE-DIMENSIONAL REGIONAL FLOW FIELD THROUGH THE OREBODY.

If fractured, the country rock could have significant secondary permeability. Fractures in the country rock could be connected to the glacial aquifer and there could be flow of water from the glacial aquifer through fractures in the bedrock and through the sides of the orebody. Hence, the sides of the orebody may not be impermeable. THE THREE-DIMENSIONAL FLOW MODEL SHOULD INCLUDE PART OF THE COUNTRY ROCK SO THAT THE FEASIBILITY OF FLOW THROUGH THE SIDES (AND BOTTOM) OF THE OREBODY CAN BE TESTED.

D. WATER BALANCES: In Appendix Q it is said that the water balance for the orebody model is within -100% (e.g., p. Q-20). It is not clear what is meant by this. Water balances are usually within 1%. EXXON SHOULD PROVIDE COMPLETE DOCUMENTATION REGARDING THE WAY IN WHICH THE WATER BALANCE FOR THE OREBODY

MODEL WAS COMPUTED. WATER BALANCES FOR ALL RUNS SHOULD BE TABULATED SEPARATELY FROM OTHER MODEL OUTPUT.

II. RESISTIVE LAYER

Based on analysis of pumping test data, Prickett believes that there is a layer of low permeability separating the orebody from the glacial aquifer, which he calls the resistive layer. In fact, the assumption that such a layer exists is necessary in order to couple the orebody model to the model of the glacial aquifer. In the model, the resistive layer is treated as a leaky confining layer through which water flows from the source bed (the glacial aquifer) to the main aquifer, which in this case is the orebody.

A. GEOLOGIC EVIDENCE FOR THE EXISTENCE OF THE RESISTIVE LAYER: The geologic basis Prickett used to define his four zones of relative hydraulic conductivity for the resistive layer (Fig. 3.5) is discussed in the Geohydrologic Characterization Report (p. 79-86). The resistive layer is envisioned to include part of the glacial drift or till and part of the orebody subcrop. The cross sections shown in Fig. 6.1 as well as Fig. 6.3 of the Geohydrologic Characterization Report suggest that in Prickett's areas #3 and #4 there is a layer of low permeability beween the coarse-grained stratified drift and the orebody, which could act as a leaky confining bed. However, geologic evidence suggests that a physically real layer of low permeability between the orebody and the aquifer does not exist in areas #1 and #2.

Moreover, the total thickness of the resistive layer is unknown. For convenience in modeling, Prickett assumed that the layer is 1 ft thick. The thickness is immaterial for modeling purposes because the transmission property of the resistive layer in the model is defined by K/b, i.e., the hydraulic conductivity (K) divided by the thickness (b). If in fact the resistive layer is thicker than 1 ft, the hydraulic conductivity values assigned to the layer during model calibration would be higher, but the ratio of K to b would not change. However, because the thickness of the resistive layer is unknown it is impossible to judge whether the calibrated K values are reasonable. See section II.C below.

The geologic evidence to support the existence of a resistive layer, as presented in the Geohydrologic Characterization Report is sketchy. In fact, the data suggest that a physically real layer of low permeability does not exist in areas #1 and #2 of the mine inflow model. Very little seems to be known about the properties of the resistive layer. Yet, Prickett implies (p. 83) that the properties of the resistive are critical in predicting mine inflow rates: "...the mine inflows are directly proportional to resistive layer area and permeability while being inversely proportional to layer thickness." EXXON SHOULD PROVIDE DETAILED GEOLOGIC INFORMATION TO JUSTIFY THE EXISTENCE OF A RESISTIVE LAYER AND SHOULD PROVIDE A DETAILED SUMMARY OF ANY GEOLOGIC INFORMATION THAT CAN BE USED TO ESTIMATE THE PROPERTIES (THICKNESSES, AREAS, AND HYDRAULIC CONDUCTIVITES) OF THE RESISTIVE LAYER. FIGURES 6.2-6.4 IN THE GEOHYDROLOGIC CHARACTERIZATION REPORT ARE INADEQUATE FOR THIS PURPOSE. FIG. 3.5 IN PRICKETT'S REPORT IS EXTREMELY DIFFICULT TO DECIPHER AND SHOULD BE REPLACED BY A LARGER, LESS CLUTTERED FIGURE.

B. HYDROLOGIC EVIDENCE FOR THE EXISTENCE OF THE RESISTIVE LAYER: Prickett presents what he believes to be hydrologic evidence for the existence of a resistive layer in the form of a drawdown curve for observation well 210 obtained during a pumping test of well 213 in the orebody (Fig. 3.14). Prickett states that he performed an analysis of this test using image well theory. Fig. 3.12 shows the locations of his image wells based on the use of three impermeable boundaries (the sides and bottom of the orebody) and one constant head boundary (the glacial aquifer). This configuration of image wells can be rationalized by recognizing that the pumping well in the orebody is a horizontal well.

1. Prickett used the type curve shown in Fig. 3.13 to analyze the pumping test results. This type curve can be used directly only if the test is affected by only one boundary--either one recharge boundary or one impermeable boundary. It is not clear whether the drawdown curve in Fig. 3.14 represents raw data or whether the data have been corrected for the effects of the impermeable boundary. It is necessary to separate out the effects of the impermeable boundaries before applying a type curve analysis based on Fig. 3.13. Presumably this is what Prickett did but did not document the separation procedure in the report. EXXON SHOULD PROVIDE COMPLETE DETAILS REGARDING THE IMAGE WELL ANALYSIS PERFORMED BY PRICKETT. SPECIFICALLY THE WAY IN WHICH THE EFFECTS OF THE IMPERMEABLE BOUNDARIES WERE FILTERED FROM THE DRAWDOWN CURVE SHOWN IN FIG. 3.14 SHOULD BE DOCUMENTED.

2. Prickett assumed that the glacial aquifer acts like a recharge boundary. The usual recharge boundary is a stream and the type curve in Fig. 3.13 is generally applied when the "recharging image" is a stream. In the usual application of image well analysis, the location to the stream is predicted and if the predicted location of the stream is farther from the well than in reality, the existence of a layer of low permeability sediments between

the stream and the aquifer is postulated. Prickett found that his analysis predicted that the recharging image well was located above the land surface. Since this is clearly impossible he introduced the resistive layer to explain why the source of water appeared to be farther away than it actually is.

However, a stream, as used in the standard application of image well analysis, has no intrinsic hydraulic resistence, while the glacial aquifer does. The resistence to flow predicted by Prickett's analysis may be merely indicative of the natural resistence to flow through the glacial aquifer itself. I DO NOT BELIEVE THAT THE IMAGE WELL ANAYLSIS DEMONSTRATES THE EXISTENCE OF A RESISTIVE LAYER. EXXON SHOULD PROVIDE ADDITIONAL COMMENTS ON THE VALIDITY OF THIS TECHNIQUE FOR THE CRANDON SITUATION. FURTHERMORE, DRAWDOWN DATA FOR OTHER PUMPING TESTS IN THE OREBODY SHOULD BE PROVIDED AND ANALYZED IN THE CONTEXT OF PROVING THE EXISTENCE OF A RESISTIVE LAYER.

C. CALIBRATED VALUES FOR THE TRANSMISSION CHARACTERISTIC (K/b) OF THE RESISTIVE LAYER: The final calibrated parameter values for the mine inflow model are given in Table 3.3 (p. 49). The second column in this table is labelled "Calibrated Value (cm/sec)". Apparently these values are the hydraulic conductivities (K) of the resistive layer, assuming that b is equal to 1 ft.

The hydraulic conductivies of the resistive layer determined by model calibration are the same as or lower than the calibrated value for the hydraulic conductivity of the "light relative permeability" zone of the orebody and are in the middle range of values recommended for glacial till in Freeze and Cherry (1979) and toward the middle to low end of the range of values for till found at the Crandon site (Table A-3 of Appendix 4.1A). However, these comparisons are meaningful only if the resistive layer is in fact 1 foot thick. If the resistive layer is thicker than 1 foot, the calibrated hydraulic conductivities for the resistive layer would be larger.

Another complication is that according to Prickett (p. 86), the resistive layer also provides a way of incorporating three-dimensional effects, caused by stratification of the glacial aquifer, into the model. Specifically, the low permeability of the resistive layer is said to simulate the greater resistence to vertical flow in the glacial aquifer above the mine site during dewatering.

Because of the combination of things supposedly accounted for by the resistive layer, it is difficult to compare the values of K specified for the resistive layer to physically meaningful hydraulic conductivities. The K/b factors supposedly account for the physically real resistence to flow at the orebody subcrop and act as correction factors to account for the fact that the two-dimensional areal view model of the glacial aquifer cannot directly account for vertical flow components which occur as a result of mine dewatering. Furthermore, geologic and hydrologic evidence for the existence of an areally extensive resistive layer over the orebody is weak. Yet, the properties of the resistive layer are critical in the modeling effort. The resistive layer in effect, slows down the transmission of water from the overburden to the orebody. In Prickett's words, it acts as a "throttle" (p. 82).

EXXON SHOULD USE A FULLY THREE-DIMENSIONAL MODEL OF THE GLACIAL AQUIFER-OREBODY SYSTEM INSTEAD OF THE CURRENT QUASI-THREE- DIMENSIONAL MODEL. THAT IS, A THREE-DIMENSIONAL MODEL OF THE GLACIAL AQUIFER AS WELL AS THE OREBODY IS NEEDED IN ORDER TO PREDICT MINE INFLOW RATES. IN THIS WAY A LAYER OF LOW PERMEABILITY TILL COULD BE INCORPORATED DIRECTLY INTO A

THREE-DIMENSIONAL GLACIAL AQUIFER MODEL IN AREAS #3 AND #4, AND THE WEATHERED BEDROCK AT THE TOP OF THE OREBODY COULD THEN BE INCLUDED DIRECTLY INTO THE OREBODY MODEL. THE THREE-DIMENSIONAL FLOW IN THE GLACIAL AQUIFER ABOVE THE MINE AREA COULD ALSO BE SIMULATED DIRECTLY. THE ATTEMPTS TO REPRESENT A THREE-DIMENSIONAL SYSTEM BY A QUASI-THREE- DIMENSIONAL MODEL NECESSITATE THE INTRODUCTION OF ARTIFICES SUCH AS THE RESISTIVE LAYER AND THE CREATION OF WATER DURING THE SIMULATION (SEE SECTION III). SUCH ARTIFICES UNDERMINE THE VALIDITY OF THE PREDICTIONS.

III. MODEL OF THE GLACIAL AQUIFER

A. INITIAL CONDITIONS

1. Prickett says (p. 4) that he used maps provided by Golder as the initial conditions for the model of the glacial aquifer. Standard modeling procedures require that the steady state head configuration as computed by the model be used as initial conditions. One almost never uses field data (or computer output from another model) as initial conditions. This is because field measured heads will not be exactly the same as the computer generated steady state solution. Nor will output from one model be exactly the same as output from another model. The transient simulation must begin from a steady state solution which is exactly consistent with the model being used. EXXON SHOULD PROVIDE ADDITIONAL DETAILS REGARDING THE INITIAL CONDITIONS USED FOR THE GLACIAL AQUIFER COMPONENT OF THE MINE INFLOW MODEL.

2. On p. 18, Prickett says that his model was run in "impact mode", meaning that regional flows were ignored. Presumably this statement refers to the

regional flow through the orebody. I gather that Prickett did not ignore regional flows in the glacial aquifer. EXXON SHOULD PROVIDE CLARIFICATION ON THIS POINT.

B. EXTENT OF THE CONE OF DEPRESSION: The models of the glacial aquifer used by Prickett and D'Appolonia agree in boundary conditions and input parameters and are based on the same governing equation, yet THE DRAWDOWN CONES PREDICTED BY PRICKETT AND D'APPOLONIA ARE QUITE DIFFERENT. Compare Prickett's Fig. 4.3 with D'Appolonia's Fig. A-29 in Appendix 4.1A. The cone of depression predicted by D'Appolonia is much larger in areal extent and is also deeper.

One difference in the models is the way in which flow to the mine was simulated. D'Appolonia apparently assumed that the mine would withdraw water at a constant rate of 2000 gpm (for Case II) and 1000 gpm (for Case I) for the entire simulation period. Prickett's analysis assumes a constant rate of 1870 gpm after approximately 3 years for Case II. However, even D'Appolonia's Case I cone of depression (Fig.A-25) is larger than the one computed with Prickett's model (Fig. 4.3). I don't understand why there is such a marked difference between Prickett's Fig. 4.3 and D'Appolonia's Figs. A-25 and A-29. THE REASONS FOR THIS DISCREPANCY BETWEEN THE RESULTS OF D'APPOLONIA'S MODEL AND PRICKETT'S MODEL SHOULD BE CLARIFIED.

C. STORAGE COEFFICIENT: Prickett calibrated his model to transient conditions from relatively short term (7 day) pumping tests. He found it necessary to use a storage coefficient of 0.15 for the unconfined portion of the glacial aquifer and a value of 0.001 for the semi-confined portion of the glacial aquifer in order to calibrate his model to the short term pumping test data. Moreover, as the semi-confined portion of the aquifer converted to unconfined conditions in response to pumping, Prickett's model changed the storage coefficient for those nodes undergoing conversion from 0.001 to 0.15 (p. 21).

However, for impact analysis Prickett used a uniform storage coefficient of 0.05 in order to be consistent with the value selected by D'Appolonia. D'Appolonia's model was calibrated to steady state conditions. D'Appolonia did not test the validity of the storage coefficient (0.05) they assumed for impact prediction. While one could argue that the value of 0.001 for the semi-confined portion of the aquifer may be too low for long-term pumping simulations, it is difficult to make an argument for reducing the value for the unconfined portion from 0.15 to 0.05. In fact, a value of 0.05 seems rather low for an unconfined aquifer.

Increasing the storage coefficient of the glacial aquifer would not change the steady state solution. However, an increase in storage coefficient would increase the length of time to reach steady state and would increase the mine inflow rate at early times. Furthermore, one does not usually change the value of a calibrated parameter when shifting from the calibration phase to the prediction phase of modeling. EXXON SHOULD EXPLAIN WHY STORAGE COEFFICIENT WAS CHANGED IN THIS CASE.

D. "CREATION" OF WATER DURING THE SIMULATION: The only connection between the orebody model and the glacial aquifer model is through the resistive layer directly over the mine. Hence, the simulation cannot proceed if nodes or elements in the glacial aquifer over the mine area go dry during the simulation. If nodes in the glacial aquifer directly over the mine go dry, the area above the mine would soon have zero transmissivity and no water could reach the mine. A similar situation arises in the D'Appolonia model.

In the field it is possible that when the glacial aquifer over the mine desaturates, water might flow from the glacial aquifer, through fractures in the bedrock and from the bedrock into the orebody and the mine. Because the sides of the orebody are considered impermeable, flow through the surrounding bedrock is not included in the model. Therefore, it is necessary to allow water to flow into the mine in some other way. For this reason the glacial aquifer model as constructed by both Prickett and D'Appolonia cannot allow nodes or elements near the mine to go dry--it is through these nodes that water must flow through the resistive layer and the orebody toward the mine.

1. If the D'Appolonia model predicts that an element goes dry, the model is directed to re-set the saturated thickness in that element to 0.457 m. If a node in the Prickett model goes dry, the model is directed to re-set the saturated thickness to 0.305 m. Hence, the models "create" enough water to maintain a thin skin of water to connect the bulk of the glacial aquifer to the orebody. In effect, a zone of low transmissivity is created above the mine to allow transmission of water to the mine. IT IS UNCLEAR HOW THIS CONCEPTULIZATION RELATES TO WHAT IS EXPECTED TO HAPPEN IN THE FIELD. EXXON SHOULD PROVIDE ADDITIONAL DISCUSSION AND RATIONALIZATION FOR THIS ARTIFICE. A FULLY THREE-DIMENSIONAL MODEL SHOULD BE CONSTRUCTED FOR USE IN FUTURE SIMULATIONS.

SPECIFICALLY EXXON SHOULD COMMENT ON THE FOLLOWING POINTS:

(a) Creation of water keeps the water table in the glacial aquifer constantly at the orebody subcrop. This procedure artificially limits the depth of the cone of depression to the depth of the glacial aquifer (16 m in Prickett's model; 21 m in D'Appolonia's model).

(b) The transmissivity of the glacial aquifer over the orebody is equal to the hydraulic conductivity times the saturated thickness. Limiting the saturated thickness to roughly one foot creates a thin layer of low transmissivity in the glacial aquifer over the mine. It would seem that this layer would artificially limit the flow of water to the mine.

(c) WATER BALANCES: It is unclear how the "creation" of water affects the water balance of the model. The water balances for the model of the glacial aquifer appear to be good (0.2 - 0.6 percent according to numbers in Appendix Q). However, no documentation is provided on the way in which the water balance was computed.

EXXON SHOULD FURNISH DOCUMENTATION ON THE WAY IN WHICH THE WATER BALANCES FOR THE GLACIAL AQUIFER MODEL WERE CALCULATED. FURTHERMORE, WATER BALANCE CHECKS FOR ALL RUNS SHOULD BE TABULATED SEPARATELY FROM OTHER MODEL OUTPUT.

IV. TRANSIENT MODEL CALIBRATION

The mine inflow model was calibrated against results from two pumping tests when wells 211 and 213 in the orebody were pumped separately for 7 day periods. During the calibration procedure 11 parameters were adjusted: hydraulic conductivities for four different zones in the orebody, the artesian storage coefficient for the orebody, the four K/b factors representing the transmissive properties of the resistive layer, and the two storage coefficient values for the unconfined and semi-confined portions of the glacial aquifer.

A. DRAWDOWN COMPARISONS: Results of the calibration are presented as comparisons of observed and model- computed drawdowns for a total of four wells--2 in the orebody and 2 in the glacial aquifer. However, these wells are not identified by well number making it difficult to speculate on the reasons for the discrepancies evident in the comparisons (Fig. 3.17- 3.20). Furthermore, it is not stated whether the graphs shown are only selected comparisons or whether they represent all of the wells used in the calibration process. EXXON SHOULD PROVIDE WELL NUMBERS AND LOCATIONS FOR THE WELLS USED IN FIG. 3.17-3.29. ALL OF THE DRAWDOWN COMPARISONS USED IN THE CALIBRATION PROCESS SHOULD BE PROVIDED.

B. RELEASE OF WATER FROM STORAGE IN THE TILL: In general the measured drawdowns in the overburden are lower than predicted drawdowns. This could be due to the fact that in the real world there is release of water from storage in the till. (Release of water from storage in the till is also suggested by the analysis of the pumping test in the glacial aquifer discussed in the Supplement to Appendix 4.1A.) The model does not account for release of water from the till. Such water could represent an important additional source of water to the mine during early times. THE FULLY THREE-DIMENSIONAL MODEL TO BE USED IN FUTURE SIMULATIONS SHOULD INCLUDE A WAY OF SIMULATING RELEASE OF WATER FROM THE TILL.

C. VALIDITY OF THE CALIBRATION: It is possible that the model could have been calibrated equally well with a different set of parameters. For example, it may be that reducing the hydraulic conductivity of the orebody while increasing the hydraulic conductivity of the resistive layer would have produced an adequate calibration. The large number of parameters involved in the calibration process and the relatively large number of drawdown curves available for calibration make a complete sensitivity analysis virtually impossible.

Ultimately, it is necessary to trust the judgement of the modeler, in this case Mr. Prickett, that the final set of calibration parameters represents the best possible calibration. However, one is always left with some uncertainty over the uniqueness of the calibration. It would be safe to assume that the model as calibrated could predict drawdowns resulting from pumping wells 211 and 213 with the same accuracy as demonstrated in Figs. 3.17-3.20. However, it is possible that the model as currently calibrated would not accurately simulate drawdowns under a different stressed condition such as mine dewatering. FOR THIS REASON SOME TYPE OF SENSITIVITY ANALYSIS IS A CRITICAL PART OF THE MODELING EFFORT. VERY LITTLE INFORMATION IS REPORTED ON THE SENSITIVITY ANALYSIS PERFORMED BY MR. PRICKETT. EXXON SHOULD PROVIDE COMPLETE DETAILS ON THE SENSITIVITY OF THE MODEL TO UNCERTAINTIES IN THE PARAMETERS. SEE SECTION V BELOW.

V. SENSITIVITY ANALYSIS

A. CALIBRATION SENSITIVITY: Prickett comments on his observations during model calibration regarding the effects of varying certain parameters (p. 57 and Chap. 5). For example, the permeabilities of the resistive layer are singled out as sensitive parameters (p. 57 and p. 83). However, no insight is given with regard to how adjustments of these parameters affected the calibration. We are told that if the permeability of the weak relative permeability bedrock region is given any value other than zero, the model produces abnormally high drawdowns in excess of those measured during pumping tests. More information of this nature is needed in order to help judge the validity of the calibration.

EXXON SHOULD PROVIDE COMPLETE DETAILS ON THE SENSITIVITY ANALYSIS PERFORMED BY PRICKETT DURING MODEL CALIBRATION.

B. PREDICTION SENSITIVITY: Prickett notes (p. 58) that: "Larger permeabilities, greater overburden aquifer saturated thicknesses, higher storage, and greater recharge rates would tend to increase the mine inflow rate." However, he does not quantify the effects of uncertainties in these parameters on the predictions of mine inflow rate.

EXXON SHOULD PROVIDE A SENSITIVITY ANALYSIS WHICH QUANTIFIES THE SENSITIVITY OF PREDICTED MINE INFLOW RATES TO UNCERTAINTIES IN THE ELEVEN CALIBRATION PARAMETERS GIVEN IN TABLE 3.3 (p. 49). A SIMILAR SENSITIVITY ANALSIS OF MODEL PREDICTIONS SHOULD BE DONE FOR FUTURE SIMULATIONS PERFORMED USING THE FULLY THREE-DIMENSIONAL MODEL. IN ADDITION, SENSITIVITY OF THE MODEL TO RECHARGE RATE TO THE GLACIAL AQUIFER SHOULD BE TESTED.

VI. SUMMARY OF MAJOR RECOMMENDATIONS

A. MODEL STRUCTURE: A quasi-three-dimensional model has been used to simulate a three-dimensional problem. The three-dimensional flow field in the glacial aquifer above the orebody has been simulated by assuming two-dimensional horizontal flow in the coase-grained stratified drift and one-dimensional vertical flow through a leaky confining bed known as the resistive layer. A physically real layer of low permeability in fact does not exist in model areas #1 and #2. Here the resistive layer is an artifice of the model structure. See Section II.

A similar artifice involving creation of water during the simulation is introduced as a consequence of the quasi-three-dimensional nature of the model. See Section III.D.

These artifices undermine the validity of the predictions. A fully-three-dimensional model of the glacial aquifer-bedrock system should be constructed. This model should be used to predict mine inflow rates. The model should include regional flow through the orebody. Furthermore, the model should be constructed to allow the possibility of flow through the country rock to be tested. The model should also include the possibility for release of water from the till.

B. SENSITIVITY ANALYSIS: The reports I have reviewed contain essentially no hydrogeologic data for establishing absolute values for the hydraulic conductivities of the various permeability zones of the orebody and the resistive layer. These parameters are established by the trial and error method of model calibration and as a result there is no certainty of obtaining a unique solution. For this reason, a good sensitivity analysis is essential to the credibility of the modeling results. A sensitivity analysis is needed for both the calibration and the prediction phases of modeling. See Section V.

REFERENCES

Freeze, R.A. and J.A. Cherry, 1979, Groundwater, Prentice-Hall, 604 p.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES
Carroll D. Besadny
Secretary
BOX 7921
MADISON, WISCONSIN 53707

November 14, 1984

File Ref: 1630
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RE: Exxon Crandon Mine Project EIR/
Additional Documents for Public
Information and Review

Dear Librarian:

Please place the enclosed document along with the rest of the Exxon environmental impact report (EIR):

October 29, 1984 letter from Garrett G. Hollands, IEP Inc., to Dr. Joseph Demarte, Exxon Re: Wetland Water Balance Analysis - Compatibiltiy of Methods and Results of IEP, Inc. and Ayres Associates.

November 9, 1984 letter from Barry Hansen (Exxon) to Gary Kulibert (DNR) Re: Disposal of Non-Tailing Mining Waste.

November 9, 1984 letter from Barry Hanson (Exxon) to Robert Ramharter (DNR) Re: 0.33 m (1.0 foot) Ground Water Drawdown Contour.

"Transportation of Reagent Materials Off-Site Risk Related Issues", by Zordan Associates, Inc., November, 1984.

These documents pertain to the EIR. People who have comments or questions about this item should contact Mr. Robert Ramharter at (608) 266-3915 or at DNR, Box 7921, Madison, WI, 53707.

Thank you for your assistance.

Sincerely,
Bureau of Environmental Analysis and Review

Carol Nelson

Carol Nelson
Environmental Specialist

Enclosure

IEP Inc.
CONSULTING ENVIRONMENTAL ...
6 MAPLE ST. · P.O. BOX 780, NORTHBOROUGH, MA 01532
(617) 393-8558 / 890-2130

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File 84-92

Dr. Joseph DeMarte
Exxon Minerals Company
PO Box 813
Rhinelander, Wisconsin 54501

RE: Wetland Water Balance Analysis - Compatibility of Methods and Results of IEP, Inc. and Ayres Associates

Dear Dr. DeMarte:

Per your request, IEP, Inc. has reviewed the report "Mine Waste Disposal Facility Reclamation Cap Design and Water Balance Analysis," prepared by Ayres Associates, September 1984. The review was specifically in regards to Sections 6.0 and 7.0 and the compatibility of this report's methodology and results to that of the earlier report "Hydrological Balance of Selected Wetlands, prepared by IEP, Inc., in 1982. Also reviewed has been the report "Water Balance Analysis for Wetlands in the Mine Waste Disposal Facility Area," prepared by Ayers Associates, October 1984. The later report contains Ayres Associates' discussion of the differences between the two firms work as to methodology, data input and results.

It is our understanding that Ayres Associates performed the work presented in the September 1984 report because the Wisconsin Department of Natural Resources (WDNR) expressed concerns related to the previously proposed reclamation cap. The 1982 IEP, Inc. work (Phase 6) was based upon this earlier cap design. Ayres Associates were to assess the effectiveness of the new cap design to meet water quality criteria of the WDNR within the 1200 foot compliance boundary. Emphasis was placed upon recharge within the compliance boundary. Following discussion between Exxon, Ayres Associates and IEP, Inc., it was decided that Ayres should also reassess the Phase 6 impacts to the water balance of wetlands within the compliance boundary, since Ayres was already involved in detail in determining runoff and infiltration on the cap and within the compliance boundary. In addition, all three parties believed that this work would be an independant assessment which would either verify or refute the earlier IEP, Inc. analysis, which was stated to be 'hypothetical.' In addition, Ayres' new work was party to data and experience of earlier work by other consultants and data generated since the 1982 IEP work was done. Long discussions were held between Ayres and IEP concerning methods and data input used. Both Ayres reports reference this data.

Any method to model a wetland's water balance contains a degree of sensitivity. Every water balance assessment is a progress report which reflects the data base and methodology used, which is a reflection of the state-of-the-art at a point in time and the experience of the hydrologist in wetland hydrology.

The October 1983 Ayres report (Section 5.0 Water Balance Sensitivity) contains a detailed discussion and analysis of the data, methods and results of the IEP, 1982 report versus the September 1984 Ayres report. We see no need to restate the findings of the Ayres report (Section 5.0). We agree with the findings of Section 5.0. The IEP method generates more runoff than the Ayres method. But both methods generate very low flows, IEP in hundredths of a cfs and Ayres to the thousands of a cfs. Observations of surface water discharge from these wetlands collaborate these two very low discharge rates. Of particular interest is Figure 3 of Ayres' October 1984 report which illustrates the water curve differences between the two firms. While the average seasonal runoff values are different, the seasonal periods of high discharge versus low or no discharge are identical. It is changes in the periods of 'wetness' versus 'dryness' that will effect wetland vegetation. The two methods for all practical purposes are identical in this prediction. If one method was in error, this compatibility would not occur. In addition, it shows that while data input may be slightly different (i.e., IEP used climaticalogical data from Laona, Wisconsin while Ayres used data from Rhinelander, Wisconsin) and one would expect a change in the amount of discharge, no major change occurred in the trends of the water curve on a seasonal and yearly basis.

We believe that the wetland hydrological balance work prepared by Ayres Associates is compatible with the 1982 IEP work. In addition, the Ayres work is a verification of the IEP work. The differences between the results of the two consultants is well within the realm of scientific probability of attempting to numerically model wetland water balances.

Yours truly,

IEP, Inc.

Garrett G. Hollands

Garrett G. Hollands
Vice President
Senior Geologist

GGH/ei

EXXON MINERALS COMPANY

P. O. Box 813, RHINELANDER, WISCONSIN 54501

CRANDON PROJECT

November 9, 1984

Mr. Robert H. Ramharter
Department of Natural Resources
GEF II
P.O. Box 7921
Madison, Wisconsin 53707

Dear Mr. Ramharter:

During the August 14, 1984 DNR/Exxon ground water meeting Dr. Charles Fetter indicated the Towns of Nashville and Lincoln were interested in knowing the approximate location of the 0.33 m (1.0 foot) ground water drawdown contour. IT-D'Appolonia has recently completed this additional work and we are providing you with the information.

Attached Figure 1 depicts the locations of the 1 m (3.3 foot) and 0.33 m (1.0 foot) drawdown contours at Project year 28 for the expected mine inflow value for the middle recharge case (8.5 inches). Project year 28 has been used in EIR Appendix 4.1.A to portray steady-state conditions for mine inflow and ground water drawdown effects. Other study work associated with the preparation of Appendix 4.1.A determined that the drawdown changes were approximately the same for all three (low, middle, and high) recharge cases.

Any use of the location information for the 0.33 m (1.0 foot) drawdown contour should be made with some considered judgment. The presentation in Appendix 4.1.A of the 1.0 m (3.3 foot) drawdown contour as the limit of the zone of influence was made because of consideration of the accuracy of the estimates at the outer limits of the zone of influence. Projecting the 0.33 m (1.0 foot) drawdown is beyond the accuracy of the model parameters and other modeling criteria.

In addition to the question of accuracy for the small drawdown values from the mine inflow, these changes have to be superimposed on a ground water surface that is constantly fluctuating in position from normal influences. Our studies have indicated that the ground water surface normally fluctuates to over 1.0 m (3.3 feet) in the upland areas of the site to smaller values (0.2 m [0.7 feet]) or less in the outer lowland ground water discharge areas. As a practical consideration during operations monitoring, beyond the 1.0 m (3.3 foot) drawdown contour it will become increasingly difficult to distinguish the mine inflow effect from normal ground water fluctuation.

I hope this information will meet your and Dr. Fetter's needs. If you require any additional detail please let me know.

Very truly yours,

EXXON MINERALS COMPANY

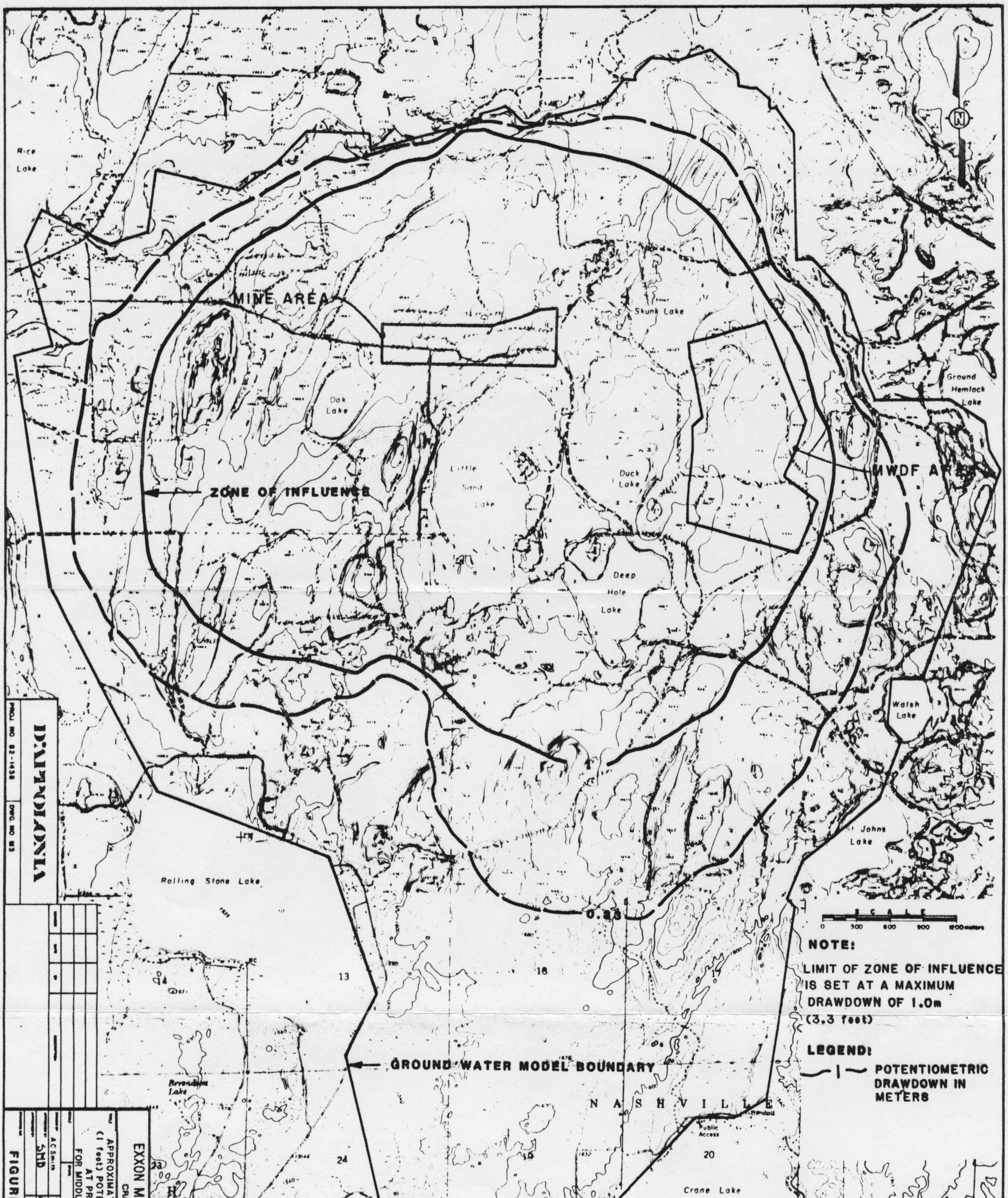
Barry J Hansen

Barry J. Hansen
Permitting Manager

BJH:CCS:sjq

Attachment

xc: w/attachment
T. C. McKnight


Rice Lake
MINE AREA
Skunk Lake
Oak Lake
Little Sand Lake
Duck Lake
Ground Hemlock Lake
MWDF AREA
ZONE OF INFLUENCE
Deep Hole Lake
Walsh Lake
Johns Lake
Rolling Stone Lake
0.33
SCALE
0 300 600 900 1200 meters
NOTE:
LIMIT OF ZONE OF INFLUENCE IS SET AT A MAXIMUM DRAWDOWN OF 1.0m (3.3 feet)
LEGEND:
POTENTIOMETRIC DRAWDOWN IN METERS
GROUND WATER MODEL BOUNDARY
NASHVILLE
Public Access
Crane Lake
Pickerel Lake
Woods Island
EXXON MINERALS COMPANY
CRANDON PROJECT
APPROXIMATE LOCATION OF 0.33m (1 foot) POTENTIOMETRIC DRAWDOWN AT PROJECT YEAR 28 FOR MIDDLE RECHARGE CASE
FIGURE 1

NOV 12 1984

EXXON MINERALS COMPANY

P. O. Box 813, RHINELANDER, WISCONSIN 54501

CRANDON PROJECT

November 9, 1984

Reference 4400
Non-Tailing Mining Wastes

Mr. Gary Kulibert
Department of Natural Resources
North Central District Office
P.O. Box 818
Rhinelander, Wisconsin 54501

Dear Mr. Kulibert:

This letter is written in reply to the questions and information needs identified in the August 22, 1984 letter to Exxon Minerals Company regarding non-tailing mining wastes associated with the Crandon Project. As described in various sections of the EIR we will utilize a combination of waste disposal services or facilities for various Project wastes. The City of Antigo landfill, speciality disposers, recyclers, scrap dealers, and supplies will ultimately dispose of all Project non-tailing mining wastes. The estimates of waste volumes are based on existing data where available, although generally, there is a lack of substantial and detailed historical data available to project waste estimates. When historical data were not available, assumptions were made based on professional experience. Also, based on the planned disposal methods, the absolute waste volume is not critical to the disposal plans. Estimate variances of ± 25 percent or even higher would not change the disposal plans described in the various Project documents. Information is provided following Section II of the August 22 letter.

Question II.A.1:

What volume and weight of the wastes indicated in Section IA will be generated by the construction activity?

Response:

Clearing and Grubbing Wastes (I.A.1)

Current estimates for the clearing and grubbing construction wastes are presented in Table 1.

TABLE 1

CONSTRUCTION PHASE

Clearing and Grubbing Wastes

Facility	Construction Period Yr(1)	Area For Clear & Grub ha (acres)(1)	Marketable Timber(2)	Brush, Limbs Unmarketable Timber (In the Field)(3)	Brush, Limbs Unmarketable Timber (Chipped)(4) Yd^3	Stumps (In the Field)(5)	Stumps (Chipped)(6) Yd^3
Access Road	1	15 (37)	272 Cord 5,997 Board Ft.	316 S.T.(8) 2,350 Yd^3	1,175	146 S.T. 541 Yd^3	541
Railroad Spur	1	18 (45)	411 Cord 24,755 Board Ft.	497 S.T. 3,681 Yd^3	1,840	229 S.T. 850 Yd^3	850
Tailings/Route Haul Road	1	4 (10)	109 Cord 4,056 Board Ft.	129 S.T. 958 Yd^3	479	60 S.T. 221 Yd^3	221
Mine/Mill Site	1	46 (114)	1,565 Cords 105,943 Board Ft.	1,909 S.T. 14,113 Yd^3	7,071	881 S.T. 3,259 Yd^3	3,259
Excess Water Discharge	1	6 (15)	137 Cords(7) 8,251 Board Ft.	166 S.T. 1,228 Yd^3	613	77 S.T. 283 Yd^3	283
MWDF							
Phase 1 - Waste Rock Area + R1 + Construction Support Area	1	48 (119)	1,667 Cords 107,700 Board Ft.	2,027 S.T. 15,015 Yd^3	7,507	936 S.T. 3,467 Yd^3	3,467
Phase 2 - T1 + R2	4	50 (124)	1,737 Cords 112,230 Board Ft.	2,113 S.T. 15,652 Yd^3	7,826	975 S.T. 3,611 Yd^3	3,611
Phase 3 - T2	9	55 (136)	1,906 Cords 123,090 Board Ft.	2,319 S.T. 17,178 Yd^3	8,589	1,070 S.T. 3,963 Yd^3	3,963
Phase 4 - T3	16	55 (136)	1,906 Cords 123,090 Board Ft.	2,319 S.T. 17,178 Yd^3	8,589	1,070 S.T. 3,963 Yd^3	3,963
Phase 5 - T4	22	50 (124)	1,737 Cords 112,230 Board Ft.	2,113 S.T. 15,652 Yd^3	7,826	975 S.T. 3,611 Yd^3	3,611
TOTALS	-	347 (860)	11,447 Cords 727,342 Board Ft.	13,908 S.T. 103,005 Yd^3	51,515	6,419 S.T. 23,769 Yd^3	23,769

NOTES:
(1) See Table 1.3-1 of EIR.
(2) From Steigerwaldt, 1982. Adjusted on an area basis to current clear and grub area estimates.
(3) Weight estimated at 65% of weight of marketable timber assuming:
a) Cord = 128 Ft^3 with wood volume = 80 ft^3; b) Air dry wood weight = 3500 lb/cord; c) For timber quantities air dry wood weight = 45 lb/ft^3; d) Volume estimate based on 10 lb/ft^3.
(4) Volume estimate based on 20 lb/ft^3.
(5) Weight estimated at 30% of weight of marketable timber. Volume estimate based on 20 lb/ft^3.
(6) Volume estimate based on 20 lb/ft^3.
(7) Tree density/acre assumed same as railroad spur.
(8) S.T. - Short tons; Yd^3 - Cubic yards.

Refuse (I.A.2)

Including:
a. Solid waste from construction crews;
b. Packaging waste; and
c. Scrap metals.

These estimated quantities are presented in EIR Section 1.3.5.1 Solid Waste. The data presented in Table 2 were developed by applying the high end of the range of estimated weekly waste quantities.

Building Materials (I.A.3)

a. Waste rates for construction materials (i.e. concrete, asphalt, etc.) will be kept low through detailed job planning and a high level of construction management. Although normal estimating rules of thumb might project closer to 5% waste for the following materials, with better work management an average waste rate of 3 percent can be assumed, resulting in the following waste quantities:

Item	Approximate Estimated Quantity For Project	Approximate Waste Quantity With 3 Percent Waste
Concrete (includes surface and underground)	46,900 m^3	1407 m^3 (1840 cubic yards)
Base Course (includes access road and in-plant roads)	24,400 m^3	732 m^3 (959 cubic yards)
Subbase (includes access road and in-plant roads	28,800 m^3	864 m^3 (1132 cubic yards)
Asphalt Pavement	7,400 m^3	222 m^3 (291 cubic yards)
Railroad Ballast (includes spur and siding)	37,900 t	1137 t (1251 short tons)
Railroad Subbase	12,400 t	372 t (409 short tons)
Bentonite	7,700 t	231 t (254 short tons)

b. Waste estimates for steel, rebar, metal siding, insulation, etc. and similar building materials can be approximated according to the following table. For concrete form materials a 25% overall waste rate is included based on a 10% waste rate with each use and an average 2.5 uses; other wood wastes are insignificant. Other waste rates are based on a nominal or rule of thumb estimate of 5% waste adjusted for the particular item according to any prefabrication plan or field installation plan. Portions of some of the wastes would be salvageable.

TABLE 2

Construction Phase Refuse Quantities

Construction Year	Period	Weekly Rate (Short Tons)	Total Short Tons	Total Volume* (Yd^3)
1	May-Sept	5	110	220
1	Oct-Dec	1	13	26
2	Jan-Apr	1	17	34
2	May-Sept	5	110	220
2	Oct-Dec	1	13	26
3	Jan-Apr	3	51	102
3	May-Sept	10	220	440
3	Oct-Dec	3	39	78
4	Jan-Apr	3	51	102
4	May-Sept	10	220	440
4	Oct-Dec	3	39	78
		Total	883	1766

* Volume based on 1000 lb/yd^3 density.

Similar refuse quantity estimates based on workforce size and a representative pounds per capita per day (pcd) of waste provide a nearly equal quantity estimate:

Construction Year	Average Workforce	pcd[(a)]	Total Short Tons[(b)]	Total Volume[(c)] (Yd^3)
1	516[(d)]	1.5	71	142
2	652	1.5	152	305
3	1101	1.5	258	516
4	1206	1.5	282	564
		Total	763	1527

NOTES: (a) pcd estimate from Handbook of Solid Waste Management, by David Gordon Wilson, Van Nostrand Reinhold, page 553.
(b) 26 work-days per month assumed.
(c) Volume based on 1000 lb/yd^3 density.
(d) Average workforce from EIR Figure 1.1-5. Construction Year 1 for 7 months.

Item	Approximate Estimated Quantity For Project	Approximate Waste Quantity at Waste Rate Noted		
		Assumed Waste Rate (%)	Waste Quantity	
Reinforcing Steel (Mostly Shop Bent)	2,000 t	3	60 t	(66 Short Ton)
Structural and Building Steel (Shop Fabricated)	5,000 t	1	50 t	(55 Short Ton)
Concrete Formwork	63,000 m^2	25	16,000 m^2	(19,100 Square Yards)
Metal Siding and Roofing	60,000 m^2	5	3,000 m^2	(3,600 Square Yards)
Metal Liner Panel	43,000 m^2	5	2,150 m^2	(2,600 Square Yards)
Drywall	9,000 m^2	20	1,800 m^2	(2,200 Square Yards)
Insulation	43,000 m^2	5	2,150 m^2	(2,600 Square Yards)

c. Estimates of waste oils, lubricants, hydraulic fluids and other petroleum products were based on estimated fuel consumptions and an overall waste rate assumed at 1:250. Most waste petroleum products would be recycled or ultimately re-used.

Construction Year	Total Diesel Fuel Consumed (gallons)	Total Gasoline Consumed (gallons)	Total Estimated Petroleum Based Waste (gallons)
1	2,044,000	43,800	8,400
2	414,000	43,100	1,800
3	1,129,000	36,800	4,700
4	1,399,000	40,300	5,800
Totals	4,986,000	164,000	20,700

d. Total painting wastes can be estimated based on an assumed 5 percent waste rate. Based on estimated material takeoffs of 5,000 t of structural steel (at 1.2 gallon/short ton for two coats) and 26,000 m^2 of steel plate and wall (at 1.0 gallon/200 square feet for two coats), a total paint quantity of approximately 8,000 gallons will be required. With a 5 percent waste rate there would be 400 gallons of waste paint.

Other Wastes (I.A.4)

a. Sanitary wastes have been estimated to start at a conservative level of 2,800 gallons per day over the first 6 months of Project construction. During this initial 6-month period the wastes would be removed and disposed off-site by a licensed disposer. Following this 6 month period (after installation of the sanitary waste disposal system), sanitary wastes would be disposed on-site except for the periodic removal and off-site disposal of septic tank sludge. Over the remainder of the construction phase (approximately 3 years) sanitary sewage volume would increase from the 2,800 gallon per day rate to the approximate 29,000 gallon per day rate expected during the operating period. After the sanitary waste disposal system is in operation a maximum of 2,400 cubic feet per year of sludge will be removed from the system and disposed off-site by a licensed disposer.

b. No significant quantity of hazardous material packaging waste or containers are expected to be generated during Project construction. Disposal of any minor amounts of these materials will be handled similar to the plans during operations, i.e. either by returning them to the vendor or by utilizing a speciality waste disposer licensed to handle and dispose of the particular waste.

Question II.A.2:

At what rate will the wastes be generated during the construction activity?

Response:

Maximum clear and grub rates (Item I.A.1) would occur in construction year 1 with much of the work starting at about the same time. The highest rate for an individual facility is for the first phase of the MWDF construction where 48-ha (119 acres) will be cleared and grubbed in approximately one month.

Refuse quantities (Item I.A.2) are assumed to be generated at constant rates throughout the individual periods shown in Table 2.

Building materials (Item I.A.3) should be assumed to be generated at a constant rate over the approximate 2 1/2 years required for surface facilities construction (the last 2 1/2 years of the construction period). Each individual waste would probably predominate at some time in the schedule but the overall rate would probably be approximately constant.

Sanitary wastes (Item I.A.4) would fluctuate according to the construction workforce and the continually increasing percentage of people with access to complete sanitary facilities as opposed to only portable facilities. An approximate estimate of rate of sanitary sewage generation would be a linear increase from 2,800 gallons per day at the 6 month point in construction to the 29,000 gallon per day volume at the start of operations.

Question II.A.3:

What will be the time frame for the production of wastes?

Response:

The responses to questions II.A.1 and II.A.2 include the approximate Project time frames when the wastes will be generated.

Question II.A.4:

How and where will the wastes be collected and stored prior to disposal?

Response:

Clear and grub tree wastes (Item I.A.1) will be temporarily piled in convenient areas adjacent to the construction area. Storage areas will be located during detailed final construction planning but probably 3 or 4 storage areas would be planned for each major facility (i.e. mill site, MWDF).

Refuse wastes (Item I.A.2) will be stored in dumpsters or similar containers conveniently located around the Project area.

Building materials wastes (Item I.A.3) would be temporarily stored in segregated areas located in the mine/mill area. Waste oils, paints, other toxic fluids or any hazardous solid or liquid wastes would be segregated and isolated in separate secure containers or facilities while being temporarily held.

For the first 6 months of Project construction, sanitary wastes (Item I.A.4) will be removed off-site and disposed by a licensed disposer at an approved location or facility of his choice. From the 6-month period onward (except for twice yearly off-site sludge disposal) sanitary wastes will be disposed on-site through the sanitary waste disposal system.

Question II.A.5:

Where and how will the waste be disposed?

Response:

Clear and grub wastes (Item I.A.1) will be chipped at the temporary storage locations and transported to a stockpile area on the east side of the mine/mill area. Any stumps or other grubbing materials that cannot be chipped will be disposed by burning in an approved air curtain destructor(s).

Refuse wastes (Item I.A.2) will be collected periodically from the dumpsters and transported and disposed at the City of Antigo landfill or another approved facility including potentially an on-site facility.

Building materials wastes (Item I.A.3) will be disposed of differently according to the waste. Concrete, gravel, asphalt pavement and similar wastes will be dumped in an area that either requires fill or else can be worked into the final grading plans for the various facilities. Any wastes with salvage value will be segregated and salvaged. Non-salvageable wastes that can be burned will be burned in the mine/mill area in an approved facility. If a waste cannot be burned or if burning is not allowed, then the waste would be disposed at the City of Antigo landfill or another approved facility including potentially an on-site facility. Any remaining wastes not allowable in the landfill (potentially hazardous wastes) would be transported to and disposed in a suitable facility such as Waste Research and Reclamation (Eau Claire) or Milwaukee Solvent. Waste oils, hydraulic fluids and other petroleum product wastes would be periodically removed from the temporary holding facilities by a waste oil recycler. Any of these types of waste fluids not recycleable would be disposed at one of the facilities (or a similar one) noted above.

Final disposition of sanitary wastes (Item I.A.4) has been previously described.

Question II.A.6:

What alternatives to disposal were and are being considered for these wastes?

Response:

Significantly different alternative methods of disposal of the various wastes have not been considered. However, variations of the proposed action have been considered:

a) For the wastes proposed for disposal at the City of Antigo landfill several other landfills have been considered, including the Town of Nashville landfill, Ridgeview Landfill in Manitowoc County, and also a new on-site facility developed as part of the Project;

b) For the clear and grub waste, chipping is preferred followed by burning as a second choice. However, burying has also been considered as an alternative; and

c) Other facilities or equipment to better manage the wastes (baler or an incinerator) have also been considered. At this time it is preferable to wait until a firm pattern of waste generation is established (one or two years into operations) to determine if equipment like this would be beneficial.

Question II.A.7:

Are there any other wastes not indicated in Section IA which will be produced during construction activity?

Response:

It is possible that some minor amounts of wastes have not been identified; however, it is assumed that any unidentified waste would conform with one of the existing waste categories identified previously and could be disposed in accordance with an existing plan.

Question II.B.1:

What volume and weight of the wastes identified in I.B. will be generated during operation of the Project?

Response:

Responses are provided for both the mine and mill by item according to the wastes identified in Section I.B. of your letter. The basis for determining the waste estimate is also included with the response. Table 3 summarizes the information for all waste types.

Solid Waste, Refuse (Item I.B.1)

a. Refuse from Exxon employees, cafeteria, office etc.

Quantity of this waste is based on an estimate of 2.3 t (2.5 short tons) per year per employee. Assuming a conservative workforce estimate of 800 employees, the total yearly waste quantity would be 1,815 t (2,000 short tons). Over the 22-year Project operating life the total quantity of this waste would be 39,930 t (44,000 short tons). Assuming a density of 1,000 pounds per cubic yard, the waste volume is 4,000 cubic yards per year and 88,000 cubic yards over the life of the Project. The waste is expected to consist of the following materials and it is all currently planned to be disposed at the City of Antigo landfill or another approved landfill including potentially an on-site facility:

Material	Percentage
Paper and Garbage	75
Plastic	5
Wood	5
Metal	10
Miscellaneous	5

b. Tires

Used or worn out tires will be recycled by periodically returning them to the vendors. Tire life under similar conditions is approximately 1,000 - 3,000 hours with an average life of approximately 2,000 hours. For the approximate 100 mobile vehicle fleet, with a total of approximately 500 tires, and with an average vehicle operation of 3,000 hours per year, approximately 750 tires per year would be worn out and returned to the vendors.

At an average weight of 150 pounds per tire total yearly weight of disposed tires would be approximately 56 short tons. For the 22-year operating period the total weight of recycled tires would be 1,232 shorts tons. With an approximate volume of 7 cubic feet per tire total waste tire volume would be 195 cubic yards per year and 4,300 cubic yards over the life of the Project.

c. Scrap Metal

Project scrap metal will be returned to vendors or sold to scrap dealers to be recycled or ultimately reused. Based on the Project equipment, operating rates and typical scrap rates, the following estimated scrap metal will be generated annually:

	Short Tons
Mine	
Drill Steel, Pipe, Roof Bolts	7
Hoist Cables	5
Crusher Liners	6
Chutes	6
Mobile Equipment Parts/Buckets	12
Mill	
Crusher Liners	184
Mill Liners	190
Screens	5
Chutes, Piping, etc.	3
Overall contingency (approximately 20%)	82
Total Annual Scrap Metal	500

Assuming a piled or stacked density of 400 pounds per cubic foot approximately 93 cubic yards of scrap metal would be generated per year. Over the 22-year operating period total scrap metal would be 11,000 short tons with a volume of 2,040 cubic yards.

d. Others

Estimates of other scrap or waste material (some with possible reuse) include:

	Annual		Over Project Life	
Item	Short Tons	Cubic Yards	Short Tons	Cubic Yards
Conveyor Belting	4	3	88	66
Plastic Piping	2	3	44	66
Rubber Hose and Pipe	2	4	44	88
Mine Planks and Timber	3	6	66	132
Blasting Supplies Packaging	1	4	22	88
Totals	12	20	264	440

Petroleum Products, Chemical Wastes (Item I.B.2)

a. Waste Oil, Hydraulic Fluids, Lubricants

For equipment oil changes, hydraulic fluid changes, or oil or fluid removal for repairs or preventative maintenance, a total weekly disposal of 500 gallons is estimated. On an annual basis this is 26,000 gallons and over the 22-year operating period this totals approximately 572,000 gallons. Portions of these waste products may be recycled or adapted for secondary use.

b. Solvents, Degreasers

Estimated solvent and degreaser use may amount to 2 gallons per day. Assuming this entire quantity is recycled or handled by a speciality disposer, the yearly quantity would be 730 gallons and the amount over the entire Project life would be 16,060 gallons.

c. Waste Fuels, i.e., Spills

To account for potential fuel spills an allowance or projection of one barrel (55 gallon drum) every 3 months of recoverable spills was assumed. This is equivalent to 220 gallons per year or 4,840 gallons of fuel over the Project life.

d. Waste Chemical Residue Produced as the Result of a Spill or Off-Specification Products and Waste Containers

The practice followed will be to return chemical containers and any off-specification products to the supplier. To provide for potential spills or other circumstances that result in chemicals or containers that must be disposed of an allowance of one barrel (55 gallon drum) every 6 months was assumed. This is equivalent to 110 gallons per year or 2,420 gallons of chemical waste over the Project life. Overall it was assumed that these wastes have a density of approximately 60 pounds per cubic foot.

To the extent they are suitable, all of the petroleum and chemical wastes noted above will be returned to recyclers. Any non-recyclable wastes would be disposed with a specialty disposer such as Waste Research and Reclamation (Eau Claire) or Milwaukee Solvent.

Potential Hazardous Wastes. Wastes which may be classified as hazardous according to NR 181, subchapter II (Item I.B.3).

a. Laboratory Wastes

Ordinary paper wastes, cardboard boxes, and similar waste materials are included in the solid waste refuse projections under item I.B.1.a. Laboratory sink drains will carry liquids for transfer to the reclaim water pond system. To provide allowance for other laboratory wastes that may be potentially hazardous and that require special handling (i.e., broken containers, waste chemicals or material samples) 25 pounds per day or approximately 0.5 cubic foot of laboratory waste per day was assumed. On a yearly basis this is approximately 4.5 short tons or 7 cubic yards. Over the life of the Project it is 100 short tons or 154 cubic yards.

b. Machine, Repair, or Paint Shops Waste

Salvageable scrap metal and recycleable oils or solvents from these operations have been included under Item I.B.2.a. and b. Other wastes might include paint cans with some waste paint, oily, greasy or solvent soaked rags, waste absorbents, and non-salvageable waste machine cuttings. Altogether these wastes are estimated to be generated at the rate of approximately 35 pounds per day with a disposal volume of approximately 2 cubic feet. On a yearly basis this is 6.4 short tons or 27 cubic yards; and 141 short tons or 594 cubic yards for the Project life.

c. Spill Residues

All potential Project spills are included under Items I.B.2.c. and d.

d. Other

All types of potentially hazardous wastes have been included in the categories above. Any minor amounts of other specific wastes would fit into one of the above groups.

Disposal of these types of potentially hazardous wastes (other than the laboratory waste liquids transferred to the reclaim ponds) would be through a specialty disposer. All applicable regulations covering handling, transfer, and disposal of the wastes would be followed.

Sanitary Wastes (Item I.B.4)

All sanitary waste related questions are covered in the response to Question II.B.8. Yearly and total septic tank sludge disposal volumes are included in Table 3.

Question II.B.2:

At what rate (tons or yd^3/day) will these wastes be produced?

Response:

Table 3 represents estimated daily and annual waste generation rates and also a total waste volume and weight for the life of the Project. Most of the wastes will be generated at relatively uniform rates throughout the year and applying a daily average waste generation rate is considered accurate. Some wastes, such as the scrap metal (consisting in large part of the mill liners) will be generated at higher rates over shorter periods of time; however, considering the overall amount of waste generation for the Project applying a uniform daily rate is a reasonable approximation.

Question II.B.3:

How will waste generation rate change during any changes in mine/mill operations, i.e. temporary shutdowns, equipment failure?

Response:

Temporary shutdowns will not immediately affect waste generation because they will not be of sufficient duration. Prolonged shutdowns will obviously reduce waste quantities.

Equipment failure may influence the generation of waste. For instance, crusher and mill liner changeout is a periodic occurrence which will result in generation of several tons of scrap metal. However, liner steel is a valuable scrap and will be salvaged. Rags and shipping carton wastage will also increase for a major repair job. Since there will be numerous pieces of equipment under constant maintenance, even a major repair job will not result in a major increase in the annualized estimates of disposable waste.

TABLE 3
OPERATIONS WASTE SUMMARY

Type	Item	Volume (Yd^3)(1) Daily	Volume (Yd^3)(1) Annually	Volume (Yd^3)(1) Total	Weight (S.T.)(2) Daily	Weight (S.T.)(2) Annually	Weight (S.T.)(2) Total
Solid Waste, Refuse	General Refuse	11	4,000	88,000	5.5	2,000	44,000
	Tires	0.5	195	4,300	0.15	56	1,232
	Scrap Metal	0.25	93	2,040	1.4	500	11,000
	Others	0.05	20	440	0.03	12	264
Petroleum Products, Chemical Wastes	Waste Oil and Hydraulic Fluid	0.35	129	2,830	0.28	104	2,294
	Solvents and Degreasers	0.01	4	80	0.01	3	58
	Fuel Spills	0.003	1	24	0.003	1	19
	Chemical Residues	0.001	0.5	12	0.001	0.5	10
Potentially Hazardous Wastes	Laboratory Wastes	0.02	7	154	0.01	4.5	100
	Machine and Paint Shop	0.07	27	594	0.02	6.4	141
	Spill Residues		(Included in Fuel Spills and Chemical Residues).				
	Other		(Nothing Else Identified)				
Sanitary Wastes	Sludge	0.24	89	1,955	0.21	75	1,647

Notes:

(1) Yd^3 = cubic yards.
(2) S.T. = short tons.

Question II.B.4:

How will the wastes indicated in I.B be collected and stored on site?

Response:

The following collection and storage procedures will be used:

Item	Collection*	Storage
Refuse	Trash cans, barrel	Dumpsters
Tires	Truck/hoist	Timber & steel storage yard
Scrap Metal	Plant metal bins, truck, recyclers, etc.	Timber & steel storage yard
Others	Trash cans, etc.	Timber & steel storage yard
Oil	Shop storage drums	Lubricant storage on surface
Waste Fuel, Solvents, Chemical Spills	Pump, barrel if needed, truck if needed	Lubricant, cold storage building on surface
Laboratory (Other than ordinary refuse and liquids drained to reclaim ponds.)	Lab trash cans, jars, etc.	Reagent, supply storage area in lab
Machine & Paint	Special dumpsters for paint, solvent cans to be removed by specialty disposer	Cold storage building area on surface
Spill Residues (Potentially hazardous)	Special sumps designed to contain all materials in case of a spill on the property by a delivery truck; spills will be placed in pilot plant tails sump by front end loader.	Secure area such as pilot plant tails sump until removed by specialty disposer

* Underground collection procedures which apply will be similar. Transportation to the ultimate surface waste storage locations will employ the main shaft service cage. Drums, bins, etc. will be either caged by forklift or carried on-board a suitable mine vehicle of cageable dimensions.

Question II.B.5:

What alternatives to disposal such as recycling/reuse were and are being considered?

Response:

Except for the solid waste refuse from the Exxon employees, cafeteria, office and other facilities to be disposed of at the City of Antigo Landfill or another approved landfill and the potentially hazardous wastes to be handled by special disposer, nearly all wastes are recycled:

1) Tire casings will be returned to the supplier for recapping or disposal.

2) Scrap metal will be recycled. This is common practice in the mining industry today. Mill liners are returned to vendors in most cases, while scrap angle iron and other common scrap metal is sold to scrap dealers.

3) Common scrap metal will be segregated in a storage area for a period of time and then proposals from scrap dealers will be accepted with the scrap going to the highest bidder.

4) To the extent possible, chemicals and reagents will be purchased in returnable containers. Cyanide, for instance, will be purchased in "Flo-bins" which are returnable and minimize the handling of the chemical.

5) The laboratory will follow common industry practice of keeping glass wastage (empty bottles, broken glassware) in separate trash cans. This will enable the Crandon Project to offer this glass to recyclers.

6) The chemicals used in the analytical laboratory will consist of small quantities of acids, bases, and very small amounts of organics. The present plan includes piping the laboratory sinks to drain into the reclaim ponds. Accordingly, there will be virtually no need to discard toxic chemicals from the laboratory.

7) The reagents used in the laboratory are not significantly different than those used in the mill and, in quantity, they are very low in comparison to the total flow through the reclaim ponds. These ponds are routinely used for recycling mill water and disposal of these small quantities of waste reagents will not affect the chemical composition of the ponds.

8) Paper waste could be recycled to the local mills if sufficient quantities of different paper types are generated.

Question II.B.6:

Due to the large volume of petroleum products, waste oil, hydraulic fluids, chemical reagents, a spill plan for all storage areas will be needed. The spill plan must address the prevention, containment, clean-up and disposal of spilled materials.

Response:

Chapter 1.0 of the Crandon Project EIR addresses this concern in several sections. All storage tanks have been designed with containment berms and sumps which will contain the entire contents of the storage tank. Blind sumps, which are part of the spill containment design, do not contain drains or automatic pumps which might inadvertently displace a spill into some unsafe location. Such sumps would contain the entire spill.

In most instances, spills will not preclude the reuse of the chemical in the plant since the sumps avoid contamination of the chemical and the environment. Should a spill occur during transport of a chemical to the storage area while on the property, it would be reclaimed by pumps, front-end loaders, shovels or by whatever means is appropriate. If a spill should contaminate soils, the contaminated soil would be removed immediately by front-end loader and truck and stored in the pilot plant tailings sump or other safe storage until a licensed disposal firm could remove it to an appropriate disposal facility.

Question II.B.7:

A number of industrial processes located at the project have the potential for generating a hazardous waste (as defined by NR 181), i.e., machine shop, laboratory, maintenance areas, etc. What areas will generate hazadous waste? What type and volume of hazardous waste will be generated? How will the material be handled, stored and disposed?

Response:

a. Surface and Underground Repair/Machine Shops

Hazardous wastes will be restricted to solvents and solvent soaked rags. These will be held in an approved fire resistant container for recycle/disposal by licensed hazardous waste handlers.

Used batteries will be stored prior to recycle in the covered area near the timber and steel storage compound. they will be offered as part of metal recycle to the scrap dealers.

b. Laboratory

Hazardous wastes would consist of empty containers which previously contained chemicals. These chemicals consist of mostly acids, alkalies and occasionally some organics.

The chemicals themselves are consumed in the assaying and experimental procedures. Since they are similar to reagents used in the mill processes, they will be disposed in the mill streams and end up in the mill recycle water where they are decomposed and/or eliminated in the water treatment plant. They represent a negligible part of the mill water system (less than 1 gpm of the 6,000 gpm recycle).

The empty bottles from the chemicals will be rinsed, segregated and stored according to chemical type and held for disposal or recycle by a licensed handler (4 - 5 one-gallon bottles per day). Laboratory drains flow to the reclaim ponds and the water is recycled in the mill.

c. <u>Reagent Handling and Storage Facility</u>

The reagent handling and storage facility in the mill has a possibility for accidental generation of hazardous wastes. The reagents used in the processes consist of sodium cyanide, sodium dichromate, sulfuric acid, sulfur dioxide, lime, xanthates, and various organic chemicals. For normal circumstances, it is not anticipated that this facility will generate hazardous wastes. All containers for these chemicals will be returned to the vendors. All storage areas are protected by retaining walls and sumps. Accidental spills in these areas will normally be returned to the process as they would not harm the reagents.

In the event that a reagent was spilled outside the storage area, it could get contaminated in such a way as to make it unusable. This spill could possibly be a liquid and could saturate a limited amount of soil. This spill residue would be cleaned up by removing the affected soil. The pilot plant tailings sump is a concrete sump with vehicle access so that it might be used to store the residue until a licensed handler could remove it.

Question II.B.8:

What volume of septic tank sludge and/or chemical toilet waste will be produced? At what rate will the waste be produced? How will it be disposed? Will the chemical toilet waste be compatible with the proposed septic system? Can the chemical toilet waste be disposed with the septic sludge or will it require special handling?

Response:

The total Project sanitary wastewater flow is estimated at 109 m^3 (28,750 gallons) per day during the 22-year operating period. These waste generation rates are assumed to remain constant over the 22-year operating period. This estimate is conservatively based on an 800 person employee and visitor population and a 0.13 m^3 (35 gallon) per person per day waste generation rate. By DILHR code a 2.84 m^3 (750 gallon) base flow is added to the total daily volume.

This estimate is also conservative because approximately one-third of the work force will utilize chemical toilets in the mine. They will have access to full sanitary facilities before and after their shift but will occassionally utilize the chemical toilets. This will tend to reduce their total waste contribution.

The chemical toilets will generate less than 0.004 m^3 (1 gallon) per person per day of sanitary waste. Waste from these chemical toilets will be flushed into the surface sanitary sewer system for disposal in the permanent surface sanitary waste disposal facility. Flush to waste rates of 5:1 would still only yield a total waste quantity from the chemical toilets of 0.02 m^3 (5 gallons) per person per day.

The chemical toilets are normally charged with a small volume of formaldehyde and perfume when they are emptied, cleaned, and prepared for reuse. Based on the dilution that these chemical toilet wastes ultimately receive from the flushing when they are dumped into the surface sewage system and also when they are combined with the other sewage normally handled in the permanent facilities, these chemicals are not expected to affect the operation of the sanitary waste disposal system septic tanks.

The quantity of sanitary sewage solids has been approximated based on a per capita contribution of 0.07 kg (0.15 pound) total suspended solids per day. For the 800 person population this is equivalent to approximately 120 pounds per day. Assuming a specific gravity of 1.0, a solids volume of approximately 2.0 cubic feet would be generated per day. On a yearly basis this would amount to approximately 730 cubic feet.

To provide a conservative projection of sludge disposal, it has been assumed that one-fourth of the total septic tank system storage capacity is pumped and removed for disposal twice a year. Based on this approximation a total yearly sludge disposal volume of 2,400 cubic feet has been estimated. At this yearly rate, over the 22-year operating period, a total of 52,800 cubic feet of sludge will be disposed of off-site.

Question II.C.1:

What volume of demolition material will be disposed on site at the end of the Project?

Response:

Assuming no other use is determined for any of the Project facilities and all facilities are either demolished or dismantled, the following waste materials and quanities would be disposed on-site during final Project reclamation. Where disposal options are noted as (1) and (2) options are given in order of preference. However, if the preferable options are not available at the time of disposal, all listed wastes will be disposed on-site.

The waste quantities estimated for on-site disposal include all items with significant volumes. Other minor amounts of building wastes (e.g., masonary walls, drywall) may be buried on-site in a legal and environmentally acceptable manner.

Facility	Item	Quantity	Disposal
Access Road	Asphalt Pavement	7,216 t	(1) Recycled and used elsewhere. (2) Buried within roadway right-of-way or in mine/mill area and worked into the final grading plan.
	Stone Base	56,700 t	(1) Recovered and reused elsewhere. (2) Buried within roadway right-of-way or in mine/mill area and worked into the final grading plan.
	Bridge Girders	194 m	(1) Salvaged and reused elsewhere. (2) Demolished and buried within roadway right-of-way and worked into the final grading plan.
	Other Bridge Concrete	247 m^3	(1) Demolished and buried within roadway right-of-way and worked into the final grading plan.
Railroad Spur	Ballast	25,820 t	(1) Recovered and reused elsewhere. (2) Buried within railroad right-of-way or in mine/mill area and worked into the final grading plan.
	Subballast	12,430 t	(1) Same as for ballast. (2) Same as for ballast.

Facility	Item	Quantity	Disposal
	Bridge Girders	61 m	(1) Salvaged and reused elsewhere. (2) Demolished and buried within railroad right-of-way and worked into the final gradng plan.
	Other Bridge Concrete	191 m^3	(1) Demolished and buried within railroad right-of-way and worked into the final grading plan.
Mine/Mill Area	Asphalt Pavement	5,075 t	(1) Recycled and used elsewhere. (2) Buried within mine/mill area and worked into the final grading plan.
	Stone Base	35,130 m^3	(1) Recovered and reused elsewhere. (2) Buried within mine/mill area and worked into the final grading plan.
	Railroad Ballast	6,625 m^3	(1) Same as for stone base.
	Concrete*	13,900 m^3	(1) Demolished and buried within mine/mill area and worked into the final grading plan.

* Concrete for on-site disposal estimated to include all suspended slabs, all walls, one-half the volume of all grade beams, one-half the volume of all slabs on grade, all tunnel roofs, and one-half the volume of all tunnel walls.

Question II.C.2:

What material will be removed from the Project for reuse or off-site disposal?

Response:

Assuming the Project site is completely reclaimed, the following materials will be removed from the site for reuse, scrap, or waste disposal elsewhere. The following list includes all major items; however, there may be other minor amounts of similar materials that will also be removed for reuse or scrap or actual disposal.

Facility	Item	Quantity	Disposal
Access Road	Fencing	2,650 m	Reuse or scrap
	Guardrail	325 m	Reuse or scrap
Railroad Spur	Track (2 rails)	8,116 m	Relayer or scrap
	Ties	14,500	Reuse
	Wood Plank	4,200 Bd. Ft.	Reuse
Mine/Mill Area	Structural and Building Steel	5,000 t	Reuse or scrap
	Metal Siding and Roofing	60,000 m^2	Reuse or scrap
	Metal Liner Panel	43,000 m^2	Reuse or scrap
	Prefabricated Buildings	5	Reuse or scrap
	Insulation	43,000 m^2	Waste
	Process Equipment	Lump Sum	Reuse or scrap
	Above Ground Mechanical Systems	Lump Sum	Reuse or scrap
	Above Ground Electrical Systems	Lump Sum	Reuse or scrap
	Other Above Ground Utility Systems	Lump Sum	Reuse or scrap
	Track (2 rails)	3,310 m	Relayer or scrap
	Ties	6,000	Reuse
	Fencing	5,635 m	Reuse or scrap
	Doors and Windows	Lump Sum	Reuse or scrap
MWDF Area	Above Ground Mechanical Systems	Lump Sum	Reuse or scrap
	Above Ground Electrical Systems	Lump Sum	Reuse or scrap
Mine	Mine Hoisting Equipment and Conveyances	Lump Sum	Reuse or scrap
	Salvageable Mine Electrical, Mechanical, and Processing Equipment		

Facility	Item	Quantity	Disposal
	i.e. Crushers, Main Fans, Pumps, Transformers etc.	Lump Sum	Reuse of scrap
	Salvageable Mine Mobile and Portable Equipment i.e. LHD's, Blasthole Drills, Compressors, Diamond Drills, Utilities, etc.	Lump Sum	Reuse or scrap

Question II.C.3:

What structures, etc., will remain on site after closure?

Response:

The portions or items of the various Project facilities noted below will remain in place in the final reclamation work. Building floor slabs, pit floors, or other larger concrete areas left in place would be broken up to allow normal rainfall infiltration.

Within the mine/mill area all concrete, pipes, conduits, or other facility components or materials will be removed to 0.5 m below the final reclamation grades and disposed either on-site (in the case of concrete) or off-site.

Facility	Item	Quantity
Project Area Monitoring System	Piezometers, lysimeters, etc.	Lump Sum
Access Road	Culverts	200 m
	Bridge Piling	213 m
Railroad Spur	Culverts	213 m
	Bridge Piling	234 m
Tailings Slurry Lines & Haul Road	Tailings Slurry Pipe	1.0 km
	Water Pipe	2.0 km
	Stone Roadway Base	19,000 Mt
	Culverts	150 m
Excess Water Discharge Line	Pipe	9.8 km

Facility	Item	Quantity
Mine/Mill Area	Concrete*	14,700 m^3
	Underground Pipe and Conduit	14,000 m
	Culverts	975 m
MWDF	Essentially entire MWDF plus reclamation cap remains in place. Additional information is included in MWDF Feasibility Report and Reclamation Plan.	
Mine	Essentially entire underground portion of mine remains in place. Additional information is included in Reclamation Plan.	

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* Concrete left in place estimated to include all building and equipment foundations, one-half the volume of all grade beams, one-half the volume of all slabs on grade, all tunnel floors, and one-half the volume of all tunnel walls.

Question II.D.

Have any other wastes of concern been identified since the original submittal of the EIR?

Response:

The information presented in this letter represents our current waste information and estimates. This information will also be included in the final EIR.

Please contact me or Carlton Schroeder if you have any questions or comments regarding the information provided in these responses.

Sincerely,

EXXON MINERALS COMPANY

B. J. Hansen
Permitting Manager

BJH:CCS:sjq

xc/R. Ramharter

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

April 26, 1985

File Ref: 1630
(Exxon)

RE: Exxon Crandon Mine Project/
Additional Documents for Public
Information and Review

Dear Librarian:

Please place the enclosed documents with the rest of the Exxon Crandon Mine Project environmental impact report (EIR):

1. Exxon's April 12, 1985 response to DNR comments, dated December 28, 1985, on the revised EIR.

2. Report by DNR's "noise" consultant, Howard Needles Tammen and Bergendoff, dated April 2, 1985. (This material will be used by the Department to develop the environmental impact statement [EIS] sections pertaining to noise and seismic vibration.)

3. Hydraulic Relations between Little Sand, Oak, Duck, Skunk, and Deep Hole Lakes and the Main Ground Water Aquifer, Crandon Poject", by Dames & Moore, April 4, 1985. (This is a revision of the report dated September, 1984, also by Dames & Moore.)

These documents pertain to the EIR. People who have comments or questions about them may contact Mr. Robert Ramharter at (608) 266-3915 or at DNR, Box 7921, Madison, WI, 53707.

Thank you for your assistance.

Sincerely,
Bureau of Environmental Analysis and Review

Carol Nelson

Carol Nelson
Environmental Specialist

Enclosure

EXXON MINERALS COMPANY

P. O. Box 813, RHINELANDER, WISCONSIN 54501

CRANDON PROJECT

April 12, 1985

Responses to DNR comments on the Revised EIR, DNR Letter Dated December 28, 1984

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

Dear Mr. Ramharter:

Enclosed are responses to DNR comments contained in H. S. Druckenmiller's letter dated December 28, 1984, on the revised Environmental Impact Report for the Crandon Project. This submittal includes 44 copies of the responses. In addition, one copy will be transmitted to Mr. Terry McKnight at the North Central District office.

The responses to comments on Chapter 2 and on noise and seismic vibration will be integrated into the revised EIR. Most of the responses to comments on Chapter 1 will also be included in the revised EIR; however, several of the responses to comments on Chapter 1 and all responses on Chapter 3 comments will be included as an addendum to the EIR.

Please contact me if you have questions on this submittal.

Yours truly,

EXXON MINERALS COMPANY

Barry J. Hansen
Permitting Manager

BJH:ef

Enclosures (44)

xc/w/encl: Mr. T. C. McKnight
DNR-NCD

Chapter 1 - Description of the Proposed Action

Section 1.1.3.2 - Statutory Requirements

Comment No. 1

The citation of 42 U.S.C. 300 h et seq should be changed to the appropriate state authority since this function has been delegated to the state.

Response:

Comment acknowledged. The citation of 42 U.S.C 300 h et seq will be removed from Table 1.1-3 in the revised EIR.

Comment No. 2

The explanation on page 2 of the table discussing Federal - State delegation should be changed to read "...will remain or become authorized to administer...".

Response:

Comment acknowledged. This change will be included in the revised EIR.

Comment No. 3

A permit for diversion of surface water under Wis. Stats. 144.855(2) is cited. There has been no activity identified which would require this permit and no such application has been submitted to the Department. What activity is envisioned and will a permit application be submitted?

Response:

No Project-related activities that would require a permit for diversion of surface water are proposed. This permit requirement will be removed from the list presented in Table 1.1-3 of the revised EIR.

Comment No. 4

The listing of the County Forest Withdrawal activity is somewhat misleading. Exxon has already applied to and received approval from Forest County for withdrawal of the land. The application before the Department is the County's and, as such, will not be considered along with the other listed permits at the Master Hearing. We will, however, include this Department action in the Project EIS.

Response:

Comment acknowledged.

Comment No. 5

The correct citation for a high capacity well permit authority is 144.025(2)(e).

Response:

Comment acknowledged. This change will be included in Table 1.1-3 of the revised EIR.

Comment No. 6

Section 147.02 is cited as a statutory obligation for the private sewage system. While a large size septic system does not presently require a s. 147.02 permit, one probably will be required for such systems by the time of the Master Hearing. The "Actions" should be "permit issuance (county), permit issuance (DNR), review and approval of final plans (DILHR).

Response:

Comment acknowledged. This change will be included in Table 1.1-3 of the revised EIR.

Comment No. 7

For the Mine Waste Feasibility Report, Plan of Operation, the action should read "Plan Approval and License".

Response:

Comment acknowledged. This change will be included in Table 1.1-3 of the revised EIR.

Section 1.1.3.3 - Project Schedules and Manpower Requirements

Comment No. 8

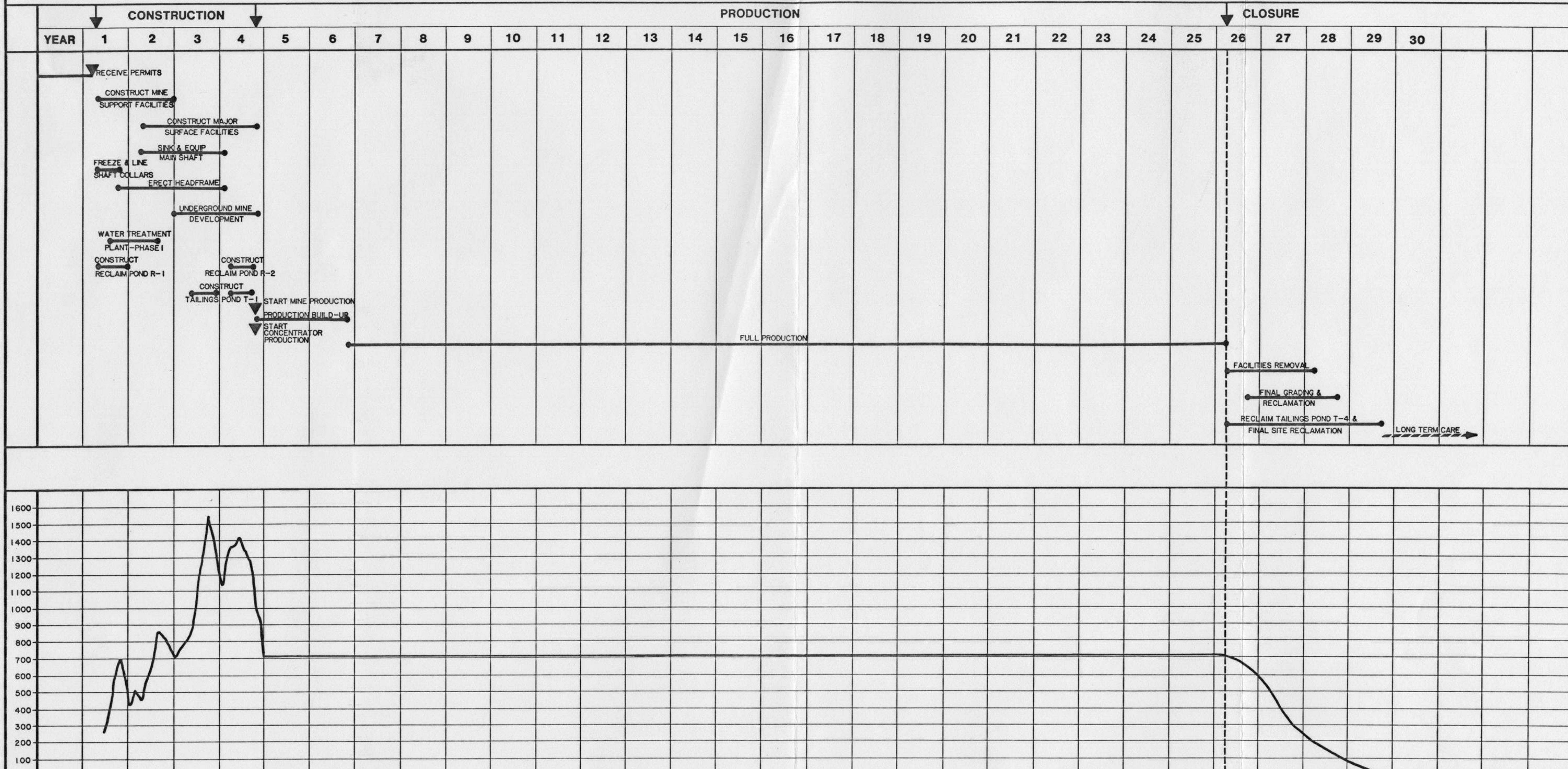
Figures 1.1-15 and 1.3-19 show the construction schedule for the entire project, including that for the wastewater treatment plant (WTP) and the reclaim ponds. These schedules differ significantly from that presented for the WTP in the Preliminary Engineering Report dated October 19, 1984. Which is the correct schedule? Is there an updated EIR project schedule available?

Response:

It is presumed that the above referenced figure is 1.1-5 as there is no Figure 1.1-15.

Figures 1.1-5 and 1.3-19 from the revised EIR showing the Project construction schedules have been updated and are consistent with the wastewater treatment plant (WTP) Preliminary Engineering Report dated October 19, 1984. The updated Project schedules were contained in the February 1985 revision to Chapter 1 of the EIR which was previously submitted to the DNR. Copies of these figures are attached.

EXXON MINERALS COMPANY
CRANDON PROJECT
SCHEDULE



YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			
PEAK	696*	872*	1567*	1430*	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	600	250	80	1	1	1	1
AVG.	516**	652	1101	1206	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	703	641	325	165	55	1	1	1	1

NOTES:

1) CONSTRUCTION OF TAILINGS POND 2, 3, & 4 WILL BE DONE AS REQUIRED DURING PRODUCTION. RECLAMATION OF TAILINGS POND 1, 2, & 3 WILL BE DONE DURING PRODUCTION.

2) ACTUAL CONSTRUCTION SCHEDULE MAY VARY DEPENDING ON PERMIT ISSUANCE & ECONOMIC CONDITIONS.

* CONSTRUCTION MANPOWER INCLUDES 20% CONTINGENCY.

** 7 MONTH AVERAGE

REVISED	DATE	BY	DESCRIPTION
3	1-29-85	DRS	GEN REVISION
2	4-23-84	DRS	GEN REVISION

Typical Representations: Refinements May Be Made During Final Engineering

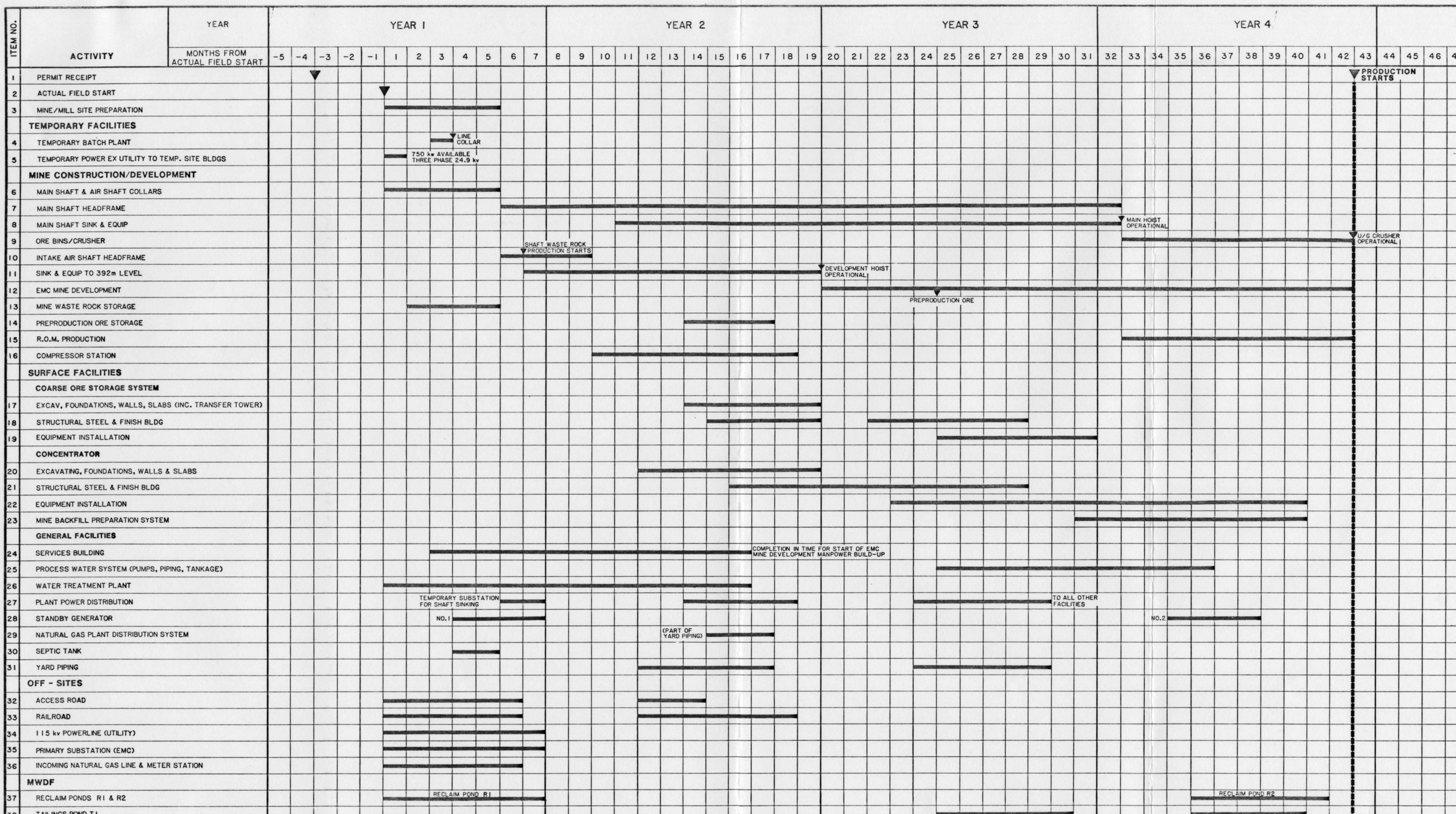
EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE: **PROJECT SCHEDULE**

SCALE: NONE | STATE: WISCONSIN | COUNTY: FOREST
DRAWN: DR SPRINGBORN | DATE: 4/84 | CHECKED BY | DATE
APPROVED BY | DATE | APPROVED BY | DATE
APPROVED BY | DATE | EXXON | DATE

DRAWING NO: **FIGURE 1.1-5** | SHEET ___ OF ___ | REVISION NO: 3

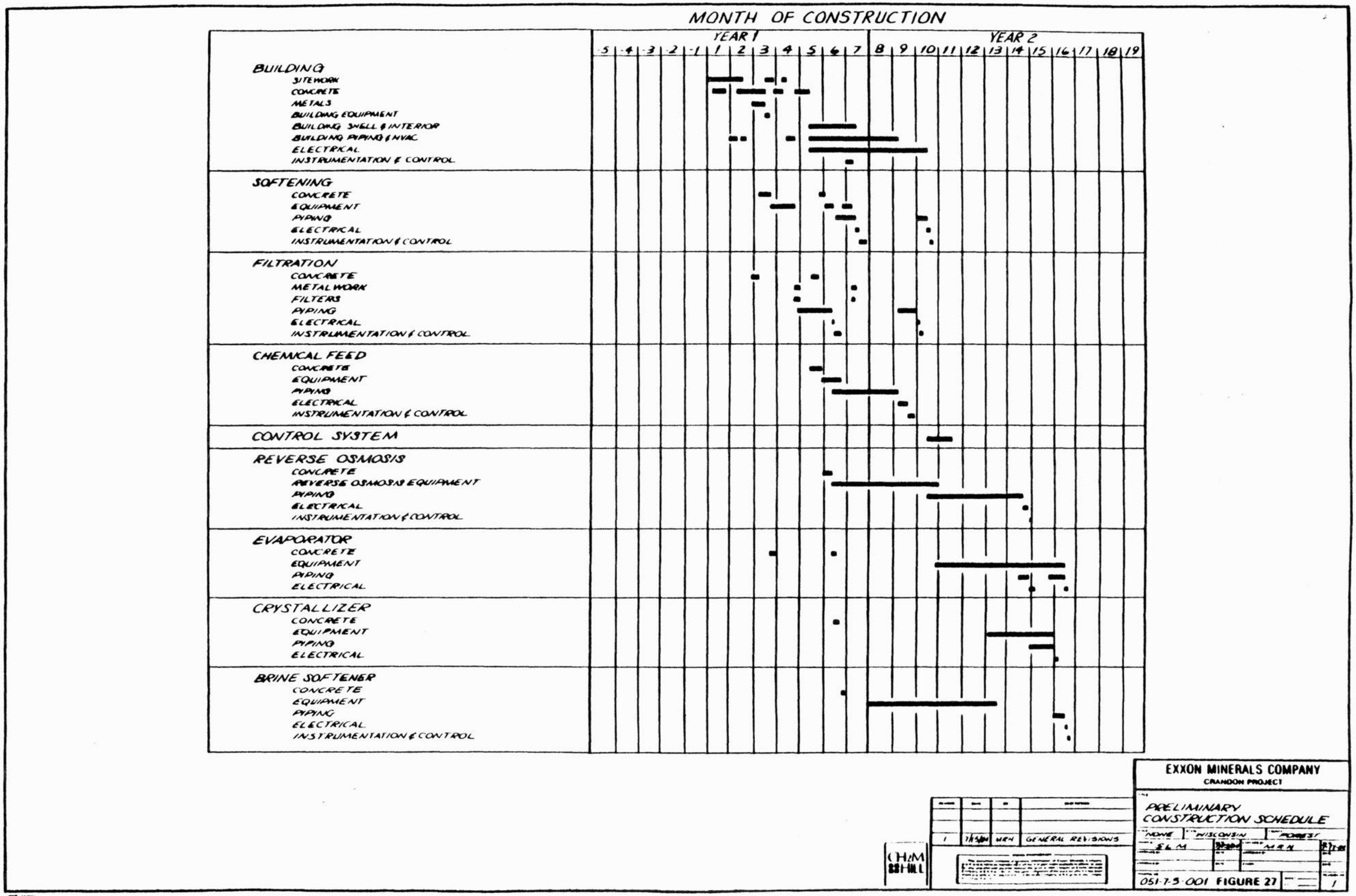
GBB 5/1981



Typical Representation: Refinements May Be Made During Final Engineering

EXXON MINERALS COMPANY CRANDON PROJECT	
TITLE: CRANDON PROJECT CONSTRUCTION SCHEDULE	
SCALE: NONE	STATE: WISCONSIN	COUNTY: FOREST
DRAWN BY: DR SPRINGBORN	DATE: 4/84	CHECKED BY	DATE
APPROVED BY	DATE	APPROVED BY	DATE
APPROVED BY	DATE	EXXON	DATE
DRAWING NO: FIGURE 1.3-19	SHEET ___ OF ___	REVISION NO: 5

GBB 5/1981



(FIGURE FOR THE RESPONSE TO COMMENT NO. 8)

Section 1.1.3.3 - Project Schedules and Manpower Requirements

Comment No. 9

The description of the monitoring program in this section does not reflect our current understanding of the program. This section will likely be inconsistent with the monitoring plan once it is submitted.

Response:

The Monitoring and Quality Assurance Plan (Monitoring Plan) is currently undergoing revisions and it is anticipated that this will remain the situation through the Master Hearing. However, a current version of the Monitoring Plan will be provided to the DNR with the revised Mining Permit Application. Many of the general descriptions of the current version of the Monitoring Plan have been incorporated in the revised EIR subsection 1.1.3.3. There will, however, be portions of this EIR subsection and the revised Monitoring Plan which are inconsistent. These inconsistencies cannot be totally eliminated since the Monitoring Plan will continuously be revised to accommodate the various permit requirements as they relate to predicted Project effects. The general descriptions of the Monitoring Plan provided in subsection 1.1.3.3 of the EIR should enable the DNR, even with the minor inconsistencies, to complete the DEIS and FEIS.

Section 1.2.1.2-16 - Mine Drainage

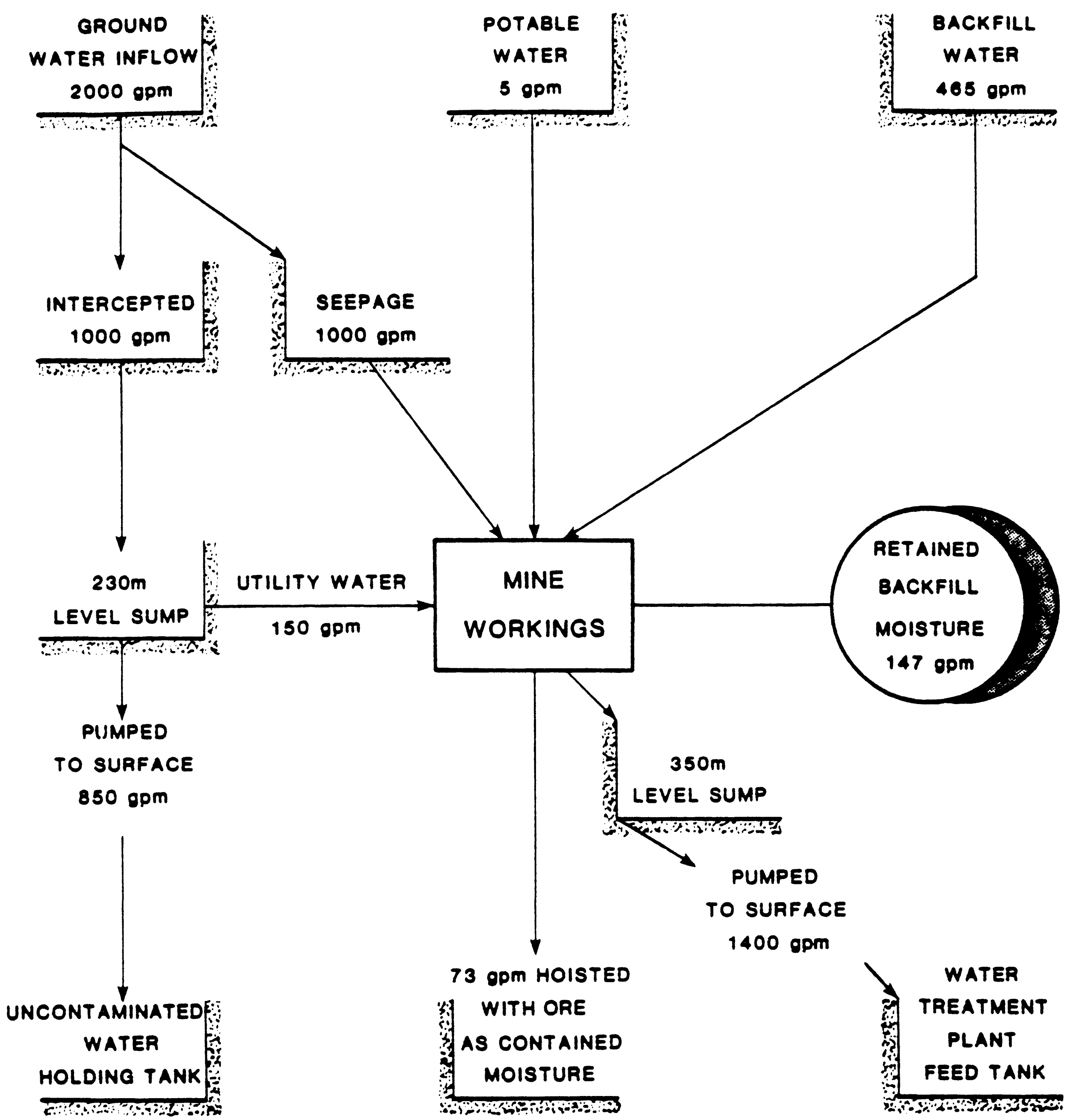
Comment No. 10

The 2,000 gallons per minute cited for site area impact modelling and system design is inconsistent with the revised Appendix 4.1A. A maximum of 1,600 gallons per minute was used for impact modelling and it is unclear what figure was used for mine water handling system design.

Response:

The mine pumping and drainage design basis, depicted on the attached Figure 1, provides for a steady state ground water inflow of 2,000 gallons per minute or 25 percent more than the steady state inflow range of 934 to 1,592 gallons per minute predicted by the mine inflow computer modelling (D'Appolonia, 1984). Mine pumping systems have been designed for a total capacity of 2,600 gallons per minute to account for other mine water flows such as backfill water drainage, potable water, utility water, bedrock storage depletion and minor downtime on the pumps. Each operating pump will be backed up by an installed spare. Dual full capacity pump discharge columns to the surface will be provided.

Refer to the High Capacity Well Approval Application for the Underground Mine for further discussion of mine water handling system details.



REPLACES DRAWING NO. 050-2.125.M.001 284-1-71M-2

CRANDON PROJECT

MINE DRAINAGE SCHEMATIC

(FIGURE 1 FOR THE RESPONSE TO COMMENT NO. 10)

Section 1.3.1.1 - Mine/Mill Site Preparation

Comment No. 11

Open burning appears to be Exxon's favored method of forest residue disposal. While the EIR mentions using contractors to chip whole trees, Exxon should consider the sale of the residue, its use on-site as fuel, composting for use as a soil amendment, or the use of air curtain destructor to provide cleaner disposal.

Response:

Additional detail regarding disposal of forest residuals has been provided in a November 9, 1984 letter to the DNR. The letter indicates chipping is our preferred disposal method followed by burning. Chipped residuals will be stockpiled and used for mulching or possibly sold for use off-site as fuel. If burning is necessary for any of the forest residuals, an approved air curtain destructor(s) would be utilized.

Section 1.2.4.-12 - Reclaim Water Ponds

Comment No. 12

Page 1.2-86 indicates that the lower liner for the reclaim pond will be six inches thick. The WTP Preliminary Engineering Report indicates that the reclaim pond liners would be eight inches thick.

Response:

The WTP Preliminary Engineering Report, indicating the bentonite modified soil liner is 0.2 m (8 inches) thick, is correct. Subsection 1.2.4.12 will be updated accordingly in the revised EIR.

Section 1.3.1.7 - Mine Waste Disposal Facility and Reclaim Pond Construction

Comment No. 13

The discussion on page 1.3-28 indicates the use of a settling pond and small high capacity clarifiers for wastewater generated during liner construction. The discussion does not, however, clearly designate the fate of the wastewater prior to reclaim pond construction or during tailings pond liner construction.

Response:

The settling pond and clarifiers will handle the water used in preparation of underdrain materials. For this process there is no discharge from the settling pond. Because of the moisture loss continually occurring with the prepared materials, makeup water must be continually added to the process. Based on the processing rates planned and the nature of the materials being processed and prepared, the makeup water requirement is expected to range from 400 to 600 gallons per minute.

In addition to the use for the processing plant, surface runoff from the construction support area will also be routed to this settling pond. Depending on the runoff quantities received, the actual makeup water required would be somewhat reduced.

Section 1.5 - Facilities Closure

Comment No. 14

Air emissions will be generated during the seven year closure period. Fugitive dust emissions during closure are estimated in the January 24, 1984 air permit submittal. While these emissions will be less than those during construction and operation, they are nonetheless significant. This section should provide a summary of emissions during closure including fugitive dust emissions, emissions from fuel consumptions, expected noise emissions and any other sources of air emissions.

Response:

The estimated air emissions and supporting calculations for the Project during closure have been provided to the DNR in the February 1985 Revised Air Permit Application. The estimated air emissions included fugitive dust emissions, emissions from fuel consumptions, and other sources of air emissions (see Tables 1.3-10 of the revised EIR, and 2.5 and 4.2 of the February 1985 Revised Air Permit Application). A summary of this information will be provided in an addendum to Section 1.5 of the EIR.

Similarly, the expected noise emissions during closure will be discussed in an addendum to EIR Section 1.5. The estimated noise emissions are likely to be less than those currently estimated for the construction and operation phase activities as provided in subsections 1.3.5.1 and 1.4.9 of the EIR. The equipment to be used during closure will be similar to that indicated for the construction and operation phases of the Project although it is likely they will be fewer in number. Newer models of the equipment, with improved noise suppression features, are also likely by the time of closure. However, the closure noise emission estimates will conservatively assume the levels of the construction and operation phase activities.

Chapter 2

Section 2.3.1.5 - Water Well Inventory

Comment No. 15

This section should indicate that the well survey was initiated in July, 1984 and that data collection is still in progress.

Response:

Comment acknowledged. Subsection 2.3.1.5 will be revised to indicate the water well inventory was initiated in July 1984 and that the results are presented in the High Capacity Well Approval Application.

Section 2.3.4.1 - Water Quality-Glacial Drift

Comment No. 16

This section indicates that water quality parameter concentrations are highest in the recharge areas and lowest in the discharge areas. Since this is contrary to generally observed trends, a brief discussion is necessary.

Response:

The measured values of alkalinity, calcium and mean hardness are higher in the ground water recharge areas than in the ground water discharge areas, as noted. This is possibly due to the solution of ions as the recharge water passes through the till which overlays the main aquifer. Because water movement through the till is much slower than through the main aquifer, the recharge water has more time to dissolve ions, but as the ground water moves through the drift aquifer it is subjected to dilution and is moving relatively, much faster and does not tend to dissolve more ions. This explanation is substantiated by the fact that water in the streams is very similar in quality to the ground water near them and ground water base flow is a substantial portion of the total flow of the streams.

Section 2.4.1.2 - Stream Flow Rates

Comment No. 17

The values of $Q_{7,10}$ taken from Golder in 1982 (as discussed on page 2.4-13 and in Table 24-19 were derived from incorrect use of the equations in Holmstrom (1980). The equation used for most of the sites has four variables, three of which were misinterpreted in Golder (1982). Entirely incorrect and unrelated values were substituted.

Response:

See response to comment No. 18.

Comment No. 18

Better estimates could probably be made by correlation with a long-term station using measured discharge. Also, the $Q_{7,10}$ estimates for the two U.S.G.S. gauges were different from those found in Golder (1982) without explanation. Golder had 11.6 ft^3/s downstream and 14.6 ft^3/s upstream from Rice Lake, a downstream reduction in flow that is difficult to explain.

Response:

On December 3, 1984, estimates of the $Q_{7,2}$ and $Q_{7,10}$ values for various streams gages in the site area were received from the DNR. Subsequently, EMC recalculated the $Q_{7,10}$ values using the Holmstrom (1980) methods and compared the values obtained with those received from the DNR. All values compared favorably except for those calculated by the DNR for gage SG 3. It is our opinion that the DNR values for SG 3 are in error and should be reevaluated. Otherwise, EMC intends to use the $Q_{7,2}$ and $Q_{7,10}$ values provided by the DNR in the revision of Section 2.4.

Section 2.4.4.1 - Drainage Lakes and Associated Streams

Comment No. 19

The assertion on page 2.4-33 that Hemlock Creek accounts for 10% of the base flow of Swamp Creek at Highway 55 is inadequately supported by the data. It relies on the base flow in Table 2.4-19, but the base flow values in the table are computed in different ways and for different periods of record at the various locations. Comparisons between base flow at different locations are meaningless unless the base flows are determined in a consistent manner for the same period of record.

Response:

Values of base flows and the site-to-site comparisons were intended only to provide a general characterization of the magnitudes and sources of low flows. The specific statement that Hemlock Creek accounts for 10 percent of the base flow of Swamp Creek at Highway 55 is, of course, based upon assumptions that there is a definable average surface water-ground water interchange between the two gage sites and that the base flows used are reasonable estimates of long-term average base flows. Similar assumptions are required to substantiate statements for other tributary sites such as Outlet Creek (page 2.4-42) and Creek 12-9 (page 2.4-59).

The revised version of EIR Section 2.4 will redefine the flow magnitudes used to characterize low-flows and will provide appropriate qualifying statements for any site-to-site comparisons.

Comment No. 20

As noted above, the comparison of base flow rates on page 2.4-37 that were determined for different periods of record is not adequately supported by the data. A comparison of $Q_{7,10}$ determined in a consistent manner would be more meaningful. Some of the base flows are determined by a proportional relationship using drainage areas. Comparisons of these base flows are no more than a comparison of drainage areas.

Response:

Comment acknowledged.

Comment No. 21

It is to be expected that the minimum observed flow at a continuous station would be proportionally lower than the minimum observed flow at gauges read weekly. This is true simply because weekly readings probably do not include the lowest flow for the period.

Response:

Comment acknowledged.

Comment No. 22

Hoffman Creek is included among tributaries that account for 3.8 ft^3/s to base flow, yet there are not enough discharge measurements to calculate base flow for Hemlock Creek (Table 2.4-9 and page 2.4-44).

Response:

Table 2.4-9 describes water and bottom sediment chemistry and we believe this is a typographical error. It should have read Table 2.4-19.

On page 2.4-44, second paragraph, last sentence, there is a statement to the effect that no base flow estimate has been made for Hoffman Creek.

Table 2.4-19 summarizes the flow characteristics of the study area streams. The table indicates that no base flow calculation was made for Hoffman Creek.

Comment No. 23

The above comments on comparing base flow rates also apply to the discussion of Outlet Creek on page 2.4-42. In addition, it is inaccurate to state that base flow in Outlet Creek is 38% of the base flow of Swamp Creek at Highway 55 since the base flow in Outlet Creek is only reported as less than 3 ft^3/s.

Response:

Comment acknowledged. The following correction will be made in line 6, paragraph 2, page 2.4-42: "Outlet Creek accounts for less than 25 percent of the base flow of..."

Comment No. 24

The terminology on page 2.4-56 conflicts with Table 2.4-19. Flow rates which are called "average base flow" in the text are listed under "base flow" in the table.

Response:

In line 4, paragraph 2, page 2.4-56 the word "average" will be deleted.

Comment No. 25

How was a base flow of 0.9 ft^3/s determined for SG 19 if the minimum flow for which the rating curve was valid was 1.8 ft^3/s? The above discussions of base flow comparisons also apply to page 2.4-59 and 2.4-81.

Response:

The base flows shown in Table 2.4-19 that are less than the "lower reliability limit" of the rating curves were defined from minimum recorded flow at the USGS operated Langlade gage and a drainage area ratio. The technique is described on page 2.4-11 and in footnote b of Table 2.4-19.

In the revised EIR Section 2.4, a more technically derived and presumably more precise estimate of low stream flow will be used.

Comment No. 26

A base flow for the outlet of Duck Lake is given as 0.2 ft^3/s on page 2.4-66. While it may be a matter of definition of base flow, it seems that base flow should be zero if there is no base flow for significant periods.

Response:

Appendix 2.4A, Table A-14, lists the record of stream gage SG B on the outlet from Duck Lake. During the period of record for the gage there were three measurements attempted which were small enough to be beyond the range of the rating curve. The outlet from Duck Lake is a wetland and is perched above the ground water table. Therefore, the term base flow, in the classical sense, does not apply to the stream. However, the wetland that borders the outlet channel is large and is probably capable of supplying sufficient water to the stream to maintain some flow for all periods except sustained drought conditions. Perhaps a better word to describe the nearly constant flow in the stream would be "sustained flow." The text on page 2.4-66 in the revised EIR will be changed to read sustained flow instead of base flow.

Section 2.4.7 - Hydrological Relationships

Comment No. 27

The discussion of WATER BALANCES correctly states that significant inaccuracies are likely in the various components of the water budgets. Given a possible error of an order of magnitude in the groundwater term, no significance should be attached to the differences in evapotranspiration between 60% and 67% of precipitation. The possible error in evapotranspiration in the water balance far exceeds any difference between values shown in Table 2.4-21.

Response:

Comment acknowledged. Line 2, paragraph 1, page 2.4-90 will be changed to read: "...transpiration was larger, 67 percent..." This change will reduce the significance of the difference in evapotranspiration percentages of precipitation.

Comment No. 28

How was the determination of 18 ft^3/s discharged in Swamp Creek on page 2.4-91 made? The mean discharge for six years (1978 - 1983) is 31.7 ft^3/s. How were the percentages of flow from Hemlock, Outlet, and Hoffman Creeks determined?

Response:

Based on USGS data for Swamp Creek at the continuous recording gage at State Highway 55, the average base flow at this location for the period of record between April 1977 and November 1980 was 0.54 m^3/s (19 cubic feet per second) (see Table 2.4-19). All discharge values for Swamp Creek and its tributaries will be checked and revised accordingly based on the USGS's 1984 estimates of stream flow.

Material in this subsection and in Table 2.4-21 attempts to characterize the hydrologic flow system by evaluating precipitation inputs, evapotranspiration and streamflow losses and ground water inflows or outflows through a water balance analysis. As discussed, the values of each component were estimated from limited data and balanced either by arithmetic means or by engineering judgements.

Section 2.9.2.1 - Forestry

Comment No. 29

The saw timber volume of 9,928 board feet per acre cited in this section includes Menominee and Shawano Counties and is therefore very high for Forest, Langlade, and Oneida Counties. A more appropriate figure would be in the range of 5,000 to 6,000 board feet per acre.

Response:

Subsection 2.9.2.1 will be revised to designate a saw timber volume of 5,000 to 6,000 board feet per acre in Forest, Langlade and Oneida counties using the DNR as the source for the estimated volume.

Chapter 3

Comment No. 30

We have only a few specific comments on the alternatives section at this time. Please be aware, however, that as our impact analyses proceeds, newly identified impacts may require that additional alternatives be developed.

Response:

Comment acknowledged.

Comment No. 31

We believe, for example, that on-going analyses could indicate adverse impacts to surface waters from the ground water drawdown. By developing alternatives to mitigate these potential impacts now, Exxon could avoid future delays in the process. Specifically, we recommend further evaluation of alternatives to maintain ground water levels and/or surface water levels through discharge of excess water. Exxon should also assess the effect of these alternatives on the wastewater treatment plant design.

Response:

A Contingency Plan is being prepared that will identify and describe potential alternative actions for use in mitigating ground water and surface water impacts caused by mine dewatering in the event that such action is necessary. The effect of these alternatives on wastewater treatment plant design will be included in the plan. When completed, the plan will be provided to the DNR.

Comment No. 32

In addition, it appears that our socioeconomic analyses may reveal that a substantial portion of both construction and operation workers may originate from areas south of the mine site. If this is the case, an access road connecting with Highway 55 at a more southerly location may be preferable. While our analyses of worker distributions are not yet completed, we recommend that Exxon conduct initial evaluations of southern route alternatives at this time.

Response:

An alternative route for the access road located south of alternative route E (Sand Lake Road) would require additional engineering study and could have as much or more environmental impact than the proposed route, depending upon the specific route alignment and its connection with State Highway 55. A more southerly route would still not prevent the flow of Project-related traffic (those workers living north of the Project site) through the Mole Lake Indian Reservation and the community of Mole Lake. The potential for disturbing residences during construction of an access road at a more southerly location would be greater than for the proposed route.

Section 3.4.2.2 - Haul Road Corridor

Comment No. 33

The alternative of paving the haul road should be considered. This alternative would reduce fugitive dust and eliminate the need for chemical stabilizers and watering.

Response:

Paving or possible other permanent treatments of the haul road between the mine/mill site and the MWDF area were considered and after evaluation rejected because of technical and economic reasons. The haul road is designed to support 35-ton off-highway trucks. Trucks of this size are required to provide an economic transfer of waste rock to the MWDF throughout the Project. The use of this size truck also reduces potential fugitive dust emissions because fewer trips are required to transport the rocks.

Construction of the haul road will include an additional thickness to the base course in order to support the 35-ton trucks. Similarly, the top layer of gravel for the haul road surface will require an extra thickness. There would also be an increase in the thickness of the top layer if it were asphalt or other possible permanent treatment in comparison to the gravel.

For example, the access road is currently designed to have a 12-inch crushed aggregate base course covered by a 3-inch asphalt surface. It will support a maximum axle load of 9 tons. The crushed aggregate base layer could double in thickness (i.e., 24 inches) for the haul road to support the 35-ton trucks. An asphalt surface layer would be a minimum of 6 inches or approximately 100 percent thicker than the access road.

The estimated cost for the access road is approximately $9.50/sq. yd. (12 inch base = $3.50/sq. yd.; 3 inch asphalt = $6.00 sq. yd.). The estimated cost for the haul road would be approximately $19.00/sq. yd. (24 inch base = $7.00/sq. yd.; 6 inch asphalt = $12.00 sq. yd.), also an increase of 100 percent.

Similarly, additional costs would be required for maintenance of the haul road. A gravel haul road can be repaired for approximately $7.00/sq. yd., whereas the asphalt surfaced haul road would require approximately $19.00/sq. yd. of maintenance cost.

Frost damage to the haul road is likely to occur every year. Direct repair costs, as presented above, for an asphalt surfaced haul road would be more than double those of a gravel road. In addition, the potential out-of-service costs because of a damaged asphalt surfaced haul road are also much higher than for a gravel road. Several days may be required to fix the asphalt road, whereas a road grader available at the mine/mill site can easily and quickly repair a gravel haul road.

Finally, the estimated fugitive dust emissions for the gravel haul road during the operation phase are generally not greater than 10 tons per year with watering and chemical stabilizers (see Table 4.1 of the February 1985 Revised Air Permit Application). This quantity of fugitive dust emissions would not be reduced below 8 tons per year with a paved road. Therefore, this estimated fugitive dust quantity difference does not warrant the additional cost required to reduce these emissions further.

Comment No. 34

Overall, it appears fugitive dust from general construction, excavation, and hauling could be better controlled through greater use of chemical dust suppressants. This alternative should be evaluated further.

Response:

Chemical dust suppressants were evaluated as a control mechanism for general construction, excavation, and hauling activities of the Project. However, chemical dust suppressants are most effective for longer term (i.e., several days or more) control of exposed dirt surface areas. General construction, excavation and hauling tasks will be short-term activities (i.e., minutes and hours) occurring in succession throughout the day. Therefore, water spraying immediately before clearing, scraping, excavating and hauling activities will sufficiently suppress dust generation. Further, this will be a rather continuous activity with water being sprayed on construction areas prior to work initiation. Since the soil material will be worked and moved while still damp, the fugitive dust emissions will be controlled.

Chemical dust suppressants will not increase the efficiency or be more effective in controlling fugitive dust emissions because the construction activities will rapidly displace the sprayed surface layers. Therefore, the chemical dust suppressant will not have a long-term controlling effect. Further, the additional cost required for the chemical dust suppressant, without additional benefit, is not cost-effective when compared with water spraying. If construction activity will be discontinuous in any area and soil will be exposed for long periods of time (i.e., days or weeks), chemical dust suppressants will be considered to control possible fugitive dust emissions. Use of chemical dust suppressants would also be evaluated in relation to weather (i.e., rain, wind) and seasonal (i.e., snow cover) conditions.

Noise and Seismic Vibration

Comment No. 35

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:

The response to this comment was provided previously in the letter dated January 4, 1985, from B. J. Hansen, EMC, to R. H. Ramharter, DNR.

Comment No. 36

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:

The response to this comment was provided previously in the letter dated January 4, 1985, from B. J. Hansen, EMC, to R. H. Ramharter, DNR.

Comment No. 37

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.

Response:

The response to this comment was provided previously in the letter dated January 4, 1985, from B. J. Hansen, EMC, to R. H. Ramharter, DNR.

Comment No. 38

Figures 2 to 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:

The response to this comment was provided previously in the letter dated January 4, 1985, from B. J. Hansen, EMC, to R. H. Ramharter, DNR.

Comment No. 39

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 response to this comment was provided previously in the letter dated January 4, 1985, from B. J. Hansen, EMC, to R. H. Ramharter, DNR.

Comment No. 40

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:

The response to this comment was provided previously in the letter dated January 4, 1985, from B. J. Hansen, EMC, to R. H. Ramharter, DNR.

Comment No. 41

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:

The response to this comment was provided previously in the letter dated January 4, 1985, from B. J. Hansen, EMC, to R. H. Ramharter, DNR.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

BOX 7921
MADISON, WISCONSIN 53707

January 21, 1985

File Ref: 1630
(Exxon)

RE: Exxon Crandon Mine Project EIR/
Additional Documents for Public
Information and Review

Dear Librarian:

Please place the enclosed document along with the rest of the Exxon environmental impact report (EIR):

> Response to DNR Comments, dated September 17 and October 22, 1984, Re: Ground Water Modeling and Mine Dewatering Impact Analysis; by Exxon Minerals Company, January 10, 1985.

This document pertains to the EIR. People who have comments or questions about it may contact Mr. Robert Ramharter at (608) 266-3915 or at DNR, Box 7921, Madison, WI, 53707.

Thank you for your assistance.

Sincerely,
Bureau of Environmental Analysis and Review

Carol Nelson

Carol Nelson
Environmental Specialist

Enclosure

JAN 18 1985

EXXON MINERALS COMPANY

P O Box 813, RHINELANDER, WISCONSIN 54501

CRANDON PROJECT

January 10, 1985

Reference 4400
Ground Water Modeling and Mine Dewatering Impact Analysis, Crandon Project and Baseline Data Needed to Evaluate Mine Dewatering Impacts

Mr. Richard Schuff, Chief
Land Disposal and Residuals Management
Section, Bureau of Solid Waste Management

and

Mr. William Rock, Chief
Private Water Supply Section,
Bureau of Water Supply
Department of Natural Resources
GEF II
P.O. Box 7921
Madison, Wisconsin 53707

Dear Messrs. Schuff and Rock:

This letter is written in response to your letters dated September 17, and October 22, 1984. The comments contained in these two letters were closely related; therefore, a single response letter has been prepared.

September 17, 1984 Letter

Comment No. 1, Paragraph 1:

"Exxon should include a discussion of the limitations of horizontal two dimensional ground water flow modeling in both the text of technical reports and where results are used to describe impacts in the EIR. One specific area of concern is in the Swamp Creek area. The modeling assumptions include the use of a constant head boundary at Swamp Creek, which means the stream is assumed to completely penetrate the thickness of the aquifer. In reality, the hydraulic connection between the aquifer and the stream consists of significant vertical flow through stream sediments and aquifer materials. The modeling undertaken to date by Exxon does not simulate the detailed three-dimensional flow of ground water at the Swamp Creek boundary. Similar situations occur at Hemlock Creek, Upper Pickerel Creek, and the wetlands northeast Rolling Stone Lake."

Response:

A summary of the response presented below will be included in Chapter 4.0 of the revised EIR.

The overall applicability of the main two-dimensional horizontal model has been discussed many times with the Department staff and DNR consultants. The absence of major vertical gradients throughout the model/study area was confirmed by the winter/spring 1984 field program and measured water levels. The well points installed across the streams (Swamp and Hemlock creeks) showed the flows in these localized areas had vertical upward gradients confirming ground water discharge to the streams.

Model boundary condition sensitivity analysis performed by D'Appolonia confirmed that use of a constant head boundary was the most appropriate condition for modeling the stream (Swamp Creek) condition. Results of the sensitivity analysis are included in Section 5.2.6 (Calibrated Model Evaluation) and in Attachment A.6 of EIR Appendix 4.1A (revised D'Appolonia report submitted to DNR on October 15, 1984).

All these analyses verify that the two-dimensional horizontal model is an appropriate model for the Crandon Project hydrogeological setting. In areas where vertical simulation was important, two-dimensional vertical modeling was performed. The modeling included flow model calibration and dispersion analysis.

Regardless of the computer model utilized, an individual model could have advantages and disadvantages for projecting impacts depending upon the hydrogeological site characteristics. Whereas the two-dimensional horizontal model does not provide three-dimensional flow system definition at the stream boundaries, the model results are properly predicting the ground water flow directions and changes in the flow. For the minor flow changes being predicted at the boundaries (streams), analysis for full flow system definition is purely academic.

Comment No. 1, Paragraph 2:

"Departmental staff and consultants agree with Exxon's contention that the expected mine dewatering flow rates are not likely to cause a reversal of ground water flow from Swamp Creek to the mine, but we are still concerned that changes in vertical gradients not simulated by the horizontal model, result in the potentially greater depression of water table or piezometric levels in the Swamp Creek area than can be presently simulated with the GEOFLOW horizontal model. These concerns are not strictly academic in that reductions in hydraulic head values in the Swamp Creek area could have significant impact on wetlands areas immediately south of the stream which are supported by discharging ground water. It should be noted in the text of the modeling and impact analysis reports that should mine inflow be greater than predicted and cause a reversal of ground water gradient from Swamp Creek, then the constant head boundary condition may no longer be appropriate and would need to be modified to simulate more closely the true hydraulic connection between the creek and underlying aquifer."

Response:

The zero head (open node) analysis by D'Appolonia to determine maximum mine inflow provides a high level of confidence in the estimate of expected mine inflow and also showed that maximum potential mine inflow was only approximately 20 percent higher than the projected inflow (1,271 gpm). Although ground water and surface water monitoring plans have not been finalized, they will be sufficient to determine the extent of ground water decline. As a part of construction and operations monitoring the ground water model could be utilized to verify actual ground water declines against model projected declines based on model runs made at the actual mine dewatering rates.

Some localized areas might experience ground water changes different than GEOFLOW has simulated; however, the changes will be less than the average yearly natural changes that now occur.

Comment No. 1., Paragraph 3:

"At meetings with Exxon the Department has suggested that Exxon examine the drawdown in the Swamp Creek area by exercising the areal portion of Prickett's mine in-flow model in a modified form. The model domain could be enlarged to extend north of Swamp Creek and the creek modeled as a leaky confining bed. The model would need to be calibrated with varying confining bed permeabilities in order to determine the value at which the discharge of ground water into the stream would be inhibited. This would be the minimum possible confining bed permeability value. The model could then be run simulating mine dewatering conditions to see if significant drawdowns occur in the Swamp Creek area. This option would not appear to be a useful exercise as long as the dewatering of the mine is not expected to reverse ground water flow from Swamp Creek. However, it should be mentioned as a evaluation tool should dewatering impacts be larger than presently expected."

Response:

The question of the adequacy of the modeling of the Swamp Creek boundary in the GEOFLOW model has been discussed at length with the Department staff and DNR consultants. We believe that the Swamp Creek boundary has been modeled satisfactorily in the GEOFLOW model for the Project conditions. The boundary sensitivity analysis included in the recent D'Appolonia Report (EIR, October 1984 Appendix 4.1A) also indicated that the selection of different boundary conditions had minor influence on mine inflow rate and the associated projected hydrological impacts. Exxon Minerals Company agrees with the DNR that additional study of the boundary condition is not warranted and Appendix 4.1A has adequately addressed this concern.

Comment No. 1., Paragraph 4:

"Decreases in ground water flow from the mine area to surrounding discharge points may cause significant impacts to local discharge areas even though total stream flows in those areas may not be affected dramatically. It may be possible to evaluate these impacts more precisely using a three-dimensional ground water flow model with a finely spaced element distribution at the discharge points and the addition of detailed control over the aquifer, streambed, and wetland hydraulic properties, but the Department believes this would be impractical due to the data collection needed to support such a modeling effort. The Department is presently evaluating the feasibility of using a simplified three-dimensional approach to evaluate discharge area sensitivity to reduction in discharge."

Response:

Our evaluations thus far have indicated there will not be significant impacts to any of the streamside wetlands. Answers to other questions in this letter indicate we are continuing evaluation of detailed hydrologic changes to streamside wetlands and will provide the DNR with refined impact evaluations at a later date.

Comment No. 2, Paragraph 1:

"Exxon must provide additional analysis of potential impacts to the following areas: the southern margin of Swamp Creek, western margin of Hemlock Creek, the wetlands and associated stream headwaters northeast of Rolling Stone Lake including Martin Springs, and Hoffman Springs. Though Exxon has previously shown that reductions in flow to the combined total stream flow of Swamp and Hemlock Creeks due to mine dewatering are generally small, it is noted that most of the steam flow (estimated through areal recharge calculations) is from the north side of Swamp Creek. This means that relatively large decreases in flow from the southern (mine) side of Swamp Creek are possible. The Department's concern is that the wetlands and springs at discharge points could have a significant reduction in ground water flowing into them. Exxon must address this potential. The following evaluation must be included:".

Response:

The recently completed D'Appolonia modeling work (October 1984 EIR Appendix 4.1A) includes the detailed hydrological information necessary to evaluate associated wetlands and springs impacts for the areas noted. This completed work plus additional field work (being performed by the DNR and USGS) including topographical surveying and site hydrological evaluations should allow more detailed projections of impacts. Exxon will utilize additional information to be provided by the DNR (October 22, 1984 comment letter) to further refine projections of impact in the areas noted.

Comment No. 2.a.:

"The quantity and percent reduction of ground water flow to the southern margin of Swamp Creek, the western margin of Hemlock Creek, and the eastern margin of Upper Pickerel Creek should be calculated. The areas of Swamp Creek directly across from the mine should receive special emphasis as a high impact area".

Response:

Tables A-18 through A-26 from the October 1984 EIR 4.1A report prepared by D'Appolonia provide a summary of this information.

For the middle recharge case (Tables A-19 and A-24), stream base flow reductions for the model area contribution and the total area contribution to the streams are:

Stream Segment*	Model Area Contribution: Preconstruction Ground Water Discharge to Stream (m^3/s)	(cfs)	Project Year 28 Ground Water Discharge to Stream (m^3/s)	(cfs)	Reduction (m^3/s)	(cfs)	(%)	Total Area Contribution: Reduction (m^3/s)	(cfs)	(%)
A-B	0.026	0.93	0.014	0.51	0.012	0.42	45	0.012	0.42	10.5
B-C	0.039	1.339	0.024	0.86	0.015	0.53	38	0.015	0.53	2.3
C-D	0.062	2.18	0.046	1.64	0.016	0.54	25	0.016	0.54	2.8
E-F	0.027	0.94	0.020	0.71	0.007	0.23	25	0.007	0.23	5.8

* See Figure A.2-1 of the October 1984 Appendix 4.1A.

When total stream flow is considered for the segment, as opposed to only base flow, the percentage reductions are lowered by about one-half.

Tables A-18 and A-20 present similar information for the low and high recharge cases for the model area related base flow changes. The results are based on the summaries of flow changes in all the model elements forming the boundary segment. Consequently, flow changes for any portion of the boundary are available from the detailed data by summarizing changes in a continuous string of model elements or nodes. This is discussed below for the middle recharge case.

In the area of Swamp Creek directly north of the mine, an approximate 1.6 km (1.0 mile) length of boundary was selected and changes in flow were summarized in individual nodes along that boundary segment, to provide the following information for the middle recharge case:

Boundary Node*	Preconstruction Discharge to Stream		Project Year 28 Discharge to Stream		Reduction	
	(m^3/s)	(cfs)	(m^3/s)	(cfs)	(m^3/s)	(cfs)
61	0.0019	0.068	0.0012	0.043	0.0007	0.025
83	0.0022	0.077	0.0014	0.051	0.0008	0.026
108	0.0022	0.079	0.0015	0.054	0.0007	0.025
137	0.0015	0.053	0.0010	0.037	0.0005	0.016
163	0.0014	0.049	0.0010	0.035	0.0004	0.014
191	0.0019	0.068	0.0014	0.049	0.0005	0.019
225	0.0004	0.015	0.0003	0.011	0.0001	0.004
226	0.0004	0.015	0.0003	0.011	0.0001	0.004
260	0.0001	0.002	0.00005	0.002	0.00005	0.000
297	0.0001	0.002	0.00005	0.002	0.00005	0.000
335	0.0005	0.016	0.0004	0.013	0.0001	0.003
374	0.0011	0.039	0.0009	0.032	0.0002	0.007
TOTAL	0.0137	0.483	0.0095	0.34	0.0042	0.143

*See Figure A.7-2 of the October 1984 Appendix 4.1A.

For this length of boundary the discharge reduction is approximately 30% and not significantly different than the reductions shown for the complete segments B-C (38%) and C-D (25%). Again, reductions to total stream baseflows, when the entire ground water contribution is included, are considerabley smaller.

Changes in flow in any other specific length of the model boundary can be determined in a similar manner using the computer output.

Comment No. 2.b:

"A minimal contribution of wetland ground water discharge for the Swamp Creek drainage basin should be computed by comparing stream baseflow rates at times of minimum and maximum evapotranspiration. A rough, per acre wetland discharge rate value could then be computed by dividing by the total stream margin wetlands within the basin. The reductions in flow to the affected wetland areas due to mine dewatering determined by computer modeling should then be compared to the values proportioned from the method discussed above."

Response:

IEP, Inc., one of the consultants responsible for the wetlands assessment reports for the Project, has evaluated this approach for establishing a wetland

ET rate and advised us that it would not provide information as accurate as what is contained in the literature. Based on the hydrological complexity of the entire watershed and the assumptions that would have to be made, the results would be questionable. In recent research in north central Minnesota by the North Central Forest Experiment Station (Boelter and Verry, 1977*) wetland ET values have been measured which we feel will be applicable to our Project. These values are more defensible and will be used in the impact evaluation for streamside wetlands.

Comment No. 2.c.:

"The distribution of the marginal stream wetlands south of Swamp Creek and west of Hemlock Creek should be documented and descriptions of their hydraulic connection to the adjacent aquifer described. Particular attention should be given to the elevation of ground water discharge areas within or flowing to wetland areas. These areas are likely to be the most sensitive to reductions in ground water discharge rates and corresponding declines in hydraulic head levels. Potential impacts to wetland communities should be discussed".

Response:

A qualitative description of the hydraulic connection between streamside wetlands south of Swamp Creek and west of Hemlock Creek and the adjacent aquifer will be provided at a later date. This description will be based on the results of observations and measurements taken during the wetlands assessment performed by Normandeau Associates and IEP, Inc. The data collected on November 15 and 16, 1984, by the DNR on the locations of wetlands and seeps adjacent to streams in the site area will also be used to supplement the field data collected by Normandeau and IEP, Inc. Potential impacts to wetland communities from mine dewatering will be discussed using the projected reductions in ground water discharge rates and corresponding declines in hydraulic head levels.

Comment No. 2.d., Paragraphs 1 and 2:

"The dewatering impact to the wetland area northeast of Rolling Stone Lake including Martin Springs and other stream headwaters in this area require evaluation. This area has been modeled by Exxon as a constant head boundary area. This assumption prevents any drawdown in ground water levels to occur

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*Boetler, D. G., and E. S. Verry, 1977. Peatland and water in the northern lake states. USDA General Technical Report NC-31.

during mine dewatering model simulations. Exxon must provide justification and documentation of this assumption and evaluate the actual potential for water level declines in this area due to mine pumping."

"Exxon must compute the flow volumes discharging to the constant head nodes on this area during normal steady-state and mine-dewatering conditions. The change in flow should be evaluated as to potential for impact to the discharge area".

Response:

The boundary conditions in the Rolling Stone Lake area have been appropriately modeled for the hydrogeological conditions of the Crandon Project area and the expected hydrological changes.

The reductions in discharge to this area of the model boundary from the mine inflow are shown in Tables A-18, A-19, and A-20 of the October 1984 EIR Appendix 4.1A. For the length of boundary including the east side of Rolling Stone Lake south to Pickerel Lake (segment F-G on Figure A.2-1) the baseflow discharge reductions are approximately 2.3%, 2.5%, and 2.6% for the low, middle, and high recharge cases, respectively.

When normal ground water discharge from outside the modeled area is also included to the segment these reductions in baseflow are lowered to 0.6%, 0.9%, and 1.1% (Tables A-22, A-24, and A-26). When average flow in this segment is considered, the flow percent reductions for the three recharge values and associated mine inflows are approximately 50% less.

Individual element data provide the most detailed information for flow changes in the immediate area of the wetland northeast of Rolling Stone Lake. For the middle recharge case the following flow changes occur around the constant head area (wetland area):

Element Number*	Preconstruction Groundwater Discharge Per Horizontal Unit Width (m³/s)	(cfs)	Project Year 28 Groundwater Discharge (m³/s)	(cfs)	Reduction (m³/s)	(cfs)
903	$2.71x10^{-5}$	$9.57x10^{-4}$	$1.77x10^{-5}$	$6.25x10^{-4}$	$0.94x10^{-5}$	$3.32x10^{-4}$
951	$4.60x10^{-5}$	$1.62x10^{-3}$	$3.30x10^{-5}$	$1.16x10^{-3}$	$1.30x10^{-5}$	$4.64x10^{-4}$
950	$4.57x10^{-5}$	$1.61x10^{-3}$	$3.52x10^{-5}$	$1.24x10^{-3}$	$1.05x10^{7-5}$	$5.70x10^{-4}$

*See Figure A.7-2 of the October 1984 Appendix 4.1A.

This table indicates that the quantity of water that would normally discharge to the wetland would be reduced by approximately 30% during the mining period.

Overall these reductions are small and do not cause a reversal of flow to the wetlands or Rolling Stone Lake. The reductions in stream flow will not result in any measurable impacts to the hydrologic system (including the wetlands and Rolling Stone Lake) in this area. Since the typical range of hydrologic conditions extends beyond the projected flow change, isolating the flow reduction related to mine inflow from the larger normally occurring fluctuations in the hydrologic regime would be impractical.

Comment No. 3:

"Exxon should also evaluate potential impacts of declining water levels on Hoffman Springs and Creek."

Response:

The information presented in the revised Hydrologic Impact Assessment Report (October 1984 EIR Appendix 4.1A) indicates an approximate potentiometric surface decline of 0.8 m (2.6 feet) in the area of Hoffman Spring. Also, ground water flow to the area was expected to be reduced by approximately 29 percent but no reversal in the direction of ground water flow occurred. Although the estimate of the potentiometric surface decline is slightly less than 1.0 m (3.3 feet), we have assumed the 0.8 m (2.6 feet) decline can be used to further project expected impact to Hoffman Springs.

The results of ongoing DNR/USGS detailed topographic survey work in the area of the Hoffman Spring will be evaluated and utilized by Exxon to determine what specific effect the 0.8 m (2.6 feet) potentiometric surface decline will have on the spring and other portions of the hydrologic system in the immediate area.

Comment No. 4, Paragraph 1:

"More complete evaluation of the hydrogeology at Little Sand Lake is required. At the Exxon/DNR meeting of 12/20/83 Exxon agreed to provide a detailed cross-section including wells CDM-16 - 20, LSL1, and Y15, Y15A. The cross-section B-B[1] provided on drawing 12959-16 of the STS report does not include all these data points, nor show the effective screen and gravel pack interval. The boring logs for CDM-17 - 20 must be provided to the Department along with well construction and ground water potentials for all CDM wells. Ground water potentials and resultant flow lines should be marked on the cross section".

Response:

Wells CDM-17 - CDM-20 are shallow well points surrounding CDM-16. No boring logs exist for wells CDM-17 - CDM-20. The additional information from wells CDM-17 - CDM-20 and well G40-Y15A is shown on the attached figures (STS drawing Nos. 12959-16 and 12959-17) (Attachment A).

Of the remaining CDM borings (CDM-1 - CDM-16) three borings (CDM-4, CDM-15, and CDM-16) had wells installed with the following screen and gravel pack intervals:

Boring No.	Representative Potentiometric Surface Elevation and Date (m)		Top of Piezometer Elevation (m)	Screen Interval (m)	Gravel Pack Interval (m)
CDM-4	481.13	09/26/84	501.10	18.3-27.4	15.0-56.1
CDM-15	474.87	10/01/84	501.84	18.3-27.4	15.0-55.2
CDM-16	481.69	02/22/82	486.77	15.2-24.4	12.0-56.4

The remaining CDM borings were grouted after the boring was geophysically logged.

The readings in the wells around Little Sand Lake have been quite consistent according to the depths they are placed at and show the following pattern:

CDM-16	-	Reflects regional ground water table.
CDM-17	-	Dry
CDM-18	-	Reflects regional ground water table.
CDM-19	-	Reflects lake water elevation.
CDM-20	-	Reflects lake water elevation.
G40-Y15	-	Reflects regional ground water table.
G40-Y15A	-	Reflects lake water elevation.

The deeper wells (CDM-16, CDM-18, and G40-Y15) and the LSL series borings placed directly in the lake area all indicate a consistent potential head separation from the lake to the regional ground water system and a downward gradient for seepage from the lake. The additional lake bed seepage tests and lake water budget studies underway with Dames and Moore are expected to provide final required information necessary to project impacts to the Project area lakes.

Comment No. 4, Paragraph 2:

"There have been persistent reports of springs occurring in Little Sand Lake. Exxon must address the occurrence of these springs and clearly define their role in the hydrologic regime of the lake. Potential impacts due to mine dewatering must be evaluated".

Response:

From information received in the DNR letter to Exxon dated November 8, 1984, we understand the DNR has found no evidence of any springs in Little Sand Lake in the areas noted by the Lake residents. Exxon also has not seen any evidence of springs in Little Sand Lake during the periods of our field activities.

Comment No. 5, (3 Paragraphs):

"The Department would like to make you aware of the ground water modeling work which is now presently being conducted through a joint effort of the DNR and its USGS and WGNHS contractors. The purpose of the modeling is to provide a verification to the definition of ground water flow and potential contaminant flow."

"A vertical two-dimensional flow model along a combined cross section of $D-D^1/F-F^1$ as marked on the STS report will be made. This same model grid will then be utilized to develop a solute transport model to examine contaminants from the MWDF. The modeling is expected to be completed at the end of 1984."

"No mine dewatering evaluation is presently being conducted though as indicated elsewhere the feasibility of examining detailed hydraulic potential distributions at stressed discharge boundaries is being examined".

Response:

EMC appreciates the information concerning the verification modeling work being completed by the USGS and DNR. We request that the Department keep EMC informed of the progress of this work and also request that the Department provide EMC with a data tape of the program and the model data sets after the work is completed.

October 22, 1984 Letter

The October 22, 1984 letter provides further elaboration of some of the issues discussed in the September 17, 1984 letter.

Comment No. 1:

"Detailed surveying is needed in critical areas to provide accurate elevations of stream stage, wetland elevations adjacent to streams and spring discharge elevations and outfall configurations".

Response:

As indicated in other responses to the Department, we are concerned about the accuracy of the estimates of mine inflow related ground water declines beyond the 1.0 m (3.3 foot) line. While these model determined potentiometric surface declines can be used to project impacts to the surface hydrological features, a degree of caution should be exercised to avoid possibly attributing a higher level of accuracy to them than is justified. This could lead to a much more specific projection of impacts than is warranted based on the accuracy of the available data.

However, EMC agrees that detailed topographic survey data sufficient for 0.33 m (1.0 foot) contour interval definition and including existing hydrologic information would be helpful in estimating surface water impacts related to ground water drawdown.

EMC also understands that the USGS, under a contract with the DNR, is proceeding to obtain some of this detailed topographical survey data that can be used for the impact projections. When this additional data is available Exxon will utilize it to further define Project impacts.

Comment No. 2:

"Transects should be made in those stream areas where significant quantities of discharge wetlands occur and in areas where ground water discharge has been shown by modeling to be significantly reduced by mine dewatering impacts. The transects should begin at the far sides of the stream at an elevation high enough to include the highest stream stage and depth and water elevation. The transect should be extended on past any discharge points on the mine impact side of the stream. Vegetation should be described by species and stream sediments and surface soils should be described. Existing vegetation data could be used to compliment or eliminate the need for additional field data. Ground water discharge points should be described and located on the transect. Estimates of seepage flow rates should be made and any indication of seasonal discharge location or flow rate changes should be noted. The date of the transect should be recorded to allow correlation of stream stage with stream gaging station data. The report should include the value of any relevant stream gaging station elevations that correspond to the dates of individual transects. Since the gaging station at the State Highway 55 bridge has a continuous recorder, this should provide the minimum gaging information possible. Simultaneous measurements at other appropriate gaging stations and transects should also be made".

Response:

We understand that the DNR/USGS is conducting this work.

Comment No. 3:

"If not precisely known, the elevations of Hoffman and Martin Springs should be surveyed. Transect cross-sections of these spring areas should be prepared similar in nature and scope to the stream and wetland surveys described above. Dewatering impact drawdowns, determined by ground water modeling, can be applied to allow for evaluation of impacts to the springs. If possible, measurements of spring flows should be made. Small temporary weirs may be useful in obtaining this data. Seasonal fluctuations of both discharge volume and location should be examined. The model predicted drawdown at Hoffman Spring should be interpolated from the nearest model nodes utilized in the GEOFLOW ground water model".

Response:

As indicated in an earlier response detailed topographical surveying in the areas of the springs would allow a more complete projection of the impacts to the area (subject to the accuracy limitations noted above). We are in agreement with the DNR/USGS proceeding to gather the necessary field data. The model predicted drawdowns and ground water flow changes in these areas are available for any additional impact prediction analysis for these areas. When the additional field data is available Exxon will utilize it to further project impacts to the springs and surrounding areas.

Comment No. 4:

"Department concern over potential dewatering impacts to Little Sand Lake, Deep Hole Lake, Duck Lake and Skunk Lake indicated Exxon must reinstate the monitoring of lake levels. Oak Lake, Rolling Stone Lake, and Ground Hemlock Lake should also be monitored for lake level fluctuations. This background data is needed to compare potential impacts to historical lake level fluctuations. The Department recommends the lake levels be measured quarterly simultaneously with the ground water measurments. Adjustments to this monitoring program may be made through the mine dewatering permit".

Response:

EMC understands the USGS is proceeding with the installation of permanent staff gages in each of the five project lakes (Skunk, Oak, Duck, Deep Hole, and Little Sand). Exxon will read these new gages quarterly and the lake level data will be included with the other quarterly groundwater level data.

Comment No. 5:

"The most expedient way for the above concerns to be addressed may be for Department personnel with our USGS contractor to perform the required field work and analysis."

Response:

EMC is interested in responding to DNR comments in the most expedient and efficient manner possible. Based on discussions at our meeting December 11, 1984 with DNR and USGS personnel we are in agreement that the DNR/USGS proceed to gather the field data noted in the October 22, 1984 DNR letter. As that information becomes available it will be provided to Exxon for further use by Exxon in refining Project impact definitions. These refined Project impacts will then be presented in the revised EIR Chapter 4.0.

Please let me know if you have further questions at this time.

Very truly yours,

EXXON MINERALS COMPANY

Barry J. Hansen
Permitting Manager

BJH:CCS:sjq

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

BOX 7921
MADISON, WISCONSIN 53707

January 9, 1985

File Ref 1630
(Exxon)

RE: Exxon Crandon Mine Project EIR/
Additional Documents for Public
Information and Review

Dear Librarian:

Please place the enclosed document along with the rest of the Exxon environmental impact report (EIR):

> Exxon January 4, 1985 responses to DNR's Noise and Seismic Vibration comments, dated December 28, 1984.

This document pertains to the EIR. People who have comments or questions about it may contact Mr. Robert Ramharter at (608) 266-3915 or at DNR, Box 7921, Madison, WI, 53707.

Thank you for your assistance.

Sincerely,
Bureau of Environmental Analysis and Review

Carol Nelson

Carol Nelson
Environmental Specialist

Enclosure

JAN 8 - 1985

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
P. O. Box 7921, GEF II
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:

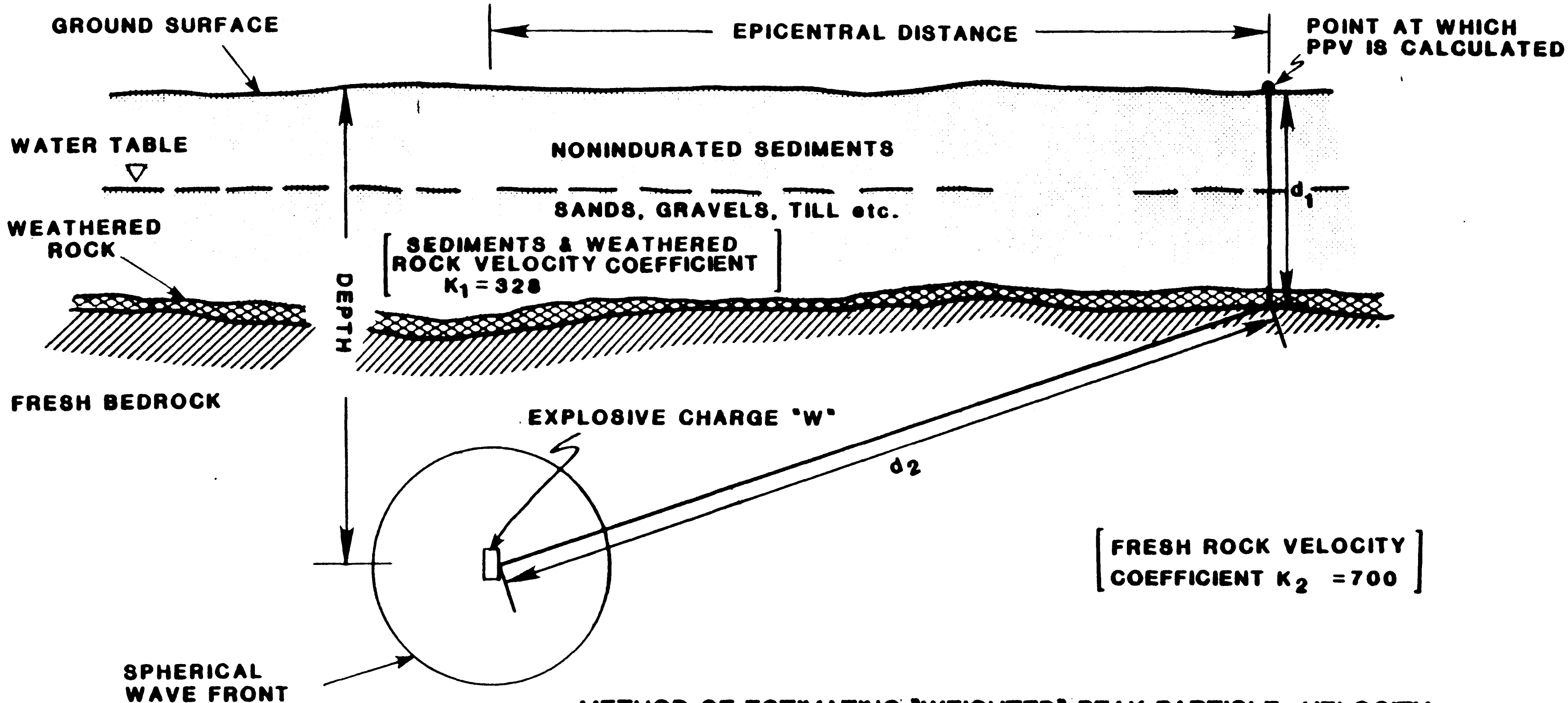
Structure	Delay Charge Wt-Kg.	PPV -mm/s (inches/second)
Intake Air Shaft	Max. - 88	0.503 (0.02)
	Min. - 11	0.11 (0.004)
Main Shaft	Max. - 88	0.501 (0.02)
	Min. - 11	0.109 (0.004)

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

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)

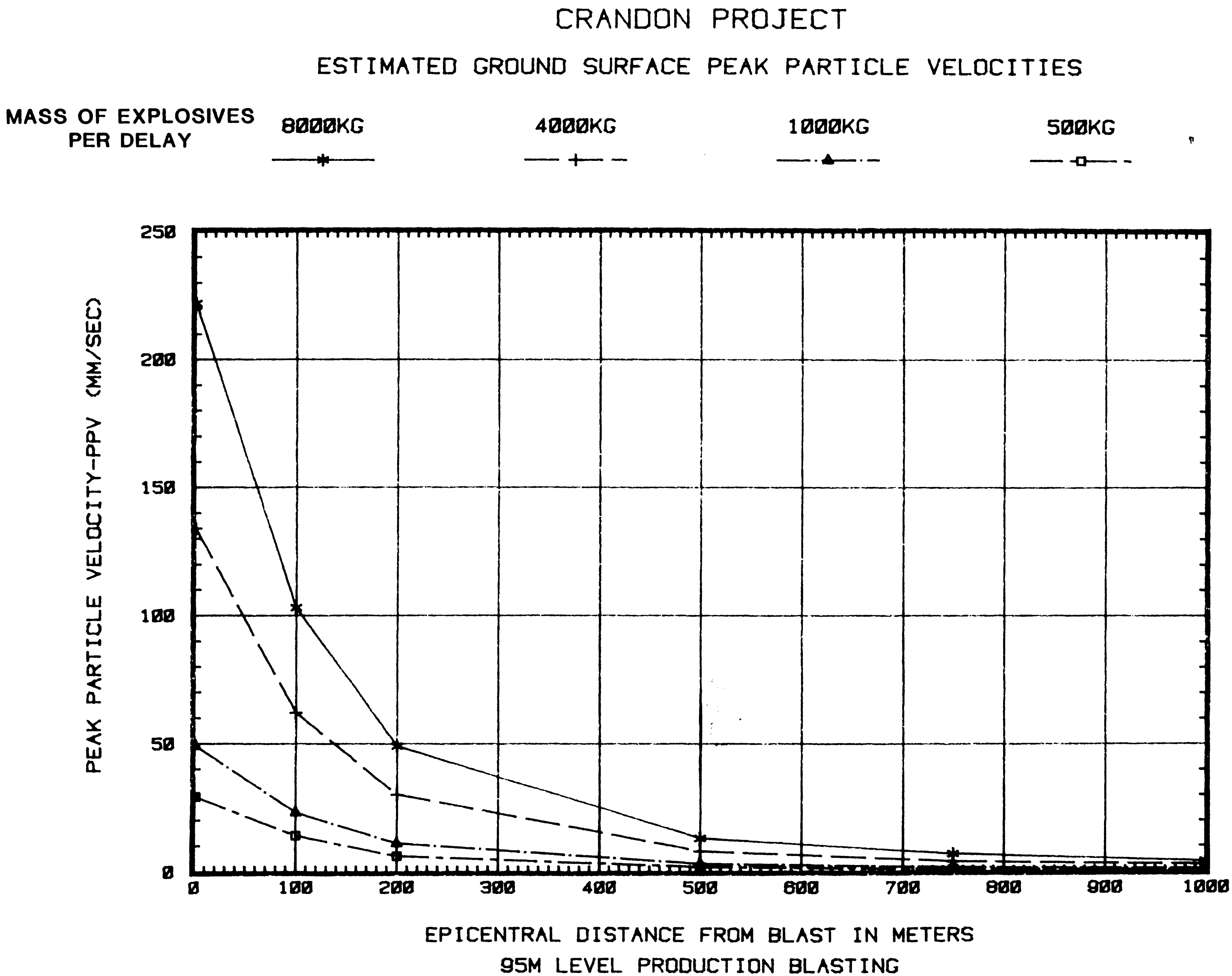
d_2 = DISTANCE WAVE FRONT TRAVELS IN FRESH ROCK(m)

R = $d_1 + d_2$ IN METERS

W = CHARGE WEIGHT (kg)

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

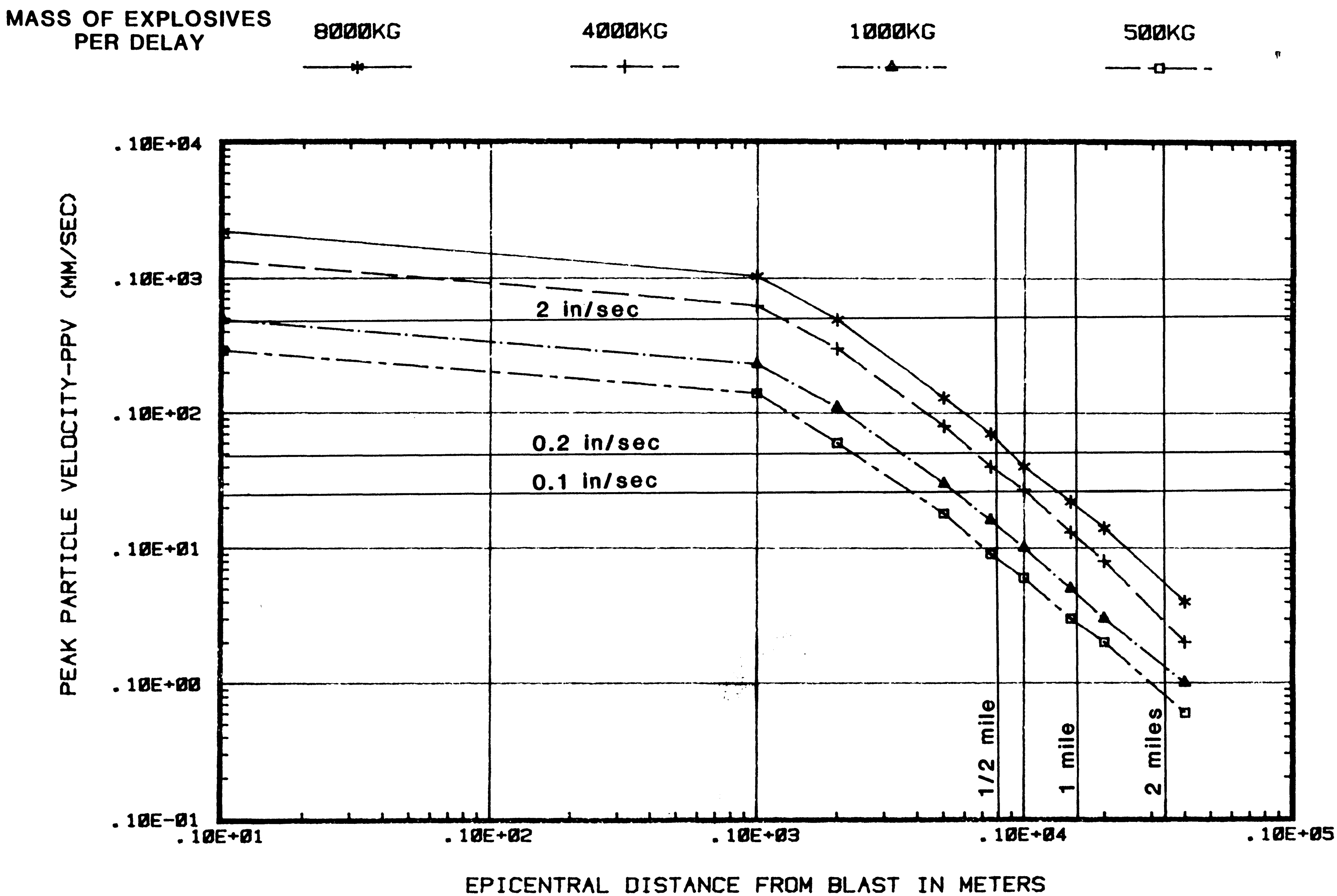
(FIGURE 2 FOR THE RESPONSE TO COMMENT NO. 2)



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

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES

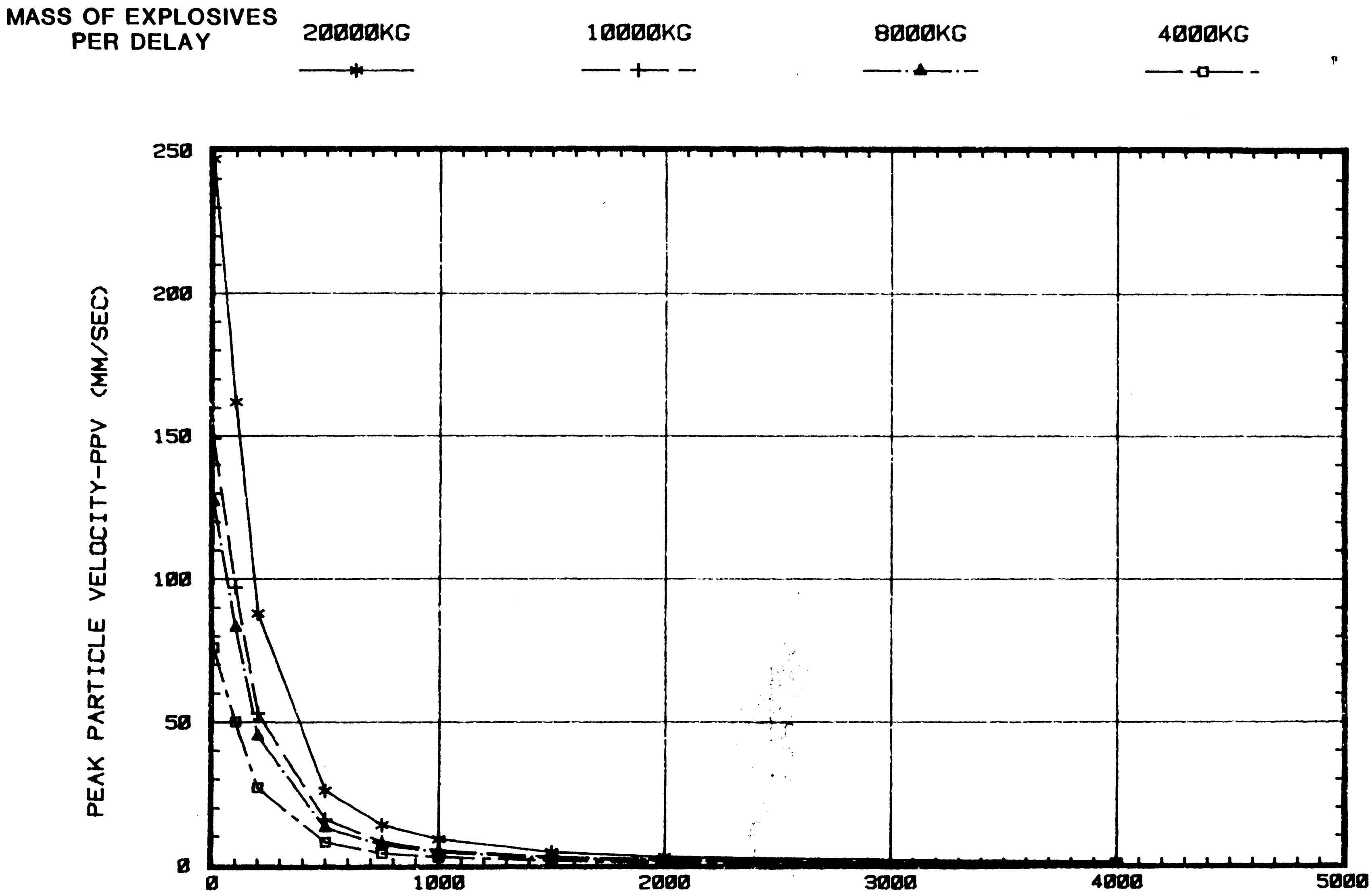


95M LEVEL PRODUCTION BLASTING

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

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES

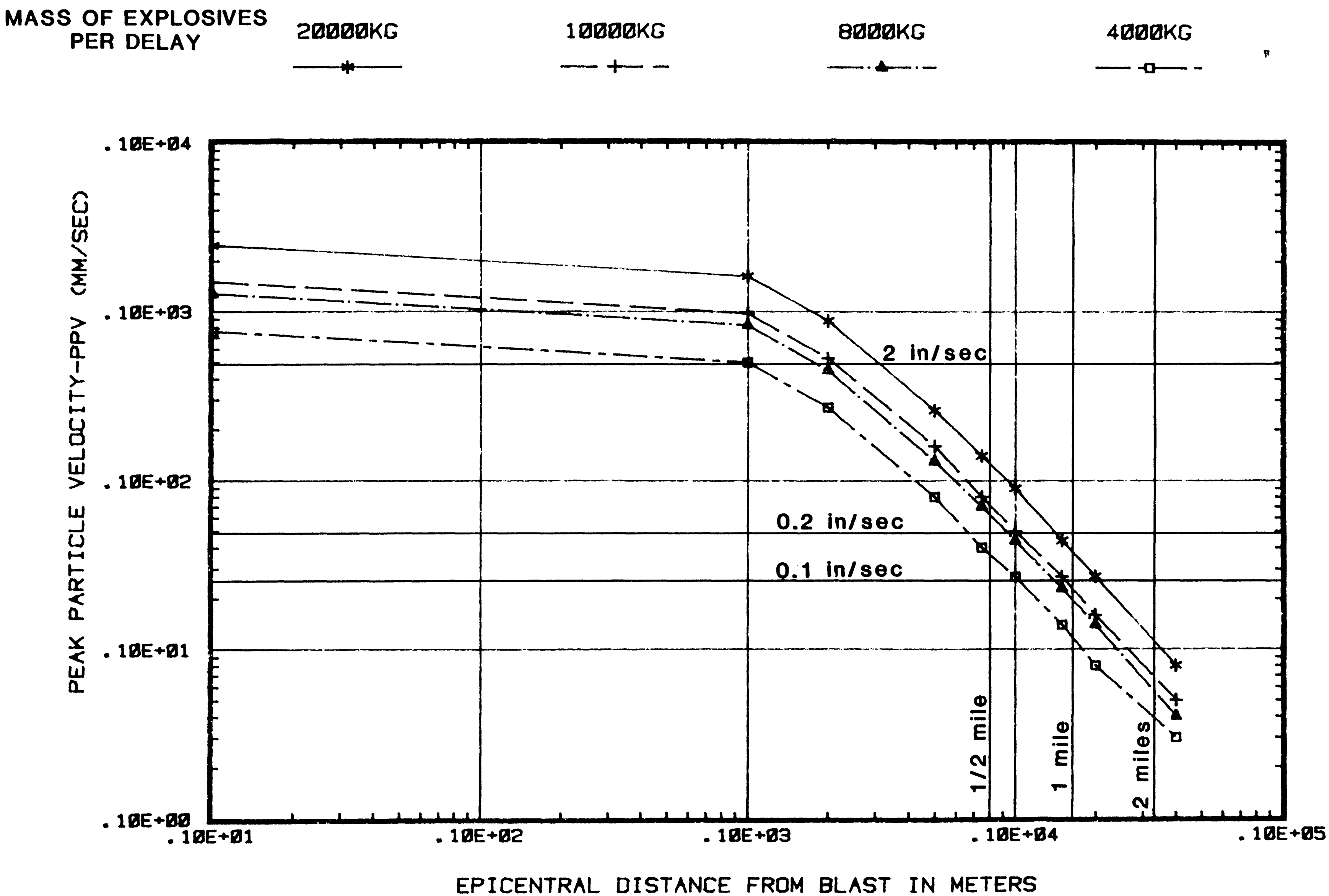


EPICENTRAL DISTANCE FROM BLAST IN METERS
140M LEVEL PRODUCTION BLASTING

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

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES

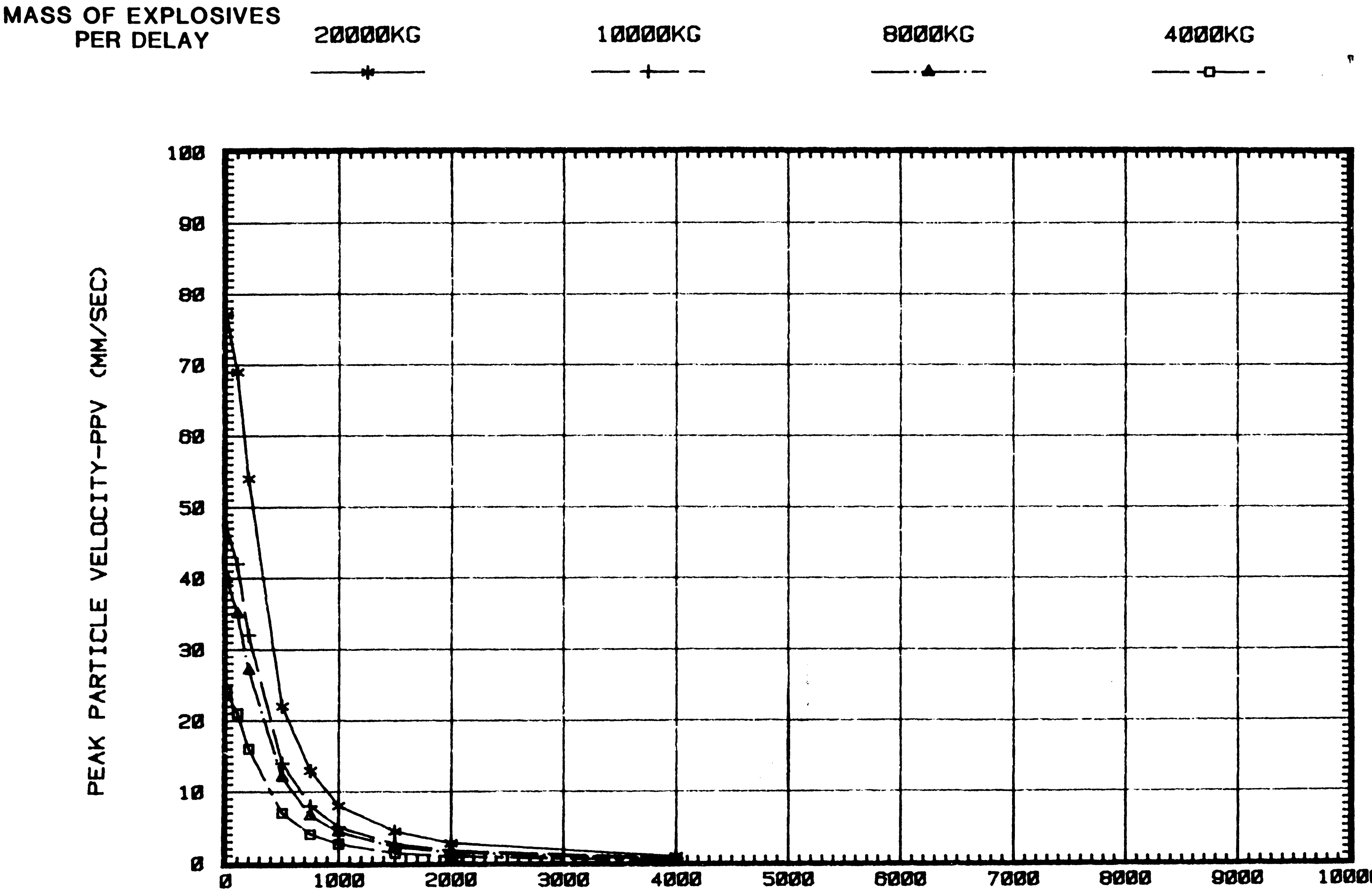


140M LEVEL PRODUCTION BLASTING

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

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES



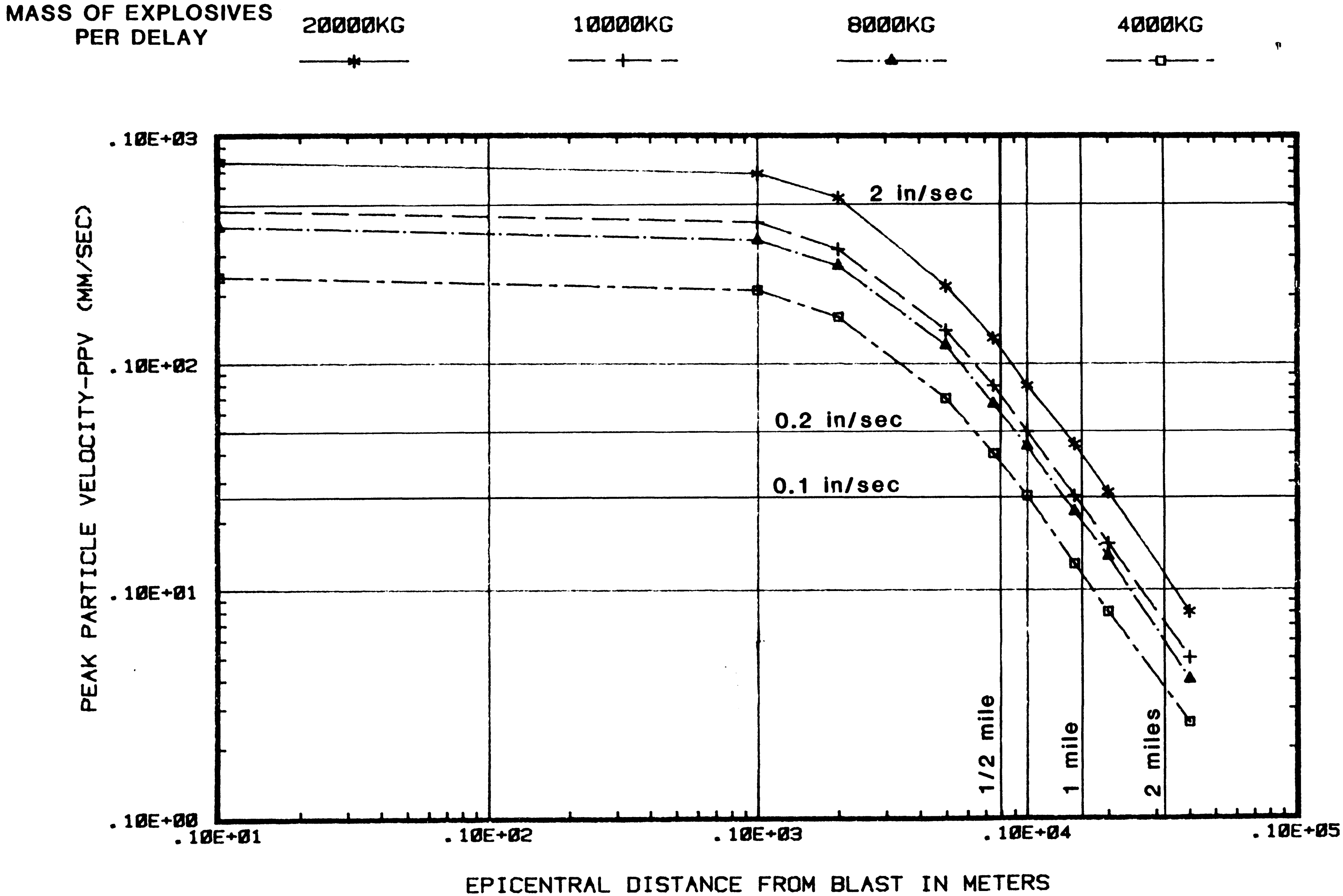
EPICENTRAL DISTANCE FROM BLAST IN METERS

290M LEVEL PRODUCTION BLASTING

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

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES

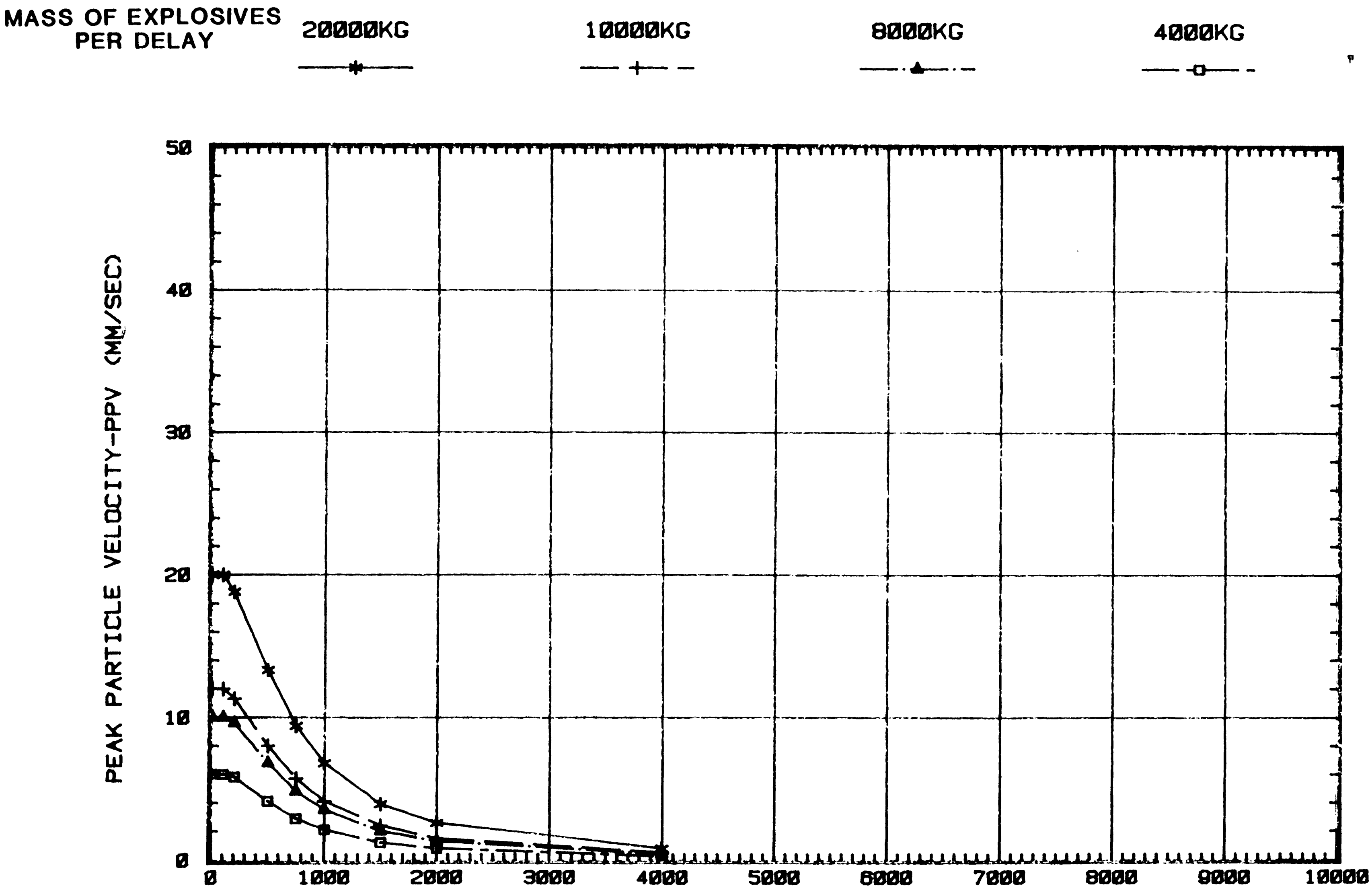


290M LEVEL PRODUCTION BLASTING

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

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES



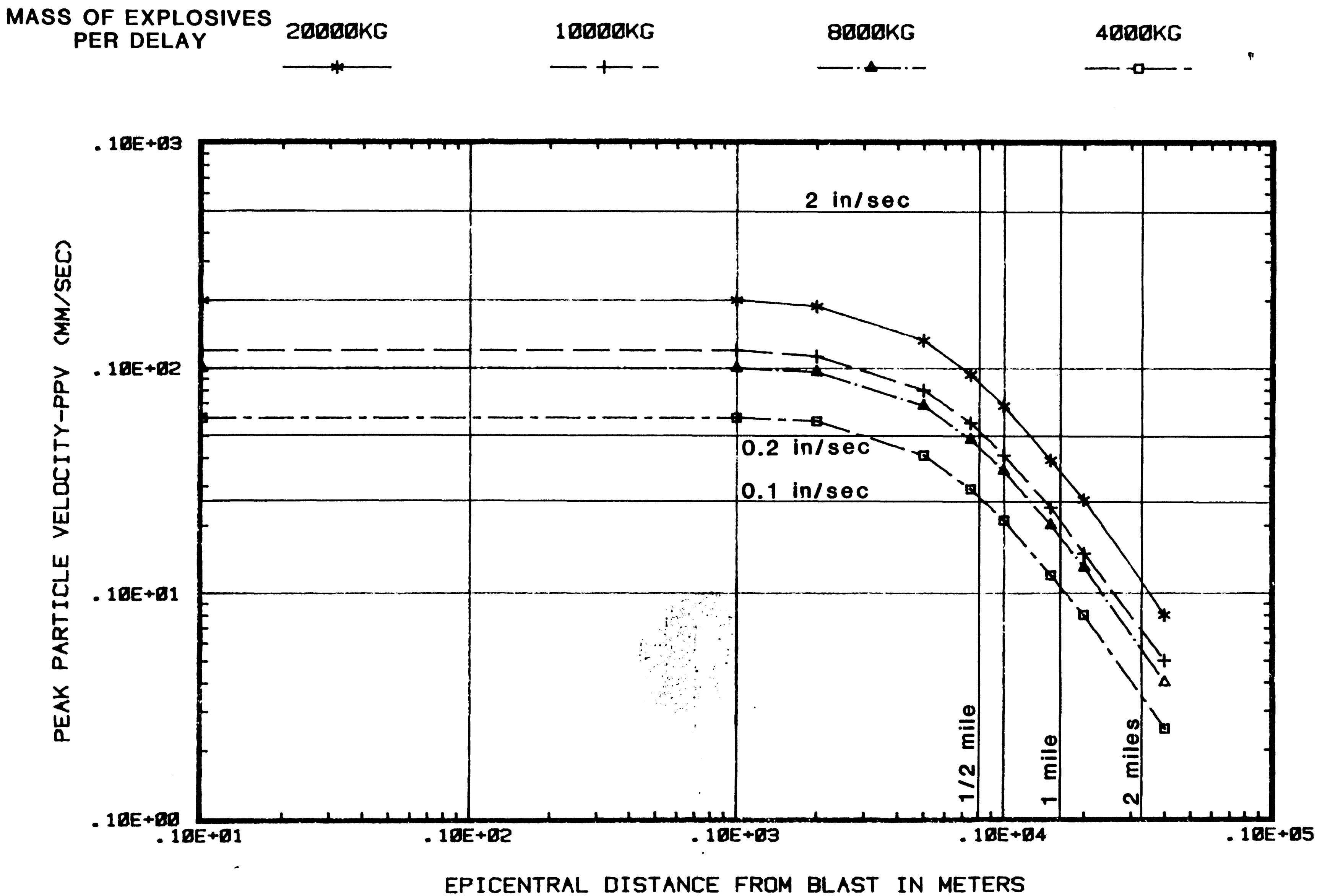
EPICENTRAL DISTANCE FROM BLAST IN METERS

640M LEVEL PRODUCTION BLASTING

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

CRANDON PROJECT

ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITIES



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

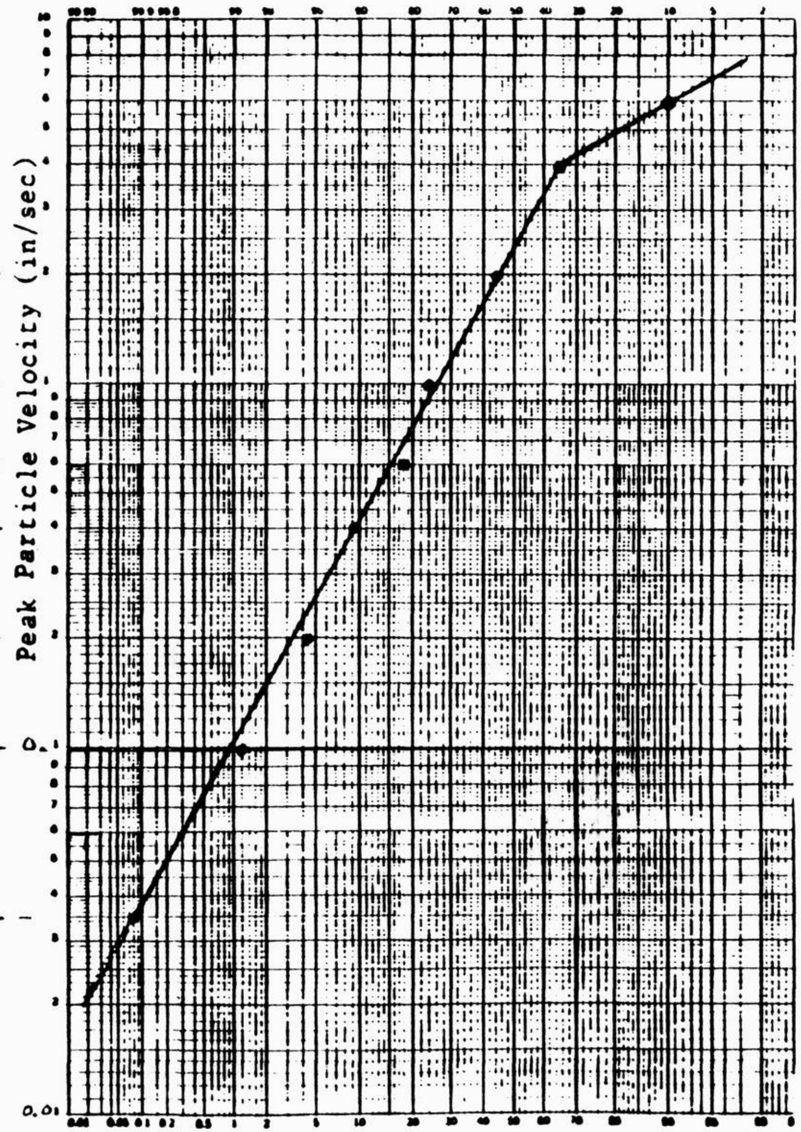
etectable

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.

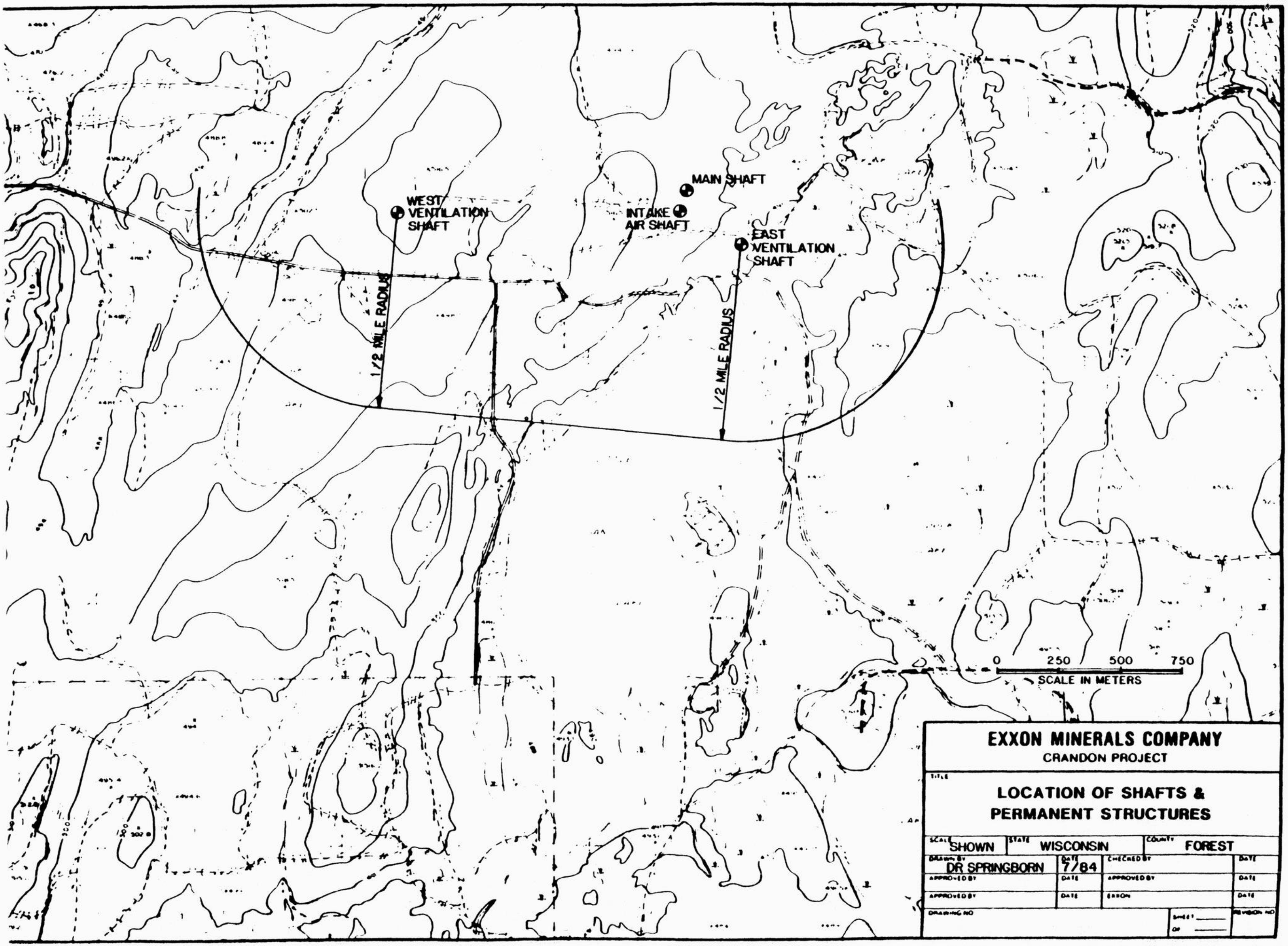
Response:

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.

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.

III.A.3. Projected Noise Levels and Model Evaluation

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

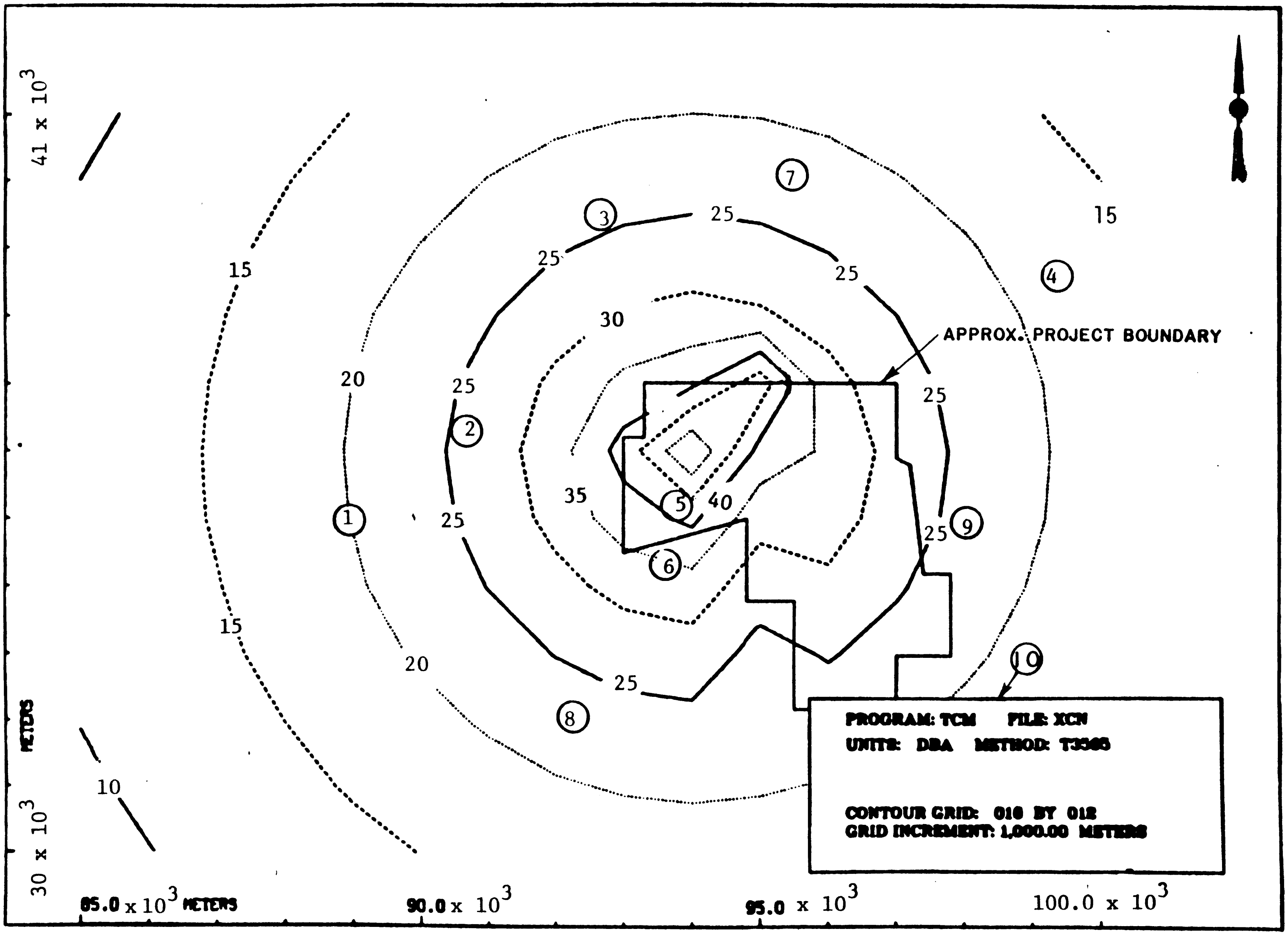
The location and the distance attenuation utilized in projecting future sound levels from the Mine/Mill, Mine Waste Disposal Facility, Access Road, Railroad Spur and Haul Road is valid.

Response:

Comment acknowledged.

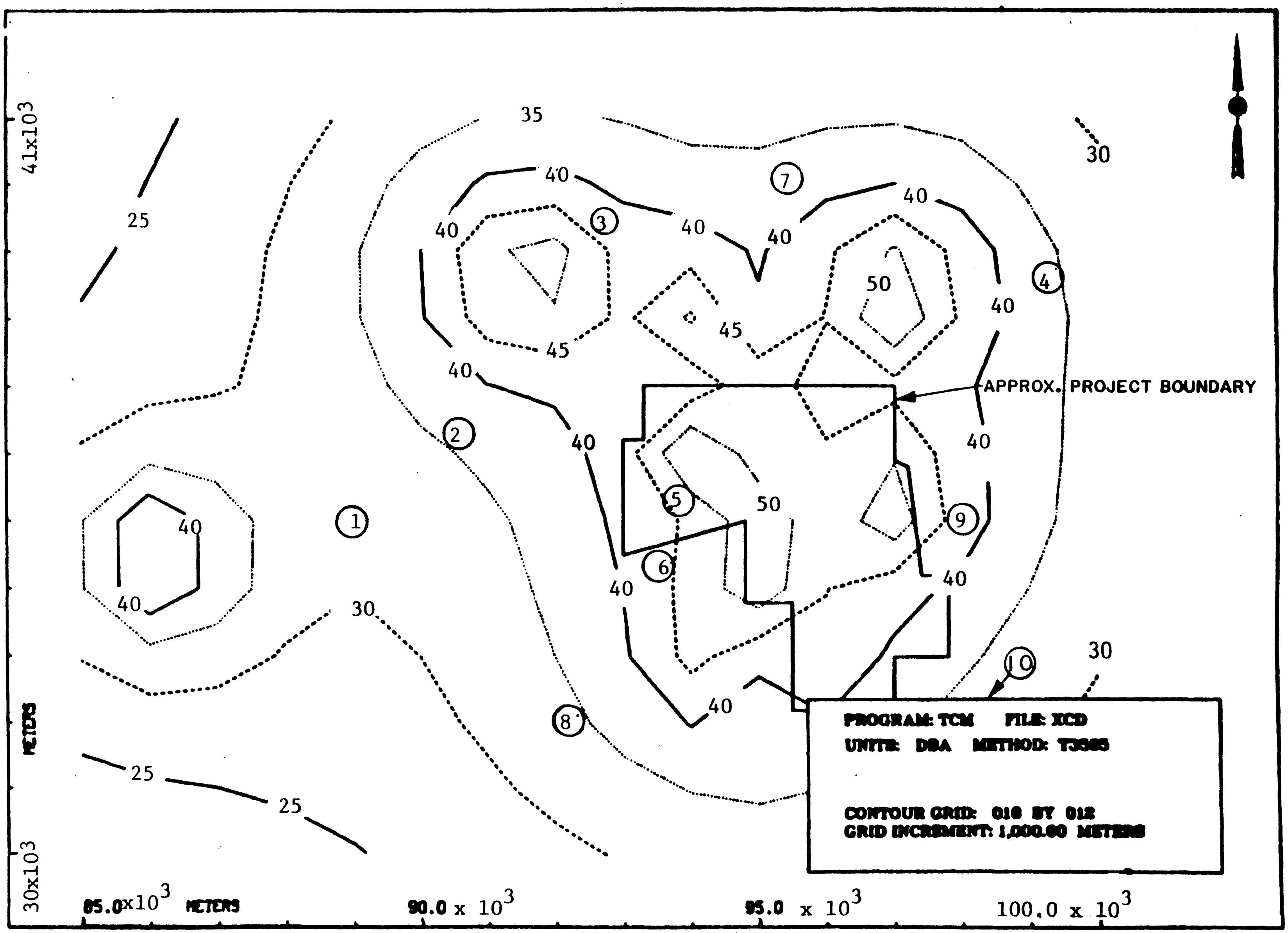
(FIGURE 1 FOR THE RESPONSE TO COMMENT NO. A13)

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.

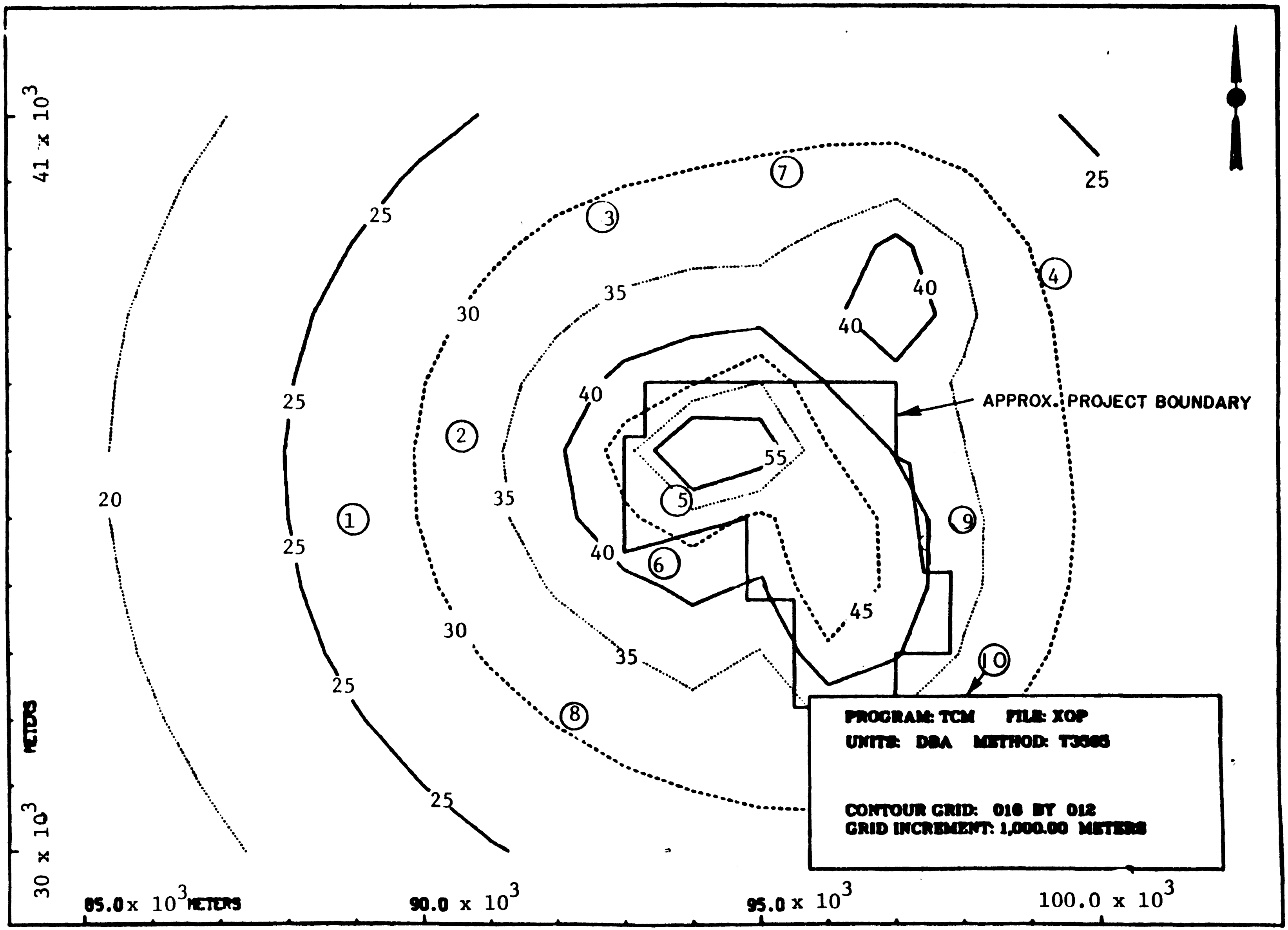
(FIGURE 2 FOR THE RESPONSE TO COMMENT NO. A13)
NOISE LEVEL ESTIMATES FOR DAY CONSTRUCTION ACTIVITIES



<u>Notes</u>: 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 ± @ 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.

11

CENTRIFUGAL AIRFOIL FANS

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

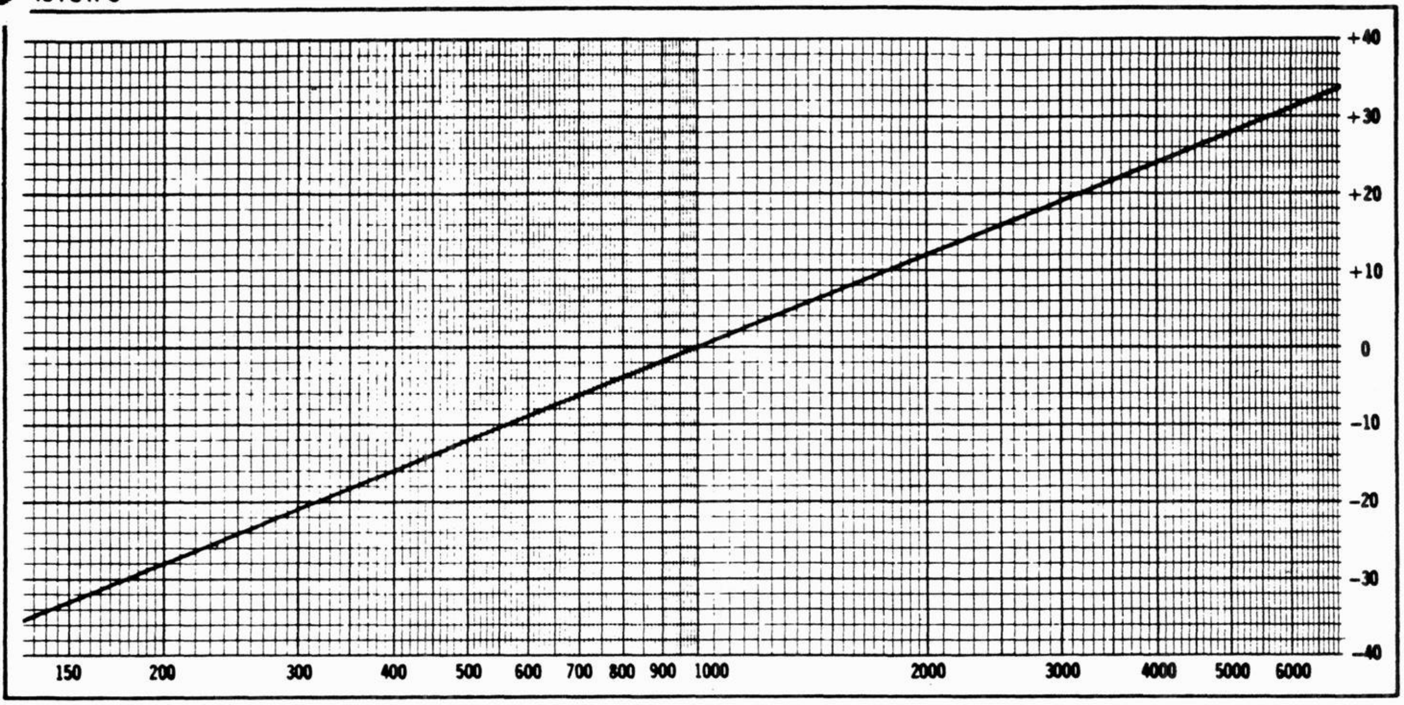
EQUIVALENT STATIC PRESSURES

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

ACTOR C



SIZES 122 SISW THROUGH 182 SISW

	BAND 1					BAND 2					BAND 3					BAND 4				
	SP/VP					SP/VP					SP/VP					SP/VP				
RPM	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3	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	85	81	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	81	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	83	72	71	71	71	75	67	66	66	65	68

	BAND 5					BAND 6					BAND 7					BAND 8				
	SP/VP					SP/VP					SP/VP					SP/VP				
RPM	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3	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	56	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

	BAND 1					BAND 2					BAND 3					BAND 4				
	SP/VP					SP/VP					SP/VP					SP/VP				
RPM	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3	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

	BAND 5					BAND 6					BAND 7					BAND 8				
	SP/VP					SP/VP					SP/VP					SP/VP				
RPM	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3	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					BAND 2					BAND 3					BAND 4				
	SP/VP					SP/VP					SP/VP					SP/VP				
	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3	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
500	71	71	71	72	74	64	64	65	67	69	56	57	57	59	62	51	52	52	54	57
600	73	72	72	72	74	66	67	68	69	71	58	58	59	61	63	52	53	53	55	58
700	74	73	73	73	75	68	69	70	71	74	59	60	60	62	64	53	54	54	56	59
800	76	75	75	74	77	69	70	70	71	74	61	61	62	64	66	54	55	55	57	60
900	78	77	76	76	78	70	71	71	72	74	62	63	64	65	68	55	56	57	58	61
1000	80	79	78	78	80	71	71	71	72	74	64	64	65	67	69	56	57	57	59	62
1200	82	81	80	80	83	73	72	72	72	74	66	67	68	69	71	58	58	59	61	63
1400	85	83	82	83	85	74	73	73	73	75	68	69	70	71	74	59	60	60	62	64
1600	87	85	84	85	87	76	75	75	75	77	69	70	70	71	74	61	61	62	64	66
1800	89	87	86	86	89	78	77	76	76	78	70	71	71	72	74	62	63	64	65	68
2000	91	89	87	88	90	80	79	78	78	80	71	71	71	72	74	64	64	65	67	69
2400	94	91	89	91	93	83	81	80	81	83	73	72	72	72	74	66	67	68	69	71
2600	96	94	91	93	95	85	84	82	83	85	74	73	73	73	75	68	69	70	71	74
3200	98	95	93	95	97	87	85	84	85	87	76	75	75	75	77	69	70	70	71	74

RPM	BAND 5					BAND 6					BAND 7					BAND 8				
	SP/VP					SP/VP					SP/VP					SP/VP				
	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3
400	42	42	43	44	47	36	36	37	37	40	31	31	31	30	33	25	26	26	24	26
500	45	45	45	47	50	36	38	38	39	42	32	33	33	32	35	27	27	27	26	28
600	47	47	48	49	52	39	39	40	41	44	34	34	34	34	37	28	29	29	28	30
700	49	49	50	51	54	40	41	41	42	45	35	35	35	36	38	29	30	30	29	31
800	50	50	51	52	55	42	42	43	44	47	36	36	37	37	40	31	31	31	30	33
900	50	51	51	53	56	44	44	44	46	49	37	37	37	38	41	31	32	32	31	34
1000	51	52	52	54	57	45	45	45	47	50	38	38	38	39	42	32	33	33	32	35
1200	52	53	53	55	58	47	47	48	49	52	39	39	40	41	44	34	34	34	34	37
1400	53	54	54	56	59	49	49	50	51	54	40	41	41	42	45	35	35	35	36	38
1600	54	55	55	57	60	50	50	51	52	55	42	42	43	44	47	36	36	37	37	40
1800	55	56	57	58	61	50	51	51	53	56	44	44	44	46	49	37	37	37	38	41
2000	56	57	57	59	62	51	52	52	54	57	45	45	45	47	50	38	38	38	39	42
2400	58	58	59	61	63	52	53	53	55	58	47	47	48	49	52	39	39	40	41	44
2600	59	60	60	62	64	53	54	54	56	59	49	49	50	51	54	40	41	41	42	45
3200	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					BAND 2					BAND 3					BAND 4				
	SP/VP					SP/VP					SP/VP					SP/VP				
	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3	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
400	62	63	63	65	68	54	54	55	58	61	46	46	47	50	53	41	41	42	45	46
500	64	63	63	65	68	56	58	59	62	64	47	48	48	52	55	42	43	44	46	46
600	64	63	62	64	68	61	62	63	66	67	49	49	49	53	56	44	44	45	47	50
700	67	66	64	66	70	62	62	63	66	68	51	52	52	56	59	45	45	46	49	51
800	69	68	66	68	72	63	63	63	65	68	54	54	55	58	61	46	46	47	50	53
900	71	70	68	70	74	63	63	63	65	68	56	56	57	61	63	47	47	47	51	54
1000	73	72	70	72	75	64	63	63	65	68	58	58	59	62	64	47	48	48	52	55
1200	77	75	73	74	78	64	63	62	64	68	61	62	63	66	67	49	49	49	53	56
1400	79	77	75	77	80	67	66	65	66	70	62	62	63	66	68	51	52	52	56	59
1600	82	80	77	79	82	69	68	67	68	72	63	63	63	65	68	54	54	55	58	61
1800	84	81	79	80	84	72	70	68	70	74	63	63	63	65	68	56	56	57	61	63
2000	86	83	80	82	86	73	72	70	72	75	64	63	63	65	68	58	58	59	62	64
2400	89	86	83	85	88	77	75	73	74	78	64	63	62	64	68	61	62	63	66	67
2800	92	89	85	87	91	79	77	75	77	80	67	66	65	66	70	62	62	63	66	68
3200	94	91	88	89	93	82	80	77	79	82	69	68	67	68	72	63	63	63	65	68

RPM	BAND 5					BAND 6					BAND 7					BAND 8				
	SP/VP					SP/VP					SP/VP					SP/VP				
	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3
300	33	34	36	36	38	32	34	35	35	38	31	33	34	34	37	30	33	34	33	36
400	36	36	37	39	40	33	34	35	36	38	32	33	35	35	37	31	33	34	34	36
500	38	38	38	42	42	33	34	36	36	38	32	34	35	35	37	31	33	34	34	37
600	39	39	39	44	43	33	34	36	36	38	32	34	35	35	38	31	33	34	34	37
700	40	40	41	45	44	35	35	36	38	39	33	34	35	36	38	32	33	35	35	37
800	41	41	42	45	46	36	36	37	39	40	33	34	35	36	38	32	33	35	35	37
900	42	42	43	46	47	37	37	38	41	41	33	34	35	36	38	32	34	35	35	37
1000	42	43	44	46	48	38	38	38	42	42	33	34	36	36	38	32	34	35	35	37
1200	44	44	45	47	50	39	39	39	44	43	33	34	36	36	38	32	34	35	35	38
1400	45	45	46	49	51	40	40	41	45	44	35	35	36	38	39	33	34	35	36	38
1600	46	46	47	50	53	41	41	42	45	46	36	36	37	39	40	33	34	35	36	38
1800	47	47	47	51	54	42	42	43	46	47	37	37	38	41	41	33	34	35	36	38
2000	47	48	48	52	55	42	43	44	46	48	38	38	38	42	42	33	34	36	36	38
2400	49	49	49	53	56	44	44	45	47	50	39	39	39	44	43	33	34	36	36	38
2800	51	52	52	56	59	45	45	46	49	51	40	40	41	45	44	35	35	36	38	39
3200	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					BAND 2					BAND 3					BAND 4				
	SP/VP					SP/VP					SP/VP					SP/VP				
	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3	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
200	63	63	64	67	72	58	58	59	61	65	51	51	51	53	57	42	42	42	45	49
300	66	66	68	72	76	61	61	62	65	69	56	56	56	58	62	47	47	48	50	54
400	69	69	72	75	80	63	63	64	67	72	58	58	59	61	65	51	51	51	53	57
500	72	72	75	78	83	64	64	65	69	74	60	60	61	63	68	54	54	54	56	60
600	74	74	77	81	85	66	66	68	72	76	61	61	62	65	69	56	56	56	58	62
700	76	76	79	83	88	68	68	70	74	79	62	62	63	66	71	57	57	57	59	64
800	77	77	81	85	89	69	69	72	76	80	63	63	64	67	72	58	58	59	61	65
900	79	79	82	86	91	71	71	73	77	82	63	63	65	68	73	59	59	60	62	66
1000	80	80	84	88	92	72	72	75	79	83	64	64	65	69	74	60	60	61	63	68
1200	82	82	86	90	95	74	74	77	81	86	66	66	68	72	76	61	61	62	65	69
1400	84	84	88	92	97	76	76	79	83	88	68	68	70	74	79	62	62	63	66	71
1600	86	86	90	94	98	78	78	81	85	89	69	69	72	76	80	63	63	64	67	72
1800	87	87	92	95	100	79	79	83	86	91	71	71	73	77	82	63	63	65	68	73
2000	88	88	93	97	101	80	80	84	88	92	72	72	75	79	83	64	64	65	69	74
2400	90	90	95	99	104	82	82	86	90	95	74	74	77	81	86	66	66	68	72	76

RPM	BAND 5					BAND 6					BAND 7					BAND 8				
	SP/VP					SP/VP					SP/VP					SP/VP				
	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3	24	14	8	3	.3
100	28	28	29	32	37	25	25	26	29	32	22	22	23	26	28	19	19	20	23	23
200	33	33	34	37	42	28	28	29	32	37	25	25	26	29	32	22	22	23	26	28
300	38	38	38	41	46	31	31	32	34	40	27	27	28	31	35	24	24	25	28	30
400	42	42	42	45	49	33	33	34	37	42	28	28	29	32	37	25	25	26	29	32
500	45	45	45	48	52	35	35	35	39	44	29	29	30	33	38	26	26	27	30	34
600	47	47	48	50	54	38	38	38	41	46	31	31	32	34	40	27	27	28	31	35
700	49	49	50	52	56	40	40	40	43	48	32	32	33	36	41	28	28	29	31	36
800	51	51	51	53	57	42	42	42	45	49	33	33	34	37	42	28	28	29	32	37
900	53	53	53	55	59	44	44	44	46	50	34	34	35	38	43	29	29	30	32	37
1000	54	54	54	56	60	45	45	45	48	52	35	35	35	39	44	29	29	30	33	38
1200	56	56	56	58	62	47	47	48	50	54	38	38	38	41	46	31	31	32	34	40
1400	57	57	57	59	64	49	49	50	52	56	40	40	40	43	48	32	32	33	36	41
1600	58	58	59	61	65	51	51	51	53	57	42	42	42	45	49	33	33	34	37	42
1800	59	59	60	62	66	53	53	53	55	59	44	44	44	46	50	34	34	35	38	43
2000	60	60	61	63	68	54	54	54	56	60	45	45	45	48	52	35	35	35	39	44
2400	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"
TIP SPEED (FPM)	- 22.66xRPM
INLET AREA	- 85.40 Sq. Ft.
OUTLET AREA	- 67.48 Sq. Ft.
MAX. BHP - 1930 $\left(\frac{RPM}{1000}\right)^3$	

CLASS	I	II	III	IV	V
MAX TIP SPEED	10,000	14,000	17,500	20,000	22,500
MAX RPM	441	618	772	883	993

CFM	OV	¼ SP RPM BHP	½ SP RPM BHP	¾ SP RPM BHP	1 SP RPM BHP	1¼ SP RPM BHP	1½ SP RPM BHP	1¾ SP RPM BHP	2 SP RPM BHP	2½ SP RPM 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 36.8	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]
243042	3600	406 90.2	414 98.7	422 107	428 115	435 124	[illegible]	[illegible]	[illegible]	469 172

CFM	OV	3 SP RPM BHP	3½ SP RPM BHP	4 SP RPM BHP	4½ SP RPM BHP	5 SP RPM BHP	5½ SP RPM BHP	6 SP RPM BHP	6½ SP RPM BHP	7 SP RPM 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]	[illegible] 179		
162028	2400	374 99.9	388 112	403 126	420 141	437 157	[illegible]	472 191	[illegible]	[illegible]
175530	2600	390 111	404 126	418 139	431 154		[illegible]	477 205	493 223	510 242
189033	2800	408 125	421 140	434 155	[illegible]	459 186	472 202	486 219	501 238	515 258
202535	3000	426 140	439 156	[illegible]	[illegible]	474 204	486 220	498 237	511 255	524 274
216037	3200	[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	[illegible] 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]	[illegible]	[illegible]	[illegible]	[illegible]	599 403
283549	4200	[illegible] 256	550 277	561 301	570 322	580 344	590 366	599 389	608 412	617 436
297051	4400	[illegible]	[illegible]	579 326	[illegible]	[illegible]	[illegible]	[illegible] 421	626 443	635 467

CFM	OV	8 SP RPM BHP	9 SP RPM BHP	11 SP RPM BHP	13 SP RPM BHP	15 SP RPM BHP	17 SP RPM BHP	19 SP RPM BHP	21 SP RPM BHP	23 SP RPM BHP
175530	2600	[illegible]								
189033	2800	[illegible]	[illegible]							
202535	3000	[illegible]	[illegible]	635 446						
216037	3200	[illegible]	[illegible]	638 470	690 568					
229540	3400	[illegible]	[illegible]	642 494	692 591					
243042	3600	[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]	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			CONSTRUCTION NOISE	TOTAL[b] NOISE DURING CONSTRUCTION			CHANGE		
	L_d	L_n	L_{dn}	L_A	L_d	L_n	L_{dn}	L_d	L_n	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]

	BASELINE			OPERATION NOISE	TOTAL[b] NOISE DURING OPERATIONS			CHANGE		
LOCATION	L_d	L_n	L_{dn}	L_A	L_d	L_n	L_{dn}	L_d	L_n	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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Herrington, L. P. and Brock, C., Propagation of noise over and through a forest stand, Metropolitan Physical Environment Conf. Proc., USDA Forest Service Northeast Forest Experimental Station, 1975.

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Roth, D. S., Acoustic propagation in the surface layer under convectively unstable conditions, Ph.D. Thesis, The Pennsylvania State University, (November, 1983).

Thompson, D. W., Noise propagation in the atmosphere's surface and planatary boundary layers, Internoise 1982 Proceedings.

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.

Administrative Controls 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.

Engineering Controls 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:

Administrative

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-cars = 72 dBA

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

$(\overline{L_o})$E-Trucks = 86 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: $L_{eq}\ (1\ hr) = 72 + 10 \log \left[\frac{\left(\frac{846}{24}\right) \times 15}{88}\right] - 25$ = 54.8

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

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

North of site (Expected)

Cars: $L_{eq}\ (1\ hr) = 72 + 10 \log \left[\frac{\left(\frac{1620}{24}\right) \times 15}{88}\right] - 25$ = 57.6

Trucks: $L_{eq}\ (1\ hr) = 86 + 10 \log \left[\frac{\left(\frac{106}{24}\right) \times 15}{88}\right] - 25$ = 59.8

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

South of Site (Existing)	L_{eq}, dBA @ 15 m
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

<u>Instantaneous Noises</u> - 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)

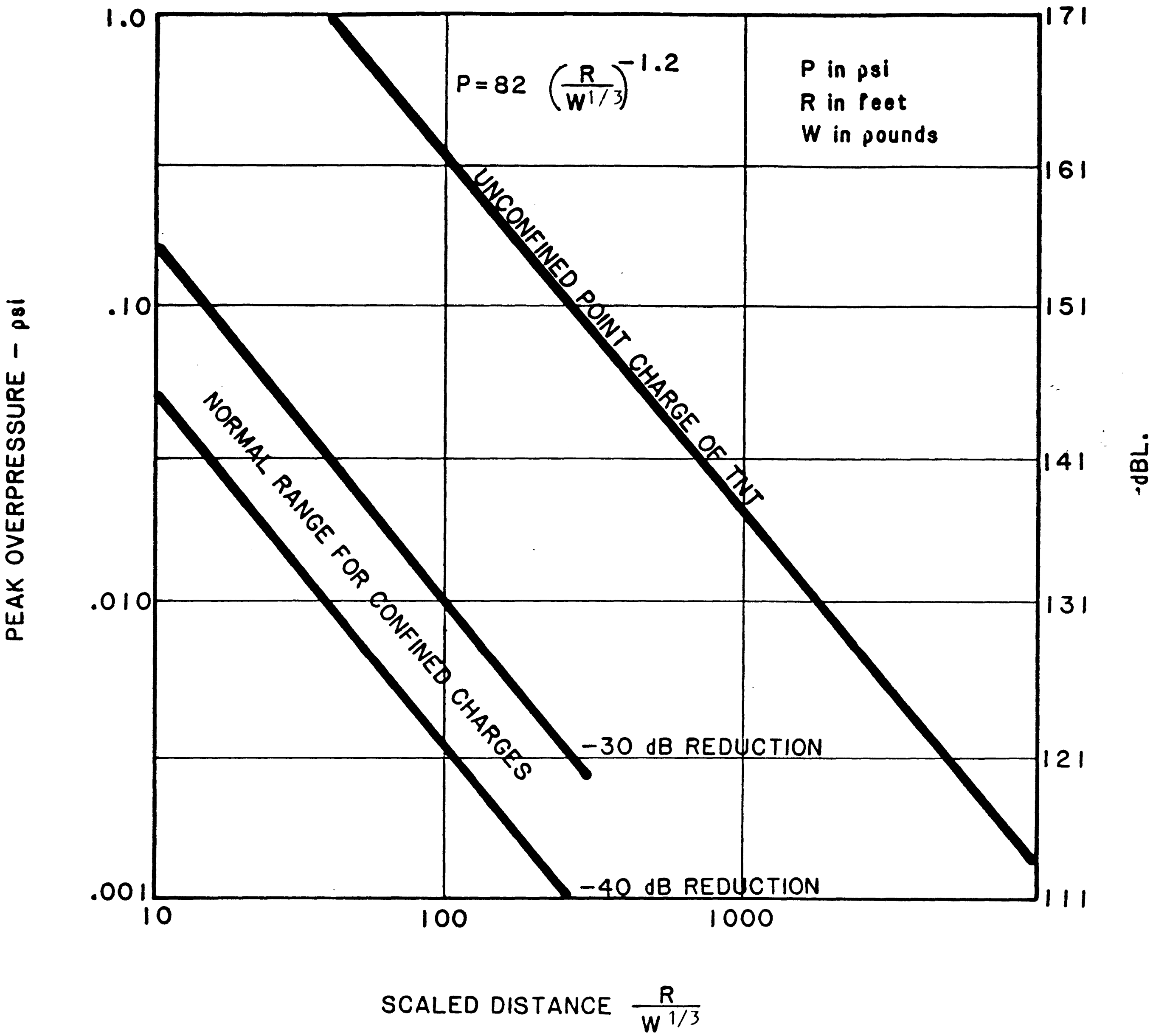


Figure 26-H. Air blast overpressure as a function of distance and charge weight for the unconfined and confined charges. P is expressed in psi, R in feet, and W in pounds.

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:

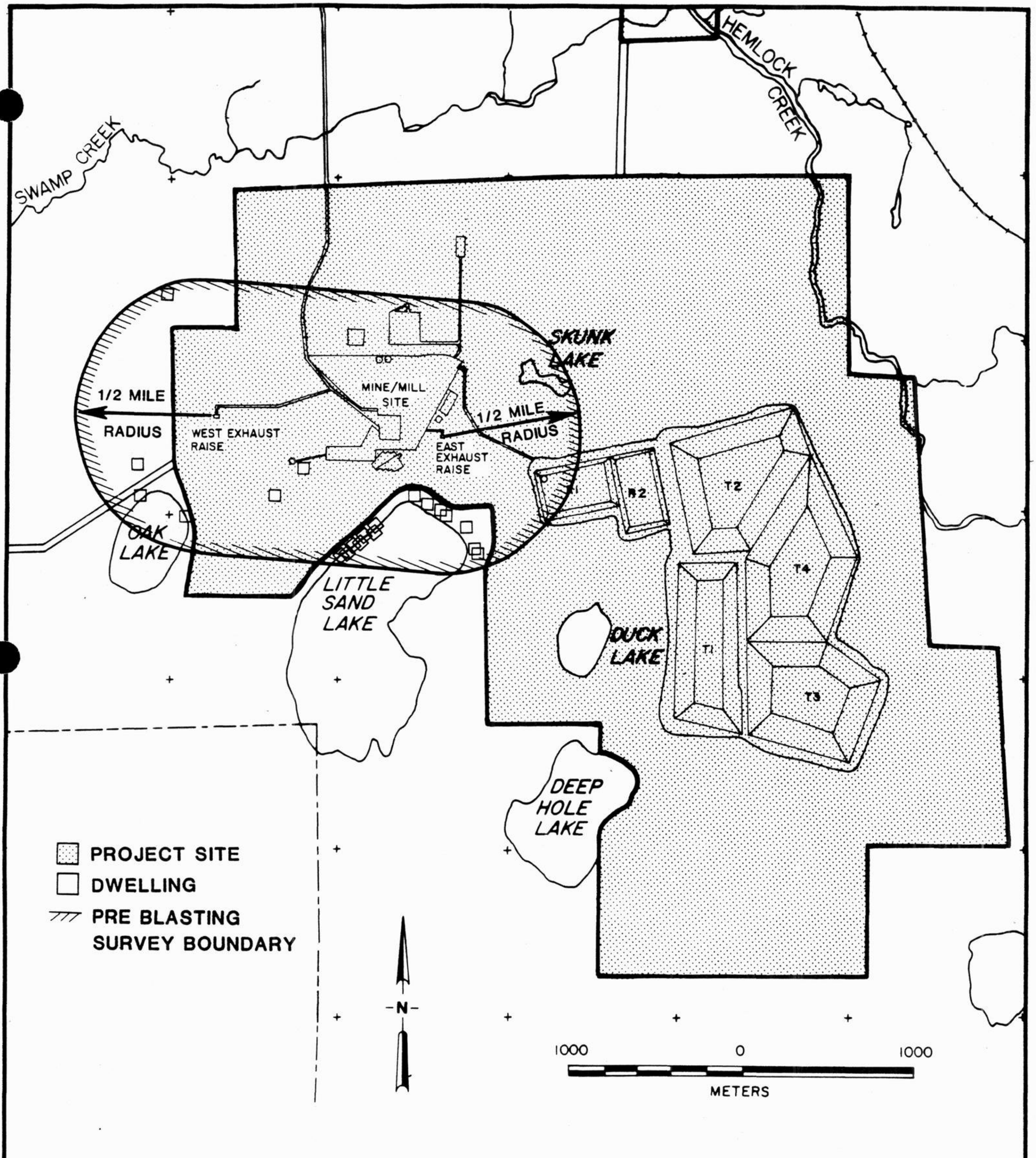
1) All permanent structures within an 0.8-km (0.5-mile) radius of any of the mine access or ventilation shafts (four) will be inspected (see attached figure).

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

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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.

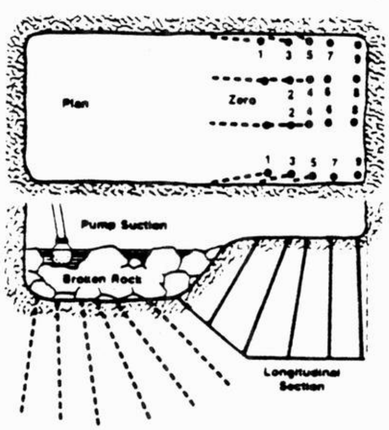


Figure 20-K. Benching illustrated above is a most efficient shaft sinking method.

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)

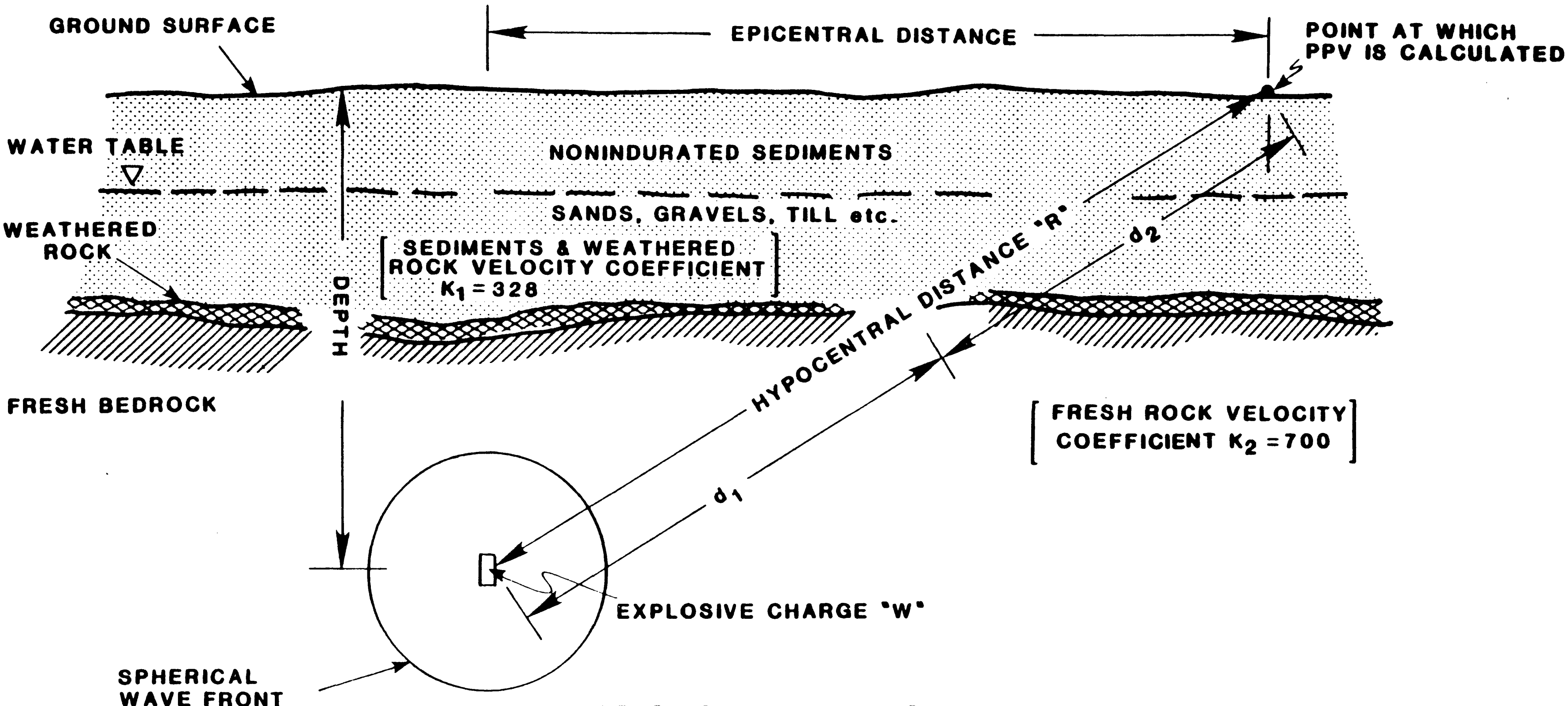
CRANDON BLAST VIBRATION STUDY

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 RES[illegible]SE TO COMMENT NO. S4)

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 = HYPOCENTRAL DISTANCE (m)
- W = CHARGE WEIGHT (kg)
- α = 0.73 β = 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. S4)

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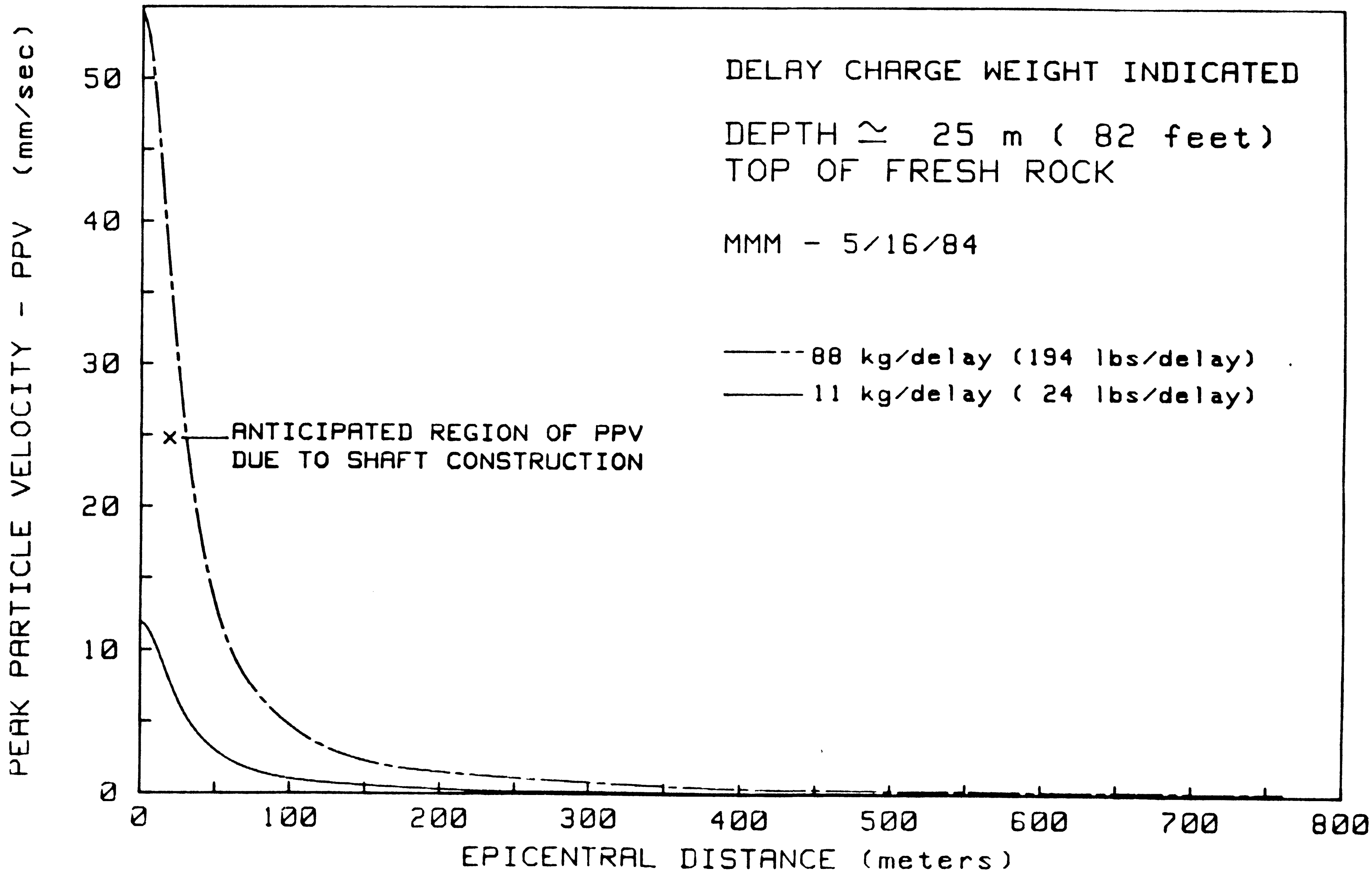
(Figure 2 for the Response to Comment No. S4)

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



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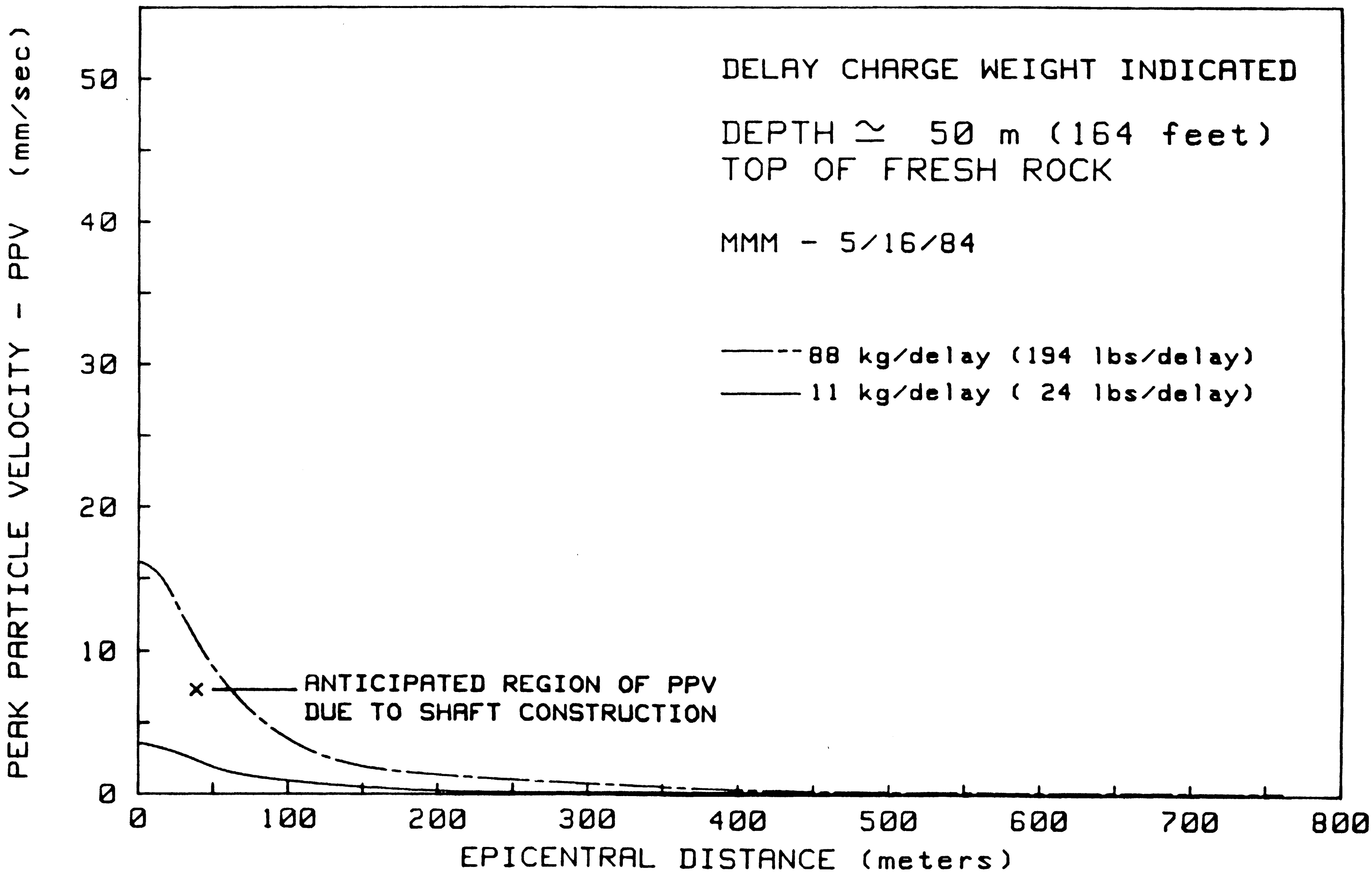
(Figure 3 for the Response to Comment No. S4)

FIGURE 3
CRANDON MAIN SHAFT
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITY



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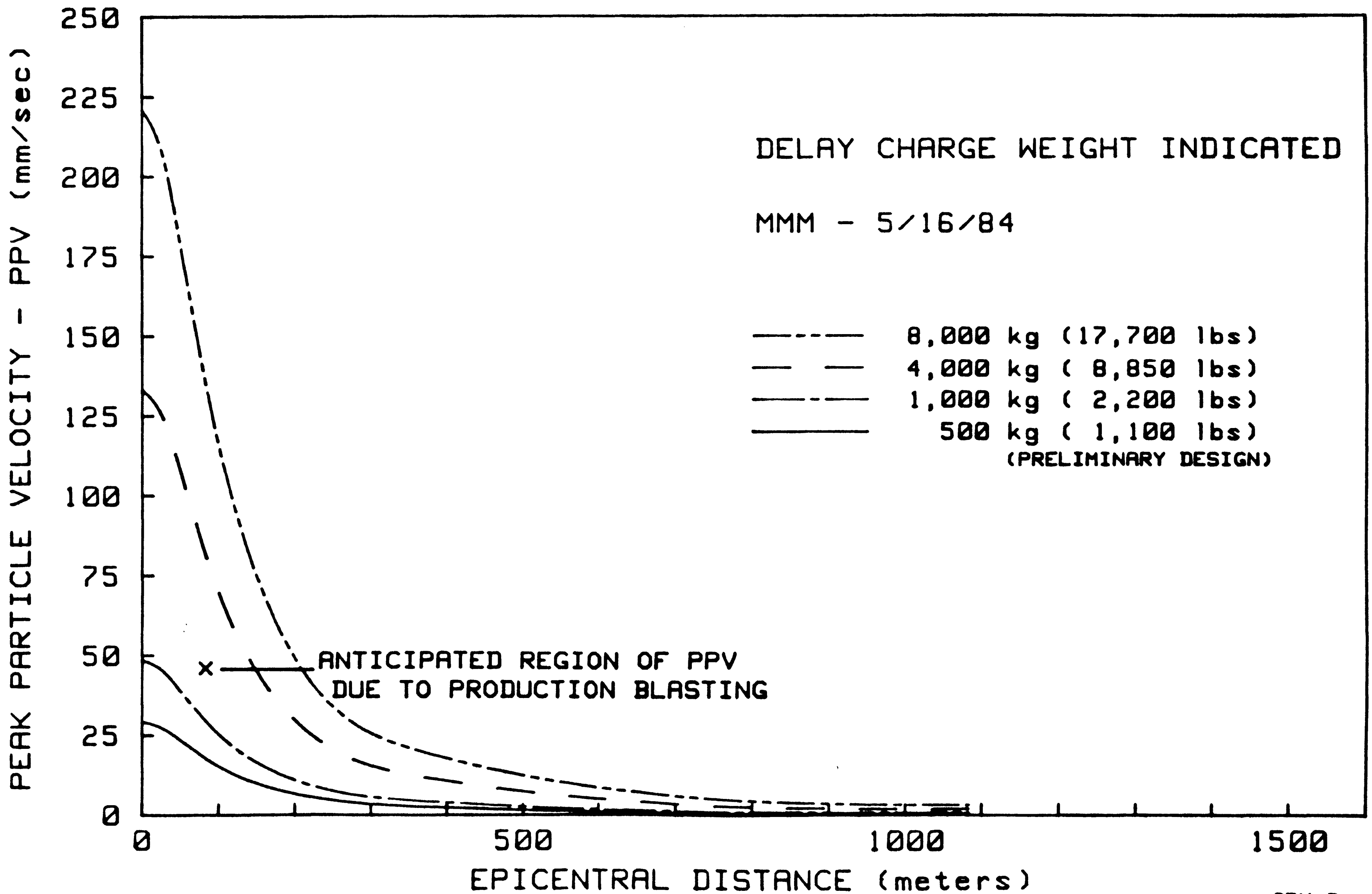
(Figure 4 for the Response to Comment No. S4)

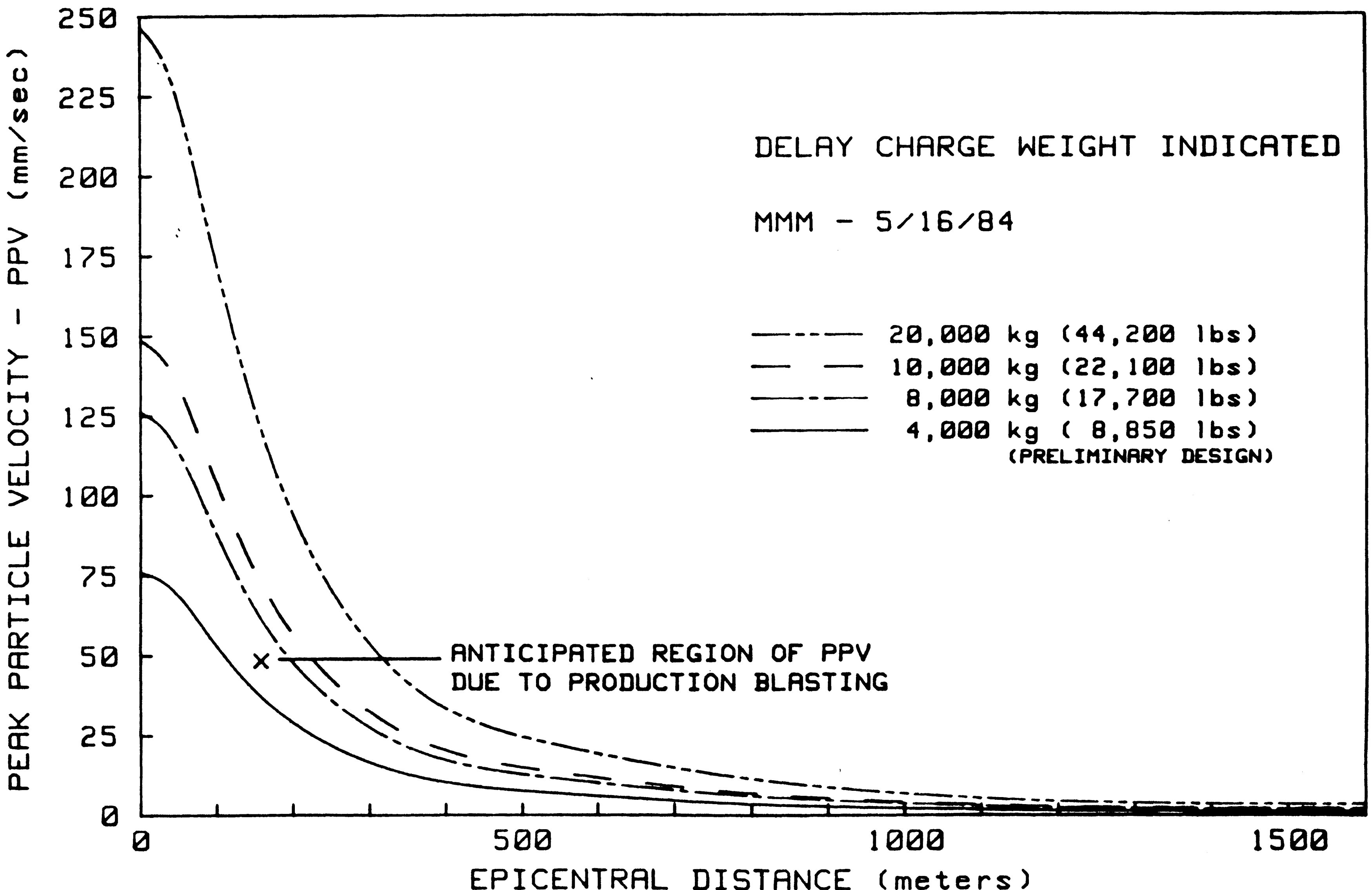
FIGURE 4
CRANDON: 95 m LEVEL PRODUCTION BLASTING
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITY



CDM-0-4

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

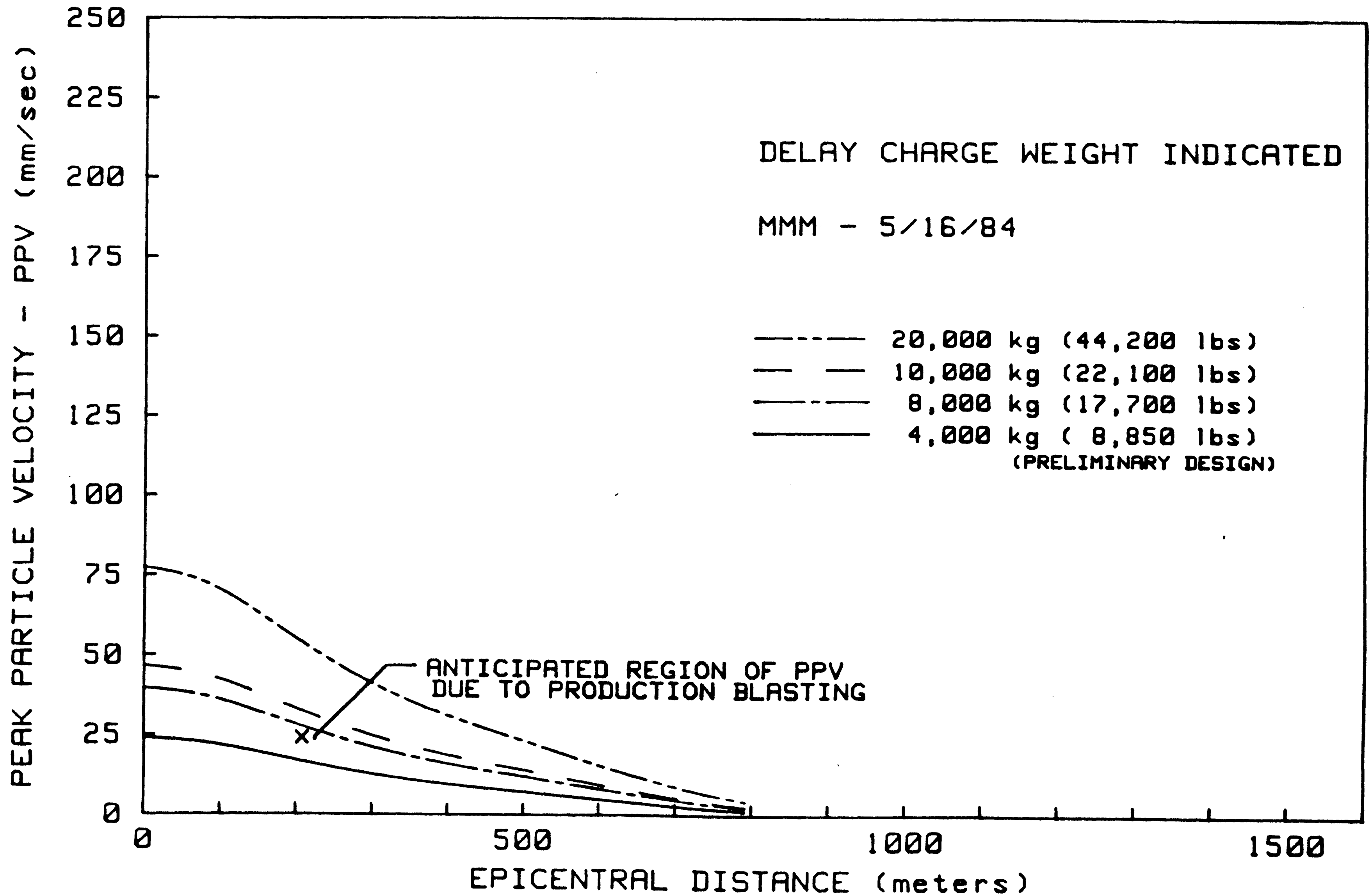
FIGURE 5
CRANDON: 140 m LEVEL PRODUCTION BLASTING
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITY



CDM-0-5

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

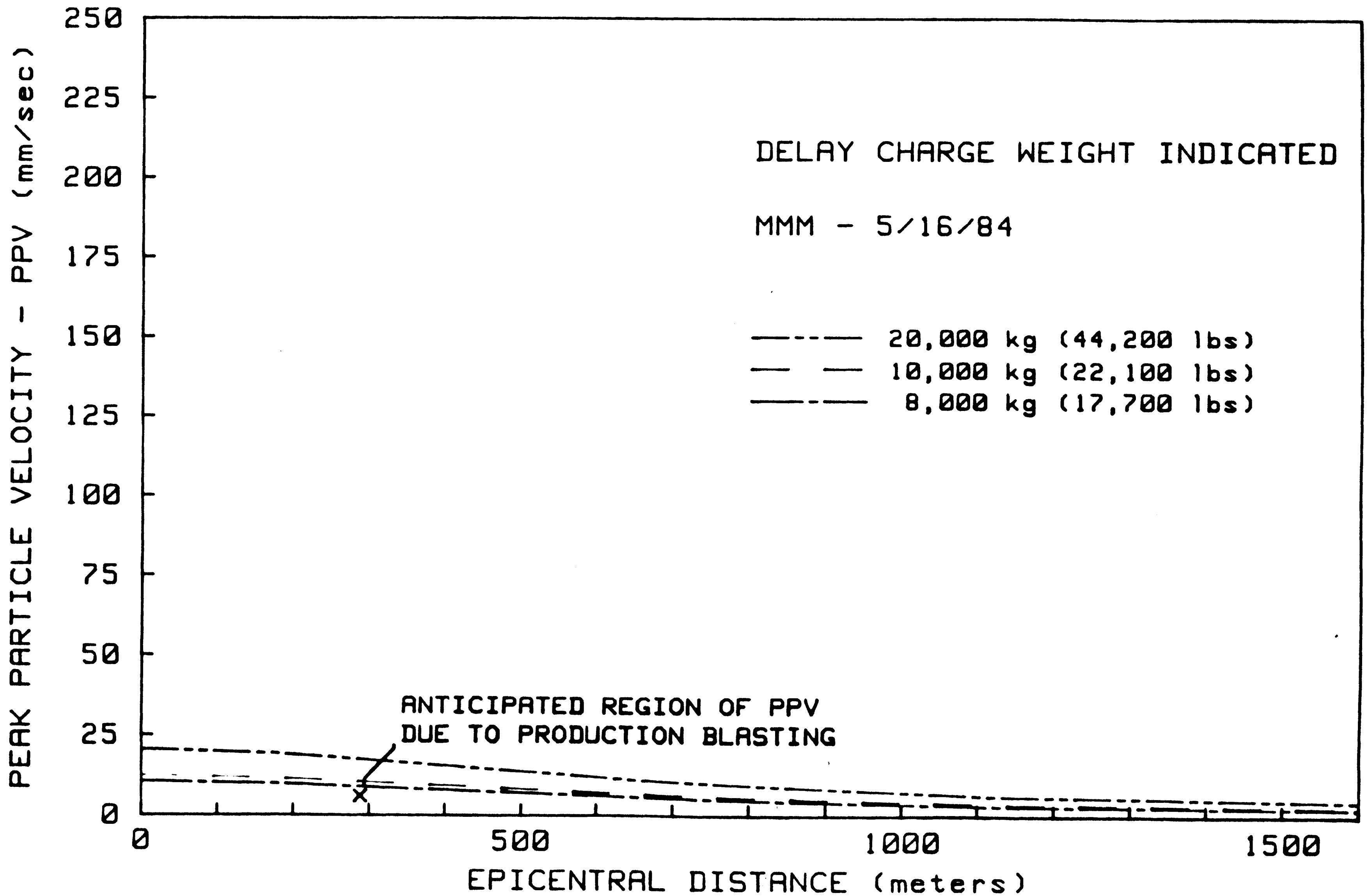
FIGURE 6
CRANDON: 290 m LEVEL PRODUCTION BLASTING
ESTIMATED GROUND SURFACE PEAK PARTICLE VELOCITY



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



CDM-0-7

(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

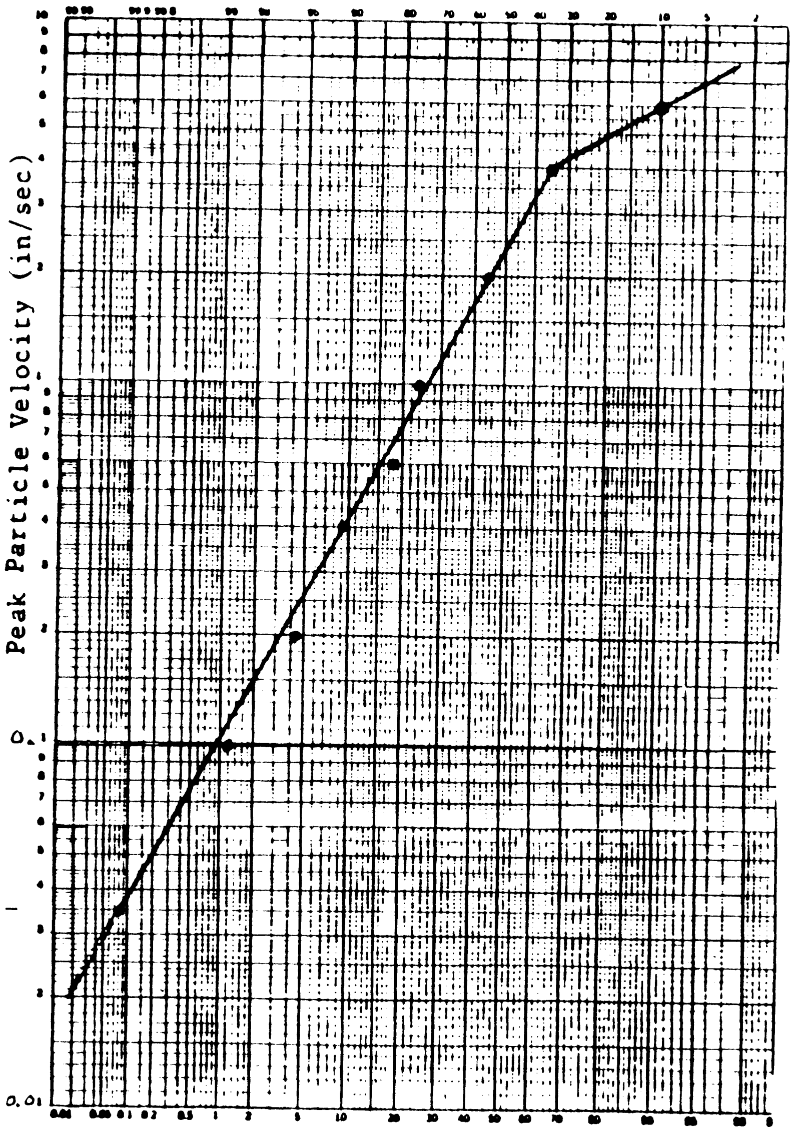
Detectable

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.

State of Wisconsin \ **DEPARTMENT OF NATURAL RESOURCES**

Carroll D. Besadny
Secretary

May 22, 1985

File Ref: 1630
(Exxon)

RE: Exxon Crandon Mine Project/
Additional Documents for Public
Information and Review

Dear Librarian:

Please place the enclosed documents with the rest of the Exxon Crandon Mine Project environmental impact report (EIR):

1. Letter dated May 17, 1985 from Barry J. Hansen (Exxon) to Robert Ramharter (DNR) Re: Revised Response to DNR Comment on Exxon's noise baseline and impact analysis reports.

2. Letter dated April 30, 1985 from Steve Klafka (DNR) to Barry Hansen (Exxon) Re: preliminary review of Exxon's air pollution control permit application for the firm's proposed Crandon Mine Project.

3. "Preconstruction Review and Preliminary Determination on the Proposed Construction, Operation and Reclamation of an Underground Zinc/Copper/Lead Mine, Ore Processing Mill and Associated Surface Facilities for Exxon Minerals Company To Be Located Five Miles South of Crandon, Forest County, Wisconsin", New Source Review #85-SJK-003, by Wisconsin Department of Natural Resources Bureau of Air Management, April 26, 1985.

These documents pertain to the EIR. People who have comments or questions about them may contact Mr. Robert Ramharter at (608) 266-3915 or at DNR, Box 7921, Madison, WI, 53707.

Thank you for your assistance.

Sincerely,
Bureau of Environmental Analysis and Review

Carol Nelson

Carol Nelson
Environmental Specialist

Enclosure

EXXON MINERALS COMPANY

P. O. Box 813, RHINELANDER, WISCONSIN 54501

CRANDON PROJECT

May 17, 1985

Revised Response To DNR Comment
On The Noise Reports

Mr. Robert H. Ramharter
Department of Natural Resources
Bureau of Environmental Review and Analysis
EAR/3
P. O. Box 7921
Madison, Wisconsin 53707

Dear Mr. Ramharter:

Enclosed are 40 copies of a revised response to one of the DNR's comments on EMC's noise baseline and impact analysis reports. This revised response is for comment No. A28 contained in the response package submitted to you on October 31, 1984.

Alan Haas, Howard, Needles, Tammen and Bergendoff, requested clarification of the example calculations and the figure presented in part 2) Blasting, of the response. The basis for the example calculations and the relationship to the figure are more fully explained in this revised response. The other parts of this response have not been changed.

Howard Lewis of our staff has informed Steve Klafka of this revision and a copy of the revised response is being sent to Messers. Klafka and Haas. One copy of the response is also being transmitted to Terry McKnight at the North Central District office.

Please contact me if you have any questions on this revised response.

Yours truly,

EXXON MINERALS COMPANY

Barry J. Hansen
Permitting Manager

BJH:HSL:ef
Enclosure

xc/w/enclosure: Alan Haas, HNTB
Steve Klafka, DNR
Terry McKnight, DNR

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. Blasting will be required, however, when bedrock is encountered during shaft sinking.

   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. They will also occur over a very brief period of mine construction activities. Blasting within the mine will have lower noise levels than what will occur during shaft construction because of their location in the interior of the mine.

   Estimated noise levels generated from a confined shaft blast at different depths (plus 4000 m [13200 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

---

*This distance was selected to represent possible receptors located approximately 4.0 km (2.5 miles) from the shaft blasting.

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

Example calculations:

a. For the start of main shaft blasting at the 34-m (110-foot) depth (i.e., the glacial soil [overburden] and bedrock interface), attached Figure 26-H:

$$\text{Overpressure} = P = 82 \left(\frac{110 + 13200}{32^{0.33}} \right)^{-1.2} = 3.64 \times 10^{-3} \text{ psi}$$

at 4000 m (13200 feet).

Using the formula from EIR Section 2.8: Sound pressure level

$(dB) = 20 \log_{10} \frac{P}{P_o}$ (converting the psi value to a unit consistent with the formula).

This overpressure corresponds to a dBL of 122.0, and

Unweighted sound pressure level at 13200 feet	122.0
A-weighting for 20 Hz[a]	-50.5[b]
A-weighted result at 13200 feet[c]	71.5 dBA.

b. For the middle of main shaft blasting at a 435-m (1425-foot) depth, from attached Figure 26-H:

$$\text{Overpressure} = P = 82 \left(\frac{1425 + 13200}{32^{0.33}} \right)^{-1.2} = 3.25 \times 10^{-3} \text{ psi}$$

at 4000 m (13200 feet).

Using the formula from EIR Section 2.8: Sound pressure level

$(dB) = 20 \log_{10} \frac{P}{P_o}$ (converting the psi value to a unit consistent with the formula).

This overpressure corresponds to a dBL of 121.0, and

Unweighted sound pressure level at 13200 feet	121.0
A-weighting for 20 Hz[a]	-50.5[b]
A-weighted result at 13200 feet[c]	70.5 dBA.

c. For the bottom of main shaft blasting at the 837-m (2745-foot) depth, from attached Figure 26-H:

$$\text{Overpressure} = P = 82 \left(\frac{2745 + 13200}{32^{0.33}}\right)^{-1.2} = 2.93 \times 10^{-3} \text{ psi}$$

at 4000 m (13200 feet).

Using the formula from EIR Section 2.8: Sound pressure level

$(dB) = 20 \log_{10} \frac{P}{P_o}$ (converting the psi value to a unit consistent with the formula).

This overpressure corresponds to a dBL of 120.1, and

Unweighted sound pressure level at 13200 feet	120.1
A-weighting for 20 Hz[(a)]	-50.5[(b)]
A-weighted result at 13200 feet[(c)]	69.6 dBA.

(a) The peak blast frequency is typically observed around 20 Hz (Source: duPont Company. 1977. Blaster's handbook. Explosives Products Division, E.I. duPont de Nemours & Co., Inc., Willmington, Delaware.)

(b) Source: Beranek, L. L. 1971. Levels, decibels and spectra, in Noise and Vibration Control, edited by L. L. Beranek: McGraw-Hill, Inc., New York.

(c) Blasting operations will produce short duration, intrusive type noise. Therefore, the L_{eq} (averaged over a 1 second time interval) will be lower than what is presented above.

3) Backup Alarms - OSHA Regulations No. 1926.602(a)(9)(ii). No employer shall permit earthmoving or compacting equipment which has an obstructed 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.

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

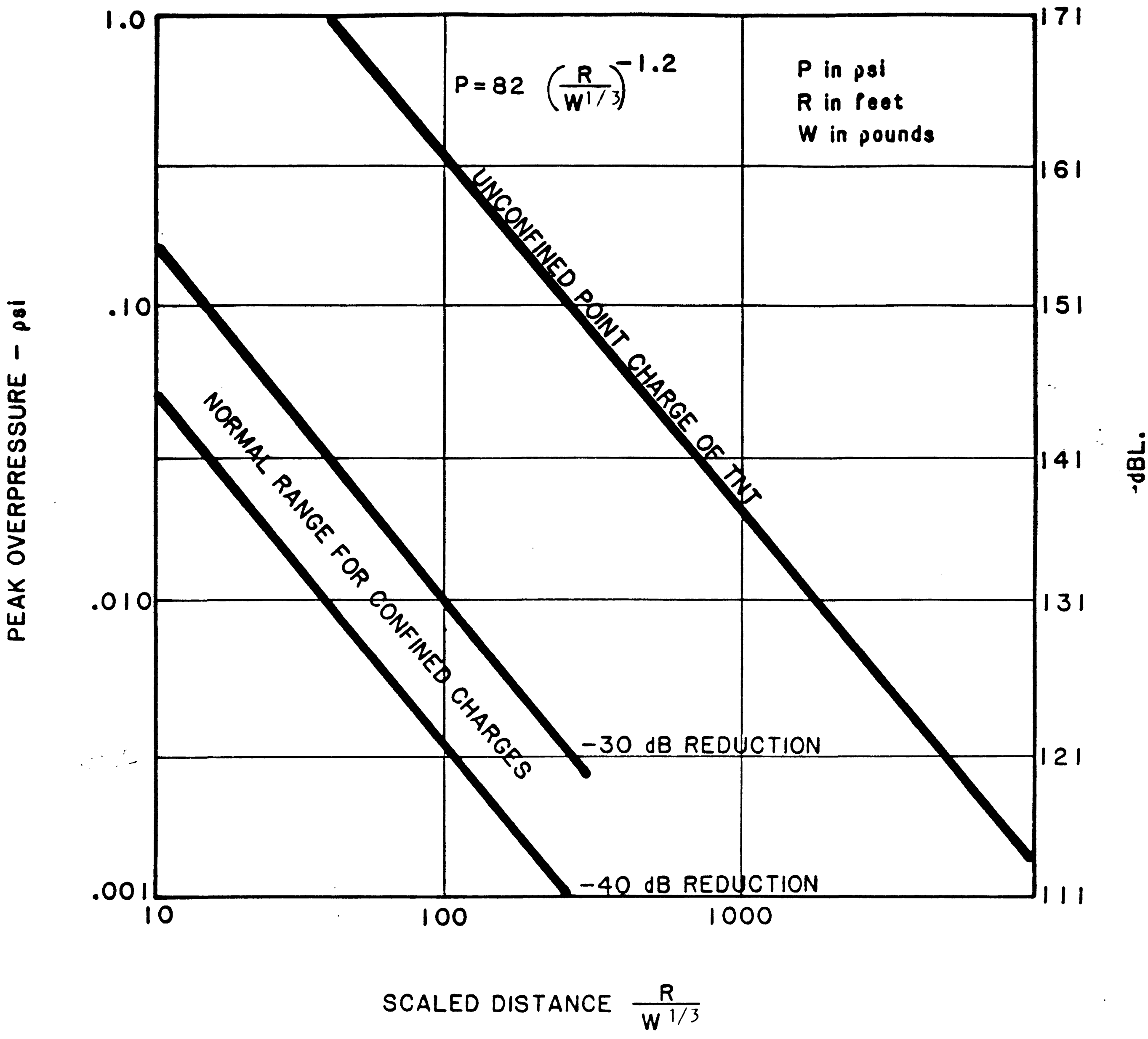


Figure 26-H. Air blast overpressure as a function of distance and charge weight for the unconfined and confined charges. P is expressed in psi, R in feet, and W in pounds.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

BOX 7921
MADISON, WISCONSIN 53707

April 30, 1985 IN REPLY REFER TO: 4530

Mr. Barry J. Hansen
Permitting Manager
Exxon Minerals Company
P.O. Box 813
Rhinelander, Wisconsin 54501

Dear Mr. Hansen:

The Engineering and Surveillance Section, Bureau of Air Management of the Department of Natural Resources has preliminarily reviewed the air pollution control permit application for the proposed underground zinc, copper and lead mine, ore processing mill and associated surface facilities to be located five miles south of Crandon, Wisconsin.

The Section has prepared an analysis of the proposed project and has made a preliminary determination that it is approvable. The analysis and preliminary determination indicate that the following emission limitations and special permit conditions should be included in any permit which may be issued by the Department.

Emission Limitations

1. Construction of the mine and surface facilities

Pollutant	Applicable Wis. Adm. Code	Limitation/Requirement
Particulates	Sec. NR 154.11(2)	See Note 1
	Sec. 144.394(6), Wis. Stats.	209.6 tons per year*
Sulfur Dioxide	Sec. 144.394(6), Wis. Stats.	18.8 tons per year*
Nitrogen Oxides	Sec. 144.394(6), Wis. Stats.	79.8 tons per year*
Carbon Monoxide	Sec. 144.394(6), Wis. Stats.	186.7 tons per year*
Hydrocarbons	Sec. 144.394(6), Wis. Stats.	74.2 tons per year*
Hydrogen Sulfide	Sec. 144.394(6), Wis. Stats.	0.5 tons per year*

Note 1: Fugitive Dust: No person shall cause, allow, or permit any materials to be handled, transported, or stored without taking precautions to prevent particulate matter from becoming airborne. Nor shall a person allow a structure, a parking lot, or a road to be used, constructed, altered, repaired, sand blasted or demolished without taking such precautions.

(a) Such precautions shall include, but not be limited to:

1. Use, where possible, of water or chemicals for control of dust in the demolition of existing buildings or structures, or construction operations.

2. Application of asphalt, oil, water, suitable chemicals, or plastic covering on dirt roads, material stockpiles, and other surfaces which can create airborne dust, provided such application does not create a hydrocarbon, odor, or water pollution problem.

3. Installation and use of hoods, fans, and air cleaning devices to enclose and vent the areas where dusty materials are handled.

4. Covering or securing of materials likely to become airborne while being moved on public roads, railroads, or navigable waters.

5. Conduct of agricultural practices such as tilling of land or application of fertilizers in such manner as not to create pollution.

6. The paving or maintenance of roadways or parking lots so as not to create air pollution.

*This emission limitation is set in order to document the allocation of the available air resources. It represents the maximum emissions expected during the project construction phase.

2. Underground mine operations venting through the east and west exhaust raises.

For purposes of determining an applicable emission limitation, the underground mine operations are treated as a process. The applicable limitation for a process is either Sec. NR 154.11(3)(a)1.a. based on the process weight rate, or Sec. NR 154.11(3)(b)1.m., Wis. Adm. Code based on the exhaust gas flow rate, whichever is more restrictive. In this case, the former of the two is more restrictive.

Pollutant	Applicable Wis. Adm. Code	Limitation/Requirement
Particulates	Sec. NR 154.11(3)(a)1.a. Sec. 144.394(6), Wis. Stats.	$E = 17.31\ P^{0.16}$ and 27.4 tons per year*
Sulfur Dioxide	Sec. 144.394(6), Wis. Stats.	8.0 pounds per hour, 17.7 tons per year**
Nitrogen Oxides	Sec. 144.394(6), Wis. Stats.	40.9 pounds per hour, 73.2 tons per year**
Carbon Monoxide	Sec. 144.394(6), Wis. Stats.	59.8 pounds per hour, 81.1 tons per year**

*E represents the allowable emission rate in pounds per hour, and P, represents the total weight of materials introduced to the process, excluding liquid and gaseous fuels and air, in tons per hour. In this case, for a maximum process weight rate of 1,213 short tons per hour, (the weight of material brought to the surface by to the hoisting skip), the allowable TSP emission rate is 53.9 pounds per hour. A yearly emission limit of 27.4 tons per year is set in order to document the allocation of available air resources. This is the maximum particulate emissions expected from mine operation.

**These emission limits are set in order to document the allocation of available air resources. These represent the maximum emissions expected from mine operation.

3. Fine ore crushing and screening operations

As this is a process, the applicable limitation is either Sec. NR 154.11(3)(a)1.a, or Sec. NR 154.11(3)(b)1.m., Wis. Adm. Code. In this case, Sec. NR 154.11(3)(b)1.m. - 0.2 pounds per 1000 pounds of exhaust gas - would be more restrictive.

Pollutant	Applicable Wis. Adm. Code	Limitation/Requirement
Particulates	Sec. NR 154.11(3)(b)1.m. Sec. 144.394(3), Wis. Stats.	0.05 grams per dry standard cubic meter*
Visible Emissions	Sec. NR 154.11(6)(a)1.	20% opacity

*This process would normally be subject to the emission limit of Sec. NR 154.11(3)(b)1.m., Wis. Adm. Code of 0.2 pounds per 1000 pounds of exhaust gas (0.24 grams per dry standard cubic meter). However, this process is also subject to the federal New Source Performance Standards (NSPS) for metallic mineral processing plants of 40 CFR Part 60 Subpart LL. In anticipation that these standards will be adopted into Chapter 440, Wis. Adm. Code, the more restrictive NSPS of 0.05 grams per dry standard cubic meter is applied.

4. Fine ore bin loading and unloading operations

As this is a process, the applicable limitation is either Sec. NR 154.11(3)(a)1.a., or Sec. NR 154.11(3)(b)1.m., Wis. Adm. Code. In this case, Sec. NR 154.11(3)(b)1.m. - 0.2 pounds per 1000 pounds of exhaust gas - would be more restrictive.

Pollutant	Applicable Wis. Adm. Code	Limitation/Requirement
Particulates	Sec. NR 154.11(3)(b)1.m. Sec. 144.394(3), Wis. Stats.	0.05 grams per dry standard cubic meter*
Visible Emissions	Sec. NR 154.11(6)(a)1.	20% opacity

*This process would normally be subject to the emission limit of Sec. NR 154.11(3)(b)1.m., Wis. Adm. Code of 0.2 pounds per 1000 pounds of exhaust gas (0.24 grams per dry standard cubic meter). However, this process is also subject to the federal New Source Performance Standards (NSPS) for metallic mineral processing plants of 40 CFR Part 60 Subpart LL. In anticipation that these standards will be adopted into Chapter 440, Wis. Adm. Code, the more restrictive NSPS of 0.05 grams per dry standard cubic meter is applied.

5. Concrete batch plant

As this is a process, the applicable limitation is either Sec. NR 154.11(3)(a)1.a., or Sec. NR 154.11(3)(b)1.i., Wis. Adm. Code. In this case, Sec. NR 154.11(3)(b)1.i. - 0.3 pounds per 1,000 pounds of exhaust gas-would be more restrictive.

Pollutant	Applicable Wis. Adm. Code	Limitation/Requirement
Particulates	Sec. NR 154.11(3)(b)1.i.	0.3 pounds per 1,000 pounds of exhaust gas.
Visible Emissions	Sec. NR 154.11(6)(a)1.	20% opacity

6. Facility heating

This includes all fuel usage for surface facility space heating, water heating and water treatment.

Pollutant	Applicable Wis. Adm. Code	Limitation/Requirement
Particulates	Sec. NR 154.11(4)(a)1.	0.01 pounds per million
	Sec. 144.394(3), Wis. Stats.	BTU heat input*
	Sec. 144.394(6), Wis. Stats.	0.9 tons per year**
Sulfur Dioxide	Sec. 144.394(6), Wis. Stats.	0.10 tons per year**
Nitrogen Oxides	Sec. 144.294(6), Wis. Stats.	10.3 tons per year**
Carbon Monoxide	Sec. 144.394(6), Wis. Stats.	1.5 tons per year**
Hydrocarbons	Sec. 144.394(6), Wis. Stats.	0.3 tons per year**

* This alternate limitation represents the maximum emissions expected. Sec. NR 154.11(4)(a)1., Wis. Adm. Code, allows 0.15 pounds per million BTU heat input.

**These emission limitations are set in order to document the allocation of the available air resource. Yearly emissions are based on a maximum total natural gas usage of 171,032,000 standard cubic feet per year for surface facilities heating.

7. Diesel and Gasoline Storage

This includes diesel and gasoline storage and handling emissions from the two 15,000 gallon diesel fuel oil storage tanks, the 3,000 gallon diesel and gasoline storage tanks at the facility service station, and the mine diesel storage tanks.

Pollutant	Applicable Wis. Adm. Code	Limitation/Requirement
Organic Compounds	Sec. NR 154.13(3)(f)2.	See Note 1
	Sec. 144.394(6), Wis. Stats.	1.56 tons per year*

Note 1: The gasoline storage tank shall be equipped with a permanent submerged fill pipe with a discharge opening which is entirely submerged when the liquid level is 6 inches above the tank bottom.

* This limitation is set in order to document the allocation of the available air resource. Yearly emissions are based on a maximum diesel fuel oil usage of 2.1 million gallons per year, and gasoline usage of 175,000 gallons per year.

8. Emergency diesel generators

Pollutant	Applicable Wis. Adm. Code	Limitation/Requirement
Particulates	Sec. NR 154.11(4)(a)1.	0.15 lbs/MMBTU heat input
	Sec. 144.394(6), Wis. Stats.	1.8 tons per year*
Sulfur Dioxide	Sec. 144.394(6), Wis. Stats.	27.7 pounds per hour,
	Sec. 144.394(6), Wis. Stats.	4.9 tons per year*
Nitrogen Oxides	Sec. 144.394(6), Wis. Stats.	230.4 pounds per hour, 40.8tons per year*
Carbon Monoxide	Sec. 144.394(6), Wis. Stats.	59.9 pounds per hour, 10.6 tons per year*
Hydrocarbons	Sec. 144.394(6), Wis. Stats.	6.5 pounds per hour, 1.1 tons per year*
Visible emissions	Sec. 154.11(6)(a)1.	20% opacity

*These emission limits are set in order to document the allocation of the available air resource. Yearly emissions are based on a maximum diesel fuel usage of 163,365 gallons per year for testing and emergency operation.

9. Surface facilities operation fugitive dust

Pollutant	Applicable Wis. Adm. Code	Limitation/Requirement
Particulates	Sec. NR 154.11(2)	See Note 1
	Sec. 144.394(6), Wis. Stats.	174.4 tons per year*

Note 1: Fugitive Dust. No person shall cause, allow, or permit any materials to be handled, transported, or stored without taking precautions to prevent particulate matter from becoming airborne. Nor shall a person allow a structure, a parking lot, or a road to be used, constructed, altered, repaired, sand blasted or demolished without taking such precautions.

(a) Such precautions shall include, but not be limited to:

1. Use, where possible, of water or chemicals for control of dust in the demolition of existing buildings or structures, or construction operations.

2. Application of asphalt, oil, water, suitable chemicals, or plastic covering on dirt roads, material stockpiles, and other surfaces which can create airborne dust, provided such application does not create a hydrocarbon, odor, or water pollution problem.

3. Installation and use of hoods, fans, and air cleaning devices to enclose and vent the areas where dusty materials are handled.

4. Covering or securing of materials likely to become airborne while being moved on public roads, railroads, or navigable waters.

5. Conduct of agricultural practices such as tilling of land or application of fertilizers in such manner as not to create pollution.

6. The paving or maintenance of roadways or parking lots so as not to create air pollution.

*This emission limitation is set in order to document the allocation of the available air resources. It represents the maximum emissions expected from access road and in-plant road usage, tailings pond construction activities and waste rock handling operations, or reclamation activities.

Special Permit Conditions

a. This permit does authorize an initial operation period of 180 days for equipment shake-down, testing and Department evaluation of operation to assure conformity with the permit conditions. Permanent operation of the source(s) covered by this permit after the initial operation period is prohibited until a release has been issued by the Department.

b. Source performance tests shall be conducted within 90 days after the start of initial operation to prove compliance with the particulate limitations for the underground mine operations, fine ore crushing and screening operations, and fine ore bin loading and unloading operations while operating at 80% or greater capacity and using U.S. EPA tests methods identified in 40 CFR 60 Subpart LL. The Department shall be informed at least 10 working days prior to the tests so a Department representative can witness the testing. At the time of notification, a stack test plan following the provisions set forth in Section NR 154.06(5), Wisconsin Administrative Code, shall also be submitted for approval.

Two copies of the report on the tests shall be submitted to the Department for evaluation within 30 days after the tests or at least 15 working days prior to the expiration of the initial operation period. Release for permanent operation will be issued only upon proof of compliance.

c. The wet scrubbers used to control particulate emissions from the fine ore crushing and screening operations, and the fine ore bin loading and unloading operations shall be equipped with monitoring devices for pressure drop across the scrubber and scrubbing liquid flow rate as required under the new source performance standards for metallic mineral processing plants (40 CFR 60 Subpart LL). The pressure drop monitoring device must be certified by the manufacturer to be accurate within ±1 inch water (± 250 pascals) gage pressure and must be calibrated on an annual basis in accordance with manufacturer's instructions. The scrubbing liquid flow rate monitoring device must be certified by the manufacturer to be accurate within ± 5% of design scrubbing liquid flow rate and must be calibrated on at least an annual basis in accordance with manufacturer's instructions.

Quarterly reports shall be submitted to the Department of occurrences when the scrubber pressure drop and scrubbing liquid flow rate differ more than ± 30% from those measurements recorded during the most recent performance test.

d. Records shall be kept indicating daily ore and waste rock production rates, and explosive and diesel fuel oil usage rates for the mine. Production rates should be for those materials removed from the mine.

e. Prior to expiration of the project shakedown period, a malfunction prevention and abatement plan shall be submitted to and approved by the Department. This shall include a specific plan for control of fugitive dust during surface facilities operation.

f. All open burning of cleared trees and brush shall use air curtain destructors. Burning rates shall not exceed 500 pounds per hour.

g. Not later than 180 days after initial start-up, no ore processing related fugitive emissions shall exhibit an opacity greater than 10 percent using U.S. EPA Method 9 as required for the NSPS for metallic mineral processing plants (40 CFR 60 Subpart LL).

h. Diesel fuel oil usage by the mill backup generators shall not exceed 163,365 gallons per year.

i. Prior to expiration of the project shakedown period, emissions data acceptable to the Department shall be submitted which verifies the emergency diesel generators used for this project comply with the applicable particulate emission limitation.

The Department will now accept public comments on the proposed underground mine project as required by Sections 144.392(9) and 144.835, Wisconsin Statutes. All public input received before and during the mining permit hearing will be used to render a final decision on the issuance of an air pollution control permit. This decision will be made within 90 days after the completion of the public hearing record.

Please be advised that this is only a preliminary determination. Construction and operation of this project cannot commence until an air pollution control permit is received from the Department. If you have any questions regarding this matter, please feel free to contact me at (608) 267-7540.

Sincerely,
Bureau of Air Management

Steven Klafka

Steven Klafka, Environmental Engineer
Engineering & Surveillance Section

SK:cn

cc: [redacted]
M. DeBrock - NCD
D. Theiler - AM/3
R. Herbst - Exxon
W. Arts - DOJ

5731R

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

May 15, 1985

File Ref: 1630 - Exxon

Dear Citizen:

An informational meeting on the proposed Exxon mine will be held on June 1, 1985 at the Nashville Town Hall, south of Crandon, Wisconsin from 9:00 a.m. - 12:00 p.m.

The news release on the reverse side of this letter outlines the content of the meeting. This will be the last public informational meeting prior to finalizing and releasing the Draft Environmental Impact Statement on the project.

Everyone is welcome to attend.

Sincerely,
Bureau of Environmental Analysis and Review

Bob Ramharter

Bob Ramharter
Environmental Specialist

BR:GB:mm

Meeting Presents Exxon Socioeconomic Impacts Overview

MADISON, WI--An informational meeting centering around potential socioeconomic and environmental impacts of the proposed Exxon project near Crandon will be held Saturday, June 1, 1985.

The meeting, which will begin at 9:00 a.m. and run through noon, will be in the Town of Nashville Hall located southwest of Crandon off Highway 55.

"The focus of the meeting will be to summarize the likely environmental and socioeconomic impacts of the project," Bob Ramharter, DNR's Exxon Project Coordinator said. "Robert Robinson of Denver, Colorado, a member of Denver Research Institute (DRI), under contract to the DNR to study socioeconomic impacts of the proposed project, will be featured at the meeting."

Robinson will present results of the nearly-completed study of the proposed Crandon project. DRI's impact analysis has been centered on three geographical areas near the proposed mine site.

1. The project site itself including the Towns of Nashville, Lincoln, Crandon and Elcho, the City of Crandon, and the Sakaogon Chippewa and Forest County Potawatomi Indian Tribes.

2. The City and Township of Antigo.

3. The City of Rhinelander and adjacent Townships of Crescent, Newbold, Pine Lake and Pelican.

Several top DNR officials will attend the meeting including Linda Bochert, DNR Executive Assistant; Lyman Wible, Administrator of the Division of Environmental Standards; and Kathy Curtner, Assistant Division of Enforcement Administrator. These people will be available to hear public concerns and discuss project issues.

"To encourage informal dialogue," Ramharter said, "We will have a series of smaller group sessions after the initial presentations. This is an opportunity for questions and comments on natural resource impacts, socioeconomic impacts, and general DNR agency processes and policies."

The public is encouraged to attend the meeting. For more information, contact Gen Bancroft at the DNR by calling 1-800-232-7367 toll free.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

May 21, 1985

File Ref: 1630 - Exxon

Ladies and Gentlemen:

Attached for your information is a status report of Department of Natural Resources activities on the proposed Exxon mine near Crandon. The purpose of this status report is to describe the Department's progress in reviewing Exxon's major permit applications and in writing the Draft Environmental Impact Statement. The report also includes a description of how we "verify" data collected by Exxon, details on the Master Hearing for the project, and some current calculations on the amount of the net proceeds tax revenues that the mine could generate.

On May 17, 1985, Exxon announced that due to the depressed minerals industry, they were investigating ways to improve the project's economics. The most significant anticipated changes are production from the zinc portion of the ore body first, reducing ore production rates, shortening the construction period and reducing the number of operation employees. As a result of these changes, some of the equipment and facilities could be downsized, while the mining duration could be increased by several years.

The impact of these project alterations on the project schedule, release date of the Draft Environmental Impact Statement, and net proceeds tax calculations which are discussed in the attached status report, is unknown. At the earliest possible time, when we have more specific information from Exxon, we will discuss these issues more fully. Meanwhile, we will make every attempt to incorporate this new information into the permit review and environmental impact statement processes as rapidly as possible.

If you have any questions contact Mr. Bob Ramharter, Exxon Project Coordinator, or me.

Sincerely,
Bureau of Environmental Analysis and Review

William E. Tans

William E. Tans
Environmental Specialist

WET:mm

Attachment

Status Report of
Department of Natural Resources Activities
on the Proposed Exxon Mine Near Crandon, Wisconsin
May, 1985

INTRODUCTION

State agency review of Exxon's proposal for a zinc/copper mine and mill complex is proceeding on schedule. Preparation of the Draft Environmental Impact Statement is moving along toward a public release date for Chapters 1 and 2 in early summer. While there are still some technical issues where additional work is required, progress is being made toward resolving them rapidly.

This status report provides additional information on project review and Draft Environmental Impact Statement writing and includes discussions of 1) how the Department of Natural Resources "verifies" data on the Exxon project, 2) the environmental impact statement review process including details on the Master Hearing for the project, 3) public involvement and notice of upcoming meetings, and 4) preliminary calculation of net proceeds taxes. (The net proceeds tax is a form of mine profits tax). In addition, technical areas where more work is required are also discussed.

This report is part of our continuing dialogue on the project with the general public, including municipal leaders, mining impact committees, tribal leaders and individuals. We encourage the public to discuss mining issues and their concerns about the project, and comments on this status report or any aspect of the Exxon proposal are welcome at any time. They can be sent to the DNR District Office in Rhinelander (Box 818, Rhinelander, 54501) or the Central Office in Madison (Bureau of Environmental Analysis and Review, Box 7921, Madison 53707).

PROGRESS IN REVIEWING EXXON'S PERMIT APPLICATIONS AND ENVIRONMENTAL IMPACT REPORT

Review of Exxon's permit applications and Environmental Impact Report (EIR) by Department of Natural Resources and other state agency staff is continuing. The majority of the review has been completed, and the current focus is on a few key technical issues remaining to be resolved. Over the last several months, Exxon has submitted numerous consultant reports, technical documents, published references and related data, in support of their permit applications to DNR. In addition, Exxon submitted the following major items:

1. October 1984 - Preliminary Engineering Report, Water Treatment Facility (revised).

2. October 1984 - Feasibility Report for the Mine Waste Disposal Facility (revised).

3. November 1984 - Final Draft Hydrologic Impact Assessment (Appendix 4.1A).

4. January 1985 - Preliminary Draft, Monitoring and Quality Assurance Plan.

5. February 1985 - Air Permit Application (revised).

6. February 1985 - EIR Chapter 1 (Description of the Proposed Action - revised).

7. February 1985 - EIR Chapter 3 (Alternatives to the Proposed Action - revised).

8. March 1985 - Reclamation Plan (revised).

Progress on our review of these reports is essentially complete. The DNR's Industrial Wastewater Section has completed its review of the Preliminary Engineering Report received in October and continues to review additional requested reports and data. Conceptually, the wastewater treatment plant design is acceptable to the Department. Our reviews of equipment design, capacities, and laboratory pilot testing data, indicate that the proposed water treatment systems now could meet the required effluent limits for the discharge to Swamp Creek. Exxon plans to add a metal polishing step to the treatment stream which should remove more residual heavy metals from the effluent water. Limits on the amount of pollutants which could be discharged have been developed by the U.S. Environmental Protection Agency and by DNR. The limits are designed to ensure the protection of fish and aquatic life, including the entire aquatic food chain, in Swamp Creek, the receiving stream.

In December 1984, DNR's Bureau of Solid Waste Management finished its "completeness" review of Exxon's revised Feasibility Report on the Mine Waste Disposal Facility. The revised Mine Waste Disposal Facility Feasibility Report included these important changes: modifications in the thickness and application of the bentonite-soil liner and reclamation cap, the supporting information on liner constructability, the addition of a synthetic membrane in the reclamation cap to reduce water inflow, and additional studies on water drainage from the reclaimed facility. Based on our review of the Feasibility Report and supporting documents, we determined that the Feasibility Report contained the minimum information required by law and was, therefore, complete. This determination did not mean our review was complete, but that Exxon had satisfied the minimum requirements in the administrative rule. Additional information could be required as part of the our continuing technical review and to develop a basis for the Department's decision at the end of the Master Hearing.

The revised Air Permit Application submitted to DNR in February, has been reviewed by the Bureau of Air Management. An analysis of the air quality impacts of constructing and operating the proposed mine and mill was prepared and used to make the preliminary determination that Exxon's project would not result in illegal air pollution. Our air analysis included modeling airborne particles to determine the amount of heavy metal deposition in the vicinity of the mine. Results of that analysis will be detailed in the Draft Environmental Impact Statement. The final approval on the air permit, as well as all the other permits, licenses, and approvals required from DNR, will be made following the Master Hearing on the project.

Discussions between DNR and Exxon on the hydrogeological investigations continued during the last six months. Much of the hydrogeological information is contained in the Final Draft Hydrologic Impact Assessment (Appendix 4.1.A). Our efforts focused on increasing the accuracy of groundwater computer modeling and developing a range of likely impact scenarios. The computer modeling of groundwater flows is done to:

1. quantify the amount of groundwater which could flow into the underground mine;

2. identify the extent and shape of the resulting groundwater cone-of-depression;

3. determine the potential impacts of the groundwater drawdown on lake levels, stream and spring flows, and wetlands;

4. define how the groundwater drawdown will affect current uses of groundwater, primarily water wells;

5. estimate the speed and direction of movement and the concentration of contaminants over time as they enter the groundwater beneath the Mine Waste Disposal Facility.

Following DNR's review of Exxon's Hydrologic Impact Assessment, Exxon agreed to provide additional information as an addendum to the mine inflow modeling report and as a revision to the Hydrologic Impact Assessment.

During this same period, the Department of Natural Resources has received final reports from its environmental consultants on several key aspects of the project. Among these are a review of alternative uses for pyrite tailings and water treatment wastes, an analysis of noise and vibrations which would result from the project, a soil chemistry study dealing with leachate generation from tailings and waste rock, and a socioeconomic impact analysis. Guidance to the Department also has come from consultants evaluating potential impacts to the groundwater system and wetlands hydrology, and conducting stream characterization studies. We have used this information to review the permit applications and will use them to write the Draft Environmental Impact Statement.

There are two key areas of the project proposal which DNR and Exxon are continuing to study. One is the impact of mine dewatering - and the resulting groundwater drawdown - on lakes in the vicinity of the mine. These lakes include Duck, Deep Hole, Skunk, Little Sand and Rolling Stone Lakes. Oak Lake apparently would not be impacted by mine dewatering because it is isolated ("perched") above the local groundwater system. The project's potential impacts to lakes, for example, are very important, because DNR, by state law, (s. 144.855(3)), cannot issue approval for mine dewatering if the withdrawal would cause an "unreasonable detriment of public rights in the waters of the state." Unreasonable detriment could include loss of fish species and thus fishing, disruption of navigation rights, substantial lake level changes, and other related impacts.

The second key issue, directly related to predicting surface water impacts, is mitigating or lessening these impacts. For example, once the range of likely impacts to lake levels or stream flows has been predicted, then a mitigation plan to minimize or prevent those negative impacts must be developed. In addition, the impacts of the mitigation proposals themselves must be analyzed. Possible means to mitigate reduced lake levels or stream flows include pumping water from adjacent shallow wells to augment flows or levels, reinjecting water into the groundwater to maintain local groundwater movement into the water bodies, adding high quality treated effluent to water bodies, or retaining spring runoff waters. These, and other possible mitigation alternatives. will be evaluated for their effectiveness, environmental impacts, cost, and engineering feasibility. This analysis of measures to mitigate surface water impacts will be included in the Draft Environmental Impact Statement.

DNR VERIFICATION ACTIVITIES

Verification is one of the Department's important functions in evaluating the adequacy of Exxon's data. The Department is required by law to ensure that the information included in an applicant's environmental impact report and supporting documents is thorough and provides adequate data for assessing the potential environmental impacts of the proposed action. The need for verification is particularly crucial for a project as large and complex as the proposed Exxon mine because of the types and magnitude of impacts expected, and the need to project long-term impacts.

We verify information that Exxon supplied in the EIR and permit applications in two ways. The first method relies upon the professional judgment of Department technical staff and our consultants to determine adequacy. We have verified most of the information in this fashion. The second method requires independent sampling and quality control checks to assure the validity of the data. Various techniques such as independent field surveys, split samples, inspections of laboratory and field procedures and the use of independent laboratories have been used. Fisheries, surface water and groundwater quality and quantity, and soil chemistry concerns have required us to conduct extensive verification work. In some of these areas, verification activities continue because Exxon is gathering additional data.

Although the amount of verification depends on the subject, our overall goal is to ensure the accuracy of the data by a representative sample. After the data from Exxon or its consultants have been independently verified, they are then considered to be acceptable for use in the Environmental Impact Statement and for review of permit applications.

PROGRESS ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

As the lead agency, DNR is preparing the Draft Environmental Impact Statement (DEIS) in cooperation with the Public Service Commission, the Department of Transportation, the Department of Industry, Labor and Human Relations, and the Department of Revenue. Substantial progress has been made in writing the DEIS, and Chapters 1 and 2 will be released about July 1. Chapter 1 of the DEIS describes the Proposed Project and Chapter 2 describes the Affected Environment. Chapters 3 and 4 of the DEIS will be released in October when the key impact and alternative analyses are completed. Chapter 3 includes the Environmental Consequences and Chapter 4, the Alternatives to the Proposed Action and their Impacts. Releasing the DEIS in two stages will allow a longer review time by the general public.

The official review period for the DEIS will be timed from the release of Chapters 3 and 4. Approximately 60 days after Chapters 3 and 4 of the DEIS are mailed, DNR will hold a public informational meeting in the local area on the contents of the DEIS. Based on the comments from the public meeting and all written comments received, DNR and the cooperating state agencies will revise the DEIS and subsequently prepare the final EIS. Within 120 to 180 days following release of the final EIS, the Master Hearing will be held.

THE MASTER HEARING

The mining permit process culminates with a hearing referred to as the Master Hearing. This hearing will be conducted by a hearing examiner from the Department of Administration, Division of Hearings and Appeals. The scope of the Master Hearing includes the consideration of the Final Environmental Impact Statement and the review of all applications for permits, licenses and approvals submitted by Exxon to DNR. During one portion of the Master Hearing, all persons who wish to provide testimony or written comments will be able to do so. The presentation of these views in this portion will not be under oath or subject to cross-examination. The second part of the Master Hearing will be conducted as a more formal legal proceeding, with all testimony delivered under oath and subject to cross-examination.

Any person or agency (e.g., township, city, tribe, or group) whose interests may be adversely affected by the proposed mine may petition to become a participant in the Master Hearing (refer to s. 227.01(6) Wis. Stats.) Based on the Master Hearing, the DNR will make its decisions on the permits and possible permit conditions and make a determination of whether it has complied with the Wisconsin Environmental Policy Act in preparing the Environmental Impact Statement. The decisions on permit applications licenses and required approvals will be made within 90 days from the completion of the Master Hearing public record. All decisions will be announced to the public by means of a Record of Decision, which will be sent to all parties and to the press.

If the necessary state, local, and federal permits and approvals are issued after the Master Hearing, the initial regulatory phase of the project will be complete. However, because the permits will contain conditions, Exxon would have to review the conditions in order to make a final corporate decision on whether or not to open the mine. In addition to permit conditions, there are other key policy and economic variables which would be instrumental in Exxon's final decision on whether to begin construction. These include the estimated rate of return on investment; the projected metals prices for the duration of the project (chiefly those of zinc and copper which would account for some 85% of mine revenues); projected construction and operation costs; and corporate policy matters. If these variables indicate too much uncertainty about mine profitability, Exxon could choose not to mine or to delay construction for a period of time. Or, Exxon could choose to sell its mining permit to another company. The likelihood of any of these various alternatives occurring is unknown, but Exxon's final decision to begin mining will depend on many factors other than environmental permits.

PUBLIC INPUT TO DNR'S REVIEW PROCESS

Throughout the Exxon project review, DNR's objective has been to involve the public as much as practical. By necessity, the information exchange between the Department and the general public must be a two way process. It is the Department's responsibility to explain the permit review and the Environmental Impact processes as they affect the proposed project. The permit review and environmental impact process are designed so that public involvement may be effective and timely.

To encourage public input we established a network of 14 public libraries across the state where Exxon's Environmental Impact Report and supporting consultant reports are available for public review. In addition, all significant correspondence and publications are routinely sent to the libraries and will continue to be sent as long as the project continues. The repository libraries are located in Antigo, Ashland, Crandon, Eau Claire, Green Bay, Hayward, Ladysmith, Madison, Milwaukee, Platteville, Rhinelander (including Nicolet College), Stevens Point, and Wausau. Exxon file information is also available for public use in both the Madison and Rhinelander Department offices. All material in the Department's files is public information and accessible to anyone during normal working hours.

On Saturday, June 1, DNR will hold a public meeting in the local study area. The primary objective will be to discuss anticipated socioeconomic impacts to municipalities in the local study area. Other projected impacts will also be discussed, and representatives from the Secretary's office will be present.

Socioeconomic impact analyses of the Exxon project have been completed by Denver Research Institute (DRI), the Department's socioeconomic consultant. The information from DRI on socioeconomic impact analysis will be released to the general public as "technical documents" after review by DNR. The socioeconomic impact analysis will contain a description of the existing or baseline conditions, projections of with- and without-project scenarios, analysis of expected impacts, ways to mitigate negative socioeconomic impacts, and sociocultural concerns, including a discussion of the impacts likely to be felt by the Native American communities near the mine site.

NET PROCEEDS TAX

One of the important considerations connected with the mine opening is revenue from the net proceeds tax - how much will there be and when will they be available? The net proceeds tax (s. 70.395, Wis. Stats.) is a form of mine tax levied on the profits from the proposed mine. Sixty percent of the net proceeds tax levied each year is distributed to the Mining Investment and Local Impact Fund (MILIF). The net proceeds tax allocations to the MILIF are intended to be a major source of revenue to the fund.

The Mining Investment and Local Impact Fund Board (MIB) is responsible for providing funds to local municipalities to mitigate the negative impacts of mining. Annual payments in lump sums are made to specific entities. For the Exxon mine, these entities are Forest County, (after mining becomes profitable), Nashville and Lincoln townships, and the Forest County Potawatomi and Sokaogan Chippewa tribes. If there are sufficient funds, the MIB also makes discretionary payments to the municipalities it judges to be adversely affected by mining.

The amount of net proceeds taxes depends on the revenues from the mine and the costs associated with developing and operating it. Revenues come from the sale of concentrated ores, and in Exxon's case, about 60% would come from zinc, and about 25% from copper. The remaining 15% of revenues would come from silver, gold and lead in that order. The market prices of these metals when the mine is in operation would be a major determinant of net proceeds tax yields.

Estimates of Net Proceeds Tax

Estimates of the net proceeds tax revenues have been made by the Department of Revenue (DOR). Several different scenarios were computer modeled, including variations in predicted metals prices, operations costs, construction costs and construction duration. Based on current assumptions of operations and construction costs, continuous mining and using the Chase Econometrics metals price forecasts, the net proceeds tax would yield about $117 million in 1984 dollars over 23 years of operation. Approximately $70 million in total would be deposited with the MILIF. The revenues would begin 9 years after the mine construction began. At that time, about $7.4 million would be paid to the MILIF. Thereafter, revenues would range from $5.5 million to $7.6 million annually.

Effects of Metal Prices on Net Proceeds Tax

If metals prices on the open market increase above the predicted values, the net proceeds tax revenues also would increase substantially. For example, if the metals prices were 20% more than the current estimate, the total revenues would increase from $117 million to $207 million, an 80% increase. However, if metals prices were 10% lower, the total net proceeds tax revenues would decrease from $117 million to $83 million, a 30% decrease. The expected rate of return on investment is also related to metals prices. If metals price were at 90% or less than predicted, the rate of return would be less than 15%; in that situation, Exxon might chose not to open the mine.

There are two important points regarding the net proceeds tax revenue estimates:

1. There is considerable uncertainty regarding estimates of net proceeds tax revenues because of the number of variables involved and because the predictions are based on events up to thirty years into the future.

2. These recent net proceeds tax revenue estimates are considerably less than earlier estimates chiefly because metals prices are lower now.

There is a further important point regarding the timing of the revenues from net proceeds tax: net proceeds tax revenues will be a major source of funds used by the Mining Impact Board to mitigate negative impacts from mining activities. The greatest need for these funds would be during construction and early operations stages of the proposed project. However, no net proceeds tax revenues would be anticipated from the Exxon mine until about the ninth year after construction starts, resulting in a substantial lag between fund need and fund availability.

For additional information on the Exxon project review, contact the Department of Natural Resources at 1-800-BEAR DNR.

BT:msg

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State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

BOX 7921
MADISON, WISCONSIN 53707

July 15, 1985

IN REPLY REFER TO: 1630
(Exxon)

Greetings:

Most of you probably are now familiar with Exxon's recently announced plans to downsize their Crandon Mine proposal. The company has informed us that the changes were prompted by continued weakness in metals prices, and the proposed modifications are intended to improve project economics. The purpose of this letter is to identify in somewhat greater detail our current understanding of Exxon's project modifications and to indicate how they may affect the permit applications and the Draft Environmental Impact Statement (DEIS).

The basic character of the proposed mine remains the same. The mine would still be an underground operation and the ore would be processed into concentrates on the site. However, a number of changes to specific aspects of the proposal are currently being planned or evaluated by Exxon. Our understanding of the more significant changes is as follows:

1. Initial production would be from the zinc-rich (massive) orebody. Whether the copper-rich (stringer) orebody would subsequently be mined is uncertain and depends chiefly on copper prices.

2. Ore production would be reduced about 30% to 7,000 tons per day, resulting in a reduction in operations employees from 700 to about 600. The massive ore mining phase would be approximately 15 years. The subsequent stringer ore phase would require about 13 years.

3. The construction schedule would be shortened from 42 months to about 30 months.

4. A variety of changes that take advantage of technological advances will be considered. These include different grinding methods, larger flotation units, and slurry-seeded reverse osmosis.

5. The water treatment plant, ore handling, and other facilities may be downsized due to a lower rate of ore processing. One reclaim pond may be eliminated, and the number and configuration of cells in the Mine Waste Disposal Facility may be altered.

6. The septic tank and drainage field for disposing of sanitary waste may be replaced with a package treatment plant and surface discharge.

7. Refuse generated from the mining operation may be disposed at a landfill built at the site rather than being transported elsewhere to an existing facility.

8. Waste rock may be ground at the surface in order to provide adequate quantities of backfill materials.

Because of these changes, the Department's July 1 scheduled release of the first part of the Draft Environmental Impact Statement was cancelled. It now appears that certain key analyses may have to be reevaluated to determine if there would be significant changes in impacts. Due to the emphasis on project downsizing, many of the changes will result in a reduced level of impact to the natural environment. Other impacts, in particular air emissions during construction, may increase. There is little anticipated change in the extent of the groundwater drawdown or in resulting surface water impacts.

The project changes proposed by Exxon will also require modifications to several applications for permits, approvals, and licenses submitted to the Department and other state agencies.

We are uncertain when the information on the project changes will be available from Exxon. They have indicated it may be 5 to 6 months before the information needed for the DEIS is provided. However, we intend to work closely with the company in developing the project modifications and plan to complete the DEIS at the earliest opportunity.

I will try to keep you informed of our progress as we receive more project information and are better able to develop a project schedule. Meanwhile, if you have any questions or comments, please feel free to call me toll-free at 1-800-232-7367.

Sincerely,
Bureau of Environmental Analysis & Review

Bob Ramharter

Bob Ramharter
Environmental Specialist

BR:WT:sm
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→ R. Ravihaster
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MAY 7 1986

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

BOX 7921
MADISON, WISCONSIN 53707

April 29, 1986

IN REPLY REFER TO: 4400

Mr. Barry J. Hansen, Permitting Manager
Exxon Minerals Company
P.O. Box 813
Rhinelander, WI 54501

RE: Groundwater Standards, Compliance Boundaries, and Contingency Plans; Exxon Minerals Company Crandon Project; Forest County

Dear Mr. Hansen:

The purpose of this letter is to transmit the Department's proposed compliance boundaries and groundwater standards to be applied to several facilities in the Exxon Minerals Company Crandon Project. At this time, we believe it is also appropriate to convey the Department's proposed intervention boundaries and to request additional detail on facility contingency plans.

Pursuant to s. NR 182.075(1), the Department is required to propose compliance boundaries and associated groundwater standards for facilities regulated under NR 182 no later than 180 days prior to the hearing required under s. 144.836, Stats. Additionally, NR 132.17(9) requires that "any mine site permitted pursuant to this chapter shall be designed, constructed, maintained, operated and reclaimed in such a manner so as to protect groundwater quality and quantity in accordance with the standards of NR 182." By definition, a mine site includes all facilities associated with the mining operation. Mining projects have been exempted from regulation under NR 140. Thus, all facilities associated with this project must address the groundwater protection requirements of NR 182.075. For this project, this includes the mine, the mill, the Mine Refuse Disposal Facility (MRDF), and the Reclaim Ponds, as well as the Mine Waste Disposal Facility (MWDF).

This letter will address groundwater standards requirements for all of these facilities. For specific details applicable to each facility, you should contact the appropriate Department unit directly. For the MWDF and the MRDF, this is the Residuals Management and Land Disposal Section. For the mine and mill, this is the Mine Reclamation Section. For the Reclaim Ponds, this is the Industrial Wastewater Section.

A few definitions should be cleared up before addressing the specifics of NR 182.075.

Specific references in NR 182.075 are to a mining waste site. When discussing the application of NR 182.075 to another facility (i.e., the MRDF, for example), any reference to or requirement of a mining waste site, waste site, site, etc. should be taken to apply to the specific facility being analyzed.

The fill area or limits of waste filling will be the crest of the interior lined sideslopes of the MWDF, MRDF, and Reclaim Ponds.

The outer perimeter will be the exterior toe of confining dikes around the MWDF, the MRDF and the Reclaim Ponds, not including perimeter roads or fences. Since much of the perimeter of the Reclaim Ponds is defined in these locations by cuts into natural ground surfaces, the outer perimeter will also be defined by the crest of the cut sideslope. The outer perimeter of the mine will be taken to be the vertical projection to ground surface of the widest extent of all mine workings, including openings which extend beyond the orebody proper. The mine and associated workings will be treated as a single unit, as it is not practical to separately address the individual components such as shafts, galleries, sumps, and backfilled stopes. The mill will also be treated as a single unit for the same reason. The mill outer perimeter will be taken to coincide with the limits of construction, excluding any extensions along the access road, railroad, haul road, explosives storage bunker, or ventilation raise corridors.

Groundwater Quality Standards

A single list of groundwater quality standards will be applied to all project facilities. Code sections relevant to groundwater standards and parameters are:

1. NR 182.075(1)(a)1. requires, at no less than 180 days prior to the master hearing, that the Department identify groundwater quality standards for substances reasonably expected to have an adverse impact on groundwater quality due to the facility operations.

2. NR 182.075(1)(a)2.a. establishes use of primary and secondary maximum contaminant levels (MCL's) and establishes procedures for setting standards more stringent than MCL's.

3. NR 182.075(1)(a)2.b. establishes use of the existing groundwater baseline concentrations where it exceeds published MCL's.

4. NR 182.075(1)(a)2.c. provides for standards for substances which are toxic to humans, but which have not been promulgated as MCL's.

5. NR 182.075(1)(a)2.d. provides for standards for other substances as needed for groundwater standards.

6. NR 182.075(1)(a)3. establishes use of an operational monitoring program for developing standards in the future if the monitoring program identifies other substances to be of concern.

The waste characterization data and mill process descriptions contained in various project documents provide sufficient basis for proposing groundwater quality standards and indicate what substances are likely to have groundwater effects. Future research may show that items used in comparatively minor volumes and which may end up in the MWDF, MRDF, mine, etc. may have groundwater effects of concern. Consequently, even though no monitoring may be presently required for some parameters for which standards are identified, you should be aware that the Department reserves the right to require environmental monitoring as it believes necessary during the baseline phase or during the construction, operation and closure phases of the project. Furthermore, the Department reserves the right to evaluate the specific groundwater quality standards that may be applied to new facilities or revised designs of existing facilities on this project.

Groundwater standards for pesticides listed as MCL's and for radioactive parameters will be established, to be consistent with NR 140.10. The Department recognizes that these particular substances will not likely be of concern on this project and may not require monitoring for them beyond the baseline monitoring required in NR 182.075(1)(d)5. Other parameters not listed as MCL's but which do have toxicity effects are included due to their possible future presence as a consequence of spills, processing leaks, or reagent or chemical decomposition effects.

Existing information indicates that there is no need to alter any potential groundwater standards due to high background levels (NR 182.075(1)(a)2.b). Nor will any non-MCL non-toxic substances be listed as part of proposed groundwater standards at this time (NR 182.075(1)(a)2.d).

We wish to emphasize that definition of a list of substances as groundwater standards for this project does not limit the Department's intention to use physical measurements, such as water levels, gradients and volumes, and analyses for indicator or other trace substances to evaluate project facility performance. A groundwater standards list does not define an effective environmental monitoring program, and site evaluation will include use of lysimeters, headwells, sumps, and leak detection systems as well as direct sampling of groundwater by monitoring wells.

The Department review of the project monitoring program will be addressed in a separate response to the proposed monitoring plan required under NR 132.06(3)(d) and NR 132.11. Additional detail will be contained in the feasibility study and plan of operation approval letters for the MWDF and the MRDF and in the final engineering plan approval letter for the Reclaim Ponds. You should be aware that Exxon Minerals Company will have to formally request an exemption if it does not want to be required to perform analyses for organic chemicals in the baseline monitoring program required in NR 182.075(1)(d)5.

Proposed groundwater standards for this project are identical to the standards applied statewide to all facilities regulated under NR 140. Substances are listed in groups for convenience, due to historical associations or chemical behavior patterns.

Inorganic Primary MCL's	Standard (mg/l)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Fluoride	2.2
Lead	0.05
Mercury	0.002
Nitrate + Nitrite as N	10.0
Selenium	0.01
Silver	0.05

Secondary MCL's	Standard (mg/l unless noted otherwise)
Chloride	250
Color	15 color units
Copper	1.0
Foaming Agents (MBAS)	0.5
Iron	0.30
Manganese	0.05
Odor	3 (threshold odor #)
Sulfate	250
Total Dissolved Solids (TDS)	500
Zinc	5

Organic Chemical Primary MCL's	Standard (ug/l)
Endrin	0.20
Lindane	0.02
Methoxychlor	100
Toxaphene	0.0007
2,4-Dichlorphenoxyacetic Acid	100
2,4,5-Trichlorophenoxyproprionic Acid	10

Radioactivity MCL's	Standard (pCi/l)
$Radium^{226}$ + $Radium^{228}$	5
Gross Alpha Particle Activity	15

Other Toxic Substances	Standard (ug/l)
Aldicarb	10.0
Benzene	0.67
Carbofuran	50.0
Carbon Tetrachloride	5.0
Cyanide	460
1,2-Dibromoethane	0.01
1,2-Dibromo-3-chloropropane (DBCP)	0.05
p-Dichlorobenzene	750
1,2-Dichloroethane	0.50
1,1-Dichloroethylene	0.24
Dinoseb	13
Methylene Chloride	150
Simazine	2150
Tetrachloroethylene	1.0
Toluene	343
1,1,1-Trichloroethane	200
1,1,2-Trichloroethane	0.6
Trichloroethylene	1.8
Vinyl Chloride	0.015
Xylene	620

Compliance Boundaries

Separate compliance boundaries will be established for each facility required to comply with NR 182.075, i.e., the MWDF, the MRDF, the Reclaim Ponds, the mine and the mill. Limits of waste filling and outer perimeters were defined previously. Due to the various facility locations, compliance boundaries will overlap in several instances. Site design and monitoring of each facility will be required to include measures to define the correct source, if groundwater sampling indicates potential violations of groundwater standards.

Code sections relevant to compliance boundary definition are:

1. NR 182.075(1)(a)1. requires that the Department propose a single compliance boundary for each facility no less than 180 days prior to the master hearing associated with the project.

2. NR 182.075(1)(b) defines a maximum compliance boundary distance and criteria which can be used to modify it.

MWDF: The compliance boundary for the MWDF is proposed to be 1200 feet from the outer perimeter of the site. Separate compliance boundaries will not be established for each individual cell, as these are integral subunits of the facility.

The constructed perimeter of the site (i.e., toe of the exterior dike slopes) may vary from the locations in the plans due to the use of shallower side slopes, disposal of excess soil, modifications for slope stabilization and erosion control, or placement and removal of soil stockpiles, and may be masked by revegetation. The outer perimeter is also not defined in the slope area between the MWDF and the Reclaim Ponds. You should be aware the Exxon will be required to define a configuration for the outer perimeter of the site based on design slopes in the MWDF plan of operation. This configuration will be the standard reference line for defining the compliance boundary regardless of the actual constructed location of the toe of the exterior slopes.

The status of property ownership around the MWDF must be clarified no later than the submittal of the MWDF plan of operation. If non-Exxon property within 1200 feet of the site is not owned or leased by Exxon through the long-term care period, the compliance boundary will be defined by the property line. You should also note that the maximum extent of the compliance boundary west of the site will be limited by the ordinary high water mark of Duck Lake.

MRDF: The compliance boundary for the MRDF is proposed to be 150 feet from the limits of waste filling. This compliance boundary reduction is proposed for the following reasons:

1. The site is located in an area of sandy soils with a moderately deep (greater than 50 feet) unsaturated zone. It will likely take a number of years for contaminants to reach the groundwater table, even in a situation of total site failure. Detection of groundwater effects thus may be delayed until well into the completion of site filling.

2. Leachate characteristics of the landfilled waste will have some differences from MWDF leachate. However, there will be sufficient similarities in the major parameters such that the effects of MWDF and MRDF leachate will not be separable at significant distances from the site (i.e., 1200 feet).

3. Seepage of leachate from the MRDF, in the case of site failure, is likely to be small in relation to flow in the groundwater system. Thus, even total site failure may not result in an enforceable condition at the & larger boundary setback.

4. The direction of flow of groundwater below the MRDF is an extension of flow patterns below the MWDF. Thus, at rather short distances, groundwater affected by the MRDF could easily be masked by MWDF seepage, or, alternatively, may imply MWDF failure where none occurs.

This reduced compliance boundary is necessary to assure that the Department has the ability to respond to groundwater contamination in a timely manner. The specific distance is proposed to be 150 feet from the limits of waste filling and was selected in part to be consistent with landfill design management zone dimensions contained in NR 140.22(5)(a).

Reclaim Ponds: The compliance boundary for the Reclaim Ponds is proposed to be 100 feet from the limits of waste filling for the reasons addressed in the section above for the MRDF. It should be further noted that MWDF leachate quality is expected to be nearly identical to quality of water held in Reclaim Pond Cell B. Thus, evaluation of leakage and preservation of Department regulatory authority close to the site is necessary to assure effective and timely remedial action, should any be necessary. The dimension of 100 feet from the limits of wastefilling was selected in part to be consistent with the design management zone dimensions in NR 140.22(5)(a).

Mine: The compliance boundary for the mine is proposed to be 1200 feet from the outer perimeter of the mine.

Mill: The compliance boundary for the mill is proposed to 100 feet from the mill outer perimeter. The compliance boundary reduction is proposed for the following reasons:

1. The mill is located in an area of sandy soils with a moderately deep (greater than 50 feet) unsaturated zone. This zone will increase in depth during mine dewatering. Detection of groundwater effects or increased concentrations in the unsaturated zone may be difficult, even in cases of uncontrolled facility leakage.

2. The mill will have a number of potential sources of contaminants, including the ore and concentrate storage and thickening areas, vehicle servicing and fueling points, runoff and water storage lagoons, water treatment facilities, and various types of mill equipment. Transport of concentrates, waste rock, fuels, and other materials may result in some spillage on roads and grounds between specifically identified potential contaminant sources. Careless maintenance may allow seepage of contaminants to occur where none would be ordinarily expected.

3. Groundwater flow during mill operation should be toward the mine. However, after site closure, eventual groundwater flow patterns will approach pre-mining conditions. Contaminants contained in the unsaturated zone may enter the groundwater table and migrate away from the site vicinity.

The reduced compliance boundary distance is necessary to ensure Department regulatory control within a reasonable timeframe. Due to the presence of multiple water, sludge, concentrate and backfill facilities on the site, the specific distance of 100 feet was selected in part to be consistent with the lagoon design management zone dimensions in NR 140.22(5)(a).

Intervention Boundaries

Separate intervention boundaries will be established for each facility required to comply with NR 182.075, i.e., the MWDF, the MRDF, the Reclaim Ponds, the mine, and the mill. The code section relevant to intervention boundary definition is NR 182.075(1)(c)3., which requires that the Department establish such a boundary between the outer perimeter of a facility and its compliance boundary.

It should be noted that several code sections refer to intervention but tie it to environmental monitoring data and predictions of future effects at the compliance boundary. No specific function is assigned in the code to the intervention boundary itself.

At this time, the Department is proposing to establish the intervention boundary at the outer perimeter of each facility. The Department further proposes to require formal evaluation of facility performance, including use of data from all lysimeters, leak detection devices, wells and well nests, and construction and operational records at such time as an exceedance (measured or interpolated) of a groundwater quality standard occurs at the intervention boundary. Should this evaluation result in a prediction of a future violation of the groundwater standards at the compliance boundary, a remedial action plan will be required to be developed and implemented.

Contingency Plans

A contingency plan has to be defined by the applicant for each facility required to comply with NR 182.075. Code sections relevant to contingency plans include:

1. NR 182.075(1)(c)1. requires that an applicant submit a contingency plan at the master hearing which specifies remedial actions and intervention in response to groundwater data.

2. NR 182.075(1)(c)2. and NR 182.075(1)(d)3. requires intervention in the event of environmental monitoring evidence which indicates present or future violations of groundwater standards at the compliance boundary.

3. NR 182.08(2)(i) requires development of a contingency plan to "prevent or minimize human health or environmental damage in the event of an accidental or emergency discharge or other condition not anticipated in the feasibility report which does not comply with the license conditions or other applicable standards".

4. NR 182.09(2)(d) requires that a more detailed contingency plan be included in the plan of operation that is based on the feasibility report information and includes reference to use of spill plans, emergency responses, and reporting requirements.

5. NR 182.13(2)(g) requires notification of the Department, analyses of data and situations, and implementation of the contingency plan as necessary, if analysis of groundwater samples indicates change in quality significantly different from either baseline or background.

6. NR 182.14(2)(a) and (b) require that a facility owner comply with certain notification requirements upon responding to any action addressed by a contingency plan.

All project facilities shall address items 1 through 4 above. The MRDF and the MWDF can address 3 and 4 separately, as both are required to submit both a feasibility study and a plan of operation. Other facilities shall address item 4 directly in accordance with NR 182.075(1)(d)3., since they lack the feasibility study requirement. Items 5 and 6 pertain only to the MWDF, although they could easily be applied to all facilities due to the general nature of their contents.

Exxon is required to develop contingency plans for the MWDF, the MRDF, the Reclaim Ponds, the mine and the mill. To date, such a plan has only been developed for the MWDF, although several aspects applicable to several other facilities have been addressed for other purposes in the mine plan risk assessment. The contingency plan for the MWDF should be revised and contingency plans for the other facilities developed in accordance with the following guidelines. The contingency plans should address short-term and long-term events.

Short-term events can be categorized as spills, accidents, pipeline or dike breaks, fuel spills, rain or dust storms, and other rapid occurrences. These are typically fast-acting and are often rapidly repairable or responded to, and should have limited effect on the environment if corrected quickly. Such activities are notable more for their impact on human beings and cultural effects rather than on the natural environment. The potential for groundwater contamination can be reduced if responded to quickly. It is typical in industrial projects to provide appropriate immediate response training and equipment and to develop detailed plans in advance for rapid application to short-term events.

Long-term events can be categorized as requiring extensive data gathering and investigations prior to developing a specific and (often) highly engineered plan for correction. This category includes groundwater contamination and geotechnical problems, which are typically slower acting (often over many years) and continuous and require unique data sources, locations, and instrumentation in order to develop a solution. Corrective measures may require long time periods, complex construction efforts, and much greater expense than is typically expended on short-term environmental responses.

Contingency plan sections for short-term events should emphasize identification of actions which may be termed spills, emergencies or accidental or emergency discharges. Spill substance identification and characterization, clean-up methods, waste disposal, response-type equipment and composition, time requirements, and reporting requirements should be addressed in sufficient detail for the Department to evaluate their likely effectiveness. While final details may have to be deferred to finalization of the facility construction and operation plans, sufficient detail must be included in order to demonstrate response effectiveness.

The contingency plan for long-term events for each facility (pertinent primarily to groundwater contamination concerns with each facility) should mirror the evaluation and response procedures contained in NR 140.24 and 140.26. Emphasis should be placed on periodic data collection and evaluation, periodic revision and rerunning of the groundwater model with updated data, periodic assessment of facility operation and effectiveness, and use of lysimeter and other seepage evaluation tools in addition to groundwater monitoring wells to assess future groundwater effects at the compliance boundary or to compare facility performance to expected performance.

The contingency plan must have flexibility to incorporate and use monitoring and assessment technology as it becomes available. In addition, potential remedial action measures should include reference not only to existing technology available in the technical literature, but include the potential to utilize new technology as it becomes available and is demonstrated in solid and hazardous waste clean-up efforts.

It should be noted that neither the MWDF Feasibility Study Chapter 9.3.6 or the Mine Plan Chapter 5 are detailed enough to serve as contingency plans for this project. A particular weakness is the lack of formally designated transfer of data, evaluations, and recommendations for future action to the Department and recognition of the range of responses and requirements which the Department may find appropriate (see Table 5 of NR 140.24(4)). Department staff are also concerned that the example for remedial actions cited in the MWDF Feasibility Study Chapter 9.3.6 may be technically inappropriate or misleading in their general applicability. Historically, remedial actions at solid waste disposal sites have been based on site-specific data which have often led to unique solutions. The purpose of the contingency plan for long-term effects should be to collect pertinent data to identify a problem and to use the best solution for the problem once it is identified.

In order for the Department to adequately review contingency plan elements for regulatory decisions and hearing presentations, the contingency plan for eacn facility should be prepared and submitted to the Department no later than June 30, 1986. These contingency plans must identify and address both short-term and long-term events with the level of detail and appropriate procedures for each category. More specific details and content should be developed with Department technical input. I suggest that you contact Department regulatory program staff directly in the near future to set up conference calls or meetings on facilities required to comply with NR 182.075 contingency plan requirements.

One additional issue is the groundwater quantity requirements of NR 182.075(2), which are applicable to all of the facilities required to comply with NR 182.075. With the information currently available, it is likely that impacts on groundwater quantity will only occur due to mine dewatering and due to groundwater withdrawals associated with water supply and surface water mitigation efforts. Those effects are currently being evaluated by the Department as part of the review of project high capacity well approval applications. It is the Department's opinion that submittal of information to satisfy the high capacity well approval requirements will also satisfy the requirements of NR 182.075(2).

In summary, this letter is intended to fulfill the Department's requirement to propose groundwater standards and compliance boundaries and is an appropriate mechanism to address intervention boundaries and contingency plan elements. If you wish to propose alternative groundwater standards or compliance boundaries, these must be submitted to the Department no later than 90 days before the master hearing, as required in NR 182.075(1)(a)1.

If you have any questions concerning issues raised in this letter, feel free to contact myself or the appropriate assigned technical staff in the individual regulatory programs.

Sincerely,

Lyman F. Wible, P.E.
Administrator
Division of Environmental Standards

RPG:pl/6330Q

cc: Gordon Reinke - SW/3
Rick Schuff - SW/3
Paul Didier - SW/3
Mike Witt/Ken Wiesner - WW/2
Robert Krill/Roger Gerhardt - WS/2
Linda Bochert - ADM/5
Robert Ramharter - EA/6
Kevin Kessler - WR/2
Chuck Hammer - LC/5
Joseph Reed - Menominee Tribal Planning Office
Donald Zuidmulder - Cohen, Zuidmulder, Gazely & Appel, Ltd.
Terry McKnight - NCD
Gary Kulibert - NCD
Ken Markart - Antigo
Wally Arts - DOJ
David Beckwith - Foley & Lardner
Kevin Lyons - Cooke & Franke
Gene Linehan - Linehan Law Offices
Archie Wilson - NCD
Earl Charlton - Charlton & Esser