Appendix R
Noise Monitoring Event Results and Analysis

APPENDIX R
NOISE MONITORING EVENT RESULTS AND ANALYSIS

Purpose

The purpose of the monitoring program performed over a two-day period beginning on September 23, 1998 was to help formulate an acceptable scenario for subsequent NEPA evaluation of proposed future dredging in the Allegheny and Ohio Rivers. A reasonable scenario could only be formulated from an understanding of the physical settings of current dredging activities, measurements of the typical noise levels generated by dredging, and an awareness of operational practices of the dredgers. The dredge noise monitoring effort discussed herein produced the data necessary for the subsequent NEPA evaluation performed in the spring of 1999.

Conforming to the study objectives, the limited monitoring program was not intended to provide in-depth evaluation of worker safety issues, or to provide precise information on where current dredging activities produce excessive noise levels for shoreline residents. A much larger and thorough noise monitoring effort would be required to meet these objectives.

Noise Monitoring Methods

Table 1 describes the dredges and dredge positions encountered during the two noise monitoring periods; the first monitoring event (ME-1) and the second monitoring event (ME-2). For both events, weather and monitoring conditions were good, and sufficient data were obtained to characterize the noise sources. For both dredges, on-board processing of dredge material was performed and noise abatement procedures (e.g., sound proofing) were employed. Both barges had a "quiet" and "noisy" side which differed by as much as 10 dB in noise generation. The loudest noise sources were (in order of magnitude) the main generator, processing equipment, and product discharge areas.

Table 1
Monitoring Event Locations and Dredge Descriptions

Monitoring Event 1	Dredge	Dredge 16 - the William L. Price (Bucket dredge with on-board processing of product)
(ME-1)	Ownership	Tri-State River Products
	Location	Ohio River - New Cumberland Pool at Ohio River Mile 32.4
	Operation Schedule	Daily operations
Monitoring Event 2	Dredge	Allegheny II (Clamshell dredge with on-board processing of product)
(ME-2)	Ownership	Pioneer Mid-Atlantic, Inc.
	Location	Allegheny River - Pool 5 at river mile 31.9
	Operation Schedule	Operating three shifts at the time of monitoring

For both of the monitoring events, the intent was to measure the sustained noise levels on-board and onshore and to collect sufficient data to help develop a noise propagation model. The monitoring performed was tailored to these goals, i.e., Monitoring was sustained at a location for sufficient time to characterize its sustained noise level. The duration of noise monitoring at any one location varied between 5 minutes and 6 hours, with the majority of locations monitored for more than 4 hours. During the day's monitoring, monitors were moved to increase the total number of locations checked in the vicinity of the dredge and/or to better characterize the dredge noise sources. The shifting of monitoring locations was justified by the relatively stable noise values observed on and around the dredge. In summary, both of the monitoring events were successful, monitoring equipment performed as expected, and the meteorologic conditions encountered were favorable (clear skies with relatively light winds).

Dredge noise monitoring was performed using five different Metrosoft dB-3080 units operated simultaneously in different locations. These meters electronically sample noise intensity, automatically perform sample period averaging, and store internally sample period averages for later downloading to a PC. All monitoring was performed with A-weighting of noise levels, with a very short noise averaging period; period average and maximum values were stored electronically every 5 seconds. Each monitor recorded 720 data points per hour, so accumulatively the five monitors produced approximately 150,000 data points per monitoring day. [Note, weighting toward higher pitch frequencies (A-weighted) is standard where noise annoyance is a problem; high pitch frequencies have a greater ability to be annoying. Weighting toward lower pitch frequencies (C-weighted) is standard where vibrations in structures are the key issue; lower frequencies travel further and induce building vibrations better than high pitch frequencies.]

The calibration of each noise monitor was checked independently against two different calibration apparatus (set for 100 dB) prior to the actual monitoring. In addition, post- monitoring calibration checks were performed between the first and second monitoring events. All of the noise monitors reported consistent values between 100.8 and 102.5 dB when exposed to the 100 dB calibrator, indicating a over-reporting bias between 0.8 to 2.5 dB. No effort was made to correct for this bias to read high; using the biased-high values provided a safety factor in later comparisons with published noise limits. As will be shown later, the measured noise intensity ranged over 45 dB (95 to 50) depending on the monitoring location on the dredge and shoreline. As a result, the relatively small error introduced by the bias was not sufficient to change the conclusions reached herein.

NEPA Interpretation of Noise Monitoring Field Data Results

For impact assessments, noise magnitude and frequency are typically combined on a daily basis by time-weighted intensity with respect to duration. This time-weighting produces a single Day-Night Level or a frequency-weighted 24-hr average intensity (all night-time noise levels are penalized by adding 10 dB to the monitored level). For comparison purposes, small town ambient noise levels (DNL or Day-Night Levels) typically fall in the 55 dB category whereas the ambient noise level in active urban centers tends to have DNL at 65 dB. Unfortunately, determining a DNL value is always a case-by-case evaluation requiring multiple monitoring events and redundant measurements of noise source and receptor population. This is well beyond the limited scope of monitoring/modeling performed for dredgers. However, if the noise intensity is relatively constant, as was found at the dredger locations monitored, it is reasonable use the "sustained noise intensity" as if it were a DNL average, as discussed below.

An extensive multi-agency evaluation of noise issues, the "Federal Agency Review of Selected Airport Noise Analysis Issues", provides a good source of the current practice with DNL values. The Federal Agency Review recognizes that source identification and noise management is difficult below the 65 dB (DNL) noise level, and typically federal agencies do not take corrective action where values are below this level. For example, the U.S. Army uses 65 dB DNL as a cut-off level for separating sensitive land use areas from Army operations with elevated noise levels (AR-200-1).

Given these guidance sources and their use of DNL averages, a simple criteria was utilized in this NEPA evaluation of the limited data on dredger noise generation. An "impact" was identified where ever the sustained noise level generated by daytime dredging was above 65 dB in sensitive areas (e.g., residential areas). In addition, where/when dredge noise levels result in a sustained value greater than 55 dB in a residential area during nighttime hours, it was stated that dredging produced an "impact" (i.e., a 10 dB penalty is added to measured ambient noise levels between 10 p.m. and 7 a.m.).

Noise Monitoring Field Data Results

The bucket dredge monitored in ME-1 was found to have a noisy (port side) and quiet side (starboard side). The primary difference in noise levels monitored on the main deck originated from product discharges – gravel discharged on the port side produced greater noise than sand-discharge on the starboard side. In addition, "loud" apparatus was found to predominately be on the port side, including the main generator located on the third deck. On the day of monitoring, some of the noise shielding had been removed to perform repairs of the main generator, a source capable of producing 100 dB levels. The significance of this will be discussed later. Table 2 indicates the number and placement of noise monitoring meters relative to the dredge. Table 3 indicates the average noise levels detected for each of the ME-1 locations.

Table 2
ME-1 Monitoring Location Descriptions

Event-Specific Gauge Location	Site Description (Note: gauges were moved during the sampling event to collect additional data)
#1	Located 18" above port deck (noisy or gravel-discharge side of dredge)
#2	Located 24" above starboard deck (quiet or sand-discharge side of dredge)
#3	Located about 5' above water surface the port shoreline near start of tree line. Placed approx. 840 feet from port side of dredge.
#4	Located 3' above waterline on starboard shoreline near start of treeline. Placed at toe of steep (1:1) bank. Placed approx. 320 feet from starboard side of dredge.
#5	Located 100' above river surface on starboard shoreline on abandoned railroad line. Placed approximately 420 feet from starboard side of dredge.
#6 (Moved from location #3)	Located 50' above river surface on shoreline on active railroad line. Placed approximately 900 feet from port side of dredge.

Table 3
ME-1 Average Noise Levels

Monitor Location	Average Noise Level for Monitoring Period	Off-set Distance from Dredge
Port Side of Dredge		
1	92	NA
3	66	840
6	62	960
Starboard Side of Dredge		
2	83	NA
4	71	320
5	68	420

The clam shell dredge monitored in ME-2 was found to have multiple elevated noise areas including the bow processing area, the main deck processing/product discharge areas, and the main generator. Noise levels were high in the bow processing zone when the twin clam shells discharged onto grates and when automated jack hammers rough-sized large boulders. Regular dumping and boulder breaking produced a relatively sustained high (93 dB) noise level. In addition, main deck processing noise was vented through large openings in sound-proofed walls in both sides of the dredge. Finally, the main deck housed the main generator (on port side) and high noise levels were encountered at the generator exhaust point. Sound proofing and noise management were evident around most high generation areas, with the exception of the bow processing area.

Table 4 indicates the number and placement of noise monitoring meters for ME-2 relative to the dredge. A decision was made to monitor only one shoreline, avoiding the steep bank located to the starboard of the dredge. In monitoring, the focus was to determine the propagation of noise as a function of distance in the absence of other noise sources. The general area surrounding the dredge was undeveloped and the flat shoreline to the starboard was easily accessed for monitoring. Table 5 indicates the average noise levels detected for each of the ME-2 locations.

Peak sustained noise levels monitored at the two dredge operations ranged between 94 and 82 dB, depending on the dredge type, monitoring position on the dredge, and the sound proofing employed. Corresponding noise levels on-shore in the vicinity of dredging ranged from 70 to 50 dB, as compared with an expected background value between 45 (undeveloped wooded areas) and 65 (active urban areas). The shoreline noise monitoring locations were sited between 320 and 1000 feet from the dredge operations.

Table 4
ME-2 Monitoring Location Descriptions

Event-Specific Gauge Location	Site Description (Note: gauges were moved during the sampling event to collect additional data)
#1	Located on the dredge starboard side at approximate halfway point near discharge chute for aggregate
#2	Located on the dredge port side at noisiest location approximately 40 feet back from the bow
#3	Located on port side shoreline just short of treeline.
#4	Located on port side approximately 250 feet back from shoreline in wooded area
#5	Located on port side approximately 600 feet from shoreline on railroad embankment

The only significant variation in noise generation resulted when there was "down time", a relatively small portion of the total time. Regular operations for the dredges meant that dredging and material processing activities were on-going. Down time only resulted when the dredge was moved, crew changes were made, or barge management was required. Except for these brief periods, the monitoring record indicates that there is a relatively stable level of noise produced by regular operations. Figure 1 illustrates this observation for the second monitoring event. The results also show that the noise levels away from the dredge are strongly correlated with the noise levels monitored on the dredge. The monitoring data indicate a standard deviation of 2-3 dB around the average noise value, and spikes in noise levels were relatively infrequent. The low variation around the mean suggests that the average or "sustained" noise value is sufficient for the NEPA evaluations performed herein (i.e., comparing sustained noise levels with noise level criteria is acceptable).

Table 5
ME-2 Average Noise Levels

Monitor Location	Average Noise Level for Monitoring Period	Off-set Distance from Dredge
Starboard Side of Dredge		
1	87	NA
Port Side of Dredge		
2	94	NA
3	66	400
4	58	650
5	52	1000

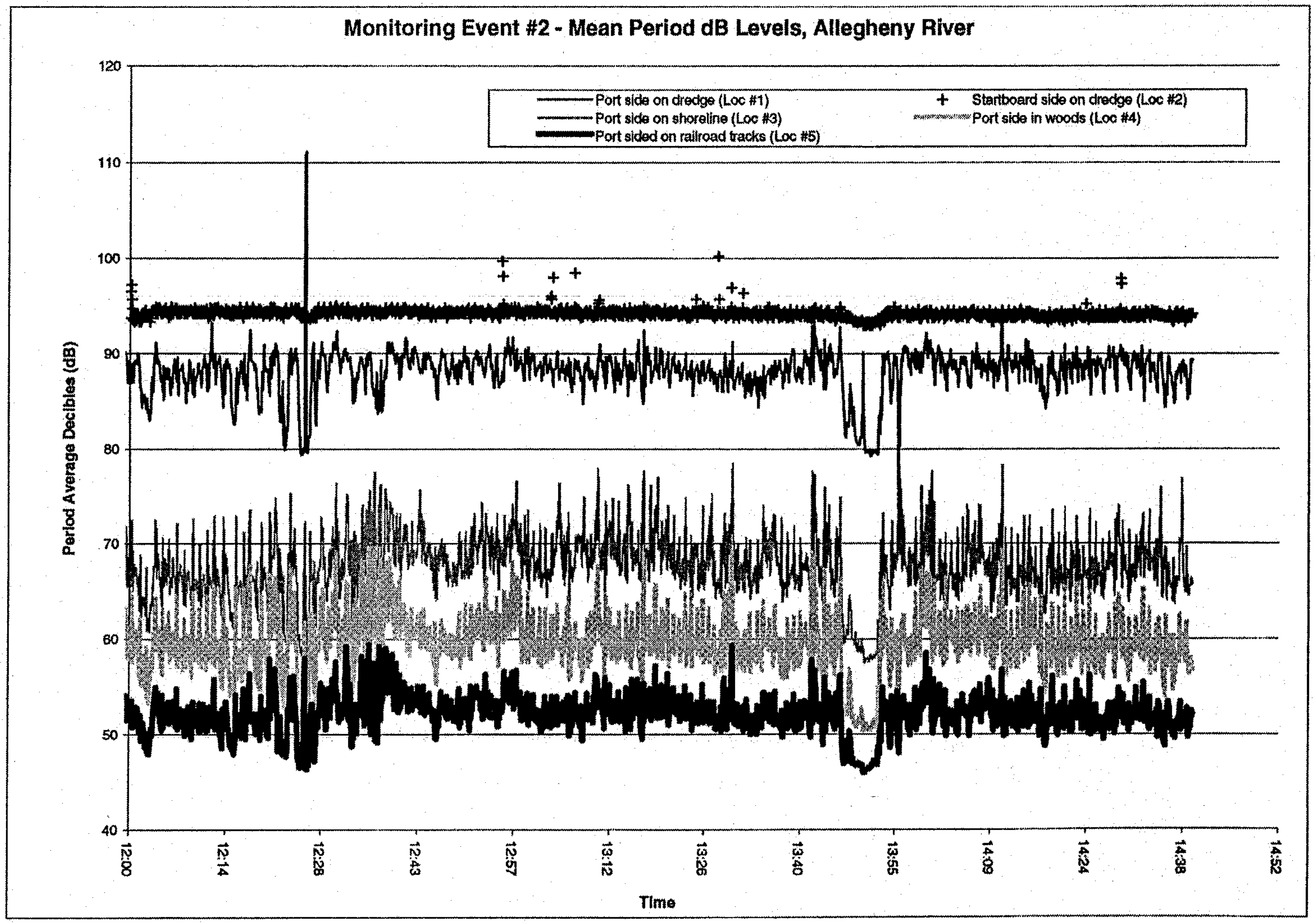

Figure 1. ME-2 Monitored Sustained Noise Levels.

Noise Model Development

The purpose of the noise model is to help develop an understanding of noise distribution about the typical dredger operating on the typical work-day. The model helps the interpretation of monitoring data and provides a means for estimating noise levels at locations not monitored. In addition, the model supports the overall assessment of potential noise impacts; a key part of the NEPA evaluation of the permit to continue dredging. Herein, "noise" is the sustained noise level experienced by an individual standing on the shoreline next to the dredger. No effort is made to account for the noise protection provided by buildings or the addition of other "loud" noise sources.

This modeling effort is not sufficient for identifying precisely when and where noise levels are unacceptably high. More in-depth modeling/study is necessary on a case-by-case basis where ever noise problems are suspected to determine 1) if they relate to dredge activities, 2) what are the contributions of other noise sources, and 3) what are appropriate noise management options.

As shown in Figure 1, noise levels in the vicinity of current dredgers do maintain a relative sustained level, and are strongly correlated with the distance between the dredge and the shoreline recipient. As a result, a simple model of noise intensity verses distance was selected as the type to use. Multiple exponential decay models were investigated in an effort to minimize the summed square error between model and actual values. Data obtained during ME-2 was used to determine model coefficients because it provided the most simultaneously monitoring sampling stations distributed from a single side of a dredge (three monitoring locations arrayed at various distanced from dredge). Data obtained from ME-1 was used to check the validity of the model and investigate model estimation error.

The noise reduction was estimated to decrease with distance from the dredge based on the following equation:

Equation 1. $N_i = N_o * 24633 \wedge (-00065 * (D_i - D_o)\wedge.6596))$

where:

N_i = Noise intensity in decibels at distance "i"

N_o = Noise intensity in decibels at the source (i.e., just off the side of the dredge)

D_i = Distance "i" in feet

D_o = A small distance or offset from the center of the noise source (where the noise monitor is placed on the dredge)

The excellent model fit of Equation 1 with ME-2 data is demonstrated in Figure 2. The maximum difference or "error" of the model is approximately 1.5 dB. Due to low magnitude of error, it can be said with confidence that Equation 1 can be used to estimate the distribution of

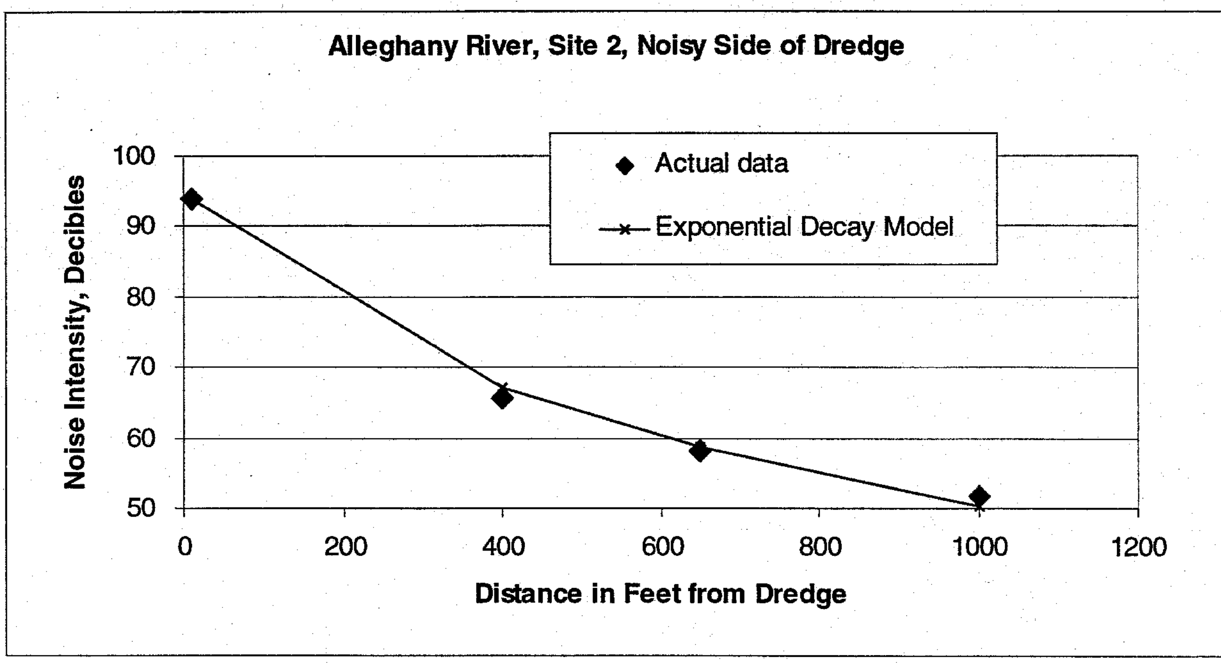

Figure 2

noise levels in conditions which match those observed at Site #2 on the Allegheny River; where there is generally flat topography with a minimum of other noise sources.

To test the general applicability of Equation 1 it was also applied to ME-1 data. Figures 3 and 4 indicates the "modeled" results compared to monitored data for both the noisy and quiet sides of the dredge. Note, the dredge was simultaneously monitored with two meters located on opposite sides of the dredge, hence there are two "source" noise intensities; 92 and 83 dB for the noisy and quiet side, respectively. From these figures it is evident that the general application of Equation 1 requires caution. In settings where dredgers operate adjacent to steep river banks which rise 50 to 100 feet, the noise level predicted by Equation 1 tends to be approximately 10 dB below the actual value.

It is the suspicion of the modeler/noise monitor that the monitored noise levels at the deck under-represent the true "source" intensity. For reasons of safety, noise monitors were placed at deck level in locations out-of-the-way of operating personal, flying gravel, and dripping water. As a result, the monitors on the dredge were "protected" somewhat from the main generator located approximately 40 feet above the monitoring location. Due to ongoing repairs, the generator was operating without some of its normal noise insulation. Short-term noise measurements taken in the immediate vicinity of the generator indicated noise values were 5 to 10 dB above those at deck level. It is suspected that the noise monitors located along the steep banks were able to detect the main generator better than deck-level monitors. However, this does not explain, totally, the poor match between modeled and actual data. It is believed that the steep shoreline topography elevate shoreline noise levels - the original model was developed from data collected in a flat setting. In conclusion, the combination of under-representing of the source noise intensity and the focusing effect of the steep banks probably explain under prediction of the noise model for ME-1. All things considered, Equation 1 is believed to be sufficiently accurate to predict where and when noise levels resulting from dredging could impact sensitive shoreline land areas. Its accuracy appears to be within +/- 2dB where ever shorelines are relatively flat near a dredger, however, accuracy may decreases to approximately -10 dB where ever shorelines are steep.

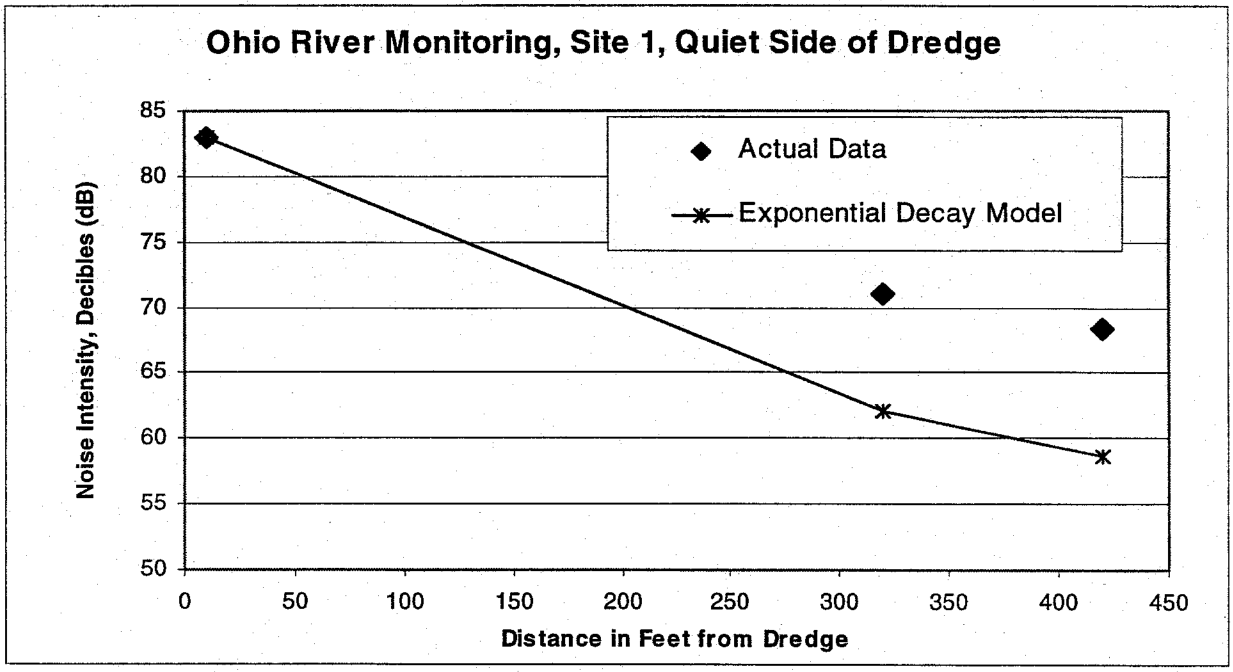

Figure 3

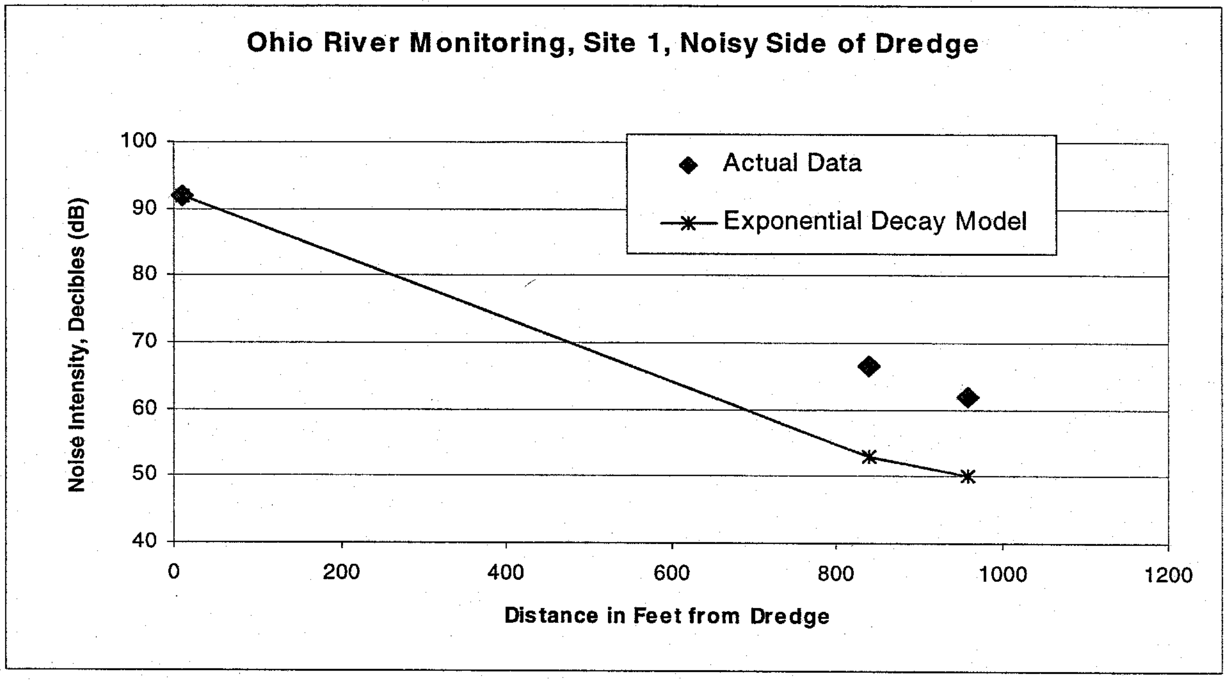

Figure 4

Conclusions

One day (each) of monitoring dredger noise at two separate locations produced a reasonably accurate picture of typical conditions. The peak sustained noise levels monitored at the two dredge operations ranged between 94 and 82 dB, depending on the dredge type, monitoring position on the dredge, and the sound proofing employed. The corresponding noise levels on-shore in the vicinity of dredging ranged from 70 to 50 dB, as compared with an expected background value between 45 (undeveloped wooded areas) and 65 (active urban areas). The shoreline noise monitoring locations were sited between 320 and 1000 feet from the dredge operations.

Given existing Federal noise criteria, a simple approach was utilized in this NEPA evaluation of the small data set produced by dredger monitoring. An "impact" was identified where ever the sustained noise level generated by daytime dredging was above 65 dB in sensitive areas (e.g., residential areas). In addition, where/when dredge noise levels result in a sustained value greater than 55 dB in a residential area during nighttime hours, it was stated that dredging produced an "impact" (i.e., a 10 dB penalty is added to measured ambient noise levels between 10 p.m. and 7 a.m.).

The field data and a custom-developed noise propagation model demonstrate that dredger noise levels have the potential to impact nearby sensitive land areas. This impact will only occur when the dredgers are operating close to shorelines and sensitive land uses are situated along the shoreline. Because there was a measured +/- 6 dB range in the magnitude of noise generated by dredging (82 to 94 dB) and there are differences in the dredger locations (e.g., topography and other noise sources vary) it is not possible to generate a single off-set distance at which dredge noise will drop below 65 dB (daytime) or 55 dB (nighttime) criteria. The evaluation performed in support of the NEPA assessment indicate dredger noise generally dissipates to below 65 dB at a distance between 300 and 600 feet from the dredger.

It should be noted that as a part of typical dredger operations, dredges will move thousands of feet upstream to downstream and across the channel in a single year. This means that any noise impacts on sensitive land uses will be short-term, i.e., dredges are not permanently located. Because it is the opinion of the analyst that the maximum probable increase in ambient noise levels is between 10 to 15 dB, where ever impacts occur they will be, at most, "moderate" in nature. While potentially annoying, dredger noise is very unlikely to produce hearing damage of shoreline residents. Moving the dredge a couple of hundred feet, orienting the "quiet-side" of the dredge toward the sensitive area, limiting night-time operations, and/or enhancing the dredge sound-proofing are all effective methods for reducing any noise impacts to acceptable levels.