APPENDIX E-4

PEORIA LAKE WATER QUALITY ANALYSIS

PEORIA RIVERFRONT DEVELOPMENT (ECOSYSTEM RESTORATION) STUDY, ILLINOIS

FEASIBILITY REPORT WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

APPENDIX E-4
PEORIA LAKE WATER QUALITY ANALYSIS

WATER QUALITY IMPACTS OF DREDGED MATERIAL PLACEMENT

Water quality impacts associated with island construction activities may result from the mechanical placement of sand to construct ring levees, which would form the perimeter of the islands, and from the filling of the interior of the islands with primarily fine-grained material by hydraulic dredging. In order to assess the water quality impacts of these actions, two numerical models were used; STFATE and EFQUAL. Both models are modules of the Automated Dredging and Disposal Alternatives Management System (ADDAMS).

For the purpose of this study, two contaminant parameters were chosen for evaluation—zinc and ammonia nitrogen. Zinc has been shown to occur in elevated concentrations in the sediments near the project site by Cahill, et al, 2000. Ammonia nitrogen is commonly found in the sediments and water column throughout the Illinois Waterway in elevated concentrations. By focusing on parameters that are known to occur in high concentrations, a conservative prediction of water column impacts can be made.

MECHANICAL PLACEMENT

Material used to construct the ring levee(s) will contain some percentage of fine-grained material. Associated with this fine-grained material will likely be contaminants. Since the placement of dredged material will be in open water, it is likely that contaminants will be released to the water column, requiring some limited mixing zone where water quality standards may be exceeded. The size of this mixing zone will depend on a number of factors including the contaminant concentration in the dredged material, concentrations in the receiving water, the applicable water quality standards of the receiving water and receiving flow rate and turbulence. STFATE is capable of estimating near-field contaminant dilution and dispersion processes which determine water column impacts.

Based on previous island construction performed in Peoria pool, and for purposes of estimating the water quality impacts resulting from the proposed action, it was assumed a large clamshell bucket dredge would be used to construct the levee(s). Often sediments dredged by clamshell remain in fairly large consolidated clumps and reach the bottom in this form. Whatever its form, the dredged material descends rapidly through the water column to the bottom and only a small amount of the material remains suspended. The behavior of the material during placement is assumed to be separated into three phases: convective descent, during which the material cloud falls under the influence of gravity; dynamic collapse, occurring when the descending cloud impacts the bottom; and passive transport-dispersion, commencing when the material transport and spreading are determined more by ambient currents and turbulence than by the dynamics of the disposal operation.

MODEL INPUT

Estimation of ambient water column conditions includes current velocity and water depths over a computational grid. The dredged material is assumed to consist of a number of solid fractions, a fluid component and conservative dissolved contaminants. Each solid fraction has a volumetric concentration, a specific gravity, a settling velocity, a void ratio for bottom deposition, critical shear stress and information on whether the fraction is cohesive and/or strippable. Table E-4-1 lists the input parameters utilized for this model.

TABLE E-4-1. STFATE Model Input Data

STFATE	Zinc	Ammonia	Units
Contaminant Selection Data			
Solid [] of dredged material	900	900	g/L
Contaminant [] in the bulk sediment	300000	200000	µg/Kg
Contaminant [] in the elutriate	87	9850	µg/L
Contaminant background [] at disposal site	0.02	0.1525	mg/L
Contaminant water quality standards	1000	15000	µg/L
Site Description			
Number of grid points (L to R)	25	25	
Number of grid points (T to B)	45	45	
Spacing between grid points (L to R)	50	50	ft
Spacing between grid points (T to B)	150	150	ft
Constant water depth	4	4	ft
Roughness height at bottom of disposal site	0.005	0.005	ft
Slope of bottom in x-direction	0	0	degrees
Slope of bottom in z-direction	0	0	degrees
Number of points in density profile	2	2	
Depth of density profile point	0,4	0,4	ft
Density at profile point	1.0000,1.0002	1.0000,1.0002	g/cc
Velocity Data			
Type of velocity profile	Site Depth Averaged Vel.	Site Depth Averaged Vel.	
Water Depth of Averaged Velocity	4	4	ft
Vertically averaged X-dir velocity	1	1	ft/sec
Vertically average Z-direction velocity	0	0	ft/sec
Velocities for entire grid in X-dir	1	1	ft/sec
Velocities for entire grid in Z-dir	0	0	ft/sec

TABLE E-4-1 (Continued)

Input, Execution, and Output Keys			
Processes to simulate			
Duration of simulation	3600	3600	sec
Long-term time step for diffusion	100	100	sec
Convective descent output option	y	y	
Collapse phase output option	y	y	
Location of upper L corner of mixing zone on gird	0	0	ft
Location of lower R corner of mixing zone on grid	0	0	ft
Water quality standards at border of mixing zone	1	15	mg/L
for contaminant of concern			
Contaminant of concern	zinc	ammonia	
Input, Execution and Output Keys (cont)			Units
Background concentration at disposal site	0.02	0.02	mg/L
Location of upper L corner of *zone of initial*	0	0	ft
dilution (ZID) on grid			
Location of lower right corner of zone of initial	0	0	ft
dilution (ZID) on grid			
Water quality standards at border of ZID for	0	0	mg/L
contaminant of concern			
Number of depths in H2O column for which			
output is desired	1	1	
Depths for transport - diffusion output	2	2	ft
Predicted initial concentration in fluid fraction	300	200	mg/L
Dilution required to meet toxicity standards			percent
Dilution required to meet toxicity standards			percent
at border of ZID			
Material Description Data			
Total volume of dredged material in the	9	9	yd3
Hopper dredge			
Number of distinct solid fractions	4	4	
Solid-fraction descriptions	Silt, Sand, Clay, Clump	Silt, Sand, Clay, Clump	
Solid-fraction specific gravity	2.65, 2.7, 2.65, 1.57	2.65, 2.7, 2.65, 1.57	
Solid-fraction volumetric concentration	0.031, 0.074, 0.022, 0.63	0.031, 0.074, 0.022, 0.63	yd3/yd3
Solid-fraction fall velocity	0.01, 0.1, 0.002, 3.0	0.01, 0.1, 0.002, 3.0	ft/sec
Solid-fraction deposited void ration	4.5, 0.6, 7.5, 0.4	4.5, 0.6, 7.5, 0.4	
Solid-fraction critical shear stress	0.008, 0.02, 0.001, 99.0	0.008, 0.02, 0.001, 99.0	lbs/sq ft
Cohesive? (y or n)	y, n, y, n,	y, n, y, n,	
Stripped during descent? (y or n)	y, y, y, n	y, y, y, n	
Moisture content of dredged material as			
multiple of liquid limit			

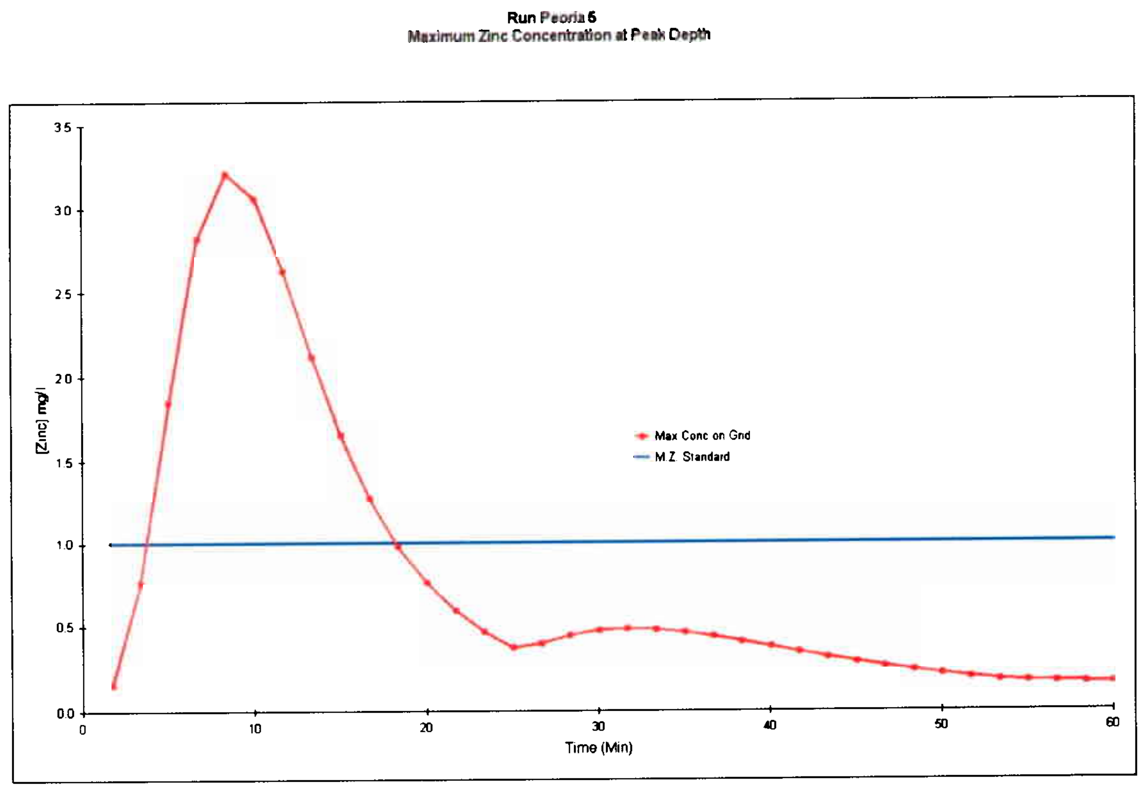
TABLE E-4-1 (Continued)

Water density at dredging site	1	1	g/cc
Desire number of layers	1	1	
Volume of each layer	9	9	yd3
Velocity of vessel in X-direction during dumping of each layer	0	0	ft/sec
Velocity of vessel in Z-direction during dumping of each layer	0	0	ft/sec
Disposal Operation Data			
Location of disposal point from top of grid	200	200	ft
Location of disposal point form left edge of grid	600	600	ft
Length of disposal vessel bin	6.5	6.5	ft
Width of disposal vessel bin	6.5	6.5	ft
Disposal Operation Data (Cont)			Units
Bottom depression length in X-direction	0	0	ft
Bottom depression length in Z-direction	0	0	ft
Bottom depression average depth	0	0	ft
Pre-disposal draft of disposal vessel	2	2	ft
Post-disposal draft of disposal vessel	0.5	0.5	ft
Time needed to empty disposal vessel	1	1	sec

MODEL OUTPUT

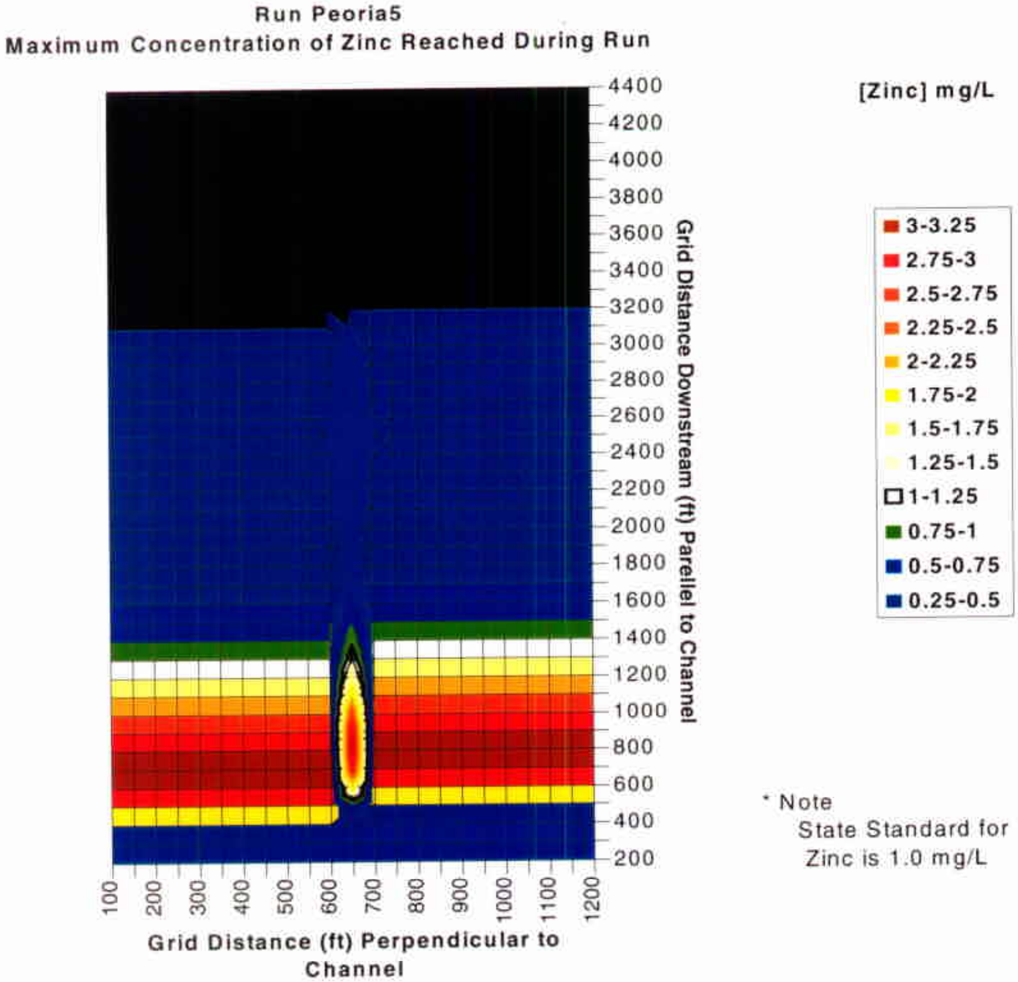
The output starts by echoing the input data and then optionally presenting the time history of the descent and collapse phases. In descent history the location and velocity of the cloud centroid, the conservative constituent concentration and the total volume and concentration of each solid fraction are provided as functions of time since release of the material. Figure E-4-1 shows the maximum concentration of zinc predicted to occur at any point downstream from the placement site. Figure E-4-2 shows the size and shape and concentrations of zinc throughout the discharge plume.

FIGURE E-4-1



Run Peoria 6
Maximum Zinc Concentration at Peak Depth
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
[Zinc] mg/l
0
10
20
30
40
50
60
Time (Min)
Max Conc on Gnd
M.Z. Standard

FIGURE E-4-2



Run Peoria5
Maximum Concentration of Zinc Reached During Run
4400
4200
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
Grid Distance Downstream (ft) Parellel to Channel
100
200
300
400
500
600
700
800
900
1000
1100
1200
Grid Distance (ft) Perpendicular to Channel
[Zinc] mg/L
3-3.25
2.75-3
2.5-2.75
2.25-2.5
2-2.25
1.75-2
1.5-1.75
1.25-1.5
1-1.25
0.75-1
0.5-0.75
0.25-0.5
* Note
State Standard for Zinc is 1.0 mg/L

Figures E-4-3 and E-4-4 show similar results for ammonia nitrogen.

FIGURE E-4-3

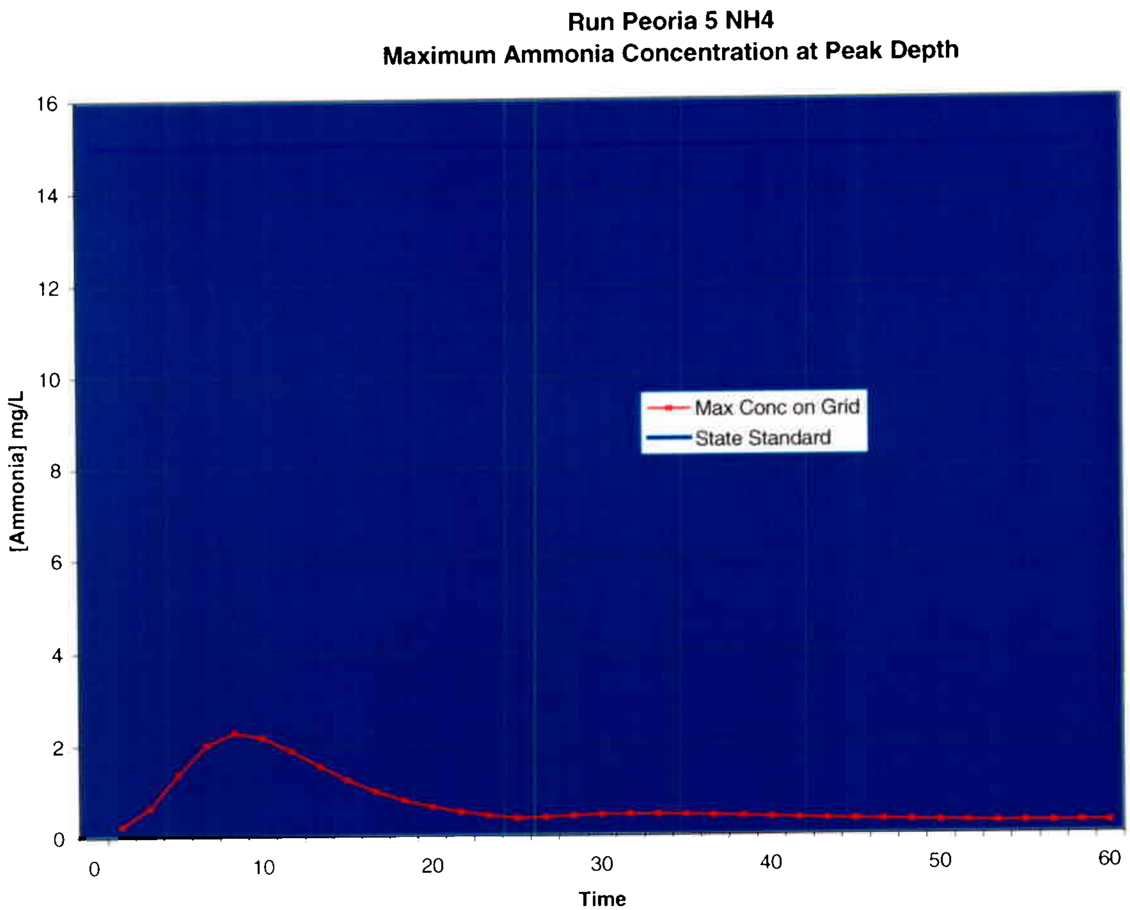
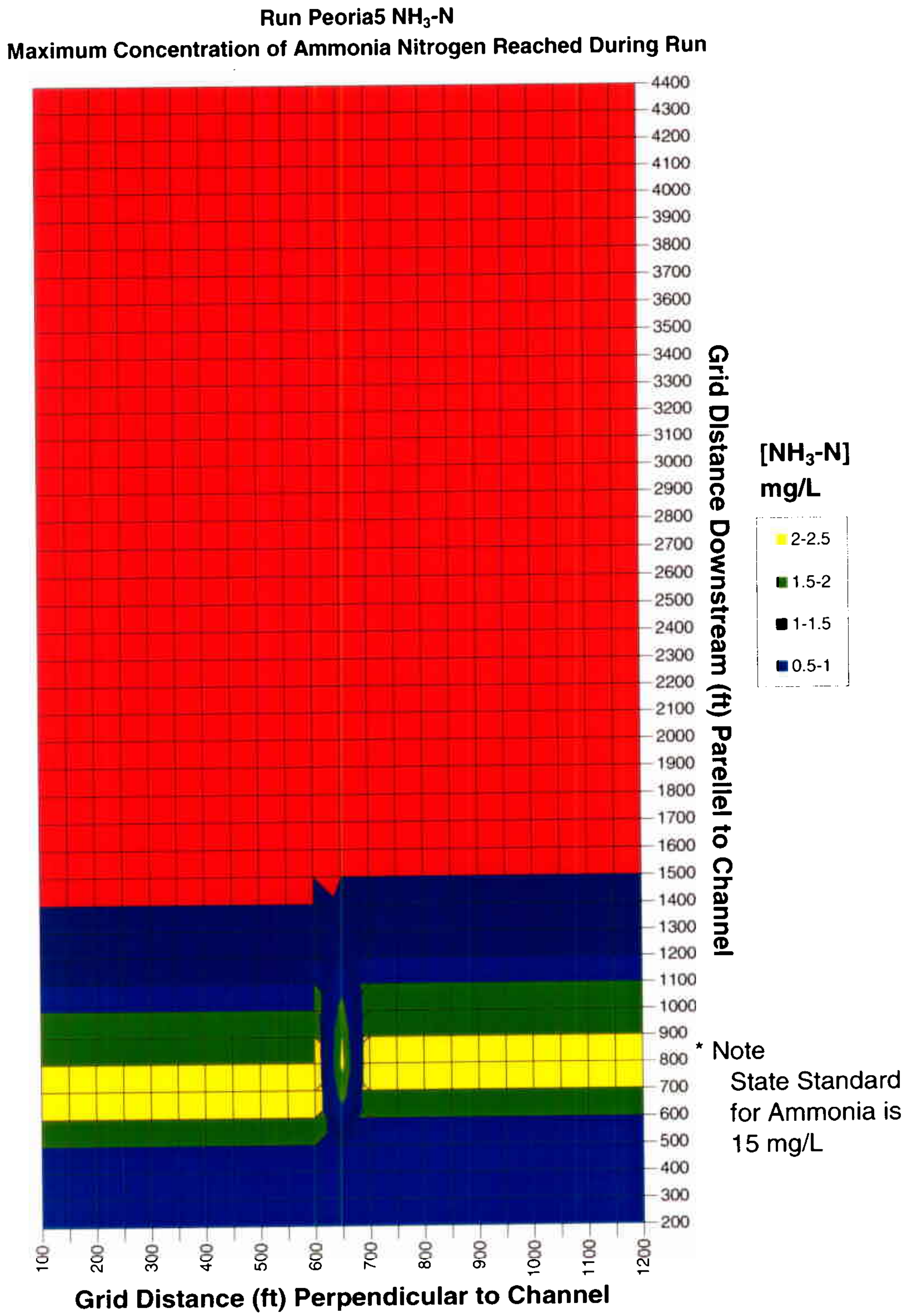


FIGURE E-4-4



Run Peoria5 NH3-N
Maximum Concentration of Ammonia Nitrogen Reached During Run
4400
4300
4200
4100
4000
3900
3800
3700
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
Grid Distance Downstream (ft) Parellel to Channel
100
200
300
400
500
600
700
800
900
1000
1100
1200
Grid Distance (ft) Perpendicular to Channel
[NH3-N] mg/L
2-2.5
1.5-2
1-1.5
0.5-1
* Note
State Standard for Ammonia is 15 mg/L

HYDRAULIC PLACEMENT

Because hydraulic dredging is the most efficient means of moving large quantities of material, it is likely that this form of dredging will be used to perform the majority of deepwater habitat formation. The quality of water discharged from confined disposal areas is also a concern that must be addressed. The predicted concentrations of the effluent can be used with appropriate water quality standards to determine the mixing zone required to meet respective water quality standards. EFQUAL is capable of computing predicted dissolved and total contaminant concentrations in the effluent from a confined disposal site, comparing predicted effluent concentrations with specified water quality standards and computing dilution of effluent required to meet specified water quality standards considering contaminant concentrations in the receiving water.

MODEL INPUT

The main data requirements for EFQUAL are modified elutriate test conditions and results, background receiving water concentrations and water quality standards for contaminants of concern. Table E-4-2 lists the input parameters used for this model.

TABLE E-4-2.

Parameters	**Zinc**	**Ammonia**
For Each evaluation:		
Descriptive title		
Number of modified elutriate replicates	4	4
For Each modified elutriate replicate:		
Slurry concentration (optional)	1024.4	1024.4
Retention time (optional)	0.5	0.5
Total suspended solids (TSS) concentration	107700	107700
For each contaminant of concern:		
Detection limit	8	50
Test sediment concentration (optional)	355	335
Test water concentration (optional)	63	152.5
Background water concentration	63	152.5
Water quality standard	1000	15000
For each contaminant of concern and each modified elutriate replicate		
Modified elutriate dissolved concentration	47, 71, 74, 20	10000, 11100, 4400, 14000
Modified elutriate concentration (required only if total concentrations used for comparison to standards	47, 71, 74, 20	10000, 11100, 4400, 14000
For each evaluation:		
Estimated effluent TSS concentration (required if total concentrations used for comparisons to standards)	107700	107700
Percentage increment above background and dilution calculations (used when standards are below or very close to background)	0	0

Modified elutriate test must have a minimum of 3 replicates and a maximum of 9 replicates

MODEL OUTPUT

Results from EFQUAL are shown in Table E-4-3. Both zinc and ammonia nitrogen are expected to be below the respective standards. It should be noted that a standard also exists for un-ionized ammonia nitrogen. This standard is dependent upon water temperature and pH. At this time, it is not possible to predict with certainty what un-ionized ammonia nitrogen concentrations may occur during dredging; however, one can use conservative estimates assuming warm water temperatures and high pH values.

TABLE E-4-3. Summary of Modified Elutriate and Predicted Effluent Quality

	Ambient Water Conc. (mg/l)	Sediment Conc. (mg/kg)	Predicted Total Conc. (mg/l)	State Std. (mg/l)
Ammonia	0.15	335	9.875	15*
Zinc	0.063	355	0.053	1.0

* If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia nitrogen shall not exceed 0.04 mg/l.

CONCLUSIONS

Model results show that two parameters which commonly occur in elevated concentrations in the sediment and water column of the Illinois Waterway will exceed water quality standards in a small area immediately downstream from the placement site during mechanical dredging. The mechanically-placed material used to construct the ring levee will be primarily sand, which will likely have contaminant concentrations much lower than those assumed in this model exercise. It is not likely that this action will have a substantial or long-term impact to the water quality of the river.

Based on available sediment and water column concentrations of zinc and ammonia nitrogen, release of supernatant water from the confining ring levee is not expected to exceed water quality standards for those parameters. Actual field conditions may differ from the assumptions used in this model exercise and it will be necessary to construct an appropriately sized confinement area.