142796

VII LAGOONS

WARZYN
ENGINEERING INC

SITE PREPARATION

WARZYN

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY DJO DATE 3-1-85 SUBJECT OMC - DESIGN ANALYSIS SHEET NO. ____ OF ____
CHKD. BY TJL DATE 3-7-85 CONCEPT SUBMITTAL JOB NO. 1082

SITE PREPARATION

VII LAGOONS

SITE PREPARATION OF THE LAGOON AREA IS DISCUSSED IN THE WATER TREATMENT PLANT SITE PREPARATION SECTION.

ACTIONS WILL INCLUDE THE FOLLOWING:

A. REMOVAL OF EXISTING SITE FEATURES
B. SITE GRADING
C. UTILITIES
D. FENCING

VII. LAGOONS

SITE PREPARATION

E. GROUNDWATER MONITORING WELLS

BASED ON PAGE 2-27 OF THE CH2M HILL CONCEPTUAL DESIGN REPORT, NINE TEMPORARY GROUNDWATER MONITORING WELLS WILL BE REQUIRED IN THE LAGOON AREA DURING THE LIFE OF THE LAGOONS TO MONITOR WATER QUALITY. MONTHLY SAMPLING HAS BEEN SPECIFIED. ANALYSIS OF SAMPLES COLLECTED IS DISCUSSED IN THE SITE SPECIFIC QUALITY MANAGEMENT PLAN (SSQMP).

1. LOCATIONS

BASED ON THE PROPOSED LAYOUT OF THE LAGOON 1 AND 2, CURING CELLS, BATCH PLANT AND TREATMENT PLANT, LOCATIONS WERE SELECTED FOR THE WELLS AS INDICATED ON THE "CONSTRUCTION GRADES" DRAWING. IN GENERAL, THESE LOCATIONS INCLUDE 3 WELLS ON THE WEST SIDE OF THE LAGOONS ADJACENT TO THE UPPER HARBOR, 2 ON THE NORTH, 2 ON THE SOUTH, AND 2 ON THE EAST SIDE

2. DETAILS

SINCE THE WELLS WILL BE USED TO MONITOR WATER QUALITY, THE WELLS WILL CONSIST OF STAINLESS STEEL WELL SCREEN AND GALVANIZED STEEL RISER PIPE. TWO INCH DIAMETER WELLS ARE CONSIDERED SUITABLE. A 10-FT LONG WELL SCREEN WILL BE USED WITH ITS TOP AT OR JUST BELOW THE GROUNDWATER TABLE. THE SCREEN ANNULUS WILL BE BACKFILLED WITH A COARSE SAND PACKING FOLLOWED BY A BENTONITE PLUG. A SAND-BENTONITE MIX BACKFILL WILL BE USED ABOVE THE PLUG FOLLOWED BY ANOTHER BENTONITE PLUG. A STEEL PROTECTIVE CASING WITH LOCKING CAP WILL BE SET IN CONCRETE OVER THE WELL. A STANDARD DETAIL IS ATTACHED.

THE WELLS WILL BE INSTALLED BY FIRST DRILLING A STANDARD PENETRATION TEST SOIL BORING WITH HOLLOW STEM AUGERS. WATER WILL BE USED AS A DRILLING FLUID IF NECESSARY. DRILLING FLUIDS CAN BE COLLECTED FOR

E. CONTINUED

LATER TREATMENT AT THE ON-SITE TREATMENT PLANT. DRILL CUTTINGS WILL BE COLLECTED AND DISPOSED OF IN THE PARKING LOT CONTAINMENT CELL. ALL DRILLING EQUIPMENT AND WELL MATERIALS WILL BE SUBJECT TO DECONTAMINATION PROCEDURES BETWEEN WELL LOCATIONS. DRILLING PERSONNEL WILL WEAR APPROPRIATE SAFETY GEAR (ANTICIPATE LEVEL C)

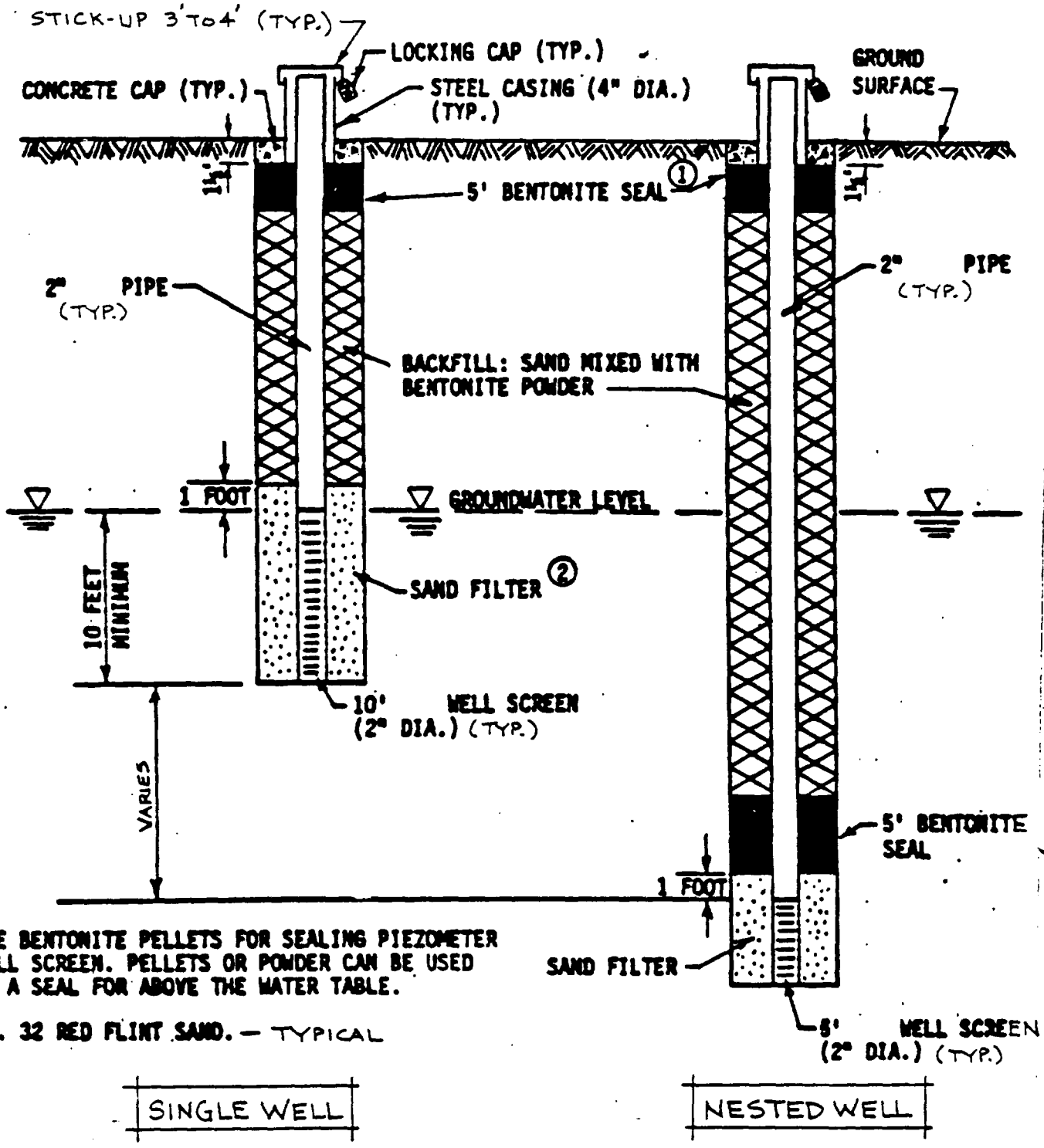
3. INSTALLATION

IT IS ANTICIPATED THAT THE GENERAL CONTRACTOR WILL SUB OUT THIS WORK TO A QUALIFIED DRILLING FIRM. THE WELLS SHOULD BE INSTALLED DURING THE SITE PREPARATION ACTIVITIES SO THAT BACKGROUND WATER SAMPLES CAN TAKEN PRIOR TO DREDGING.*

4. ESTIMATING

FOR ESTIMATING PURPOSES, ASSUME 9 WELLS ESTABLISHED AT A BOTTOM DEPTH OF 15 FT (SHALLOW GROUNDWATER TABLE). WELL NESTS AT DIFFERENT LEVELS ARE NOT CONSIDERED NECESSARY DUE TO THE RELATIVELY SHORT LIFE OF THE LAGOONS. IF CONTAMINATION IS DISCOVERED, THE EPA OR CORPS CAN DIRECT THE INSTALLATION OF ADDITIONAL WELLS AS A CHANGE ORDER.

* BACKGROUND ANALYSIS IS VERY IMPORTANT SINCE THIS AREA MAY BE CONTAMINATED WITH PCB'S OR OTHER TOXIC'S PRIOR TO REMEDIAL ACTIONS EVEN INITIATING! IT IS OUR UNDERSTANDING THIS AREA HAS NOT BEEN SUBJECT TO CONTAMINATION STUDIES EVEN THOUGH PREVIOUS DRILLERS LOGS NOTE OILY SUBSTANCE AND STRONG PETROLEUM ODORS (WARZYN INVESTIGATION, JOB NO. C9177, 1980).



① USE BENTONITE PELLETS FOR SEALING PIEZOMETER WELL SCREEN. PELLETS OR POWDER CAN BE USED AS A SEAL FOR ABOVE THE WATER TABLE.

② NO. 32 RED FLINT SAND. — TYPICAL

TYPICAL WELL INSTALLATION DETAIL

NOT TO SCALE

SITE CONSTRUCTION

WARZYN
ENGINEERING INC

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY QJD DATE 3-1-85 SUBJECT GMC - DESIGN ANALYSIS SHEET NO. 1 OF 7
CHKD BY TJLong DATE 3-1-85 CONCEPT SUBMITTAL JOB NO. 11837

SITE CONSTRUCTION

VII LAGOONS

A. DIKE CONSTRUCTION

1. DIKE KEY

TO STABILIZE THE DIKE FILL MATERIAL AND REDUCE THE POSSIBILITY OF A SHEAR SURFACE DEVELOPING AT THE BASE, THE INPLACE MATERIAL WILL BE SCARIFIED BEFORE DIKE CONSTRUCTION BEGINS.

2. DIKE FILL MATERIAL

BASED ON CALCULATIONS ON SUBSEQUENT PAGES THE GRANULAR FILL REQUIRED FOR DIKE CONSTRUCTION IS APPROXIMATELY 123,000 CY

PLACEMENT OF MATERIAL SHOULD BE IN APPROXIMATELY 8" LIFTS AND COMPACTED BASED ON MATERIAL TYPE AND SPECIFICATIONS.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY JJD DATE 2-20-85 SUBJECT CMC DESIGN ANALYSIS SHEET NO. 2 OF 7
CHKD. BY TJLynn DATE 3-7-85 CONCEPT SUBMITTAL JOB NO. 11837
SITE CONSTRUCTION

III. LAGOONS

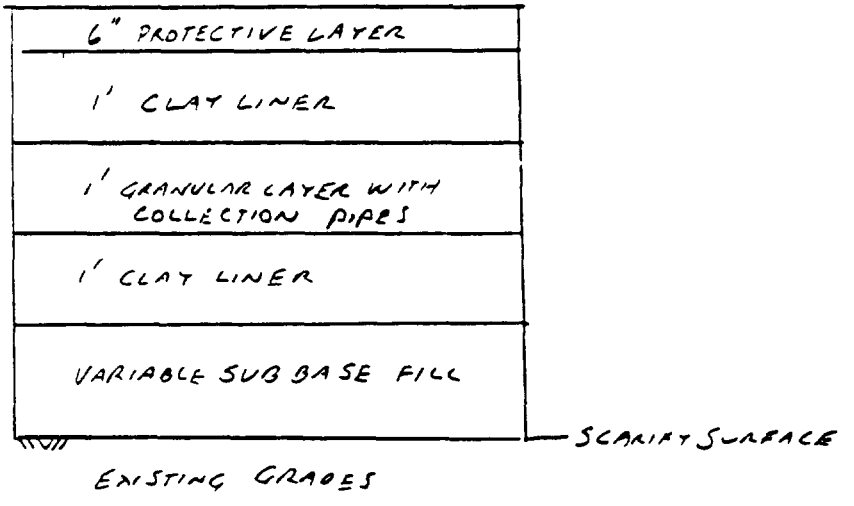
DETERMINE QUANTITIES OF MATERIALS REQUIRED FOR LAGOON CONSTRUCTION. BASED ON LAGOON LAYOUT ON DRAWING 202.

REFERENCE

1. USING CROSS SECTION/AVERAGE END AREA VOLUME METHOD WITH HP AND PANASONIC COMPUTERS. SEE APPENDIX E FOR PROGRAM DESCRIPTIONS AND DETAILED AREA/VOLUME CALCULATIONS. REFER TO APPENDIX E

ASSUMPTIONS:

1. LAGOON CROSS SECTION LINER



2. LINER EXTENDS FROM OUTSIDE TOP OF SLOPE OF EXTERIOR PERIMETER DIKE DUE TO TRAVEL OF CONTAMINATED VEHICLES ON THE DIKE TOP.

3. LAGOONS HAVE AN AVERAGE 8' WATER DEPTH W/ 2' FREEBOARD

   CURING CELLS HAVE AN AVERAGE 4' OPERATING DEPTH W/ 1' FREEBOARD

   OVERFLOW WEIR BETWEEN LAGOONS IS 8.5' ABOVE BASE

4. ONSITE DREDGED MATERIAL IS SUITABLE FOR SUB BASE FILL FOR LAGOON DIKES

5. DIKE EXTERIOR WILL BE MULCHED/FERTILIZED AND SEEDED W/O ADDITION OF TOPSOIL

6. DIKE INBOARD AND OUTBOARD SLOPE @ 3:1 FOR STABILITY

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY DJR DATE 2-5-85 SUBJECT EMC - DESIGN ANALYSIS SHEET NO. 4 OF 7
CHKD. BY TJLund DATE 3-7-85 CONCEPT SUBMITTAL JOB NO. 11837
SITE CONSTRUCTION

REFER TO APPENDIX E FOR MATERIAL QUANTITY CALCULATIONS

1. TOTAL BERM/LINER VOLUME ABOVE 585.0 266,960 CY

2. DEDUCTIONS

LAGOON 1	SOIL CEMENT	2,514	CY
	CLAY	5,036	CY
	GRAVEL	5,036	CY
	CLAY	5,036	CY
	SUBTOTAL	17,622	CY
LAGOON 2	SOIL CEMENT	7,960	CY
	CLAY	15,930	CY
	GRAVEL	15,930	CY
	CLAY	15,930	CY
	SUBTOTAL	55,750	CY
CURING CELLS	SOIL CEMENT	1385	CY
	CLAY	2,768	CY
	GRAVEL	2,768	CY
	CLAY	2,768	CY
	SUBTOTAL	9,689	CY
BATCH AREA	SOIL CEMENT	1,391	CY
	CLAY	2,775	CY
	GRAVEL	2,775	CY
	CLAY	2,775	CY
	SUBTOTAL	9,716	CY
	TOTAL DEDUCTIONS		92,777 CY
	NET FILL		174,183 CY

3. TOTALS

SOIL CEMENT	13,250	CY	- 51,140 CY
TOP CLAY	26,509	CY	
GRAVEL	26,509	CY	123,043 CY
BOTTOM CLAY	26,509	CY	
ONSITE FILL	51,140	CY	
IMPORTED FILL	123,043	CY	

SF 102934

VII. LAGOONS

SITE CONSTRUCTION

A. DIKE CONSTRUCTION

3. DIKE STABILITY

THE DIKE INTERIOR AND EXTERIOR SIDESLOPES ARE CURRENTLY DESIGNED FOR 3:1. BASED ON THE DRAWING, "BASE GRADES, SETTLING LAGOONS AND CURING CELLS," THE CRITICAL SECTION THROUGH THE LAGOON DIKES WILL HAVE THE FOLLOWING DETAILS: EXTERIOR TOE EL. 586, DIKE TOP EL. 601, INTERIOR TOE EL. 589. A FLUID LEVEL OF EL. 598 MAXIMUM COULD OCCUR BASED ON THE WEIR ELEVATION BETWEEN THE TWO LAGOONS.

IT IS CURRENTLY PLANNED TO PLACE A LINER SYSTEM ON THE INTERIOR SURFACE AS DICTATED BY THE CH2M HILL CONCEPTUAL DESIGN REPORT, p.2- i.e. 6 IN. SOIL-CEMENT, 1 FT. CLAY, 1 FT. GRANULAR AND 1 FT. CLAY, FOR A TOTAL OF 3.5 FT. THE USE OF A SYNTHETIC LINER SYSTEM WILL BE EVALUATED DURING FINAL DESIGN. PAGE 2-20 OF THE CONCEPTUAL DESIGN REPORT ALSO INDICATES THAT THE "EMBANKMENT WILL BE CONSTRUCTED OF SAND OR GRAVEL."... HOWEVER, IT WILL MOST LIKELY BE A CONTRACTOR CHOICE TO USE CLAY OR SAND DEPENDING ON COST. IN EVALUATING DIKE STABILITY, IT IS FELT THE MOST CRITICAL FORM OF DIKE INSTABILITY WOULD BE A FAILURE OF THE EXTERIOR SIDE-SLOPE CAUSING A RELEASE OF THE INTERIOR DREDGE WATER AND SOLIDS TO THE EXTERIOR ENVIRONMENT. SLOUGHING OF THE INTERIOR SLOPE, IF IT OCCURRED, WOULD BE A LESSER PROBLEM REQUIRING GENERAL MAINTENANCE.

ASSUMING NO SEEPAGE OCCURS THROUGH THE DOUBLE LINER AND OUT THE SIDESLOPE, THE EXTERIOR SIDESLOPE STABILITY WILL BE CONTROLLED BY THE FRICTIONAL COMPONENT OF SOIL STRENGTH (ϕ). A COMPACTED GRANULAR SOIL WOULD BE ANTICIPATED TO HAVE $\phi = 30°$ TO $35°$ WHILE A COMPACTED CLAY SOIL WOULD BE ANTICIPATED TO HAVE $\phi = 28°$ TO $32°$ (EFFECTIVE STRENGTH - LONG TERM CONDITION). THE FACTOR OF SAFETY

3. CONTINUED

OF THE EXTERIOR SIDESLOPE CAN BE ESTIMATED ASSUMING IT WILL ACT AS AN INFINITE SLOPE CONSISTING OF A SOIL WITH ϕ = SOME VALUE AND $C = 0$.

$$FS = \frac{\tan\phi}{\tan\beta}$$

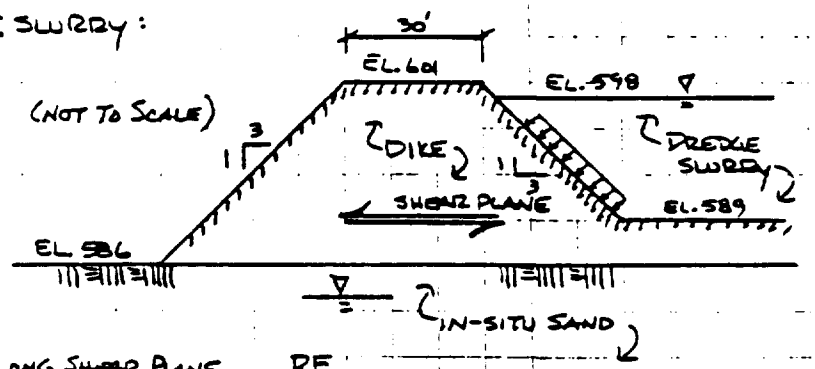
β = SLOPE ANGLE = $\tan^{-1}(1/3)$
$\tan\beta = 1/3$ FOR 3:1 SLOPE

USING WORST CASE $\phi = 28°$,

$$FS = \frac{\tan 28°}{1/3} = \underline{\underline{1.6}} > 1.0 \quad \underline{\underline{ok}}$$

A FS = 1.0 THEORETICALLY REPRESENTS FAILURE WHILE A FS = 1.2 TO 1.5 IS GENERALLY CONSIDERED ACCEPTABLE DEPENDING ON THE CONSEQUENCES OF FAILURE.

CHECK SLIDING STABILITY ALONG BASE OF EMBANKMENT DUE TO HYDROSTATIC PRESSURE OF DREDGE SLURRY:



$$FS = \frac{\text{RESISTING FORCE ALONG SHEAR PLANE}}{\text{DRIVING FORCE DUE TO SLURRY}} = \frac{RF}{DF}$$

RF = (DIKE WEIGHT)(FRICTION)

ASSUME γ_{DIKE} = 125 PCF AND $\phi = 30°$

FROM GEOMETRY: H = 601 − 589 = 12', L = 30 + (2)(12)(3) = 102'

$$RF = (125\ LB/FT^3)(12\ FT)\left(\frac{30+102}{2}\right)(\tan 30°) = 57{,}158\ LB/L.F.\ OF\ DIKE$$

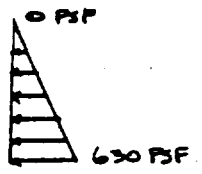
3. CONTINUED

SLURRY HYDROSTATIC PRESSURE

ASSUME $\gamma_{SLURRY} = 70 PCF$

FROM GEOMETRY: $H = 598 - 589 = 9'$

$\sigma = (9 FT)(70 LB/FT^3) = 630 LB/FT^2$



$DF = \frac{1}{2} bh = \frac{1}{2}(630 LB/FT^2)(9 FT) = 2835 LB/L.F. OF DIKE$

$$\text{FACTOR OF SAFETY} = \frac{RF}{DF} = \frac{57,158}{2835} = \underline{\underline{20}} >>> 1.0 \quad \underline{\underline{OK}}$$

IN SUMMARY, DIKE STABILITY SHOULD NOT BE A PROBLEM FOR 3H:1V SIDESLOPES REGARDLESS OF WHETHER GRANULAR OR CLAYEY SOIL IS USED PROVIDED THE SPECIFICATIONS REGARDING COMPACTION ARE SATISFIED. TYPICAL GRANULAR AND CLAY SOIL GRADATIONS THAT WILL BE ACCEPTABLE FOR DIKE CONSTRUCTION WILL BE DEVELOPED DURING FINAL DESIGN FOR INCLUSION IN THE SPECIFICATIONS.

SITE CONSTRUCTION

VII. LAGOONS

4. EROSION CONTROL

INTERIOR DIKE SIDESLOPES WILL BE LINED AND WILL NOT REQUIRE ADDITIONAL EROSION CONTROL.

EXTERIOR DIKE SIDE SLOPES AND PERIMETER DRAINAGE AREAS AND FEATURES WILL BE SEEDED FERTILIZED AND MULCHED.
APPROXIMATELY 23,730 SQ YDS WILL BE PREPARED.

5. STORAGE VOLUMES AND FREEBOARD

THE AVERAGE WATER DEPTH IN THE STORAGE LAGOONS IS 8' WITH 2' FREEBOARD

LAGOON 1 24,300 CY
LAGOON 2 89,300 CY

REFER TO APPENDIX F FOR AREA VOLUME CALCULATIONS

B. SITE DRAINAGE - REFER TO THE SITE PREPARATION/TREATMENT PLANT SECTION.

C PAVING AND ROADS

1. SUBGRADE

ALL VEHICLE ACCESS ROADS AND AREAS, OTHER THAN DIKE TOPS, WILL HAVE A MINIMUM OF 8" BASE COURSE. THOSE AREAS WHERE CONTAMINATED VEHICLES ARE PRESENT, WILL RECEIVE 2.5" OF ASPHALT, CURBS AND DRAINAGE FEATURES TO CONTAIN RUNNOFF AND SPILLAGE.

2 SLOPES

ALL DIKE ACCESS LOCATIONS WILL HAVE A MAXIMUM SLOPE OF 10%. WHERE POSSIBLE, THE ACCESS ROAD SLOPES WILL BE LESS.

VII. LAGOONS

3. ACCESS WIDTH

ONE LANE - ONE WAY VEHICLE CORRIDORS WILL BE A MINIMUM OF 12' WIDE

TWO LANE - TWO WAY CORRIDORS WILL BE A MINIMUM OF 24' WIDE.

TOP OF DIKES WILL BE A MINIMUM OF 30' WIDE TO PROVIDE FOR VEHICLE ACCESS, LOADING AND ROUTING AROUND DRAGLINE EQUIPMENT.

IN THE FIXATION AND CURING AREAS. ADEQUATE TURNING RADII WILL BE PROVIDED FOR VEHICLE/MATERIAL EXCHANGE.

D LINER CONSTRUCTION

THE ENTIRE LAGOON, FIXATION AND CURING AREA WILL BE CONSTRUCTED WITH A LINER SYSTEM ON THE TOP OF AND INSIDE THE PERIMETER DIKE. THE LINER SYSTEM PRESENTED IN THE CONCEPTUAL DESIGN IS DESCRIBED AS FOLLOWS:

1. CLAY BASE

FOLLOWING INITIAL CONSTRUCTION OF THE LAGOON/DIKE BASE GRADES, A 1' THICK COMPACTED CLAY LINER WILL BE PLACED. IN PLACE PERMEABILITY SHOULD BE 1×10^{-7} CM/S. MATERIAL SPECIFICATIONS ARE THE SAME AS NEEDED FOR THE CLAY CAP ON THE PARKING LOT CONTAINMENT CELL. REFER TO THE SITE RESTORATION SECTION OF THE CONTAINMENT CELL FOR ADDITIONAL MATERIAL DETAILS. THE CLAY BASE SERVES AS A SECONDARY LINER AND

III LAGOONS

SHOULD NOT BECOME CONTAMINATED, UNLESS THE FIRST (TOP) LINER LEAKS CONTAMINATED FLUID.

APPROXIMATE CLAY REQUIREMENT = 26,500 CY

2. GRANULAR LAYER

THE INTERMEDIATE 1' GRANULAR LAYER CREATES A CONDUIT FOR FLUID FLOW IF THE TOP LAYER OF CLAY SHOULD LEAK. RCRA REQUIRES A MINIMUM PERMEABILITY OF 1×10^{-3} cm/s.

APPROXIMATE GRANULAR MATERIAL REQUIREMENT = 26,500 CY

3. PIPING SYSTEM

POTENTIAL LEAKAGE INTO THE INTERMEDIATE GRANULAR LAYER WILL BE ROUTED OFF THE BASE CLAY LINER THROUGH A NETWORK OF 4" DIAMETER PVC PERFORATED PIPES. THE LINER SYSTEM WILL BE SLOPED AT 0.5% WITH THE COLLECTION PIPES SLIGHTLY CROSS GRADE AT 0.4%. INTERMEDIATE FLOW DISTANCES WILL BE APPROXIMATELY 200 FEET BETWEEN PIPES.

APPROXIMATELY 5800 LINEAL FEET OF COLLECTION PIPE WILL BE REQUIRED.

4. CLAY TOP

THE CLAY TOP LINER WILL CONSIST OF A 1 FOOT THICK COMPACTED LAYER WHICH WILL BE PLACED ON THE INTERMEDIATE GRANULAR DRAINAGE LAYER. SPECIFICATIONS WILL BE IDENTICAL TO THE BASE CLAY LINER.

II. LAGOONS

SITE CONSTRUCTION

D. LINER CONSTRUCTION

5. SOIL-CEMENT

ACCORDING TO PAGE 2-21 OF THE CH2M HILL CONCEPTUAL DESIGN REPORT, SEPT. 14, 1984, THE LAGOON LINER WILL HAVE A 6 IN. THICK COMPACTED SOIL-CEMENT PROTECTIVE LAYER. THE SOIL-CEMENT (S-C) LAYER IS CONSIDERED TO PROVIDE A DURABLE WEARING SURFACE FOR REMOVAL OF DREDGE SOLIDS BY DRAGLINE OR OTHER DEVICE.

REFERENCE: SOIL-CEMENT LABORATORY HANDBOOK, PORTLAND CEMENT ASSOCIATION, SKOKIE, ILLINOIS, 1971.

DISCUSSION

FROM PAGE 12 OF REFERENCE, "AS A GENERAL RULE, IT WILL BE FOUND THAT THE CEMENT REQUIREMENT OF SOILS INCREASES AS THE SILT AND CLAY CONTENT INCREASES, GRAVELLY AND SANDY SOILS REQUIRING LESS CEMENT FOR ADEQUATE HARDNESS THAN SILT AND CLAY SOILS. THE ONE EXCEPTION TO THIS RULE IS THAT POORLY-GRADED, ONE-SIZE SAND MATERIALS THAT ARE DEVOID OF SILT AND CLAY REQUIRE MORE CEMENT THAN DO SANDY SOILS CONTAINING SOME SILT AND CLAY. IN GENERAL, A WELL-GRADED MIXTURE OF STONE FRAGMENTS OR GRAVEL, COARSE SAND, AND FINE SAND EITHER WITH OR WITHOUT SMALL AMOUNTS OF SLIGHTLY PLASTIC SILT AND CLAY MATERIAL WILL REQUIRE 5 PERCENT OR LESS CEMENT BY WEIGHT. POORLY GRADED ONE-SIZE SAND MATERIALS WITH A VERY SMALL AMOUNT OF NON-PLASTIC SILT, TYPICAL OF BEACH SAND OR DESERT BLOW SAND, WILL REQUIRE ABOUT 9 PERCENT CEMENT BY WEIGHT. THE REMAINING SANDY SOILS WILL GENERALLY REQUIRE ABOUT 7 PERCENT. THE NON-PLASTIC OR MODERATELY PLASTIC SILTY SOILS GENERALLY REQUIRE ABOUT 10 PERCENT CEMENT BY WEIGHT, AND PLASTIC CLAY SOILS REQUIRE ABOUT 13 PERCENT OR MORE."

5. CONTINUED

BASED ON THE PRECEDING DISCUSSION, A WELL-GRADED SAND WITH FINES WOULD BE THE MOST ECONOMICAL SOIL FOR A S-C MIX SINCE IT WOULD REQUIRE THE LEAST % CEMENT. THE SAND DREDGE SPOILS IN THE FILL PILES ADJACENT TO THE UPPER HARBOR ARE ANTICIPATED TO CONSIST OF POORLY-GRADED SAND WITH MINIMAL FINES AND WOULD BE LESS DESIREABLE FROM A % CEMENT CONTENT BASIS, BUT ARE ESSENTIALLY FREE. HOWEVER, THE SAND DREDGE SPOILS WILL BE USED UP DURING PRELIMINARY GRADING OF THE LAGOON BASE. THEREFORE, THE SOIL OF THE S-C MIX WILL HAVE TO BE IMPORTED. BECAUSE OF THE GENERAL GEOLOGICAL CONDITIONS IN THE WAUKEGAN / CHICAGO AREA, CLAY IS ASSUMED TO BE MORE READILY AVAILABLE AT A LESSER COST THAN SANDY SOILS. IT WILL BE UP TO THE GENERAL CONTRACTOR TO PROVIDE A SUITABLE S-C MIX DESIGN TO THE ENGINEER BASED ON HIS MOST ECONOMICAL BORROW SOURCE AND SOIL TYPE. FOR PURPOSES OF GENERATING A COST ESTIMATE, A CLAYEY BORROW SOIL WILL BE ASSUMED. S-C MIX DESIGN SHALL BE IN ACCORDANCE WITH PCA HANDBOOK. CONTRACTOR TESTING REQUIREMENTS WILL BE DEVELOPED DURING FINAL DESIGN.

ESTIMATE CEMENT CONTENT

ASSUME BORROW MATERIAL IS LOW PLASTICITY SILTY (LEAN) CLAY
UNIFIED SOIL CLASSIFICATION : CL
ASSUME P200 > 50%, LL < 40% AND PI < 10%
AASHTO SOIL CLASSIFICATION : A-4

FROM TABLE 1 OF PCA HANDBOOK, PAGE 12:
USUAL RANGE IN CEMENT REQUIRED = 8 TO 12% BY VOLUME OR
7 TO 12% BY WEIGHT
SAY 10% CEMENT BY VOLUME

VOLUME

REFERENCE PRECEDING VOLUME SUMMARY : $V = 13,250\ YD^3$ (S-C MIX)

5. CONTINUED

COMPRESSIVE STRENGTH

THE COMPRESSIVE STRENGTH OF THE S-C LAYER IS AN IMPORTANT CHARACTERISTIC TO BE CONSIDERED IN THE DESIGN OF THE CONCRETE WALLS SEPARATING THE VARIOUS CELLS. REFER TO ITEM D. UNDER SITE CONSTRUCTION, DIVIDER WALL DESIGN.

THE DIVIDER WALLS WILL BE ESTABLISHED ON TOP OF THE UPPER CLAY LAYER OF THE LINER SYSTEM. THE EMBEDMENT DEPTH WILL CONSIST OF THE 6 IN. THICK S-C LAYER. THE S-C COMPRESSIVE STRENGTH WILL RESIST LATERAL PRESSURES AS DISCUSSED IN THE DIVIDER WALL DESIGN.

THE ACTUAL S-C MIX DESIGN AND COMPRESSIVE STRENGTH WILL NOT BE KNOWN UNTIL A SOIL BORROW SOURCE HAS BEEN IDENTIFIED BY THE CONTRACTOR AND THE APPROPRIATE LAB TESTS ARE PERFORMED. FOR NOW, A COMPRESSIVE STRENGTH WILL BE ESTIMATED. FROM PAGE 31 OF THE PCA HANDBOOK, " THE 7-DAY COMPRESSIVE STRENGTH OF SATURATED SPECIMENS THAT REPRESENT A DURABLE SOIL-CEMENT BASE VARIES WITH THE PHYSICAL AND CHEMICAL PROPERTIES OF THE SOIL AND WILL GENERALLY BE BETWEEN 300 AND 800 psi."

FOR PRELIMINARY CALCULATIONS, ASSUME 300 psi AS CONSERVATIVE. A MINIMUM COMPRESSIVE STRENGTH WILL BE SPECIFIED DURING FINAL DESIGN.

OTHER PHYSICAL PROPERTIES

SOIL-CEMENT DURABILITY IS MEASURED BY FREEZE-THAW AND WET-DRY TESTS DESCRIBED IN THE PCA HANDBOOK.

PERMEABILITY IS NOT A CRITICAL PROPERTY SINCE THE CLAY LAYER WILL CONTAIN THE WASTES. THE PERMEABILITY IS ANTICIPATED TO BE A FUNCTION OF THE SOIL PERMEABILITY. SINCE CLAY HAS BEEN ASSUMED, K MAY BE ON THE ORDER OF 1×10^{-5} cm/sec TO 1×10^{-7} cm/sec.

5. CONTINUED

ALTERNATIVE CONSIDERATIONS

A CONCEPT FOR UTILIZATION OF A PROTECTIVE COVER OTHER THAN SOIL-CEMENT THAT WILL BE EVALUATED DURING FINAL DESIGN INCLUDES THE USE OF A FLYASH-LIME MIXTURE. IT IS ASSUMED THAT FLYASH IS READILY AVAILABLE AT LITTLE OR NO COST FROM THE COM ED POWER PLANT LOCATED JUST NORTH OF THE OMC PLANT NO. 2. FLYASH WHEN MIXED WITH SMALL PERCENTAGES OF LIME WILL INITIATE A POZZOLANIC REACTION RESULTING IN A HARDENED MIX WITH PHYSICAL CHARACTERISTICS SIMILAR TO LOW STRENGTH CONCRETE. A FLYASH-LIME MIXTURE MAY BE MORE ECONOMICAL THAN A SOIL-CEMENT MIXTURE FOR THE PROTECTIVE COVER. THE ONLY POTENTIAL COST IS TRANSPORTING THE FLYASH AND PURCHASING THE LIME. ENVIRONMENTAL CONCERNS ASSOCIATED WITH THE DISPOSAL OF FLYASH SHOULD NOT BE A PROBLEM FOR THIS APPLICATION. THE FLYASH-LIME MIXTURE WOULD BE PLACED AS THE TOP LAYER OF A 3 LAYER LINER CONSISTING OF 1 FT. OF CLAY, 1 FT. OF SAND WITH LEACHATE COLLECTION LINES AND ANOTHER 1 FT. OF CLAY. LEACHATE, IF IT PASSED THROUGH THE FLYASH AND CLAY LAYER, WILL BE COLLECTED IN THE LEACHATE COLLECTION SYSTEM. AFTER THE CURING CELLS ARE NO LONGER NEEDED, THE FLYASH-LIME PROTECTIVE LAYER WOULD BE DISPOSED IN THE PARKING LOT CONTAINMENT CELL.

ANOTHER POSSIBILITY FOR A PROTECTIVE COVER IS A LAYER OF GRAVEL OR OTHER GRANULAR MATERIAL OF SUFFICIENT THICKNESS TO AVOID DAMAGE OF THE UNDERLYING CLAY LINER. IT IS ANTICIPATED THE SOLIDS WILL BE REMOVED FROM THE LAGOONS IN LAYERS. SINCE THE BOTTOM LAYER WILL ONLY BE REMOVED ONCE, THE PROTECTIVE COVER SHOULD ONLY BE SUBJECT TO POTENTIAL DAMAGE ONCE. IF A LAYER OF SAND OR GRAVEL (POSSIBLY 6 TO 18 INCHES THICK) IS MORE ECONOMICAL THAN SOIL-CEMENT OR FLYASH-LIME, IT MAY BE USED PROVIDED THERE ARE NO TECHNICAL REASONS WHY IT SHOULDN'T BE USED.

ALL 3 ALTERNATIVES WILL BE FURTHER EVALUATED DURING FINAL DESIGN.

VII. LAGOONS

6 MANHOLES AND FLOW ROUTING

THE 4" COLLECTION PIPE WILL BE CONNECTED INTO AN 8" DIAMETER, NON-PERFORATED PVC PIPE. THE 8" INTERCEPTOR WILL PENETRATE THE BASE CLAY LINER WITH THE USE OF AN ANTI-SEEP COLLAR TO PREVENT LEAKAGE OF THE CLAY BASE LINER AT THAT POINT. THE INTERCEPTOR PIPES WILL BE ROUTED TO A MANHOLE WHICH IS ADJACENT TO THE WATER TREATMENT PLANT.

APPROXIMATELY 2000 LINEAL FEET OF 8" PIPE IS REQUIRED.
5 MANHOLES WILL ALSO BE NEEDED TO PROVIDE INTERCEPT AND CONNECTION POINTS.

VII LAGOONS

7. LINER ALTERNATE

AN OPTION TO THE LINER SYSTEM PRESENTED, AS APART OF THE CONCEPTUAL DESIGN REPORT, AN ADDITIONAL LINER SYSTEM IS BEING EVALUATED.

THE ALTERNATE SYSTEM WOULD CONSIST OF A BASE LAYER OF (HDPE) HIGH DENSITY POLYETHELENE, A LAYER OF HDPE GRID FOR INTERMEDIATE DRAINAGE, AND A FINAL LAYER OF (HDPE). AN ADDITIONAL THICKNESS OF PROTECTIVE/SUPPORT MATERIAL MAY BE REQUIRED IN SOME AREAS. TO PRESERVE THE INTEGRITY OF THE THE TOP LINER.

ADVANTAGES AS COMPARED TO THE CLAY LINER SYSTEM INCLUDE THE FOLLOWING:

1. INCREASED CONTROL OF PLACEMENT.
2. ISOLATION OF POTENTIAL LEAKAGE. (SEAL SECTIONS)
3. MORE SECURE BONDING TO PIPING SYSTEM.
4. COST OF MATERIALS AND PLACEMENT
5. SUBSTANTIAL VOLUME AND COST REDUCTION FOR REMOVAL OF CONTAMINATED LINER DISPOSAL (3 FEET REDUCE TO < 6")
6. POSITIVE/VERIFIABLE SEAL BETWEEN SHEET SEAMS
7. ELIMINATION OF PIPING REQUIREMENTS BETWEEN LINERS
8. SUBSTANTIAL TIME SAVINGS FOR LINER CONSTRUCTION AND REMOVAL

THIS SYSTEM WILL BE FURTHER EVALUATED DURING FINAL DESIGN.

III LAGOONS

E. INFLOW PROCEEDURES - DREDGE PIPE ROUTING.
THE DREDGE PIPE WILL BE ROUTED ALONG THE INSIDE EDGE OF THE DIKE. IF ANY SPILLAGE OCCURS ALONG THE PIPE ROUTE, IT CAN BE ISOLATE AND DRAINED TO THE LAGOONS.

AT THE DISCHARGE POINT, THE LINER WILL BE PROTECTED FROM EROSION BY A 20' DIAMETER RIPRAP PAD. ONCE THE FLUID LEVEL COVERS THE DISCHARG AREA EROSION OF THE LINER SYSTEM WILL NO LONGER BE A PROBLEM FROM THE DREDGE DISCHARGE

REFER TO THE DREDGE SECTION OF THE DESIGN ANALYSIS FOR ADDITIONAL PIPING INFORMATION

A SECTION THE DIKE BETWEEN LAGOONS 1 AND 2 WILL BE CONSTRUCTED APPROXIMATELY 0.5' LOWER THAN THE REMAINING DIKE AND WILL BE PROTECTED WITH RIP RAP. THIS SECTION WILL SERVE AS AN EMERGENCY SPILLWAY/WEIR IN THE EVENT EITHER LAGOON 1 OR LAGOON 2 ARE FILLED ABOVE THE DESIGN DEPTH.

VII. LAGOONS

F. OUT FLOW STRUCTURES — DECANT SYSTEM AND SURFACE WATER DRAINS.

THE CURING CELL AREA AND THE FIXATION AREA WILL REQUIRE SURFACE DRAINAGE PROVISIONS WHICH WILL DISCHARGE INTO THE DECANT FLOWSYSTEM. SURFACE DRAINAGE PROVISIONS WILL BE ANALIZED DURING FINAL DESIGN.

THE DECANT SYSTEM WILL INCLUDE 2 WITHDRAWAL POINTS IN LAGOON 2 AND 1 WITHDRAWAL POINT IN LAGOON 1. REFER TO SHEET NO 205.

THE DECANT STRUCTURES WILL PROVIDE A METHOD OF DRAWING WATER OFF THE SURFACE OF THE DREDGED FLUIDS. THE STRUCTURE WILL BE CONTROLLED WITH VALVES AND MAY HAVE A FLOATING INLET TO DRAW WATER OFF THE THE SURFACE. VALVES CAN BE THROTTLED TO CONTROL THE RATE TO THE TREATMENT PLANT. THE DECANT STRUCTURES ARE LOCATED AT THE OPPOSITE CORNERS FROM THE DREDGE STATIONS. AS MATERIAL IS DRAG-LINED TO THE STATION, THE REMAINING FLUID WILL FLOW TO THE OPPOSITE CORNERS FOR DECANTING.

APPROXIMATELY 1540 LINEAL FEET OF 12" I.D. NON-PERFORATED PVC PIPE WILL BE REQUIRED FOR ROUTING TO THE TREATMENT PLANT. 4 MANHOLES ARE REQUIRED FOR PIPE CONNECTIONS. THE UNDERDRAIN SYSTEM AND THE DECANT SYSTEM WILL BE SEPARATE TO AVOID CROSS CONTAMINATION OF THE UNDER DRAIN SYSTEM.

ADDITIONAL DESIGN DETAILS WILL BE DEVELOPED IN THE FINAL DESIGN.

SITE RESTORATION

WARZYN
ENGINEERING INC

SITE RESTORATION

VII LAGOONS

A. UTILITY REMOVAL

THE FOLLOWING PIPING SYSTEM FOR LAGOON/CELLS DECANTING AND SURFACE WATER REMOVAL IS ASSUMED TO BE CONTAMINATED AND MUST BE PROCESSED THROUGH THE DECONTAMINATION FACILITY, PRIOR TO LEAVING THE SITE, OR SHOULD BE PLACED IN THE PARKING LOT CONTAINMENT CELL.

2 SURFACE DRAINAGE SUMP PUMPS AND ASSOCIATED PIPE

2 DECANT STRUCTURES AND ASSOCIATED PIPING

4 MANHOLES

12" DIAMETER PVC PIPING - 1590 LINEAL FT.

8" DIAMETER DREDGE DISCHARGE LINES 1250 LINEAL FT.

UTILITY PIPING ASSOCIATED WITH THE UNDERDRAIN SYSTEM TO BE REMOVED AND SHOULD NOT BE CONTAMINATED INCLUDES THE FOLLOWING:

5 MANHOLES

4" DIAMETER PVC PIPE - 5800 LINEAL FT.

8" DIAMETER PVC PIPE - 2000 LINEAL FT.

IF THE PIPING SYSTEM EXHIBITS EVIDENCE OF CONTAMINATION, THE MATERIALS WILL EITHER BE DECONTAMINATED OR PLACED IN THE PARKING LOT CONTAINMENT CELL

SITE RESTORATION

VII LAGOONS

B. CONTAMINATED MATERIAL REMOVAL

1. SOIL CEMENT

THE TOTAL VOLUME OF SOIL CEMENT/GRAVEL (6") TO BE REMOVED AND PLACED IN THE PARKING LOT CONTAINMENT CELL IS APPROXIMATELY 10,474 CY.

2. CLAY LINER

THE TOTAL VOLUME OF TOP CLAY LINER (1') TO BE REMOVED AND PLACED IN THE PARKING LOT CONTAINMENT CELL IS APPROXIMATELY 20,966 CY.

IN ADDITION, APPROXIMATELY 1000 CY OF CONTAMINATED PAVING IN THE WATER TREATMENT PLANT AND STAGING AREAS WILL BE REMOVED AND PLACED IN THE CONTAINMENT CELL.

3. CONTINGENCY

IF THE TOP CLAY LINER HAS LEAKED CONTAMINATED FLUID INTO THE UNDER DRAIN SYSTEM AND THE SECONDARY LINER, 20,966 CY OF GRANULAR MATERIAL AND 20,966 CY OF ADDITIONAL CLAY MUST BE PLACED IN THE PARKING LOT CONTAINMENT CELL.

ALTERNATIVELY, IF THE UNDER DRAIN SYSTEM IS NOT CONTAMINATED, THE MATERIAL MUST STILL BE REMOVED FROM THE TREATMENT AREA BEFORE FINAL GRADING.

VII. Lagoons

Site Restoration

C. Decontamination of Equipment and Station Removal

The soil-cement, inner clay liner and clay divider dike within the lagoons will be considered contaminated and will be disposed of in the parking lot area. Soil removal equipment, site restoration vehicles and all associated equipment will be decontaminated at the lagoon area decontamination station prior to leaving the site. All equipment and structures associated with the decontamination station will be removed and properly disposed of by the contractor.

MABS/BM4

VI. LAGOONS SITE RESTORATION

D. FINAL GRADING

FINAL GRADING REQUIREMENTS FOR THE LAGOON AREA ARE DISCUSSED IN THE SITE RESTORATION SECTION OF THE WATER TREATMENT PLANT.

E. STRUCTURE REMOVAL

STRUCTURE REMOVAL IN THE LAGOON AREA IS DISCUSSED IN THE SITE RESTORATION OF THE WATER TREATMENT PLANT.

VII. LAGOONS

SITE RESTORATION

F. ABANDON MONITORING WELLS

FOLLOWING REMOVAL OF THE LAGOONS AND ASSOCIATED FACILITIES, THE TEMPORARY GROUNDWATER MONITORING WELLS WILL BE ABANDONED. ABANDONMENT PROCEDURES WILL BE AS FOLLOWS:

1) ANY EXISTING STEEL CASING SHALL FIRST BE REMOVED BY VERTICALLY PULLING IT OFF THE EXISTING MONITORING LOCATION.
2) THE STEEL OR PVC WELL CASING SHALL THEN BE OVERDRILLED WITH HOLLOWSTEM AUGERS TO BE ADVANCED PAST THE BOTTOM OF THE EXISTING MONITORING WELL TO THE MAXIMUM DEPTH OF THE PREVIOUSLY DRILLED TEST BORING.
3) THE MONITORING WELL PIPE SHALL THEN BE EXTRACTED, IF POSSIBLE, FROM THE HOLLOW STEM AUGER AND THE INTERIOR OF THE AUGERS SHALL BE CLEANED OF DRILLING DEBRIS BY ADVANCING THE CENTRAL CORING PLUG THROUGH THE HOLLOW STEM AUGERS TO THE MAXIMUM DEPTH THAT THE AUGERS HAVE BEEN EXTENDED.

ROTARY WASH BORING USING HSA AS CASING

4) AS THE HOLLOW STEM AUGERS ARE EXTRACTED IN 5-FOOT INCREMENTS, THE RESULTING BOREHOLE SHALL BE GROUTED WITH CEMENT/BENTONITE GROUT.
5) AFTER 24 HOURS, THE CEMENT/BENTONITE GROUT SHALL BE "RETOPPED", IF NECESSARY, TO COMPLETELY FILL THE BOREHOLE TO THE EXISTING GROUND SURFACE.
6) THE REMOVED PROTECTIVE CASING AND WELL PIPE CAN BE SALVAGED, IF DESIRED, BY PROPER DECONTAMINATION PROCEDURES OR BE DISPOSED OF IN THE PARKING LOT CONTAINMENT CELL.

SITE OPERATIONS/MAINTENANCE

WARZYN
ENGINEERING INC

WARZYN ENGINEERING, INC.
MADISON WISCONSIN

BY DJD DATE 3-6-85 SUBJECT DMC DESIGN ANALYSIS SHEET NO. 1 OF 1
CHKD BY TLL DATE 3-7-85 CONCEPT SUBMITTAL JOB NO. 11937

SITE OPERATIONS AND MAINTENANCE

A. LAGOON 1

1. MATERIAL PLACEMENT

THE DREDGED MATERIAL DISCHARGE PIPE IS LOCATED AT THE NORTH EAST CORNER OF LAGOON 1. THE DECANT STRUCTURE IS LOCATED IN THE SOUTH WEST CORNER TO PREVENT SHORT CIRCUITING OF THE DREDGED SOLIDS.

THE END OF THE PIPE WILL DISCHARGE ON A 20' DIAMETER RIP-RAP PAD TO PREVENT EROSION OF THE LINER SYSTEM.

ONCE A FLUID LEVEL OF > 1' IS ESTABLISHED, THE LOCATION OF THE DISCHARGE PIPE CAN BE ALTERED TO PREVENT BUILD UP OF COARSE DREDGED SOLIDS.

B. LAGOON 2

1 MATERIAL PLACEMENT

THE DREDGED MATERIAL DISCHARGE PIPE IS LOCATED IN THE CENTER OF THE WESTERN DIKE. THIS LOCATION IS APPROXIMATELY MIDWAY BETWEEN THE TWO DECANT LOCATIONS IN THE NORTHEAST AND SOUTH WEST CORNERS OF THE LAGOON. SIMILAR TO LAGOON 1, A RIP RAP PAD WILL BE PROVIDED TO PREVENT EROSION OF THE LINER SYSTEM.

ONCE A MINIMUM FLUID LEVEL IS ACHIEVED, THE DISCHARGE PIPE CAN BE RELOCATED AS COARSE DREDGED SOLIDS SETTLE AT THE PIPE DISCHARGE POINT.

Operations and Maintenance Provisions

VII. Lagoons

A. Lagoon 1

2. Volatilization Control

The dredging in Lagoon No. 1 should develop a surface layer of clarified water. This water will be decanted and treated in the Water Treatment Plant. When the decanting is complete and the solids in the lagoon are at the surface (exposed to atmosphere), volatilization of the PCB's must be controlled. At this time a stabilized municipal sludge will be discharged onto the surface of Lagoon No. 1 to cover the exposed dredging and thereby minimize exposure of the PCB solids to the atmosphere. This cover material should remain intact during the solid removal operations. The volatilization control cover material will ultimately be fixed and disposed of similar to the dredged material.

3. Dredging Removal

Material will be removed from Lagoon No. 1 with either a dragline dredge or a submersible solids handling pump. The removal method will depend on the solids content of the material (liquid or solid).

If the material is relatively solid and "stackable," the dragline will excavate the material from the lagoon and pile it up on the southeast corner of the Lagoon No. 1 berm. A front end loader will load the dredging into trucks. The trucks will transport the dredging to the batch plant.

If the material is relatively liquid a submersible, manure type pump will remove the solids from the lagoon. The submersible pump can pump the solids directly to the batch plant or discharge the solids into Redimix trucks for transport to the batch plant.

4. Transport to the Batch Plant

Transport of material from Lagoon No. 1 to the batch plant will depend on the solids content of the material. The facility will be designed to permit flexibility in removal, transport, and fixing of this material.

B. Lagoon 2

2. Sediment Drainage Channeling

The dredged material in Lagoon 2 will be dewatered within the lagoon by decanting and evaporation. After initial decanting the solids within the lagoon will be at the lagoon surface. Two dragline dredges will be used to produce drainage channels in the surface of the lagoon. The techniques used for dewatering of the lagoon material will be as defined in the Army COE Engineering and Design Guidelines for Dewatering/ Densifying Confined Dredged Material. The decant water will be collected at multiple lagoon decant structures. The decant water will be treated in the Water Treatment Plant.

3. Dragline Excavation

The dewatered dredging in Lagoon 2 will be removed by two draglines. Due to the long dragline reach required by the lagoon size and configuration, a Sauerman dragline will be used. This type of dragline includes a crane with boom support located at each dragline station, and tractor or bulldozer on the opposite berm for a tail anchor.

The dewatered dredging will be removed from the lagoon in approximately one foot increments. When the top one foot of the lagoon surface is adequately dewatered, it will be removed. The new exposed lagoon surface will be dewatered as discussed previously. When this material is adequately dewatered to a depth of one foot, it will be removed.

This procedure will continue until all the material within Lagoon 2 has been dewatered and removed.

Each dragline will work radially from its dragline station, creating dewatering channels and then removing the dewatered dredging in one foot increments. The dewatered dredging will be stacked at the dragline station. A front end loader will load the dewatered dredging into trucks for disposal in the parking lot containment cell.

4. Transport to Containment Area.

Trucks will be loaded with dewatered dredging from Lagoon 2, at each dragline station. The lined trucks will then be covered (if required) and proceed through the decontamination station and the security control station.

All documents, permits, manifests, etc. would be processed by the contractor prior to leaving the site. The trucks would proceed to the parking lot containment area, where they would discharge their load. The trucks would proceed through the parking lot decontamination station and security control station prior to returning to Lagoon 2.

MABS/BL7

Operations and Maintenance Provisions

VII. Lagoons

C. Decontamination of Vehicles

All vehicles, equipment, and personnel that come into contact with PCB contaminated materials will require decontamination prior to leaving the site. In general, the decontamination procedures for vehicles and equipment will consist of:

1. Water and detergent wash with scrubbing to remove all sediments from the equipment. Only as much water as necessary should be used, and care must be taken to keep splashing to a minimum.

2. Water rinse.

3. Collect washing and rinse fluids and dispose of properly by discharge to Lagoon 2.

This procedure should provide sufficient decontamination for equipment exiting the site. To ensure that sufficient cleanup has taken place periodic wipe tests should be conducted using the following procedures:

1. Apply an appropriate solvent (hexane), to a piece of 11 cm filter paper (eg. Whatman 40 ashless, or Whatman "50" smear tabs or similar).

2. The moistened filter paper, held with a pair of stainless steel forceps, is used to thoroughly swab a 100 cm^2 area, measured using a sampling template.

3. The filter paper swab is then placed in a precleaned glass jar and stored at 4°C for analysis for PCB's.

Quality assurance must be applied throughout the entire monitoring program. Blank swab samples and spiked samples will be needed to insure the accuracy of the test results.

MABS/BN1

00086

CONCEPT DESIGN
CONCEPT DESIGN ANALYSIS
VOLUME II OF II
HAZARDOUS WASTE CONTAINMENT/CLEANUP
OMC - WAUKEGAN HARBOR
WAUKEGAN, ILLINOIS

Contract No. DACW 45-85-C-0023

Prepared By:

Warzyn Engineering Inc.
Madison, Wisconsin

For:

U.S. Army District
Omaha Corps of Engineers
Omaha, Nebraska

March, 1985

C 11837

WARZYN
ENGINEERING INC

VOLUME 2 - Design Analysis

Design Requirements and Provisions (Part 2)

VIII Crescent Ditch/Oval Lagoon Containment

IX East-West Portion of North Ditch and Bypass

X Parking Lot Containment Cell

WARZYN
ENGINEERING INC

VIII CRESCENT DITCH/ OVAL LAGOON CONTAINMENT

WARZYN
ENGINEERING INC

SITE PREPARATION

WARZYN

SITE PREPARATION

VIII CRES DITCH/OVAL LAGOON - This material encompasses the area within the slurry wall as depicted on Drawing Sheet Nos. 326-329.

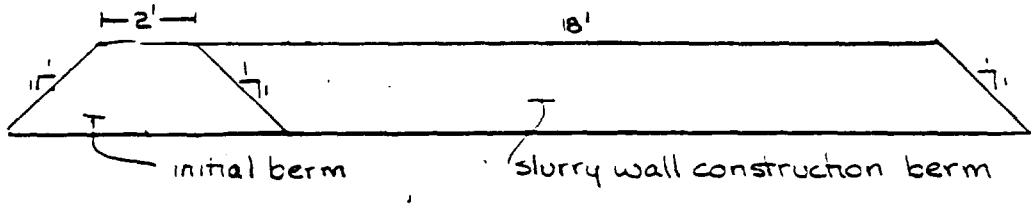
A. REMOVAL OF EXISTING SITE FEATURES

1. Pavement Removal, Breakage and Clear/Grub
Pavement area is 62,759 sf of which 13,400 sf will be removed and the remaining broken up. See Appendix F for generation of these areas. Refer to Drawing No. 326
Area to be cleared/grubbed = 144,777 - 62759 = 82,018 sf

2. Railroad. Sheet No. 326
Approximately 340' of railroad is to be removed. Ties are to be salvaged if possible. If not salvagable, ties along with ballast shall be disposed of in containment cell.

B INITIAL GRADING.
For calculation of Area, see Appendix F. Area is 144,777 sf

1 Berms
Two berms have been designed: the initial berm and slurry wall construction berm. Section is as shown:



The initial berm was designed as a containment berm during excavation activities. The 18' wide construction berm is necessary for construction of the 3' wide slurry wall to accommodate the construction equipment

Volumes - initial berm
area = 8 ft² length = 1855 ft volume = 550 cy

Slurry wall construction berm addition to alcove
area = 32 ft² length = 1855 ft volume = 2,200 cy

Total berm material = 2,750 cy

Prior to construction of the slurry wall construction berm, some material will be excavated

The volume to be excavated is:

- 1,292 cy can be used as fill after excavation in the containment area to bring grades up to final. As stated in Site Restoration, an additional 1,200 cy will be needed.

- 63 cy will be excavated beneath RR.

For calculations of these volumes, see Appendix K.

2. Drainage

The initial containment berm will contain any water from leaving the site. Any water within the cell area will be considered contaminated and will be pumped to the treatment plant. Therefore, piping, sump areas and a pump will be needed and will be addressed in the final design.

SITE PREPARATION

VIII CRES. DITCH/OVAL LAGOON

C. UTILITIES - ADDITION & MODIFICATIONS

1. Electrical - Drawings No. 328 and 331
Some electrical utilities will have to be removed, relocated, abandoned and/or new lines installed. These actions with quantities are as follows:

Underground Electrical
- Cut and Remove 20' of 7 #12, 3 #8, 9 #12, 3 #8
This is will be done so that slurry wall around the containment cell may be constructed.
- 920' of UG electrical will be installed.

Overhead Electrical
- 820' of OH 12KV Transmission lines will be removed & relocated around the containment cell
- 220' of new line will be installed.

Items to be removed and relocated
- 5 power poles
- 1 250 watt Merc. Vapor lamp
- 1 junction box

- 1 120V 1Q-1 Pump removed & not relocated

2. Water - Drawings No. 327 and 330

Two water lines (12") will be disconnected and plugged and 20' of the line will be removed for slurry wall construction. This 12" line is an already abandoned segment.

3. Sanitary Sewer - Drawing No. 327 and 330

Lines

Sanitary sewer lines will be disconnected and lines plugged in 17 locations, and abandoned inside the containment cell.
Approximately 80' will be removed for slurry wall construction

Approximately 470' of 14" sewer will be installed and 250' of 10" sewer will be installed around the containment cell

The 14" and 10" sewers will be connected to Manholes.

Manholes

Three manholes will be abandoned. Lids will be removed and manholes will be backfilled with clean materials. Assuming manholes are 4'ϕ and 5' deep, material volume = 3 × 62.83 cf = 188.5 cf = 7 cy

Two new sanitary manholes will be installed.

4. Storm

Lines

Storm lines will be disconnected and plugged in 12 locations. All lines in the containment area will be abandoned.

Approximately 100' will be removed: 40' of 30" H.S. DIP, 40' of 12", 20' of 6" VIT Tile for slurry wall construction

660' of new storm sewer will be installed

4 Storm

Culverts

Two 30"×60" culverts will be plugged and abandoned within the containment cell.

Two 27"×43" CMP culverts will be installed.

Catch Basins, Junction Box, Manholes

1 junction box will be abandoned. The lid will be removed and box will be backfilled with clean material.

4 storm sewer catch basins will be installed.

D. FENCING

Approximately 600' of existing fence line is to be removed as will 1 gate. See Sheet No. 326 for locations.

Approximately 1590' of security fencing and 3 gates will be installed. See Sheet No. 326.

VIII. CRESCENT DITCH/ OVAL LAGOON CONTAINMENT CELL

SITE PREPARATION

E. DEWATERING FOR UTILITY MODIFICATIONS

DEWATERING, IF NECESSARY, FOR UTILITY MODIFICATIONS WILL BE DESIGNED AND OPERATED BY THE CONTRACTOR BASED ON EACH PARTICULAR NEED. THE EXISTING UTILITIES ARE RELATIVELY SHALLOW AND DEWATERING, IF NECESSARY DURING ABANDONMENT, IS ANTICIPATED TO BE FEASIBLE WITH CONVENTIONAL FILTERED SUMPS PROVIDED THE EXCAVATIONS DO NOT EXTEND MORE THAN 1 TO 3 FEET BELOW THE GROUNDWATER TABLE. THE SAME APPLIES FOR UTILITY RELOCATION. DISCHARGE OF DEWATERING SHOULD BE ROUTED TO THE 200 GPM WATER TREATMENT PLANT IN THIS AREA. ...

IF EXCAVATIONS FOR UTILITY ABANDONMENT AND RELOCATION EXTEND MORE THAN 1 TO 3 FT. BELOW THE GROUNDWATER TABLE, ALTERNATIVE DEWATERING METHODS, SUCH AS A WELLPOINT SYSTEM, MAY BE NECESSARY.

THE NEED FOR DEWATERING AND THE APPLICABLE METHOD CANNOT BE EVALUATED BASED ON OUR CURRENT INFORMATION. THE GENERAL CONTRACTOR OR PRIVATE UTILITIES WILL BE EXPECTED TO PROVIDE DEWATERING AS NEEDED AND IN CONFORMANCE WITH THE PROJECT SPECIFICATIONS.

COST ESTIMATES FOR CONCEPTUAL DESIGN (30% REVIEW) WILL NOT INCLUDE ANY COSTS ASSOCIATED WITH POTENTIAL DEWATERING FOR UTILITY MODIFICATION.

VII. CRESCENT DITCH / OVAL LAGOON CONTAINMENT CELL

SITE PREPARATION

F. INSTALL GROUNDWATER MONITORING WELLS (OUTSIDE CELL)

BASED ON PAGE 2-28 OF THE CH2M HILL CONCEPTUAL DESIGN REPORT, A TOTAL OF 22 GROUNDWATER MONITORING WELLS WERE SPECIFIED FOR THE CRESCENT DITCH / OVAL LAGOON AND PARKING LOT CONTAINMENT CELLS. IT IS PROPOSED TO INSTALL TEN MONITORING WELLS NESTED AT 5 LOCATIONS AT THE CD/OL CELL. SIMILARLY, 10 WELLS AT 5 LOCATIONS ARE PROPOSED AT THE PARKING LOT. THE WELLS WILL BE OUTSIDE THE SLURRY WALLS. AS DISCUSSED UNDER SITE CONSTRUCTION FOR BOTH THE CD/OL AND PARKING LOT CONTAINMENT CELLS, GROUNDWATER WITHDRAWAL WELLS WILL BE INSTALLED INSIDE THE CELLS DURING CAPPING TO MONITOR FLUID LEVELS INSIDE THE CELL.

THE PURPOSE OF THE MONITORING WELLS OUTSIDE THE CONTAINMENT CELL IS TO ALLOW THE COLLECTION OF WATER SAMPLES TO DETERMINE WHETHER PCB'S ARE MIGRATING FROM THE CELL. SAMPLING WILL BE PERFORMED IN ACCORDANCE WITH THE SSQMP.

1. LOCATIONS

BASED ON THE LAYOUT OF THE CONTAINMENT CELL, WELL LOCATIONS WERE CHOSEN AS INDICATED ON THE "CONSTRUCTION GRADES" DRAWING. THE WELL AT THE SOUTH SIDE OF THE CELL NEAR THE WATER TANK AND OIL TANK WILL BE USED TO MONITOR WATER LEVEL DURING EXCAVATION AND DEWATERING OF THE CRESCENT DITCH.

2. DETAILS

TWO WELLS WILL MAKE UP A NEST FOR A TOTAL OF 5 NESTS. THE PURPOSE OF NESTS IS TO ALLOW WATER SAMPLING AT THE TOP AND AT A LOWER LEVEL WITHIN THE SAND AQUIFER. IT IS ANTICIPATED THE WELLS AT EACH NEST WILL BE ESTABLISHED AT DEPTHS OF 15 FT. AND 30 FT. (BOTTOM). OTHERWISE, THE DETAILS WILL BE SIMILAR TO

F. 2. CONTINUED

THOSE DISCUSSED UNDER VII. LAGOONS, SITE PREPARATION, E. GROUNDWATER MONITORING WELLS.

3. INSTALLATION

SEE VII. LAGOONS, SITE PREP, E. GW MONITORING WELLS

4. ESTIMATING

USE 5 WELLS AT 15 FT. AND 5 AT 30 FT. (BOTTOM)

G. ABANDON EXISTING WATER MONITORING WELLS

THE OMC SITE CONTAINS NUMEROUS EXISTING WELLS ESTABLISHED BY THE USEPA AND OMC DURING THE INVESTIGATIVE PHASE OF THE PCB CONTAMINATION PROBLEM. THE WELLS WITHIN THE PROPOSED CONTAINMENT CELL WILL REQUIRE ABANDONMENT DURING SITE PREPARATION. THE ABANDONMENT PROCEDURES WILL BE IN ACCORDANCE WITH THOSE OUTLINED UNDER VII. LAGOONS, SITE RESTORATION, F. ABANDON MONITORING WELLS.

SINCE SITE ACCESS HAS NOT BEEN PERMITTED TO DATE, IT ISN'T KNOWN HOW MANY WELLS ARE AFFECTED AND WILL REQUIRE ABANDONMENT. FOR ESTIMATING PURPOSES, ASSUME 6 WELLS ESTABLISHED TO A DEPTH OF 25 FEET.

H. AIR MONITORING STATIONS

REFER TO THE SITE SPECIFIC SAFETY PLAN AND APPROPRIATE DRAWINGS FOR AIR MONITORING.

SITE CONSTRUCTION

WARZYN
ENGINEERING INC

A.

ACTION NO. 3 - BRACED EXCAVATION DESIGN

1. The braced excavation design is an original design.

2. Design criteria references:

   a. USS Steel Sheet Piling Design Manual

   b. NavFac DM7

   c. Foundation Analysis & Design: Bowles

   d. AISC Steel Construction Manual - 8th Edition

3. Structural design loads and conditions

   a. Critical loading condition occurs during maximum drawdown of water level at the interior of the excavation.

   b. Assumptions:

      1) Finished grade elevation = 585

      2) Water elevation outside cofferdam = 582

      3) Water elevation inside cofferdam = 556

      4) Bottom of excavation elevation = 558; Allows for 1' over excavation.

      5) Excavation width is 13'

      6) Sheet pile penetrates 2' into hardpan

   c. Soil parameters - preliminary, subsurface investigation is not complete at this time.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAJ DATE 1-22-85 SUBJECT Action 3 - Braced Excavation Design OMC / Waukegan Harbor SHEET NO. 2 OF 33
CHKD. BY KAN DATE 2/6/85 JOB NO. 11237

c. Soil parameters continued.

$\phi_{SAND} = 35°$ $K_{a_{SAND}} = 0.248$; pg. 22 - Action 1 Cofferdam Design.

$\gamma_{SAND} = 120$ PCF

$K_{p_{SAND}} = 6.55$; pg. 22 - Action 1 Cofferdam Design

$\gamma_{SAND\ SUB.} = 58$ PCF

$\delta_{SAND} = 15°$

$\gamma_{SILT} = 135$ PCF $K_{a_{SILT}} = 1.0$

$\gamma_{SILT\ SUB.} = 73$ PCF $K_{p_{SILT}} = 1.0$

$C_{SILT} = 4000$ PSF

d. Seismic design considerations are not applicable for design of the braced excavation because of the location being one of low intensity and frequency and the fact that the structure is temporary in nature.

4. MATERIALS of CONSTRUCTION -

a. Steel walers, bracing, shapes and plates: ASTM A36 ; $F_y = 36^{KSI}$. The structural steel shapes will be used for bracing the walls of the cofferdam.

b. Steel Sheet Pile : ASTM A328 ; $F_y = 38.5^{KSI}$ The sheet pile will be used as the wall of the braced excavation.

5. DESCRIPTION of the STRUCTURAL SYSTEM

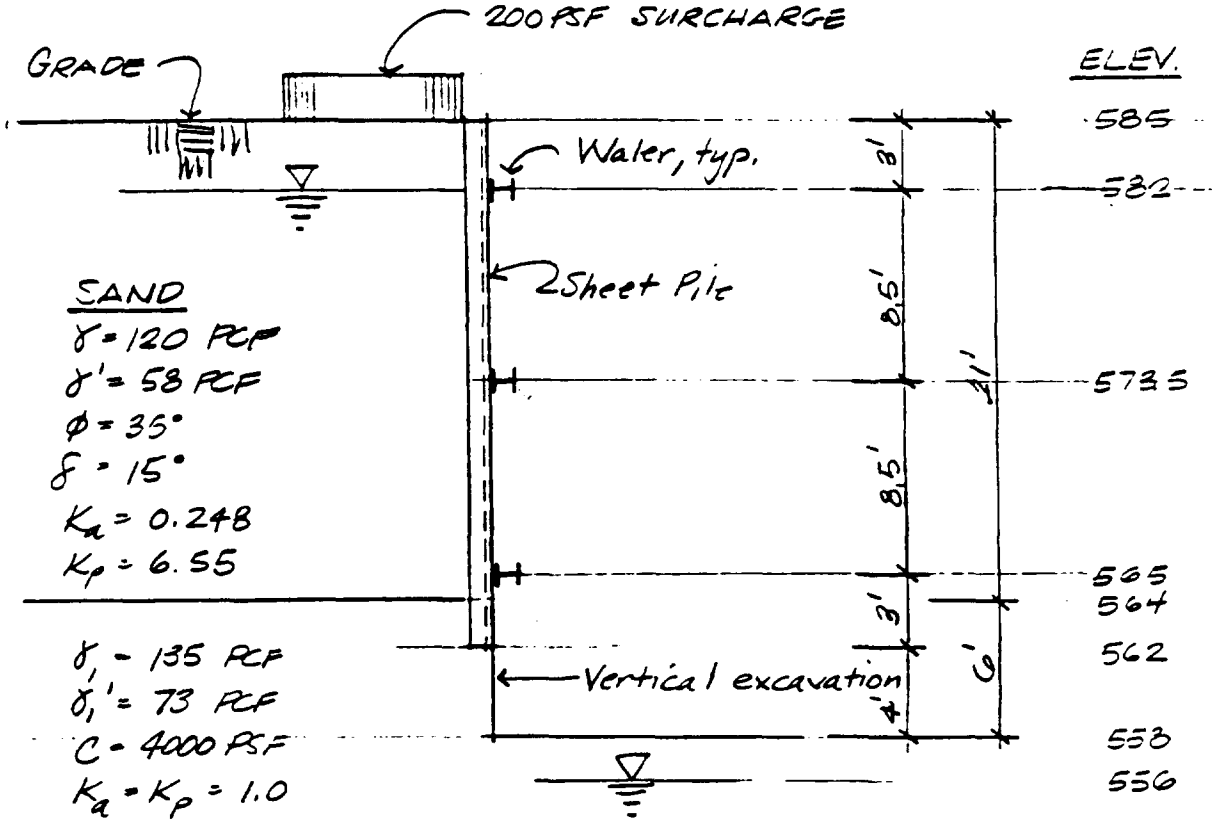
The braced excavation is comprised of steel sheet pile walls encompassing a rectangular portion of the crescent ditch approximately 13' wide, 275' long and 25' deep. Length is centered on boring B32.

6. There are no miscellaneous design features

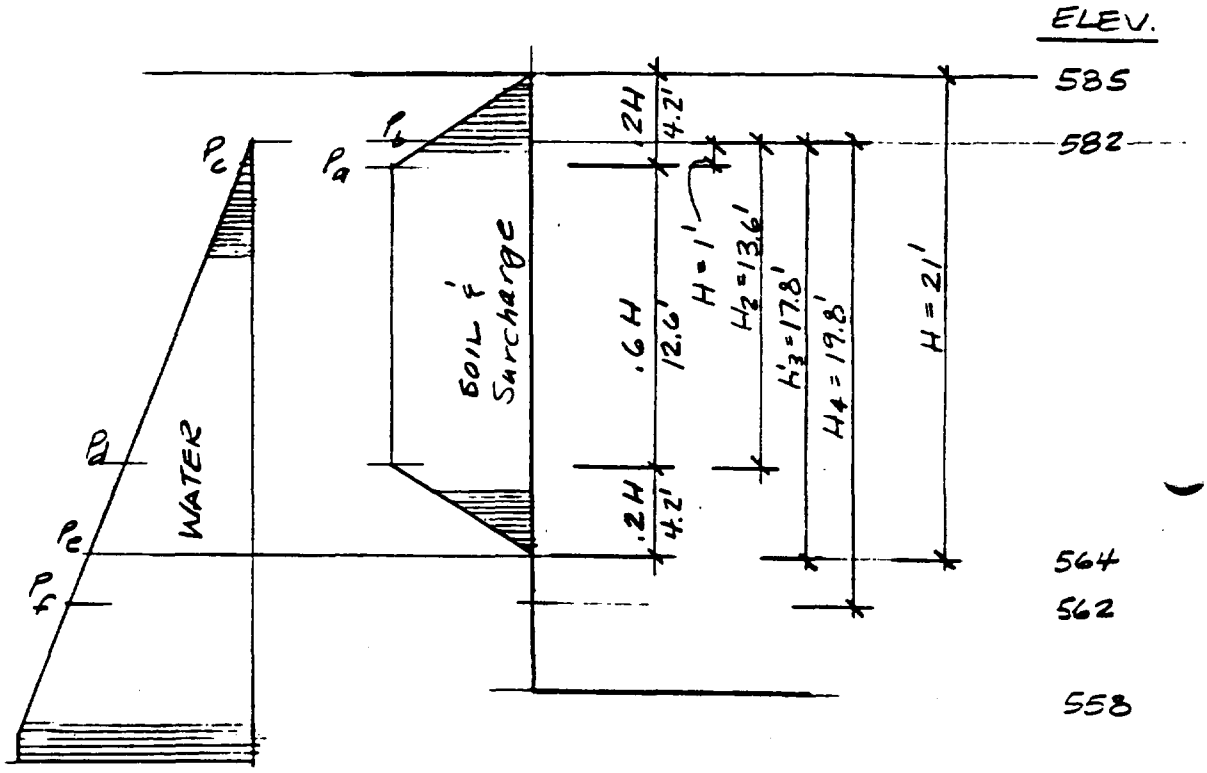
7. There is no site adaptation of a standard or existing design.

8. STRUCTURAL COMPUTATIONS -

Utilize the "Design of Cofferdams for Deep Excavations in USS Steel Sheet Pile Design Manual



Lateral Pressure Diagram



$P_a = 0.8 K_a \bar{\gamma}' \times H \times \cos\delta$

$\bar{\gamma}'$ = Effective Density = $\dfrac{S + \gamma \times 3 + \gamma' \times 18}{21}$

$= \dfrac{200 + 120 \times 3 \times 58 \times 18}{21}$

$= 76.4$ PCF

$\therefore P_a = 0.8 \times 0.248 \times 76.4 \times 21 \times \cos 15$

$= 307.5$ #/FT/FT

$P_b = \dfrac{3}{4.2} \times P_a = \dfrac{3}{4.2} \times 307.5 = 219.6$ #/FT/FT

$P_c = \gamma_w H_1 = 62.5 \times 1 = 62.5$ #/FT/FT ; $P_e = \gamma_w H_3 = 62.5 \times 17.8 = 1112.5$ #/FT/FT

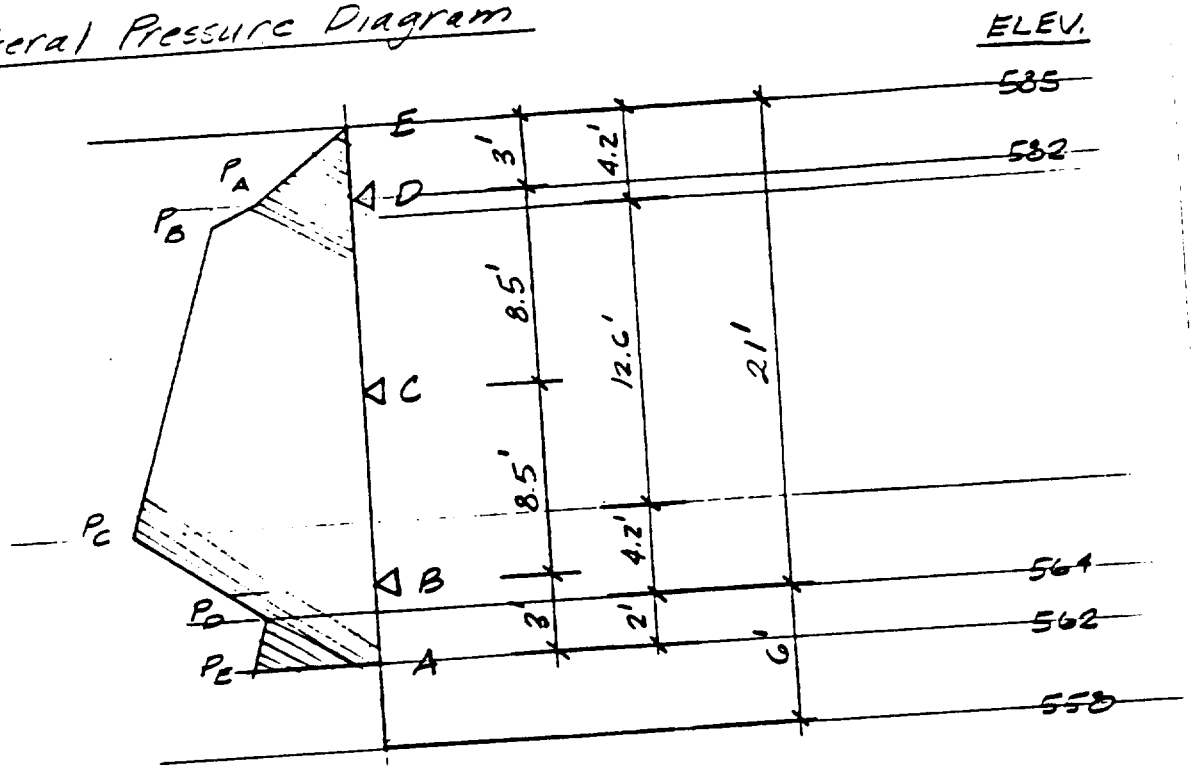
$P_d = \gamma_w H_2 = 62.5 \times 13.6 = 850$ #/FT/FT ; $P_f = \gamma_w H_4 = 62.5 \times 19.8 = 1237.5$

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAV DATE 1-23-85 SUBJECT ACTION 3 - BRACED EXCAVATION DESIGN OMC / MILWAUKEE HARBOR
CHKD. BY TJH DATE 2/6/85

SHEET NO. 5 OF 33
JOB NO. 11337

Final Lateral Pressure Diagram



$P_A = P_b = 219.6$ #/FT/FT

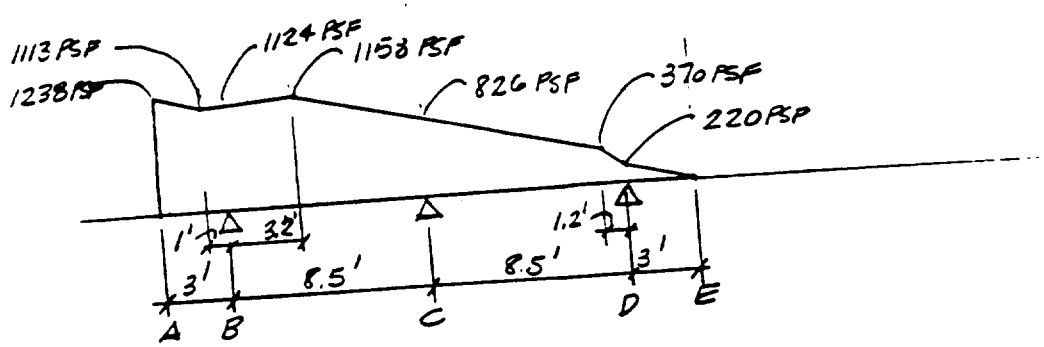
$P_B = P_a + P_c = 307.5 + 62.5 = 370$ #/FT/FT

$P_C = P_a + P_d = 307.5 + 850 = 1157.5$ #/FT/FT

$P_D = P_e = 1112.5$ #/FT/FT

$P_E = P_f = 1237.5$ #/FT/FT

Determine reactions at braced locations and moments in sheet pile wall using moment distribution.



FIXED END MOMENTS

$$FEM_{CA} = \frac{1113 \times 3^2}{2} + (1238 - 1113) \times 2 \times 1/2 \times (3 - 2/3) + (1124 - 1113) \times 1 \times 1/2 \times 1/3 = 5302'^{-\#}$$

$$FEM_{BC} = -\left(\frac{.353(6 - 8 \times .353 + 3 \times .353^2)}{12} \times 1124 \times 3 \times 8.5 + \frac{.647^2(4 - 3 \times .647)}{12} \times 826 \times 5.5 \times 8.5 + \frac{.853 \times (10 - 15 \times .353 + 6 \times .353^2)}{15} \times (1158 - 1124) \times 3 \times 1/2 \times 8.5 + \frac{.647^2(5 - 4 \times .647)}{10} (1158 - 826) \times 5.5 \times 1/2 \times 8.5\right)$$

$$= -6606'^{-\#}$$

$$FEM_{CB} = \frac{.647(6 - 8 \times .647 + 3 \times .647^2)}{12} \times 826 \times 5.5 \times 8.5 + \frac{.353^2(4 - 3 \times .353)}{12} \times 1124 \times 3 \times 8.5 + \frac{.647(10 - 15 \times .647 + 6 \times .647^2)}{15} (1158 - 826) \times 5.5 \times 1/2 \times 8.5 + \frac{.353^2(5 - 4 \times .353)}{10} (1158 - 1124) \times 3 \times 1/2 \times 8.5$$

$$= 6164'^{-\#}$$

$$FEM_{CD} = -\left[\frac{220 \times 8.5^2}{12} + \frac{.859(6 - 8 \times .859 + 3 \times .859^2)}{12} \times 7.3 \times 8.5 \times 150 + \frac{.859(10 - 10 \times .859 + 3 \times .859^2)}{30} \times (826 - 370) \times 7.3 \times 1/2 \times 8.5 + \frac{.141^2(5 - 4 \times .141)}{10} \times (370 - 220) \times 1.2 \times 1/2 \times 8.5\right]$$

$$= -3095'^{-\#}$$

$$FEM_{DC} = \frac{220 \times 8.5^2}{12} + \frac{.859^2(4 - 3 \times .859)}{12} \times (370-220) \times 7.3 \times 8.5$$

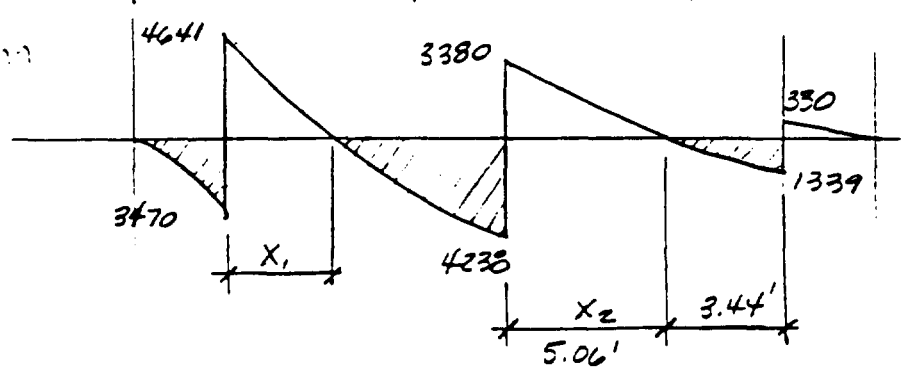
$$+ \frac{.859^2(5 - 3 \times .859)}{30} (826-370) \times 7.3 \times 1/2 \times 8.5$$

$$+ \frac{.141\,(10 - 15 \times .141 + 6 \times .141^2)}{15} (370-220) \times 1.2 \times 1/2 \times 8.5$$

$$= 3040^{\prime-\#}$$

$$FEM_{DE} = -220 \times 3 \times 1/2 \times 1 = -330^{\prime-\#}$$

JOINT	B		C		D	
MEMBER	BA	BC	CB	CD	DC	DE
D.F.	0	1.0	0.5	0.5	1.0	0
FEM	5302	-6606	+6164	-3095	+3040	-330
DM	0	+1304	-1534	-1535	-2710	0
CO	0	-767	+652	-1355	-767	0
DM	0	+767	+352	+351	+767	0
CO	0	+176	+383	+383	+176	0
DM	0	-176	-383	-383	-176	0
M	+5302	-5302	+5634	-5634	+330	-330
R_1	0	-39	+39	+624	-624	0
R_2	3470	4620	4199	2756	1963	330
R_{TOT}	8111 #/FT		7618 #/FT		1669 #/FT	



SHEAR

Determine X_1

$$4641 - (1124 + 1158) \times 1/2 \times 3.2 - (1158 + 1158 - 62.5X_3) \times 1/2 \times X_3 = 0$$

$$4641 - 3651 - 1158X_3 + 31.25X_3^2 = 0$$

$$X_3^2 - 37.06X_3 + 31.68 = 0 \quad \therefore X_3 = \frac{37.06 - \sqrt{37.06^2 - 4 \times 31.68}}{2}$$

$$= 0.876' \quad \therefore X_1 = 3.2 + .876 = 4.076'$$

Determine X_2

$$3380 - (826 + 826 - 62.5X_2) \times 1/2 \times X_2 = 0$$

$$3380 - 826X_2 + 31.25X_2^2 = 0 \; ; \; X_2^2 - 26.43X_1 + 108.16 = 0$$

$$\therefore X_2 = \frac{26.43 - \sqrt{26.43^2 - 4 \times 108.16}}{2} = 5.06'$$

Determine Moment @ X_1

$$1113 \times 6.2 \times (3.1 + .876) + (1238 - 1113) \times 2 \times 1/2 \times (5.533 + .876)$$

$$+ (1158 - 1113) \times 4.2 \times 1/2 \times (1.4 + .876) + 1103 \times .876^2 \times 1/2 + 62.5 \times .876^2 \times 1/3$$

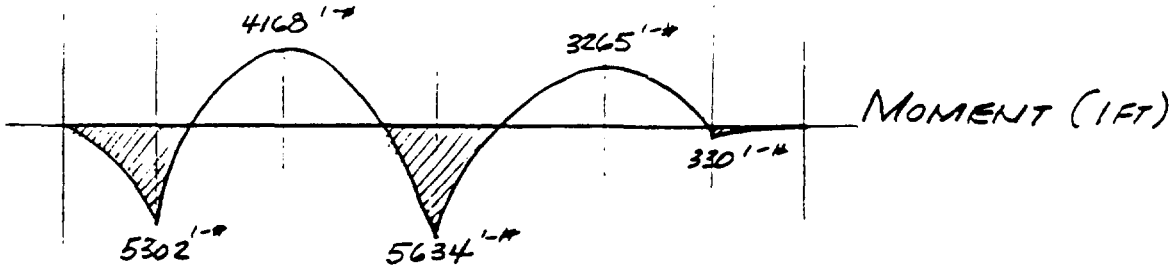
$$- 8111 \times (3.2 + .876) = -4168 \; ^{1\text{-}\#}/_{FT}$$

Determine Moment @ X_2

$$220 \times 3 \times 1/2 \times (1 + 3.44) + 220 \times 3.44^2 \times 1/2 + 150 \times 2.24^2 \times 1/2$$

$$+ 150 \times 1.2 \times 1/2 \times (3.44 - .8) + 140 \times 2.24^2 \times 1/2 \times 1/3 - 1669 \times 3.44 =$$

$$= -3265 \; ^{1\text{-}\#}/_{FT}$$



Sheetpile requirements

$$S_{req'd} = \frac{M}{F_b} \quad ; \quad M_{max} = 5634\ ^{'-\#}$$

$$S_{req'd} = \frac{5634 \times 12}{25 \times 10^3} = 2.70\ in^3/FT$$

PDA 27 , 10.7 in^3/FT
PMA 22 ; 5.4 in^3/FT
PZ 27 ; 30.2 in^3/FT

By inspection it appears that the PMA 22 section is the lightest available section.

Waler Requirements

$w_{max} = 8111\ \#/FT$; pg. 7

P_{axial} (From end wall) $= 15 \times 1/2 \times 8.111 = 60.8^k$
↑ 15' width assumed

Assume a strut spacing of 15'

$$M_{max} = \frac{wl^2}{8} = \frac{8.111 \times 15^2}{8} = 228.1\ ^{'-k}$$

Try HP 14x89

$A = 26.1\ \square''$ $\quad r_y = 3.53''$
$r_t = 3.94''$ $\quad l_x = 15'$
$S/A_f = 1.53$ $\quad l_y = 15'$
$S_x = 131\ in^3$ $\quad \bar{x} = 14.695''$
$r_x = 5.88''$ $\quad t_f = 0.615''$
$d = 13.83''$ $\quad t_w = 0.615''$

$$\frac{K_x l_x}{r_x} = \frac{1.0 \times 15 \times 12}{5.88} = 30.6 \therefore F_{e_x}' = 159.6^{ksi}$$

$$\frac{K_y l_y}{r_y} = \frac{1.0 \times 15 \times 12}{3.53} = 51.0 \therefore F_a = 18.26^{ksi}$$

$f_a = \frac{P}{A} = \frac{60.8}{26.1} = 2.33^{ksi}$; $f_a/F_a = 2.33/18.26 = 0.128 < 0.15$

$f_b = \frac{M}{S} = \frac{228.1 \times 12}{131} = 20.9 \text{ psi}$

Determine F_b ; Check AISC 1.5.1.4 $F_b = 0.66 F_y$

1. $b_f/2t_f = \frac{14.695}{2 \times .615} = 11.95 > \frac{65}{\sqrt{F_y}} = 10.83$ ∴ N.G.

$\ell/r_t = \frac{15 \times 12}{3.94} = 45.7 < \sqrt{\frac{102 \times 10^3 C_b}{F_y}}$ AISC 1.5.1.4.5

∴ $F_b = 0.6 F_y = 22^{ksi}$

$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0$ AISC 1.6-2

$0.128 + \frac{20.9}{22} = 1.078 > 1.0$ ∴ N.G.

Try W16 x 89

$A = 26.2^{\square''}$ $S_x = 155 \text{ in}^3$ $\frac{K_x \ell_x}{r_x} = \frac{1.0 \times 15 \times 12}{7.05} = 25.5$

$b_f/2t_f = 5.9$ $r_x = 7.05''$

$d/t_w = 31.9$ $r_y = 2.49''$ $\frac{K_y \ell_y}{r_y} = \frac{1.0 \times 15 \times 12}{2.49} = 72.3$; $F_a = 16.19^{ksi}$

$r_t = 2.79''$

$d/A_f = 1.85$

$f_a = \frac{P}{A} = \frac{60.8^k}{26.2^{\square''}} = 2.32^{ksi}$; $f_a/F_a = \frac{2.32}{16.19} = 0.143 < 0.15$

$f_b = \frac{M}{S} = \frac{228.1 \times 12}{155} = 17.66^{ksi}$

Check AISC 1.5.1.4 for determination of F_b :

1. $b_f/2t_f = 5.9 < \frac{65}{\sqrt{F_y}}$ OK

2. $\frac{d - 2k}{t_w} = \frac{16.75 - 2 \times 1.5625}{.525} = 25.95$; $\frac{190}{\sqrt{F_y}} = 31.7 > 25.95$ ∴ OK

3. $\frac{d}{t_w} = 31.9$; $\frac{d}{t} = \frac{640}{\sqrt{36}}\left(1 - 3.74 \times \frac{2.32}{36}\right) = 80.95 > 31.9$ OK

4. $\ell_c = \frac{76\, b_f}{\sqrt{F_y}} = \frac{76 \times 10.365}{12 \times 6} = 10.94' < 15'$ ∴ N.G.

∴ $F_b \neq 0.66 F_y$

$\ell / r_t = 15 \times 12 / 2.79 = 64.52$

∴ $F_b = \left[\frac{2}{3} - \frac{F_y (\ell/r_t)^2}{1530 \times 10^3 C_b}\right] F_y = \left[\frac{2}{3} - \frac{36 (64.52)^2}{1530 \times 10^3}\right] 36$ AISC 1.5-69

$= 20.47^{ksi}$

or

$F_b = \frac{12 \times 10^3 C_b}{\ell d / A_f} = \frac{12 \times 10^3}{15 \times 12 \times 1.85} = 36 > .6 F_y$ AISC 1.5-7 Controls

∴ $F_b = 0.6 F_y$

$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0$ AISC 1.6-2

∴ $0.143 + \frac{17.66}{22} = 0.95 < 1.0$ ∴ OK

∴ PROVIDE W16 x 89 Walers @ 2ND & 3RD Levels

Investigate 1ST Level Walers

Assume a 30' Spacing between struts and investigate the W16x89.

$w = 1.669$ #/FT ; pg. 7 $\quad \therefore P_{axial} = 15 \times 1/2 \times 1.669 = 12.52^{K}$

$$M_{max} = \frac{w\ell^2}{8} = \frac{1.669 \times 30^2}{8} = 187.8^{'K}$$

$$\frac{K_x \ell_x}{r_x} = \frac{1.0 \times 30 \times 12}{7.05} = 51.1$$

$$\frac{K_y \ell_y}{r_y} = \frac{1.0 \times 30 \times 12}{2.49} = 144.6 \quad \therefore F_a = 7.14^{KSI}$$

$$f_a = \frac{P}{A} = \frac{12.52}{26.2} = 0.478^{KSI}, \quad f_a/F_a = \frac{0.478}{7.14} = 0.067 < 0.15$$

$$f_b = \frac{M}{S} = \frac{187.8 \times 12}{155} = 14.54^{KSI}$$

$$F_b = \frac{12 \times 10^3 C_b}{\ell d/A_f} = \frac{12 \times 10^3}{30 \times 12 \times 1.85} = 18.0^{KSI}$$ AISC 1.5-7 CONTROLS

$$\therefore \frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0$$ AISC 1.6-2

$$0.067 + \frac{14.54}{18.0} = 0.875 < 1.0 \quad \therefore OK$$

$\therefore$ Provide W16x89 Waler @ 1ST level with an increased strut spacing of 30' max.

Investigate Strut Requirements

$$P_{axial\ max} \cong 1.1 \times 15' \times 8.111^{K/FT} = 134^{K}$$

Assuming continuous for 3 spans

Try W8x31

$A = 9.13^{\square''}$ $\quad r_y = 2.02''$ $\quad \ell_x = \ell_y \cong 15 - \frac{(3.25 + 16.75) \times 2}{12} = 11.67'$

$r_x = 3.47''$

$$K_y l_y / r_y = \frac{1.0 \times 11.67 \times 12}{2.02} = 69.3 \quad \therefore F_a = 16.50^{ksi}$$

$$f_a = \frac{P}{A} = \frac{134}{9.13} = 14.68^{ksi} \; ; \; \frac{f_a}{F_a} = \frac{14.68}{16.50} = 0.89 < 1.0 \quad \therefore OK$$

Try W 8x28

$A = 8.25^{\square''}$

$r_y = 1.62$

$$\therefore \frac{K_y l_y}{r_y} = \frac{1.0 \times 11.67 \times 12}{1.62} = 86.4 \; , \; F_a = 14.62^{ksi}$$

$$f_a = \frac{P}{A} = \frac{134}{8.25} = 16.24^{ksi} \; ; \; \frac{f_a}{F_a} = \frac{16.24}{14.62} = 1.11 > 1.0 \quad \therefore N.G.$$

$\therefore$ PROVIDE W 8x31 STRUTS

Check Water Web Crippling

$P_{max} = 134^k$

$$P_{allow} = 0.75 F_y t_w (N + 2k) \quad AISC\ 1.10\text{-}9$$

$$= 0.75 \times 36 \times .525 (8 \times .8 + 2 \times 1.5625)$$

$$= 135^k > 134^k \quad \therefore OK$$

Provide 9"x9" Bearing plates on struts to aid in distributing load over a greater length of web.

$$f_{brg} = \frac{P}{A} = \frac{134}{9^2} = 1.654^{ksi}$$

$$\therefore M_{max} = \frac{wL^2}{2} = 1.654 \times [(9 - 8 \times .8) \times 1/2]^2 \times 1/2 = 1.398^{IN\text{-}K}$$

$$S_{reqd} = \frac{M}{F_b} = \frac{1.398}{27} = 0.0518 \; in^3$$

$$\sigma = \frac{bt^2}{6} = 0.0518 \quad \therefore t_{reqd} = \sqrt{\frac{6S}{b}} = \sqrt{\frac{6 \times 0.0518}{1}}$$

$$= 0.56''$$

∴ Provide W8x31 Struts with 9"x5/8"x0L9' Bearing PL

CRESCENT DITCH DEEP EXCAVATION SUMMARY

I. Materials
- A. PZ27 Sheetpile
  1. Top/Sheetpile elevation = 585
  2. Pile tip shall be driven 2' min. into hard silt. If driving can proceed further, the contractor shall do so.
- B. Internal Bracing
  1. Bracing provided at elevations 582, 573.5 and 565
  2. W16x89 wales
  3. W8x31 struts @ 30'% maximum @ 1ST tier
  4. W8x31 struts @ 15'% maximum @ 2ND & 3RD tier.

II Excavation
- A. Length = 275'
- B. Width = 15'
- C. Depth = 26'
- D. Volume = 275 x 15 x 26 x 1/27 = 3972 CY
- E. Method - Excavation to be accomplished in a dewatered condition utilizing staged excavation and filtered sumps. Excavation of the material will be accomplished with a clamshell bucket because the excavation is so narrow and deep. Upon completion, excavation will be backfilled with imported fill material.

III. Removal
- A. Cofferdam components, i.e, sheetpile, walers, struts, etc. shall be systematically removed, decontaminated and transported from the site.

B.

ACTION NO. 3 - SHALLOW EXCAVATION DESIGN

1. The shallow excavation design is an original design.

2. Design criteria references:

   a. USS Steel Sheet Piling Design Manual

   b. Nav Fac DM 7

   c. Foundation Analysis & Design - Bowles

   d. AISC Steel Construction Manual - 8th Edition

3. Structural Design loads and conditions

   a. Critical loading condition occurs during maximum drawdown of water level at the interior of the excavation.

   b. Assumptions:

      1) Finished grade elevation = 585' @ Crescent ditch and 583 @ Oval Lagoon.
      2) Water elevation outside cofferdam = 582'
      3) Bottom of excavation elevation:
         a) 574.5 @ Crescent ditch
         b) 573.0 @ Oval Lagoon
         c) Allows for 1' overdredge
      4) Water elevation inside cofferdam is 2 ft. below bottom of excavation.

   c. Soil parameters - preliminary subsurface investigation is not complete at this time.

c. Soil parameters continued

$\phi_{SAND} = 35°$ $K_{A_{SAND}} = 0.248$; pg. 22 - Action 1 Cofferdam Design

$\gamma_{SAND} = 120$ PCF

$\gamma_{SAND\ SUB.} = 58$ PCF $K_{P_{SAND}} = 6.55$; pg. 22 - Action 1 Cofferdam Design

$\delta_{SAND} = 15°$

$\gamma_{SILT} = 135$ PCF $K_{A_{SILT}} = 1.0$

$\gamma_{SILT\ SUB} = 73$ PCF $K_{P_{SILT}} = 1.0$

$C_{SILT} = 4000$ PSF

d. Seismic design considerations are not applicable for design of the braced excavation because of the location being one of low intensity and frequency and the fact that the structure is temporary in nature.

4. Materials of Construction -

a. Steel walers, struts, shapes and plates: ASTM A36 ; $F_y = 36^{ksi}$. The structural steel shapes will be used for bracing the walls of the cofferdam.

b. Steel Sheetpile : ASTM A328 ; $F_y = 38.5^{ksi}$ The sheetpile will be used as the wall of the braced excavation.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

SHEET NO. 17 OF 33
JOB NO. 11557

DATE 1-30-85 SUBJECT ACTION 3 - SHALLOW EXCAVATION DESIGN
DATE 3/6/85 OMC / WAUKEGAN HARBOR

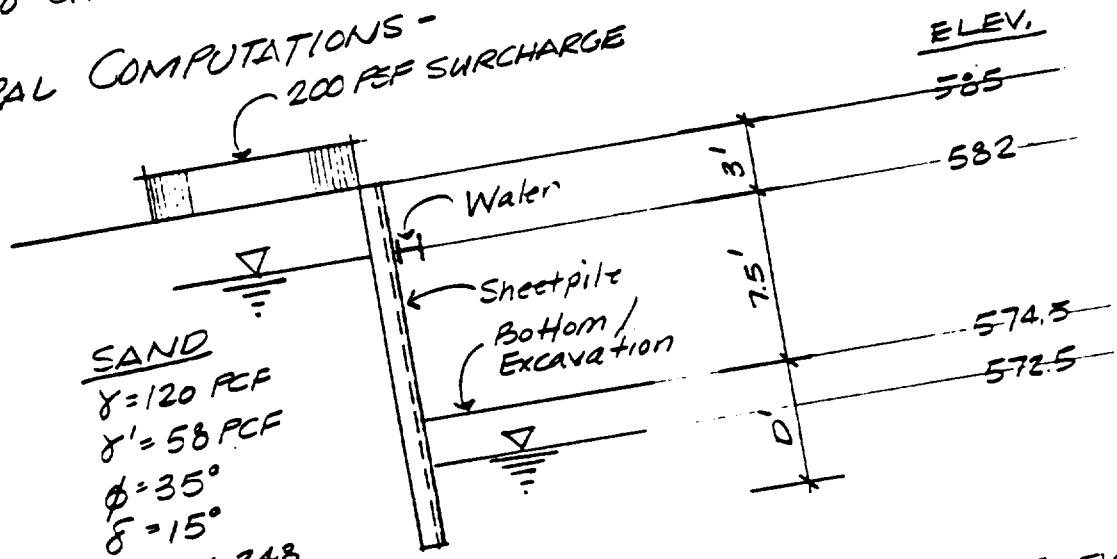
Description of the Structural System

Either internally braced or cantilever steel sheetpile walls encompassing a rectangular portion of the crescent ditch approximately 15' wide, 200' long and 10.5' deep. Or, in the case of the Oval lagoon 37' wide, 223' long & 10' deep.

6. There are no miscellaneous design features

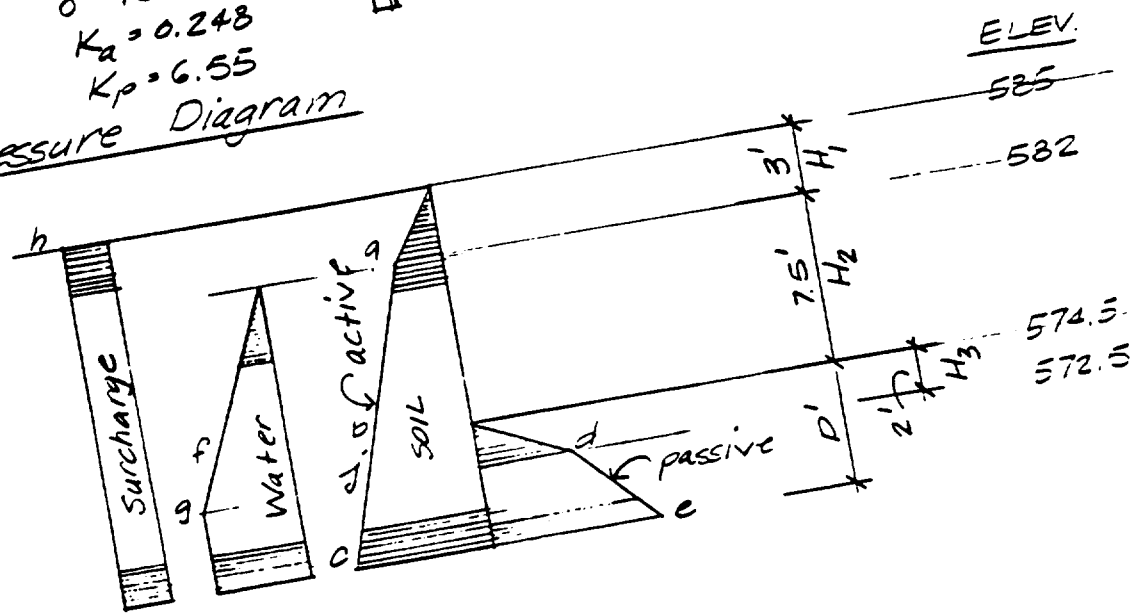
7. There is no site adaptation of a std. or exstg. design.

8. STRUCTURAL COMPUTATIONS -



SAND
$\gamma = 120$ PCF
$\gamma' = 58$ PCF
$\phi = 35°$
$\delta = 15°$
$K_a = 0.248$
$K_p = 6.55$

Lateral Pressure Diagram



WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAN DATE 1-30-85 SUBJECT ACTION 3 - SHALLOW EXCAVATION DESIGN ON IC / WAUKEGAN HARBOR SHEET NO. 18 OF 33
CHKD. BY KLW DATE 3/6/85 JOB NO. 11837

Calculate lateral Pressures -

$P_a = K_a \gamma H_1 = 0.248 \times 120 \times 3 = 89.3$ #/FT/FT

$P_b = P_a + K_a \gamma' H_2 = 89.3 + 0.248 \times 58 \times 7.5 = 197.2$ #/FT/FT

$P_c = P_b + K_a \gamma' D' = 197.2 + 0.248 \times 58 \times D' = 197.2 + 14.4 D'$ #/FT/FT

$P_d = K_p \gamma H_3 = 6.55 \times 120 \times 2 = 1572$ #/FT/FT

$P_e = P_d + K_p \gamma' (D'-2) = 1572 + 6.55 \times 58 (D'-2) = 1192 + 380 D'$ #/FT/FT

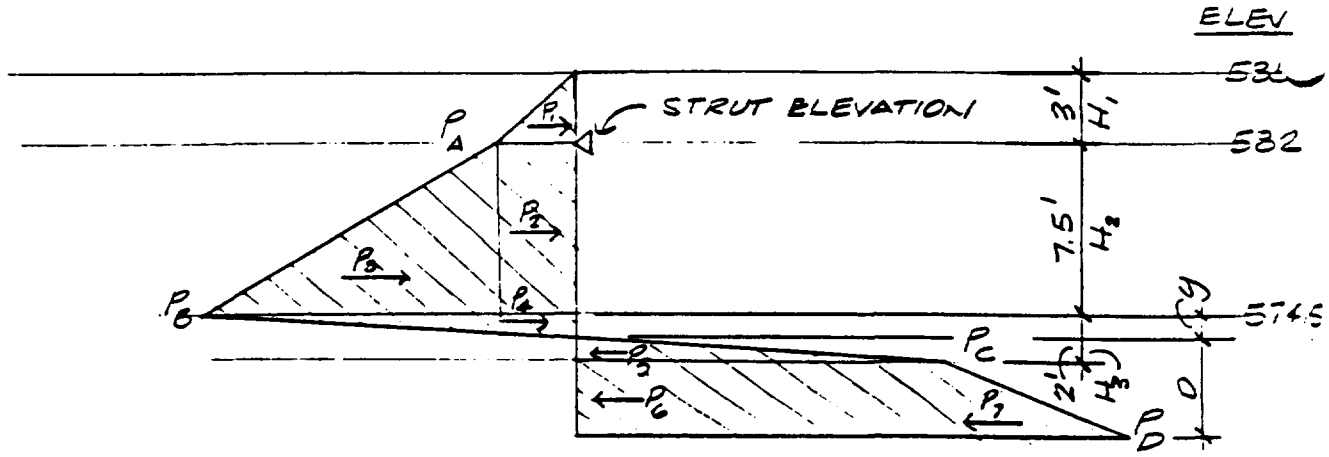
$P_f = \gamma_w H_2 = 62.5 \times 7.5 = 469$ #/FT/FT

$P_g = P_f + \gamma_w H_3 = 469 + 2 \times 62.5 = 594$ #/FT/FT

$P_h = \text{Surcharge} \times K_a = 0.248 \times 200 = 50$ #/FT/FT

$P_j = P_b + K_a \gamma' H_3 = 197.2 + .248 \times 58 \times 2 = 226$ #/FT/FT

Final Lateral Pressure Diagram



$$P_A = P_a + P_h = 89.3 + 50 = 139\ \#/FT/FT$$

$$P_B = P_b + P_f + P_h = 197.2 + 469 + 50 = 716\ \#/FT/FT$$

$$P_C = P_d - P_j - P_g - P_h = 1572 - 226 - 594 - 50 = 702\ \#/FT/FT$$

$$P_D = P_e - P_c - P_g - P_h = 1192 + 380D' - 197.2 - 14.4D' - 594 - 50$$
$$= 351 + 365.6D'$$

Determine "y"

$$y = \frac{P_B}{P_B + P_C} \times 2 = \frac{716}{716+702} \times 2 = 1.01'$$

Sum moments about strut elevation

Mark	Force	Arm	Moment
P_1	$-139 \times 3 \times 1/2 = -208.5$	$3 \times 1/3 = 1$	-208.5
P_2	$7.5 \times 139 = 1042.5$	$7.5 \times 1/2 = 3.75$	3909.4
P_3	$7.5(716-139)1/2 = 2163.8$	$7.5 \times 2/3 = 5$	10818.8
P_4	$716 \times 1.01 \times 1/2 = 361.6$	$7.5 + 1/3 \times 1.01 = 7.84$	2833.7
P_5	$-702 \times .99 \times 1/2 = -347.5$	$9.5 - 1/3 \times .99 = 9.17$	-3186.5
P_6	$-[702 \times (D'-2)] = 1404 - 702D'$	$9.5 + 1/2(D'-2) = 8.5 + \frac{D'}{2}$	$11934 - 5967D' + 702D' - 351D'$
P_7	$-[(351 + 365.6D' - 702)(D'-2)1/2]$ $-[(365.6D' - 351)(\frac{D'}{2} - 1)]$ $-182.8(D')^2 + 175.5D' + 365.6D' - 351$	$9.5 + 2/3(D'-2) = \frac{2D'}{3} + 8.167$	$-121.9(D')^3 + 360.7(D')^2 - 234D' - 1492.9(D')^2 + 4418D' - 2866.6 =$ $-121.9(D')^3 - 1132.2(D')^2 + 4184D' - 2866.6$
	$-182.8(D')^2 + 541D' - 351$		

$$\Sigma M = 0 = -208.5 + 3909.4 + 10818.8 + 2833.7 - 3186.5 + \cancel{11934} - 5967D' + 702D' - 351(D')^2 - \cancel{121.9(D')^3} - \cancel{1132.2(D')^2} + 4184D' - 2866.6$$

$$= -121.9(D')^3 - 1483.2(D')^2 - 1081(D') + 23234.3 = 0$$

Try $D' = 4'$; $-121.9(4)^3 - 1483.2(4)^2 - 1081(4) + 23234.3 = -12623$

Try $D' = 3'$; $-121.9(3)^3 - 1483.2(3)^2 - 1081 \times 3 + 23234.3 = +3351$

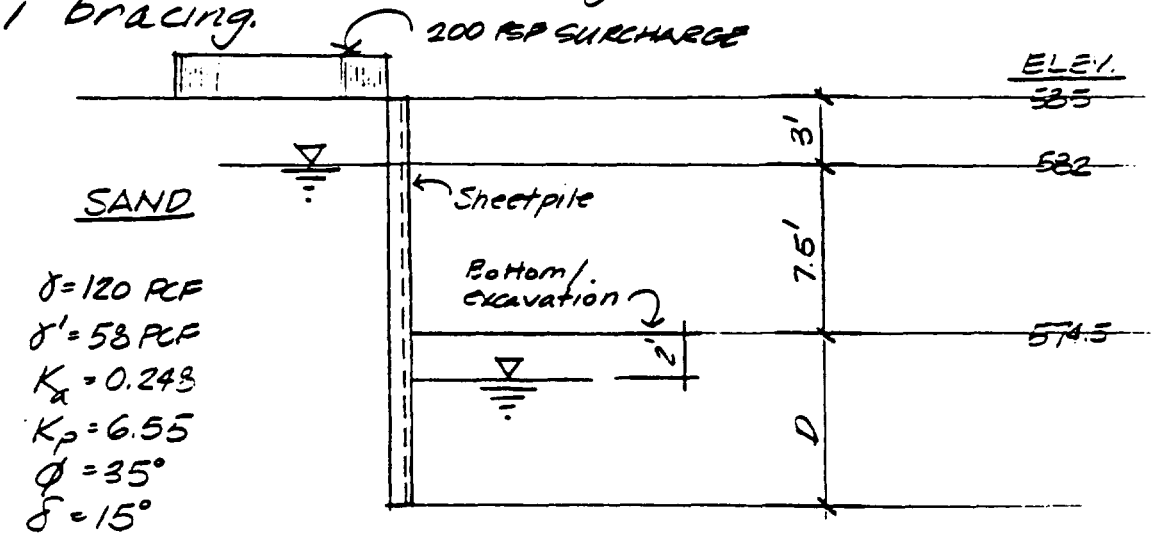
Try $D' = 3.2'$; $-121.9(3.2)^3 - 1483.2(3.2)^2 - 1081 \times 3.2 + 23234.3 = +593$

Try $D' = 3.24'$; $-121.9(3.24)^3 - 1483.2(3.24)^2 - 1081 \times 3.24 + 23234.3 = +16$ ∴ OK

To provide a margine of safety, increase calculated penetration by a factor of 20 - 40%

Provide 4' penetration ∴ Pile tip elevation = 570.5'

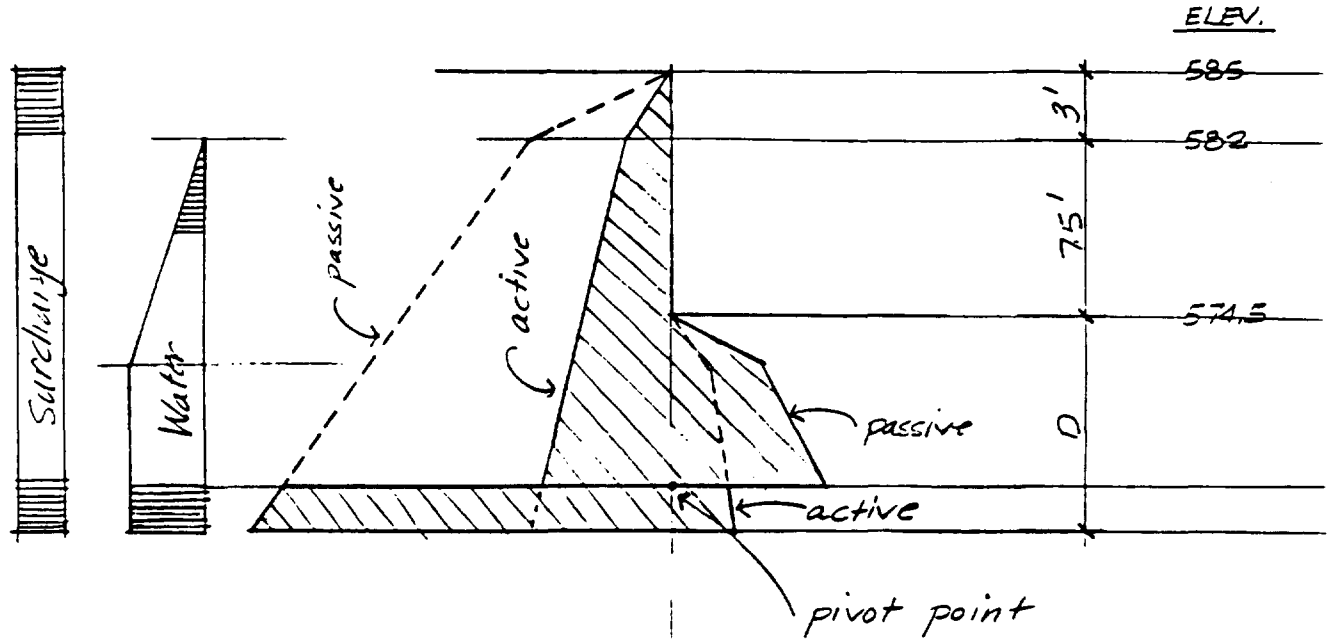
The intent is that the material within the confines of the braced excavation be excavated in the dry. Because it is most economical to dewater with the use of filtered sumps it would be most beneficial to extend the sheeting down to the hardpan to achieve a bottom seal and minimize the amount of infiltration. Because we may require to drive the sheeting a greater depth to facilitate dewatering let us investigate if this depth allows sufficient restraint to allow sheetpile to cantilever; thereby eliminated internal bracing.

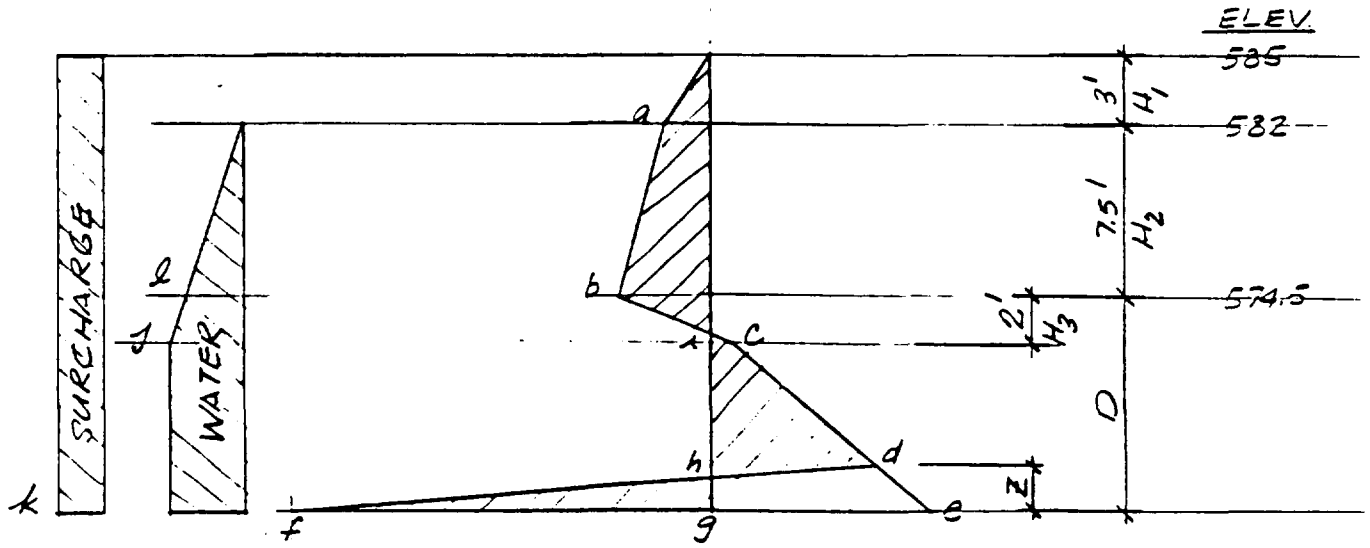


WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAJ DATE 2-7-85 SUBJECT Action 3 - SHALLOW SHEET NO. 21 OF 33
CHKD. BY KAN DATE 3/6/85 Excavation Design JOB NO. 11037
CMC/Waukegan Harbor

Lateral Pressure Diagram





$P_a = K_a \gamma H_1 = 0.248 \times 120 \times 3 = 89$ #/FT/FT

$P_b = K_a \gamma' H_2 + P_a = .248 \times 58 \times 7.5 + 89 = 197$ #/FT/FT

$P_c = K_p \gamma H_3 - K_a \gamma' H_3 - P_b = 6.55 \times 120 \times 2 - .248 \times 58 \times 2 - 197 = 1346$ #/FT/FT

$P_e = \gamma'(K_p - K_a)(D-2) + P_c = 58(6.55 - .248)(D-2) + 1346 = 365.5D + 615$ #/FT/FT

$$P_f = K_p \gamma H_1 + K_p \gamma' H_2 + K_p \gamma' D - K_a \gamma H_3 - K_a \gamma'(D-2)$$

$$= 6.55 \times 120 \times 3 + 6.55 \times 58 \times 7.5 + 6.55 \times 58 \times D - .248 \times 120 \times 2$$

$$- .248 \times 58 (D-2)$$

$$= 2358 + 2849 + 380D - 60 - 14.4(D-2)$$

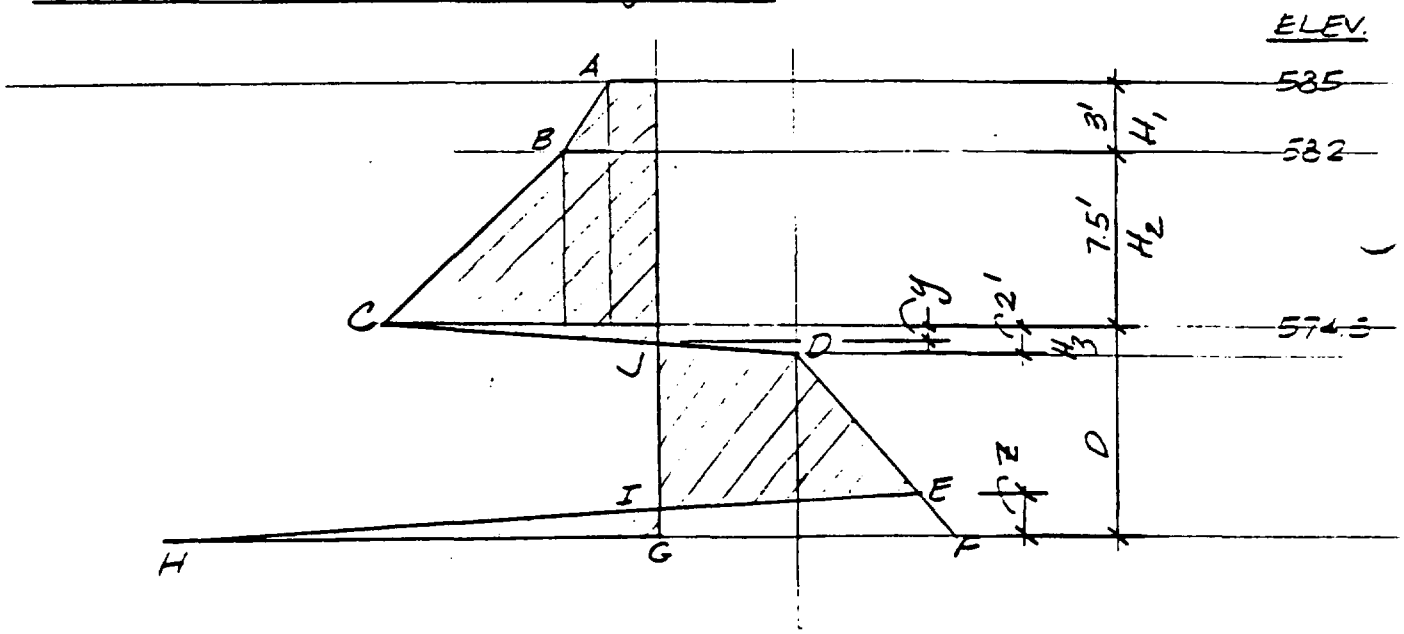
$$= 5147 + 380D - 14.4D + 28.8 = 5176 + 365.6D \ \#/FT/FT$$

$$P_j = \gamma_w (H_2 + H_3) = 62.5(7.5+2) = 594 \ \#/FT/FT$$

$$P_k = K_a \times \text{Surcharge} = .248 \times 200 = 50 \ \#/FT/FT$$

$$P_\ell = \gamma_w H_2 = 62.5 \times 7.5 = 469 \ \#/FT/FT$$

Final Lateral Pressure Diagram



$$P_A = P_k = 50 \ \#/FT/FT$$

$$P_B = P_a + P_k = 89 + 50 = 139 \ \#/FT/FT$$

$$P_C = P_b + P_\ell + P_k = 197 + 469 + 50 = 716 \ \#/FT/FT$$

$P_D = P_c - P_J - P_k = 1346 - 594 - 50 = 702$ #/FT/FT

$P_F = P_e - P_J - P_k = 365.5D + 615 - 594 - 50 = 365.5D - 29$ #/FT/FT

$P_H = P_f + P_J + P_k = 5176 + 365.6D + 594 + 50 = 5820 + 365.6D$

$\Sigma F_H = 0$

Area (ABCJ) − Area (JDFG) + Area (HEF) = 0

Determine "y"

$$y = \frac{P_c}{P_c + P_D} \times 2 = \frac{716}{716 + 702} \times 2 = 1.01'$$

$$\therefore P_A(H_1 + H_2) + (P_B - P_A)H_1 \times 1/2 + (P_B - P_A)H_2 + (P_C - P_B)H_2 \times 1/2$$
$$+ P_C \times y \times 1/2 - P_D(H_3 - y) \times 1/2 - P_D(D - H_3) - (P_F - P_D)(D - H_3)1/2$$
$$+ (P_H + P_F) \times Z \times 1/2 = 0$$

$$50(3 + 7.5) + (139 - 50)3 \times 1/2 + (139 - 50)7.5 + (716 - 139)7.5 \times 1/2$$
$$+ 716 \times 1.01 \times 1/2 - 702(2 - 1.01)1/2 - 702(D - 2) - (365.5D - 29 - 702)(D - 2)1/2$$
$$+ (5820 + 365.6D + 365.6D - 29) \times Z \times 1/2 = 0$$

$$525 + 133.5 + 667.5 + 2163.75 + 361.58 - 347.49 - 702D + 1404$$
$$(-365.5D^2 + 731D + 731D - 1404)1/2 + 2895.5Z + 365.6DZ = 0$$

$$4205.84 + 29D - 182.75D^2 + (2895.5 + 365.6D)Z = 0$$

$$\therefore Z = \frac{182.75D^2 - 29D - 4205.84}{2895.5 + 365.6D}$$

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAV DATE 2-8-85 SUBJECT ACTION 3 - SHALLOW EXCAVATION DESIGN OMC / WAUKEGAN HARBOR SHEET NO. 24 OF 33
CHKD BY TAN DATE 3/6/85 JOB NO 11337

$\Sigma M @ Toe = 0$; $\Sigma M @ G = 0$

$$P_A(H_1+H_2)\times[(H_1+H_2)\tfrac{1}{2}+D] + (P_B-P_A)H_1\times\tfrac{1}{2}(D+H_2+\tfrac{1}{3}H_1)$$
$$+(P_B-P_A)H_2(D+\tfrac{1}{2}H_2) + (P_C-P_B)H_2\times\tfrac{1}{2}(D+\tfrac{1}{3}H_2)$$
$$+P_C\times y\times\tfrac{1}{2}(D-\tfrac{1}{3}y) - P_D(H_3-y)(D-H_3+\tfrac{1}{3}(H_3-y))$$
$$-P_D(D-H_3)(D-H_3)\tfrac{1}{2} - (P_F-P_D)(D-H_3)\tfrac{1}{2}(D-H_3)\tfrac{1}{3}$$
$$+(P_F+P_H)\times Z\times\tfrac{1}{2}\times Z\times\tfrac{1}{3} = 0$$

$$525[(3+7.5)\tfrac{1}{2}+D] + 133.5(D+7.5+\tfrac{1}{3}(3)) + 667.5(D+\tfrac{1}{2}\times 7.5)$$
$$+2163.75(D+\tfrac{1}{3}\times 7.5) + 361.58(D-\tfrac{1}{3}\times 1.01) - 347.49(D-2+\tfrac{1}{3}(2-1.01))$$
$$-\frac{702}{2}(D-2)^2 \quad (-365.5D^2+1462D-1404)(D-2)\tfrac{1}{6}$$
$$+(5791+731.2D)\frac{Z^2}{6} = 0$$

$$2756.25 + 525D + 133.5D + 1134.75 + 667.5D + 2503.13 + 2163.75D$$
$$+5409.38 + 361.58D - 121.73 - 347.49D + 580.31 - 351(D^2-4D+4)$$
$$(-365.5D^3+1462D^2-1404D+731D^2-2924D+2808)\tfrac{1}{6}$$
$$+965.17Z^2 + 121.87\times D\times Z^2 = 0$$

$$12262.09 + 3503.84D - 351D^2 + 1404D - 1404 - 60.92D^3$$
$$+365.5D^2 - 721.3D + 468 + 965.17Z^2 + 121.87DZ^2 = 0$$

$$11326.09 + 4186.54D + 14.5D^2 - 60.92D^3 + 965.17Z^2 + 121.87DZ^2 = 0$$

Try $D = 8'$

$$\therefore Z = \frac{182.75D^2 - 29D - 4205.84}{2895.5 + 365.6D} = \frac{182.75(8)^2 - 29\times 8 - 4205.84}{2895.5 + 365.6\times 8}$$

$$= 1.247'$$

$$\therefore 11326.09 + 4186.54\times 8 + 14.5\times 8^2 - 60.92\times 8^3 + 965.17(1.247)^2$$

$$+ 121.87\times 8\times 1.247^2 = 0 \quad ; \; + 17572 \quad \text{N.G.}$$

Try $D = 10'$

$$\therefore Z = \frac{182.75\times 10^2 - 29\times 10 - 4205.84}{2895.5 + 365.6\times 10} = 2.103'$$

$$\therefore 11326.09 + 4186.54\times 10 + 14.5\times 10^2 - 60.92\times 10^3 + 965.17(2.103)^2$$

$$+ 121.87\times 10\times 2.103^2 = 0 \quad + 3380 \quad \text{N.G.}$$

Try $D = 10.5'$

$$\therefore Z = \frac{182.75\times 10.5^2 - 29\times 10.5 - 4205.84}{2895.5 + 365.6\times 10.5} = 2.322'$$

$$\therefore 11326.09 + 4186.54\times 10.5 + 14.5\times 10.5^2 - 60.92\times 10.5^3 + 965.17(2.322)^2$$

$$+ 121.87\times 10.5\times 2.322^2 = 0 \quad ; \; -1536 \quad \text{O.K.}$$

To provide adequate safety factor use $\underline{\underline{D = 13'}}$

Determine Maximum Moment & Sheetpile size

Maximum moment occurs @ point of zero shear

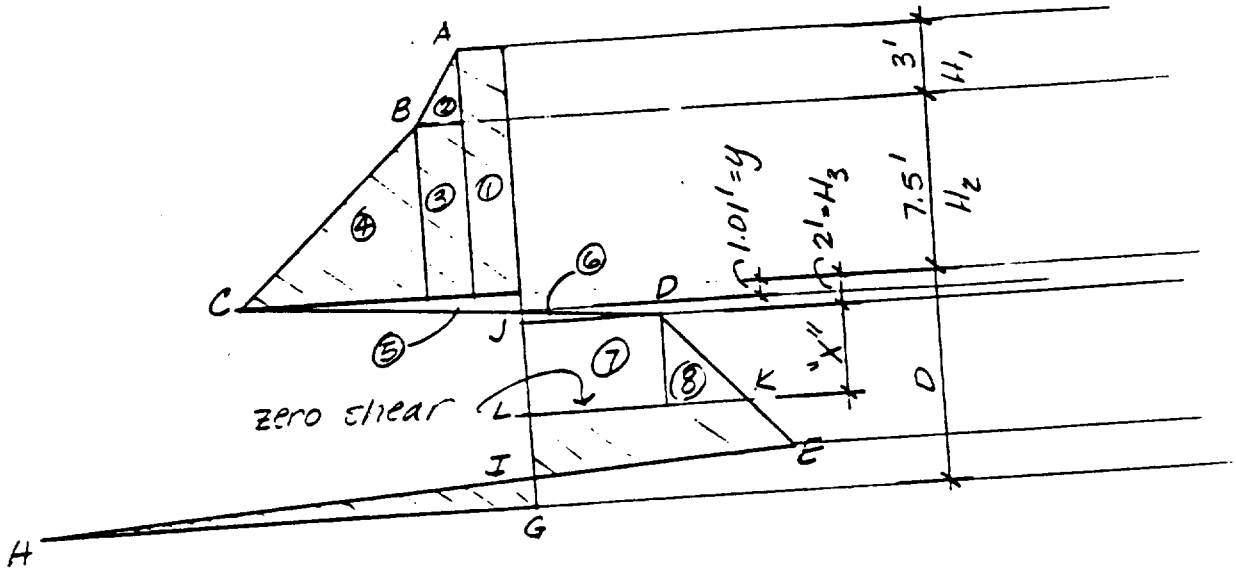
WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 2-8-85
CHKD. BY [illegible] DATE 3/6/85

SUBJECT ACTION 2 - SHALLOW EXCAVATION DESIGN
CMC/WAUKEGAN HARBOR

SHEET NO. 26 OF 33
JOB NO. 11327

ELEV.



Area (ABCJ) − Area (JDKL) = 0

$$\therefore P_A(H_1+H_2) + (P_B-P_A)H_1 \times 1/2 + (P_B-P_A)H_2 + (P_C-P_B)\times H_3 \times 1/2$$
$$+ P_C \times y \times 1/2 - P_D(H_3-y)1/2 - P_D \times X - (P_K-P_D)(X)\,1/2 = 0$$

$$50(3+7.5) + (139-50)3\times 1/2 + (139-50)7.5 + (716-139)7.5\times 1/2$$
$$+ 716\times 1.01\times 1/2 - 702(2-1.01)1/2 - 702X - (P_K-702)X/2 = 0$$

$$525 + 133.5 + 667.5 + 2163.75 + 361.58 - 347.49 - 702X$$

$$-\frac{P_K X}{2} + 351X = 0$$

$$3503.84 - 351X - \frac{P_K X}{2} = 0 \quad ; \quad P_K = P_D + \gamma'(K_p - K_a)X$$
$$= 702 + 58(6.55 - .248)X$$
$$= 702 + 365.5X$$

$$3503.84 - 351X - (702 + 365.5X)\frac{X}{2} = 0$$

$$3503.84 - 351X - 351X - 182.75X^2 = 0$$

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAJ DATE 2-8-85 SUBJECT ACTION 3 - SHALLOW EXCAVATION DESIGN OMC/WAUKEGAN HARBOR SHEET NO. 27 OF 33
CHKD BY DATE 3/6/85 JOB NO 11827

$$x^2 + 3.841x - 19.173 = 0 \quad ; \quad x = \frac{-3.841 + \sqrt{3.841^2 + 4 \times 19.173}}{2}$$

$$= 2.86'$$

ΣMoments @ point of zero shear to determine max. moment.

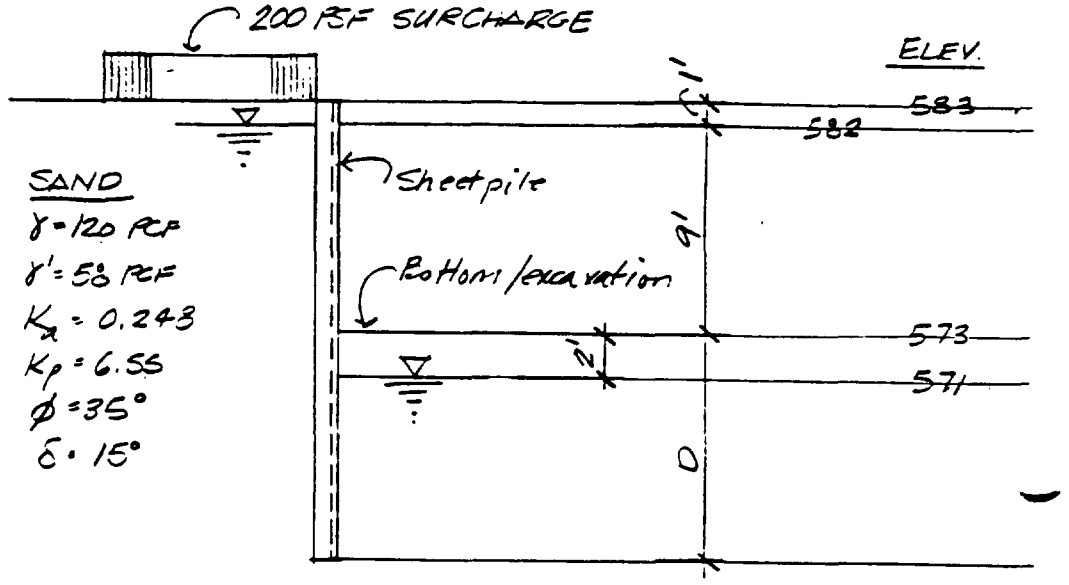
Mark	Force	Arm	Moment
1	525	2.86+2+10.5×1/2	5308
2	133.5	2.86+2+7.5+1/3×3	1784
3	667.5	2.86+2+7.5×1/2	5747
4	2163.75	2.86+2+7.5×1/3	15925
5	361.58	2.86+.99+2/3×1.01	1636
6	-347.49	2.86+.99×1/3	-1108
7	-702×2.86	2.86×1/2	-2871
8	-365.5×2.86²×1/2	2.86×1/3	-1425
M_{TOTAL}			24996 '-#

$$S_{reqd} = \frac{M}{F_b} = \frac{24996 \times 12}{25000} = 12.0 \text{ in}^3/\text{ft}$$

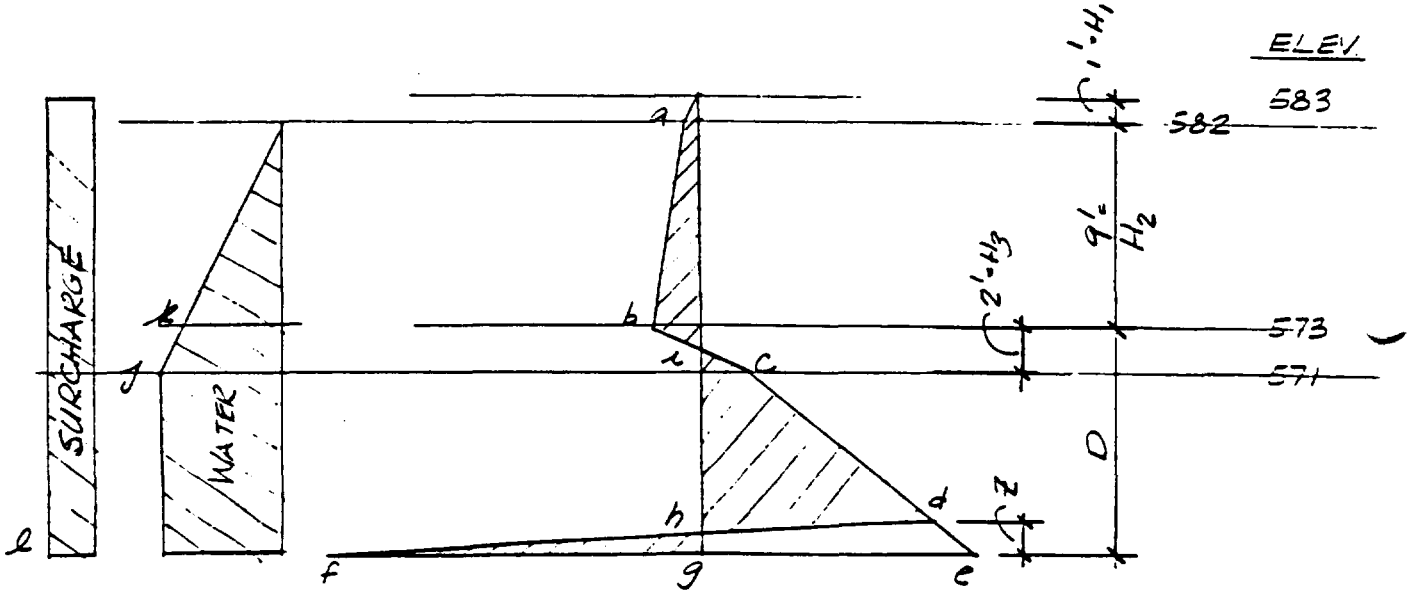
By inspection <u>provide PZ 27</u>; $S = 30.2 \text{ in}^3/\text{ft}$

SF 1027A

OVAL LAGOON CANTILEVERED SHEETPILE DESIGN



Lateral Pressure Diagram



$P_a = K_a \gamma H_1 = 0.248 \times 120 \times 1 = 30$ #/FT/FT

$P_b = K_a \gamma' H_2 + P_a = 0.248 \times 58 \times 9 + 30 = 159$ #/FT/FT

$P_c = K_p \gamma H_3 - K_a \gamma' H_3 - P_b = 6.55 \times 120 \times 2 - .248 \times 58 \times 2 - 159 = 1284$ #/FT/FT

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAV DATE 2-11-85 SUBJECT ACTION 3 - SHALLOW EXCAVATION DESIGN CMC/WAUKEGAN HARBOR SHEET NO. 29 OF 33
CHKD. BY KAN DATE 3/6/85 JOB NO. 11357

$$P_e = \gamma'(K_p - K_a)(D-2) + P_c = 58(6.55 - .248)(D-2) + 1384$$

$$= 365.5D + 653 \quad \#/FT/FT$$

$$P_f = K_p \gamma H_1 + K_p \gamma' H_2 + K_p \gamma' D - K_a \gamma H_3 - K_a \gamma'(D-2)$$

$$= 6.55 \times 120 \times 1 + 6.55 \times 58 \times 9 + 6.55 \times 58 \times D - .248 \times 120 \times 2 - .248 \times 58 \times (D-2)$$

$$= 786 + 3419 + 380D - 60 - 14.4(D-2)$$

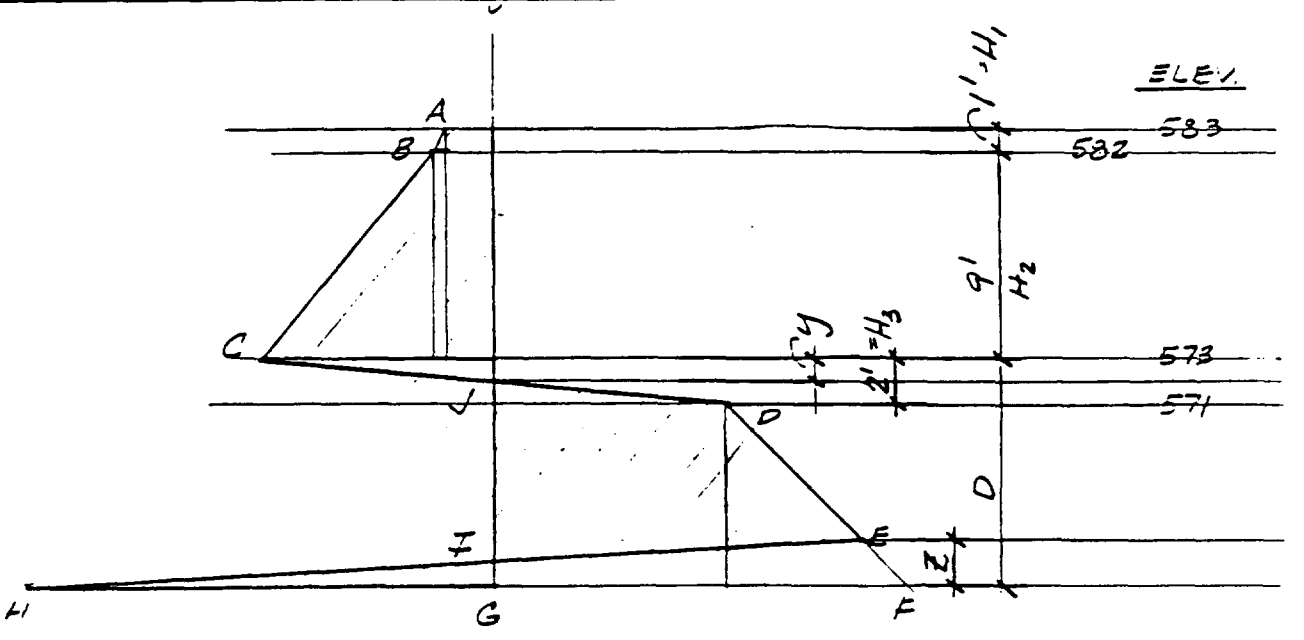
$$= 4145 + 380D - 14.4D + 28.8 = 4174 + 365.6D \quad \#/FT/FT$$

$$P_j = \gamma_w (H_2 + H_3) = 62.5(9+2) = 688 \#/FT/FT$$

$$P_k = \gamma_w H_2 = 62.5 \times 9 = 563 \#/FT/FT$$

$$P_l = K_a \times \text{Surcharge} = 0.248 \times 200 = 50 \#/FT/FT$$

Final Lateral Pressure Diagram



WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAJ DATE 2-11-85 SUBJECT ACTION 3 - SHALLOW EXCAVATION DESIGN OMC / WAUKEGAN HARBOR SHEET NO. 50 OF 33
CHKD BY [illegible] DATE 3/6/85 JOB NO. 11357

$P_A = P_\ell = 50$ #/FT/FT

$P_B = P_a + P_\ell = 30 + 50 = 80$ #/FT/FT

$P_C = P_b + P_k + P_\ell = 159 + 563 + 50 = 772$ #/FT/FT

$P_D = P_c - P_J - P_\ell = 1384 - 688 - 50 = 646$ #/FT/FT

$P_F = P_e - P_J - P_\ell = 365.5D + 653 - 688 - 50 = 365.5D - 85$

$P_H = P_f + P_J + P_\ell = 4174 + 365.6D + 688 + 50 = 4912 + 365.6D$

Determine "y"

$$y = \frac{P_C}{P_C + P_D} \times Z = \frac{772}{772 + 646} \times Z = 1.09'$$

$\Sigma F_H = 0$

Area (ABCJ) - Area (JDFG) + Area (HEF) = 0

$$P_A(H_1 + H_2) + (P_B - P_A) \times H_1 \times 1/2 + (P_B - P_A) H_2 + (P_C - P_B) H_2 \times 1/2$$

$$+ P_C \times y \times 1/2 - P_D (H_3 - y) 1/2 - P_D (D - H_3) - (P_F - P_D)(D - H_3) 1/2$$

$$+ (P_H + P_F) Z \times 1/2 = 0$$

$$50(1 + 9) + (159 - 50) \times 1/2 + (159 - 50) 9 + (772 - 159) 9 \times 1/2$$

$$+ 772 \times 1.09 \times 1/2 - 646 (2 - 1.09) 1/2 - 646 (D - 2) - (365.5D \underbrace{- 85 - 646}_{731})(D - 2) 1/2$$

$$+ (4912 + 365.6D + 365.5D - 85) \times Z \times 1/2 = 0$$

$$500 + 54.5 + 981 + 2759 + 421 - 294 - 646D + 1292 - 182.75D^2$$

$$+ 365.5D + 365.5D - 731 + 2414Z + 365.6DZ$$

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAJ DATE 2-11-85 SUBJECT ACTION 3 - SHALLOW COFFERDAM DESIGN OMC/ WAUKEGAN HARBOR SHEET NO. 31 OF 33
CHKD. BY KJW DATE 3/6/85 JOB NO 11337

$$\therefore\ 4982 + 85D - 182.75D^2 + (2414 + 365.6D)Z = 0$$

$$\therefore\ Z = \frac{182.75D^2 - 85D - 4982}{2414 + 365.6D} \qquad \underline{EQ.\ 1}$$

$\underline{\Sigma M @ G = 0}$

$$P_A(H_1+H_2)[(H_1+H_2)1/2 + D] + (P_B - P_A)H_1 \times 1/2(D + H_2 + 1/3 H_1)$$
$$+ (P_B - P_A)H_2(D + 1/2 H_2) + (P_C - P_B)H_2 \times 1/2(D + 1/3 H_2) + P_C \times y \times 1/2(D - 1/2 y)$$
$$- P_D(H_3 - y)1/2\ (D - H_3 + 1/3(H_3 - y)) - P_D(D - H_3)^2 \times 1/2 - (P_E - P_D)(D - H_3)^2 \times 1/6$$
$$+ (P_H + P_E)Z \times 1/2 \times Z \times 1/3 = 0$$

$$50(1+9)[(1+9)1/2 + D] + (80-50)1/2(D + 9 + 1/3) + (80-50)9(D + 1/2 \times 9)$$
$$+ (772-80)9 \times 1/2(D + 1/3 \times 9) + 772 \times 1.09 \times 1/2(D - 1/3 \times 1.09)$$
$$- 646(2-y)1/2(D - 2 + 1/3(2-1.09)) - 646(D-2)^2 \times 1/2$$
$$-(365.5D - 85 - 646)(D-2)^2 \times 1/6 + (4912 + 366.6D + 365.5D - 85)Z^2 \times 1/6 = 0$$

$$2500 + 500D + 150D + 45 + 270D + 1215 + 3114D + 9342$$
$$+ 421D - 153 - 323(2 + 1.09)(D - 1.697) - 323(D^2 - 4D + 4)$$
$$-(60.92D - 121.83)(D^2 - 4D + 4) + 804.5Z^2 + 121.83DZ^2 = 0$$

$$12949 + 4320D - 294D + 499 - 323D^2 + 1292D - 1292 - 60.92D^3$$
$$+ 121.83D^2 + 244D^2 - 487D - 244D + 487 + 804.5Z^2 + 121.83DZ^2 = 0$$

$$12643 + 4587D + 42.83D^2 - 60.92D^3 + 804.5Z^2 + 121.83DZ^2 = 0 \qquad \underline{Eq.\ 2}$$

WARZYN ENGINEERING, INC.
MADISON WISCONSIN

BY RAV DATE 2-11-85 SUBJECT ACTION 3 - SHALLOW EXCAVATION DESIGN OMC/WAUKEGAN HARBOR SHEET NO. 22 OF 33
CHKD. BY [illegible] DATE 3/6/85 JOB NO 11837

TRY D = 10'

Eq. 1 ; $Z = \frac{182.75 \times 10^2 - 85 \times 10 - 4982}{2414 + 365.6 \times 10} = 2.05'$

Eq. 2 ; $12643 + 4587 \times 10 + 42.83 \times 10^2 - 60.92 \times 10^3 + 804.5 \times 2.05^2 + 121.83 \times 10 \times 2.05^2 = 10377$ N.G.

Try D = 11'

Eq. 1 ; $Z = \frac{182.75 \times 11^2 - 85 \times 11 - 4982}{2414 + 365.6 \times 11} = 2.517'$

Eq. 2 ; $12643 + 4587 \times 11 + 42.83 \times 11^2 - 60.92 \times 11^3 + 804.5 \times 2.517^2 + 121.83 \times 11 \times 2.517^2 = 785$ OK

To provide adequate safety factor use D = 13.5'

CRESCENT DITCH SHALLOW EXCAVATION SUMMARY

I. Materials
   A. PZ 27 Sheetpile
      1. Top / Sheetpile elevation = 585
      2. Pile tip elevation = 561

II. Excavation
   A. Length = 200'
   B. Width = 15'
   C. Soil depth = 6.5'
   D. Volume = 200 x 15 x 6.5 x 1/27 = 722 C.Y.
   E. Method - Excavation to be accomplished in a dewatered condition utilizing staged excavation and filtered sumps. Excavation of the material will be accomplished with a clamshell bucket because it is available at the site. Upon completion excavation will be backfilled with imported fill material.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAV DATE 2-11-85 SUBJECT ACTION E- SHALLOW SHEET NO. 33 OF 33
CHKD. BY [illegible] DATE 3/6/85 EXCAVATION DESIGN JOB NO. 11327
OMC / WAUKEGAN HARBOR

III. Removal
A. Cofferdam sheetpile shall be removed after completion of backfilling, decontaminated and transported from the site.

B. OVAL LAGOON SHALLOW EXCAVATION SUMMARY

I. Materials
A. PZ 27 Sheetpile
1. Top / sheetpile elevation = 583
2. Pile tip elevation = 559

II. Excavation
A. Length = 223'
B. Average width = 37'
C. Soil depth = 5'
D. Volume = 223 x 37 x 5 x 1/27 = 1528 CY
E. Method - Excavation to be accomplished in a dewatered condition utilizing staged excavation and filtered sumps. Excavation of the material will be accomplished with a clamshell bucket because it is available at the site. Upon completion excavation will be backfilled with imported fill material

III. Removal
A. Cofferdam sheetpile shall be removed after completion of backfilling, decontaminated and transported from the site.

VIII. CRESCENT DITCH / OVAL LAGOON CONTAINMENT CELL

SITE CONSTRUCTION

C. STABILITY OF ADJACENT STRUCTURES

DETAILED FOUNDATION DRAWINGS OF THE DIE STORAGE BUILDING, ELEVATED WATER TANK AND GROUND OIL TANK WERE REQUESTED OF THE CORPS, USEPA AND OMC. TO DATE, THIS INFORMATION HAS NOT BEEN RECEIVED.

IN ORDER TO EVALUATE THE POTENTIAL EFFECT OF THE REMEDIAL ACTIVITIES ON THESE EXISTING FACILITIES, THIS INFORMATION WILL BE NEEDED. UNTIL THIS INFORMATION IS RECEIVED, THE FOLLOWING ASSUMPTIONS WERE MADE:

1) THE DIE STORAGE BUILDING IS SUPPORTED ON CONVENTIONAL SHALLOW SPREAD FOOTINGS ESTABLISHED AT FROST DEPTH (42") IN THE MEDIUM DENSE SAND STRATUM.
2) THE ELEVATED WATER TANK IS SUPPORTED ON DEEP FOUNDATIONS ESTABLISHED IN THE UNDERLYING VERY STIFF TO HARD GLACIAL TILL STRATUM.
3) THE GROUND OIL TANK IS SUPPORTED AT GRADE ON A MAT-TYPE FOUNDATION OR DIRECTLY ON THE GROUND SURFACE CONSISTING OF THE MEDIUM DENSE SAND STRATUM.

THE REMEDIAL ACTIVITIES THAT MAY AFFECT THE STABILITY / INTEGRITY OF THE ADJACENT STRUCTURES INCLUDE THE SHALLOW AND DEEP EXCAVATIONS IN THE CRESCENT DITCH, DEWATERING INSIDE THE EXCAVATIONS AND THE SLURRY WALL CONSTRUCTION.

THE DEEP EXCAVATION WILL BE SHEETED WITH INTERNAL STRUTS. THE SHALLOW EXCAVATION WILL BE SHEETED WITH CANTILEVER SHEETPILING. BECAUSE THE EXCAVATIONS WILL BE BRACED, THESE ACTIVITIES ARE NOT ANTICIPATED TO INFLUENCE THE ADJACENT STRUCTURES. THE CONTRACTOR WILL BE REQUIRED TO MONITOR THE PERFORMANCE OF THE RETENTION SYSTEMS. GROUND SETTLEMENT OUTSIDE THE EXCAVATIONS WILL NOT BE PERMITTED AND WILL BE ADDRESSED IN THE SPECIFICATIONS.

C. CONTINUED

THE SHEETPILE INTERLOCKS ARE NOT ANTICIPATED TO LEAK APPRECIABLY WHICH, IF THEY DID, COULD CAUSE A LOWERING OF THE GROUNDWATER TABLE OUTSIDE THE EXCAVATION AND POTENTIALLY CAUSE SETTLEMENT OF THE ADJACENT STRUCTURES. THE GROUNDWATER LEVELS OUTSIDE THE SHEETED EXCAVATION CAN BE MONITORED WITH THE GROUNDWATER MONITORING WELLS TO BE INSTALLED DURING THE SITE PREPARATION ACTIVITIES.

SLURRY WALL INSTALLATION IS ESSENTIALLY A 2-STEP PROCESS. THE FIRST STEP INVOLVES EXCAVATION OF A VERTICAL TRENCH, THE STABILITY OF WHICH IS MAINTAINED BY A SLURRY SLIGHTLY HEAVIER THAN WATER. THE SECOND STEP INVOLVES BACKFILLING WITH A SOIL-BENTONITE MIXTURE DISPLACING THE SLURRY. IT IS A GENERALLY ACCEPTED GUIDELINE THAT EXCAVATIONS THAT INTERCEPT AN IMAGINARY LINE EXTENDING APPROX. 3 FT. OUT FROM A FOOTING OR STRUCTURE AND DOWNWARD ON A 1:1 SLOPE SHOULD BE BRACED TO PREVENT EXCAVATION COLLAPSE AND POTENTIAL INSTABILITY OF THE ADJACENT FOOTING OR STRUCTURE. IN REVIEWING THE LOCATION OF THE SLURRY WALL TRENCH RELATIVE TO THE DIE STORAGE BUILDING, WATER TANK AND OIL TANK, IT APPEARS THAT THE OIL TANK MAY REQUIRE SOME MEANS OF BRACING DURING SLURRY TRENCH EXCAVATION. (SEE SKETCH ON NEXT PAGE). THE DESIGN OF A BRACING OR SUPPORT SYSTEM WILL BE THE RESPONSIBILITY OF THE GENERAL CONTRACTOR TO BE SUBMITTED, REVIEWED AND APPROVED BY THE ENGINEER. A POTENTIAL, RELATIVELY SIMPLE SOLUTION IS TO LEAVE A PORTION OF THE CANTILEVER SHEET PILING IN-PLACE FOLLOWING EXCAVATION AND BACKFILL OF THE DITCH. THE SHEETING COULD THEN BE PULLED FOLLOWING EXCAVATION AND BACKFILL OF THE SLURRY WALL.

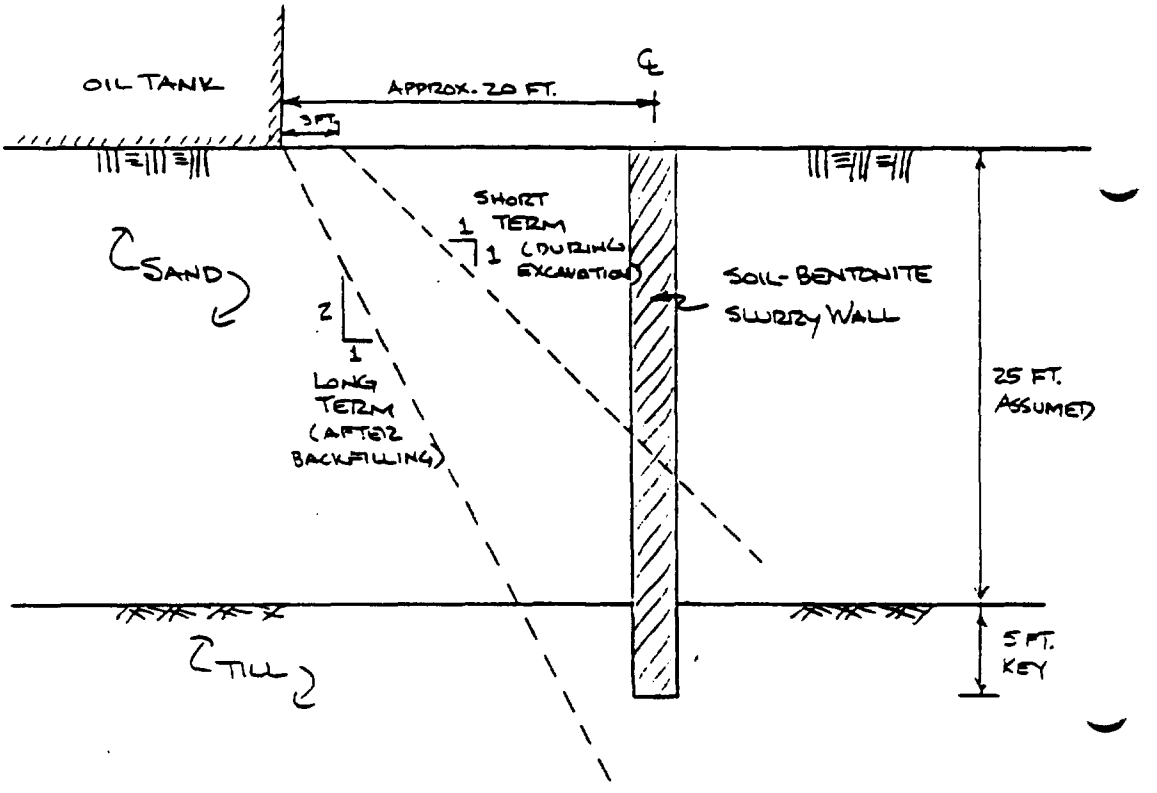
FOLLOWING BACKFILLING OF THE SLURRY TRENCH, THE SOIL-BENTONITE MIX IS ANTICIPATED TO HAVE A RELATIVELY SOFT, PLASTIC CONSISTENCY WITH LESSER OVERALL STRENGTH THAN THE IN-SITU SAND. BECAUSE OF THIS, IT IS OUR OPINION THE WALL SHOULD NOT INTERCEPT A GENERALLY ACCEPTED IMAGINARY LINE OF STRESS

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 3-4-95 SUBJECT OMC-WAUKEGAN, IL SHEET NO. 3 OF 4
CHKD BY WW DATE 3-7-95 JOB NO. 211837

C. CONTINUED

INFLUENCE EXTENDING DOWNWARD ON A 1H:2V SLOPE. BASED ON THE SKETCH BELOW, THE CLOSEST STRUCTURE (OIL TANK) WILL NOT REQUIRE LONG-TERM SUPPORT. (SEE NOTE BELOW)



NOTE:
THE 1H:2V STRESS DISTRIBUTION LINE CAN BE USED TO ESTIMATE STRESS INFLUENCE AT DEPTH FROM AN UPPER FOOTING OR STRUCTURAL LOAD. IN THE ABOVE EXAMPLE, IF THE 1H:2V IMAGINARY LINE INTERCEPTED THE WALL, THE WALL WOULD NOT AUTOMATICALLY REQUIRE RELOCATION OR THE TANK SUPPORTED. THE STRESS INFLUENCE WOULD FIRST BE ESTIMATED BELOW WHERE THE LINE INTERCEPTS THE WALL TO DETERMINE IF THE INCREASE IN STRESS COULD BE RESISTED BY THE WALL. THEN, A DECISION ON ALTERNATIVES COULD BE MADE.

C. CONTINUED

THE CONTRACTOR WILL BE REQUIRED TO MONITOR THE EXISTING DIE STORAGE BUILDING, ELEVATED WATER TANK AND GROUND OIL TANK. AT THIS TIME, A PERIODIC MONITORING OF HORIZONTAL AND VERTICAL MOVEMENT DURING THE PREVIOUSLY MENTIONED ACTIVITIES IS ANTICIPATED BY ESTABLISHING CONTROL POINTS ON THE STRUCTURES AND USING SURVEYING METHODS. THESE MONITORING ACTIVITIES ARE CONSIDERED RELATIVELY INEXPENSIVE TO PERFORM AND A COST FOR SUCH IS NOT INCLUDED IN THE CONSTRUCTION ESTIMATE. DETAILED ANALYSES CAN BE PERFORMED DURING FINAL DESIGN PROVIDED FOUNDATION DRAWINGS ARE SUBMITTED TO US. AT THAT TIME, THE COST ESTIMATES CAN BE MODIFIED IF NECESSARY FOR POSSIBLE UNDERPINNING, GROUTING, SLOPE INCLINOMETERS, STRAIN GAGES, ETC.

VIII CRESCENT DITCH / OVAL LAGOON - SITE CONSTRUCTION

D. DEWATERING

1.) ESTIMATE VOLUME OF FREE WATER TO BE PUMPED FROM SHEETED EXCAVATIONS (e.g., LEFT BEHIND AFTER REMOVAL OF EARTH) (WATER TO BE PUMPED AS EXCAVATION PROCEEDS)

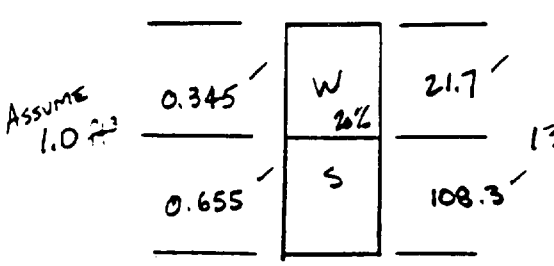
CALCULATE FREE WATER WHICH WILL DRAIN FROM EXCAVATED SOIL:

ASSUME: $G_s = 2.65$, $\gamma_{sat} = 130$ PCF
$S = 100\%$ BELOW W.T.
$w\% = 20\%$ - SATURATED CONDITION, M-H FINAL REPORT, 1981, p. 11/12

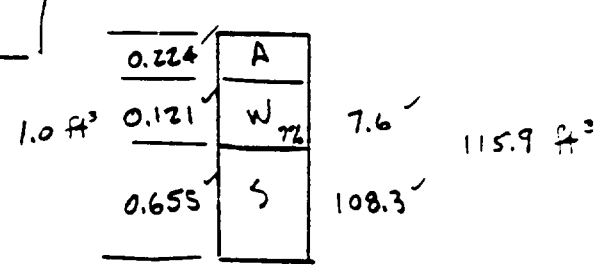
$w\% = 7\%$ - DRAINED CONDITION, BASED ON PAST EXPERIENCE W/ SIMILAR SANDS

$$Se = wG_s$$
$$e = \frac{V_v}{V_s}$$

SATURATED CONDITION



MOIST CONDITION



Volume of Air in Moist condition represents water which will drain from the soil as it is excavated.

Volume of water / cu. ft of excavated soil = 0.224 cu ft H_2O / cu ft Soil

$$\times \frac{\text{gal } H_2O}{\text{a } 1337 \text{ cu ft}} = \boxed{1.68 \text{ gal / cu. ft}}$$

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY WW DATE 2-27-95 SUBJECT OMC SHEET NO. 2 OF
CHKD. BY [illegible] DATE 2-27-95 JOB NO. 11837

Volume of free water from Crescent Lagoon:

Deep excavation: V = 275 ft long x 15 ft wide x 25' deep x 1.68 gal/cu ft

V ≅ 173,000 gal

Shallow excavation: V = 200 ft x 15 ft x 11 ft x 1.68 gal/ft³.

V = 55,400 gal

TOTAL FOR CRESCENT DITCH ≅ 228,000 gal (÷ 200 gpm ⇒ 19 hrs)

Volume of free water from Oval Lagoon (approximate area)

V = 225' x 50' x 11' x 1.68 gal/ft³

V = 208,000 gal

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY W. Wuellner DATE 2/22/95 SUBJECT OMC SHEET NO. 3 OF
CHKD. BY [illegible] DATE 2/26/95 JOB NO. 11837

DESIGN ANALYSIS

III. CRESCENT DITCH / OVAL LAGOON CONTAINMENT – SITE CONSTRUCTION
C. DEWATERING

2.) ESTIMATE SEEPAGE INTO SHEETED EXCAVATIONS (STEADY STATE DEWATERING)

TYPICAL CONDITIONS:

SHEETS DRIVEN TO CLAYEY TILL ✓
SOILS ABOVE TILL ARE F-M SAND, TR SILT ✓
ESTIMATED $K = 2 \times 10^{-3}$ cm/sec ✓ (BASED ON FIELD BAILDOWN TESTS – APPENDIX N)
TYPICAL PILE LENGTH = 30'± ✓
DISTANCE THROUGH SAND = 25'± ✓
ASSUME WATER AT OR NEAR GRND SURFACE ✓

RESEARCH AMOUNT OF FLOW THROUGH SHEET PILE INTERLOCKS

References:

1. US Steel Sheet Piling Design Manual, July 1975, p.18

"As an approximation, the seepage should be assumed to equal at least 0.025 gal/min. per sq ft of wall per ft of head across wall for installations in moderately to highly permeable soils."

2. TM 5-818-5, Dewatering and Groundwater Control for Deep Excavations, April, 1971 p.60

"As an approximation, seepage through interlocks equal to 0.01 gpm per sq.ft of wall per foot of net head on the wall."

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY WW DATE 2/22/95 SUBJECT OMC SHEET NO. 4 OF
CHKD. BY (RHW) DATE 2/26/95 JOB NO. 11037

3. Krizek, R.J. & G.M. Karadi, "Effectiveness of Leaky Sheetpile", Highway Research Record #282, pp 57-62.

Theoretical analysis - no field data to substantiate actual field performance.

Check Seepage using Ref #2

For Crescent Ditch, deep excavation = 275 ft long.

For 2 sides, total length = 580 ft. (including 15' width x 2)

Estimated seepage = $(580\,ft)(0.01\,\frac{gpm}{ft^3})(25\,ft)(25\,ft)$

$q = 3625$ gpm

This value seems high - using Ref #1, seepage would be even higher (9100 gpm).

Both cases far exceed the treatment plant capacity of 200 gpm.

Check against seepage if the sheet pile wall were totally permeable.

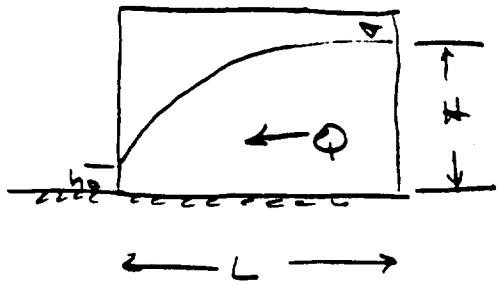
Use TM 5, Fig. IV-1 Gravity flow to fully penetrating line slot; single line source.
(Ref #2)

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY WW DATE 2/22/85 SUBJECT OMC SHEET NO. 5 OF
CHKD. BY RMW DATE 2/26/85 JOB NO 11837

Without sheet pile wall:

$$Q = \frac{kx}{2L}\left(H^2 - h_o^2\right)$$



$k = 2\times10^{-3}$ cm/sec
$= 4\times10^{-3}$ ft/min

$x = 580'$ (total length - both sides of excavation)

$L = 50$ ft (assume) [SMALLER THE VALUE, THE MORE CONSERVATIVE]

$H = 25'$

$h_o = 0$

$$Q = \frac{(4\times10^{-3}\ \text{ft/min})(580\ \text{ft})}{2\,(50\ \text{ft})}\left(25^2 - 0^2\right)$$

$Q = 14.5\ \text{ft}^3/\text{min} = 110\ \text{gpm}$

But, with sheet pile wall in place, seepage will be less.

Approximate interlock space as "windows" through wall. If interlocks are open (i.e., not in tension), space might be on the order of 1/4" wide. Window area $= \frac{0.25''}{18''} = 0.014$,

where 18" is typical sheetpile width.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY WW DATE 2/22/95 SUBJECT OMC SHEET NO. 6 OF
CHKD BY DATE 2/26/95 JOB NO 11837

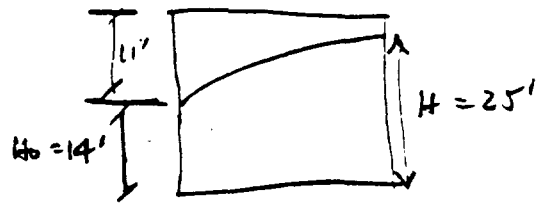
Estimate that a 1.4% "window" would reduce the effectiveness of the wall by, say, 10%. That is, a sheet pile wall with 1.4% windows would be 90% effective. The flow through the windows becomes:

$$Q = (0.10)(110\ gpm) = 11.0\ gpm$$

or:

$$\frac{Q}{580\ ft} = 0.019\ gpm / L.F.\ of\ wall \quad (\text{for deep excavation only})$$

Check seepage into shallow excavations.
by similar method.



$$Q = \frac{(4\times10^{-3}\ ft/min)(1\ ft)}{(2)(50\ ft)}(25^2 - 14^2)$$

$$Q = 0.017\ \frac{ft^3}{min}/LF \times 0.10\ (\text{eff.}) = 0.0017\ \frac{ft^3}{min}/LF$$
$$= 0.13\ gpm/LF \times 0.10 = 0.013\ gpm/LF\ of\ wall$$

SUMMARY

CONDITION	ESTIMATED SEEPAGE PER L.F. OF WALL
SHALLOW CUT (11')	0.013 gpm
DEEP CUT (25')	0.019 gpm

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY WW DATE 2/25/85 SUBJECT OMC SHEET NO. 7 OF
CHKD. BY GMW DATE 2/26/85 JOB NO. 11837

ESTIMATED FLOW QUANTITIES (THROUGH SHEET INTERLOCKS)

LOCATION	SEEPAGE PER LF OF WALL	TOTAL LENGTH	TOTAL SEEPAGE
CRESCENT LAGOON:			
DEEP SECTION	0.019 gpm	580 ft	11.0 gpm
SHALLOW SECTION	0.013 gpm	450 ft	5.9 gpm
OVAL LAGOON:			
SHALLOW CUT	0.013 gpm	500 ft	6.5 gpm
		TOTAL	23.4 gpm

Note: This is considered a "realistic" estimate if care is taken to avoid driving sheets out-of-interlock.
If problems occur which cause a leakier condition than would normally be expected, seepage into excavation will increase. However the maximum anticipated seepage should not exceed 10 times the estimate above, or 234 gpm. By staging construction, the maximum flow at any time, due to dewatering, should be less than the 200 gpm treatment plant capacity.

NOTE: CONTRACTOR IS ANTICIPATED TO EXCAVATE AND BACKFILL EACH OF THE 3 SHEETED EXCAVATIONS PRIOR TO BEGINNING THE NEXT ONE IN ORDER TO MINIMIZE THE AMOUNT OF SHEETING REQUIRED. THIS WILL LIMIT THE AMOUNT OF DEWATERING AT ANY GIVEN TIME.

WARZYN ENGINEERING, INC.
MADISON WISCONSIN

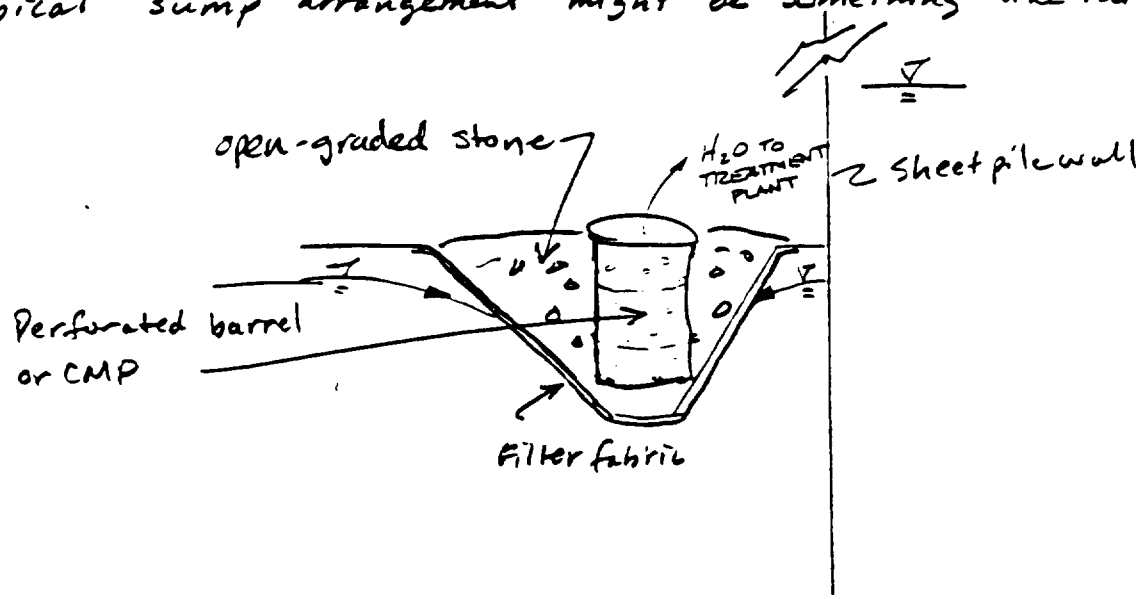
BY WW DATE 2/25/95 SUBJECT SHEET NO. 8 OF
CHKD. BY DATE 2/26/95 JOB NO.

3) Size of Sumps / Number of Sumps

Contractor to select locations of sumps, depending on actual seepage conditions. ✓

Also, number and size of pumps to be determined by contractor to allow use of his existing equipment. ✓

Typical sump arrangement might be something like this: ✓



NOTE: CONTRACTOR SHALL PERFORM EXCAVATIONS IN THE "DRY" TO FACILITATE SOIL SAMPLING FOR PCB ANALYSIS AND TO INSTALL BRACING. GROUNDWATER LEVEL SHOULD BE MAINTAINED A MINIMUM 2 FT. BELOW THE LOWEST LEVEL OF THE EXCAVATION.
CONTRACTOR SHALL BACKFILL EXCAVATION IN THE "DRY" TO FACILITATE COMPACTION AND REMOVAL OF BRACING.

2-27-95

WARZYN ENGINEERING, INC.
MADISON WISCONSIN

BY WW DATE 2/27/85 SUBJECT OMC SHEET NO. 9 OF
CHKD BY DATE 2-27-85 JOB NO. 11837

4) Routing of Flow to Treatment plant

Treatment plant to be located on east side of site at approx. location 639,200E & 2,078,400N.

Distance from crescent ditch to treatment plant ≈ 1300 ft

B32 639,200 E
− 637,900 E
1300 ft

Distance from oval lagoon to treatment plant ≈ 900 ft

639,200
638,300
900 ft

Best option for piping water to treatment plant is probably via PVC pipe or flexible hose (4 to 6 in ϕ). Choice of transport system will be left to contractor subject to engineers approval based on his available supplies. Can be buried in shallow trenches or laid directly on ground.

Cross RR tracks and roadways by routing pipe or hose through existing culverts or through new trenches.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

SHEET NO. 1 OF 2
JOB NO. 21837

DATE 3-1-85
DATE 3-6-85

SUBJECT SMC - WAUKEGAN, IL
DESIGN ANALYSIS

I. CRESCENT DITCH / OVAL LAGOON CONTAINMENT CELL

SITE CONSTRUCTION

E. BACKFILLING

1. MATERIALS, PLACEMENT TECHNIQUE AND COMPACTION

THE EXCAVATION WILL PROBABLY BE PERFORMED WITH A CLAMSHELL DEVICE INSIDE THE SHEETED, DEWATERED EXCAVATION. BECAUSE OF THE NATURE OF THE BACKFILLING OPERATIONS (CONFINED AREA, MOIST BOTTOM), GRANULAR BACKFILL MATERIALS WILL BE SPECIFIED. BACKFILL PLACEMENT WILL BE BY THE CLAMSHELL. THE BACKFILL SHOULD BE SPREAD IN UNIFORM, HORIZONTAL LIFTS WITH A LOOSE THICKNESS NO GREATER THAN 12 INCHES. THE GRANULAR BACKFILL SHOULD BE COMPACTED TO A MINIMUM DRY DENSITY OF 90% MODIFIED PROCTOR. HAND-GUIDED COMPACTING EQUIPMENT SUCH AS VIBRATORY PLATES OR JUMPING JACKS ARE ANTICIPATED TO BE NECESSARY. A MODIFIED HOE-PAK WITH SUFFICIENT REACH AND OPERATING OUTSIDE THE EXCAVATION MAY BE FEASIBLE.

POSSIBLE ALTERNATE IS 95% STANDARD PROCTOR

THE 1ST COUPLE OF LIFTS OF BACKFILL OVER THE CLAY TILL SUBGRADE MAY REQUIRE THE USE OF AN OPEN-GRADED STONE (P200 ≤ 5%) TO STABILIZE AND BRIDGE THE SUBGRADE. RESTRICTIONS ON THE AMOUNT OF FINES IN THE GRANULAR BACKFILL CAN THEN BE REDUCED (P200 < 35%) AS LONG AS THE REQUIRED COMPACTION IS OBTAINED. PERIODIC FIELD DENSITY TESTS ARE RECOMMENDED AS THE BACKFILL IS PLACED TO DETERMINE THE ADEQUACY OF COMPACTIVE EFFORT. APPROXIMATELY 3 TESTS PER UNIFORM LIFT IN THE DEEP EXCAVATION (APPROXIMATELY EQUIVALENT TO 1 TEST / 50 YD^3) AND 2 TESTS PER UNIFORM LIFT IN THE SHALLOW EXCAVATION (EQUIVALENT TO 1 TEST / 55 YD^3) ARE CONSIDERED APPROPRIATE.

THE DEWATERING SUMPS SHALL BE RAISED AS THE LEVEL OF THE BACKFILL IS RAISED AS LONG AS THE GROUNDWATER LEVEL IS MAINTAINED AT LEAST 2 FT. BELOW THE BACKFILL LEVEL. SHOULD

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 3-4-85 SUBJECT OMC - WAUKEGAN, IL SHEET NO. 2 OF 2
CHKD. BY DJC DATE 3-7-85 JOB NO. C11837

E. CONTINUED

THE DEWATERING SYSTEM FAIL AND THE EXCAVATION BECOME FLOODED AFTER THE BACKFILLING OPERATIONS HAVE BEGUN, THE CONTRACTOR SHALL PROVE THAT THE BACKFILL IN PLACE IS STILL COMPACTED TO 90% MODIFIED PROCTOR (MINIMUM) PRIOR TO CONTINUING BACKFILLING. IF THE CONTRACTOR CANNOT PROVE THE COMPACTION REQUIREMENT, THE BACKFILL SHALL BE RE-EXCAVATED AND RE-COMPACTED IN ACCORDANCE WITH THE OUTLINED REQUIREMENTS.

2. QUANTITIES

BACKFILL VOLUMES ARE AS FOLLOWS:

OVAL LAGOON	1,528 cy
CRESCENT DITCH	4,694 cy
TOTAL	6,222 cy

IN ADDITION, 1,200 cy OF CONTAMINATED MATERIAL CAN BE CONTAINED IN THE CELL. REFER TO VOLUME CALCS. IN APPENDIX E

AFTER BACKFILLING, TOTAL AIR SPACE =	20,000 cy
LESS FINAL COVER VOLUMES OF	18,800 cy
NET AIR SPACE	1,200 cy

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY M. SCHULTZ DATE 2/23/95 SUBJECT OMC/WAUKEGAN/SUPERFUND SHEET NO. 1 OF 13
CHKD BY [illegible] DATE 3/1/95 DESIGN ANALYSIS JOB NO. C11837

VIII CRESCENT DITCH / OVAL LAGOON CONTAINMENT CELL SITE CONSTRUCTION

F. SLURRY WALL

1.1 PREQUALIFICATION OF CONTRACTOR OR SUBCONTRACTOR

The (sub) contractor shall submit evidence that he is experienced and competent to construct a soil-bentonite slurry trench. This provides evidence that the (sub)contractor will have sufficient competent experienced personnel to carry out the operations specified. The personnel should probably have no less than 3 years experience in slurry trenching and shall have participated in the construction of no less than 5 jobs of similar scope and magnitude using the slurry technique. In particular, the slurry trench (sub) contractor (as approved by the Engineer) shall supervise on a full time basis the construction, slurry preparation, and quality control.

If for whatever reason, a change in the approved slurry trench specialist is deemed necessary, the new (sub) contractor will need to be approved by the Corps of Engineers.

(A possible "Statement of Bidder's Qualifications" that we might follow is attached. - Taken from Lower Landfill Specs, Warzyn Job No. C9120).

EXAMPLE OF

STATEMENT OF BIDDER'S QUALIFICATIONS

This statement shall be submitted with the Bid. All questions shall be answered and the data given shall be clear and comprehensive. If necessary, questions may be answered on separate attached sheets. The Bidder may submit any additional information he desires.

1. Name of Bidder.

2. Permanent main office address

3. How many years have you been engaged in slurry wall construction?

4. Slurry wall contracts ~~on~~ in hand: (Schedule these, showing amount of each contract and the appropriate anticipated dates of completion.)

5. Have you ever failed to complete any work awarded to you? If so, where and why?

6. Have you ever defaulted on a contract? If so, where and why?

7. List the more important slurry wall projects recently completed by your company, stating the approximate cost for each, the month and year completed, and a reference with phone number.

8. List your major equipment available for and to be placed upon this Project.

9. List the background and experience of the site foreman that will be placed on this project.

10. Upon request, furnish a detailed financial statement and any other information that may be required by the OWNER.

11. The undersigned hereby authorizes and requests any persons, firm or corporation to furnish any information requested by the OWNER, in verification of the recitals comprising this Statement of Bidder's Qualifications.

Dated at _____ this_____ day of _____, 19____.

_____
(Name of Bidder)

By _____

Title _____

1.2 SLURRY TRENCH CUTOFF WALL

The impervious slurry trench cutoff wall shall be constructed to the lines, grades and cross sections shown on the attached drawings. The trench shall have essentially vertical walls, a 24 to 36 inch width (24" min.), and shall extend through a preconstructed compacted clay dike, approximately 20 to 35 feet of medium dense sand and key a depth of 3' to 5' feet into clayey glacial till materials. A typical cross section of the slurry trench is shown on Figure 1 attached.

A generalized description of materials to be excavated follows:

Sand - medium dense, very fine to fine, trace to little silt

Glacial till - very stiff to hard clayey silt with little sand & gravel

- SPT results ranged between [illegible] to 100+ blows per foot and pocket penetrometer values between 2.5 to 4.5+ TSF

The crest of the preconstructed clay dike will be 18' wide and at El 586. The dike invert elevation shall in general be at El 584 except in the areas where the railroad tracks cross over the wall. In these areas the dike invert elevation is as low as El 581± which is roughly 1.5' below the water table. Hence, localized dewatering will probably be needed in the railroad crossing areas. Initial dike side slopes shall be 1:1 (horizontal to vertical) or flatter. The final exterior dike slope shall be 3:1. The dike will remain in place after construction of the slurry wall and placement of the impermeable membrane. The clay materials shall be compacted such that a permeability less than 1×10^{-7} cm/sec is achieved (probably on the order of 95% Standard Proctor density). 18' was chosen as the crest width because of comments by Mr. Don Tillges of Case International Corp. regarding backhoe track widths. (Ref. No. [illegible])

[OR 90% MODIFIED PROCTOR]

The bottom of the preconstructed clay dike was chosen to be a minimum of 1' below the top of the soil-bentonite slurry cutoff wall (1.5' below in railroad track crossing areas) because of Mr. Tillges' comments (Ref. No. 1) regarding settlement of the backfill materials. A trench with these type of dimensions could experience backfill material settlement on the order of 6". If 6" of settlement does indeed occur and the clay materials capping the trench do not settle an equal amount, a gap would develop between the clay cap and the backfill materials. With the clay dike 1' below the initial height of backfill, this gap would remain contained in the dike (clay dike 6" below estimated final height of backfill). The top of the dike El 586 was chosen so that slurry contained in the dike and trench could attain a minimum

(Cont.)

1.2 Cont:

2' head differential over local ground water conditions (ground water estimated to be at EL. 583) which would establish a positive hydrostatic head. A slurry level kept at EL. 585 would provide this 2' head differential and also provide one foot between the top of the slurry and the dike crest which should aid in reducing slurry spillage. A windrow will also be constructed along the exterior edge of the dike to prevent excess slurry from slopping outside of the dike.

In areas where natural ground is above EL 584, excavation will be required to place clay so that a clay dike base grade of EL. 584 is achieved. Again, clay base grades beneath the railroad tracks extend to an elevation as low as EL 581.5. The volume of excavated materials is approximately 1350 yd³ while the volume of fill materials for dike construction is about 2750 yd³. A profile section along the slurry wall alignment can be found on Figure 2, attached. Figure 2, drawn with an exaggerated vertical scale as well as exaggerated areas near the railroad tracks, shows areas that need excavation and clay backfilling, the top of the slurry wall, and the top of the clay surface. Figures 3, 4 & 5, also attached, show in more detail the compacted clay dike and how the slurry wall and clay cap tie into it.

[APPENDIX K] →
[SITE PREP. - ITEM B] →

It should be noted that the slurry wall alignment basically follows the alignment proposed in the CH2M Hill conceptual design report written previously. The alignment was basically chosen to achieve PCB containment at the OMC site. A comparison of the proposed alignment with the results of contamination analyses presented in the Mason-Hanger 1981 Final Report indicates the alignment generally includes the highly contaminated areas, and sometimes uncontaminated areas.

It should also be noted that the slurry wall is required to "dip" beneath the railroad crossings in the area because major alterations of the track grade were not permitted. Additional "dips" beneath the drainage ditch located adjacent to the tracks also were required to maintain the 2' clay cover over the contaminated areas. The ditch was designed following specifications found in the AREA Manual for Railway Engineering or Elgin, Joliet & Eastern Railway Company guidelines. Ballast was designed following the above criteria as well.

A 24 to 36 inch (24" min.) wide slurry trench was chosen primarily because in literature it states the majority of slurry walls are in the 24" to 36" width range with a

(cont.)

WARZYN ENGINEERING, INC.
MADISON WISCONSIN

BY M. SCHULTZ DATE 2/23/85 SUBJECT OMC/WAUKEGAN/SUPERFUND SHEET NO. 10 OF 10
CHKD BY [illegible] DATE 3/1/85 DESIGN ANALYSIS JOB NO. C11837

1.2 cont:

18" minimum width. According to Mr. Dan Tiltges (Ref. No. 1), if one specifies a minimum trench width of 24" and a 24" bucket is used to excavate the trench, what usually occurs is that a 30" wide trench is actually dug. On a cost basis, again according to Mr. Tiltges, a 24" wide trench is not any cheaper than a 30" or 36" wide trench (providing backfill soils are not imported). By specifying a minimum 24" wide trench be dug with a bucket 24" wide, one can minimize the imported backfill soils costs and probably still attain a final trench width of 30" which falls in the center of the range of the majority of existing slurry wall widths (24" to 36").

Another relationship used to establish wall thickness is typically a width of 0.5 to 0.75 feet per 10 feet of differential hydrostatic head acting on the wall. Since the differential head will essentially be zero, this had no bearing on choosing a wall width.

I spoke with Mr. Don Simms of N.L. Baroid (Ref. No 2), a bentonite supplier, located in Houston, Texas. Mr. Simms, referred to me by Mr. Tiltges, believed PCB's would have no adverse effects on the bentonite and hence the slurry wall integrity. In this regard, a 30" or 36" wide slurry wall again does not provide additional benefits over a 24" wide wall.

It is assumed trenching can be accomplished with the use of conventional hydraulic backhoes. The backhoe should probably have a reach of no less than about 40' in order that a 3 to 5 foot key can be excavated in the glacial till materials (boreholes indicate a maximum sand depth of 31'). Special chopping, chiseling or other suitable equipment may be used as necessary to accomplish the required excavation (a possibility of boulders or cobbles in the till exists). A 5 foot key is desireable (the original CH2M Hill Concept Report utilized a 5 foot key), but if excavation difficulties occur in the till materials, a 3 foot deep key is considered adequate. Literature states that most keys are 1 to 3 feet deep. The width of the excavating tool should be equal to or greater than 24". In general, when the excavated portion is about twice the depth, backfilling may begin. Enough space should be provided ahead of the backfill to clean the bottom of the trench by moving up the backhoe and dragging the bottom of the trench with the bucket. This should assure that excavated materials will not accumulate in the trench bottom.

1.2 cont:

If this does not prove satisfactory, the use of airlift pumps or clamshells may be required to clean the trench bottom.

Spoil materials excavated for the slurry wall will need to be trucked to the parking lot containment area and disposed of properly. Due to their contamination, they are assumed unfit for re-use as backfill materials.

Excavation Volume:

Assume Avg trench depth : 30 feet
(includes excavation through 2' thick clay dike)

Assume Avg trench width: 2.5' or 30 inches

Trench Length : 1850 ± feet (scaled from drawing)

Volume: $2.5 \text{ feet} (30 \text{ feet})(1850 \text{ feet}) \left(\frac{1 \text{ yd}^3}{27 \text{ ft}^3}\right) = 5140 \text{ yd}^3$ to a spoil

WARZYN ENGINEERING, INC.
MADISON WISCONSIN

BY M. SCHULTZ DATE 2/28/85 SUBJECT OMC/WAUKEGAN/SUPERFUND SHEET NO. 3 OF 19
CHKD BY [illegible] DATE 3/1/85 DESIGN ANALYSIS JOB NO. C11837

1.3 MATERIALS

1.3.1 Slurry

Slurry shall consist of a stable colloidal suspension of sodium bentonite in water and shall be controlled in accordance with the most current API Standard 13B, "Standard Procedure for Testing Drilling Fluids," and the following requirements:

1.3.1a Slurry when first mixed

i) The density of the slurry shall not be less than 64 lbs/ft³ measured at a point where fresh slurry is discharged into the trench. The slurry mix shall basically be of sufficient density to maintain the trench in an open condition prior to backfilling.

ii) The slurry shall be fully hydrated prior to placement in the trench. According to Mr. Tillges (Ref. No. 1), 2 ponds about 100'x100' will be needed to hydrate the bentonite. Appropriate space will need to be set aside for this. Hydration can be expected to occur overnite.

iii) The viscosity of the slurry shall not be less than 35 seconds, as measured by a Marsh funnel. For comparison sake, the Marsh funnel viscosity of water is 27 to 28 seconds. Keeping the viscosity of the slurry higher than that of the water is another way of assuring that the slurry has enough weight to prevent trench collapse.

iv) The fluid loss of the slurry shall not be more than 35 cc in 30 minutes as measured by a standard filter press. The filtrate loss test should be viewed as a confirmation test rather than a fundamental physical property test such as density & viscosity.

1.3.1b Slurry at time of backfilling

i) The viscosity of the slurry should again not be less than 35 seconds.

ii) The density of the in-trench slurry, as sampled near the bottom, should be at least 5 lbs/ft³ lighter than the backfill. This should assure that the in-trench slurry will be displaced by the backfill.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY M. Schulte DATE 2/28/95 SUBJECT CMC/WAUKEGAN/SUPERFUND SHEET NO. 9 OF 19
CHKD. BY [illegible] DATE 3/1/95 DESIGN ANALYSIS JOB NO. 011837

1.3.2 Bentonite

The bentonite powder used in preparing the slurry should be an unaltered premium grade of sodium bentonite and meet the most current API Standard 13A "API Specification for Oil-Well Drilling-Fluid Materials." The bentonite/soil/water backfill materials should be tested such that chemical compatibility with the PCB leachate is assured and a permeability of 1×10^{-7} cm/sec is not exceeded prior to construction. Testing procedures will be addressed in final design.
One unresolved issue is whether it is practical to require the contractor to test for compatibility w/ PCB's (i.e., will samples be available; etc.?)

1.3.3 Water

The water shall be clean and free from contaminants, such as soluble salts, hydrocarbons, organic matter or other deleterious substances which would affect the proper hydration and suspension properties of the slurry.

Water from Lake Michigan is a potential source as well as water from hydrants on CMC property. Water taped from the hydrants would obviously need to be metered and paid for accordingly. Whatever the water source, it should be tested to confirm its suitability for use. Donahue & Associates, Inc. has confirmed water supplied by the City of Waukegan is available on site for choices outlined in the cost estimate. It is assumed that this water is available for slurry wall use.

1.3.4 Additives

The use of additives is not planned at this time.

1.3.5 Backfill

The materials for trench backfilling shall be composed of slurry and selected soils obtained from off site borrow areas. The soils shall be free from non organic matter or other deleterious materials. The backfill shall be thoroughly mixed and reasonably well graded before placement in the trench. Mixing of the backfill on the ground surface with a dozer on the site will not be allowed because

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY M. SCHULTZ DATE 2/28/85 SUBJECT CMC/WAUKEGAN/SUPERFUND SHEET NO. 10 OF 19
CHKD. BY DATE 3/1/85 DESIGN ANALYSIS JOB NO. C11837

1.3.5 cont:

of the concern with cross-contamination. A "clean" batch mixing operation will therefore be necessary on-site. Backfill can be mixed with the bentonite slurry in an off-site area and trucked in if desired. Mixing of the backfill off site can be done on the ground surface by windrowing, dozing, blading or by other approved methods. Lumps not greater than 6 inches maximum measurement, would be permitted for placement. The backfill blend shall be placed to form a homogeneous mass, free from voids and inclusions, at least 30 inches wide and shall produce a permeability not greater than 1×10^{-7} cm/sec. Free-falling of the backfill through the slurry will be prohibited which implies the contractor must establish an angle of repose for the materials to flow down. Slump of the backfill materials should be on the order of 2 to 6 inches.

The soil's gradation and quantity of bentonite used in the backfill are the two most important elements effecting the long term permeability of a slurry wall. A desireable soil for backfill is well graded, containing sand and gravel plus 10-30% fines (materials passing a 200 mesh sieve). Typical specified gradations for backfill materials are given below (it is assumed gradations are for ground water cutoff walls):

TABLE 8-2 Typical Gradation Limits for Backfills in the United States

U.S. standard sieve	Percentage passing by weight: Wanapum Development	Camanche Dike	Southport AWT Facilities, Indianapolis
3 in	80-100	80-100	100
¾ in	40-100	60-100	55-100
No. 4	30-70	40-80	40-75
No. 30	20-50	20-60	25-50
No. 200	10-25	10-30	20-30

Taken from SLURRY WALLS by Xanthakos (1979) (Ref. No. 3)

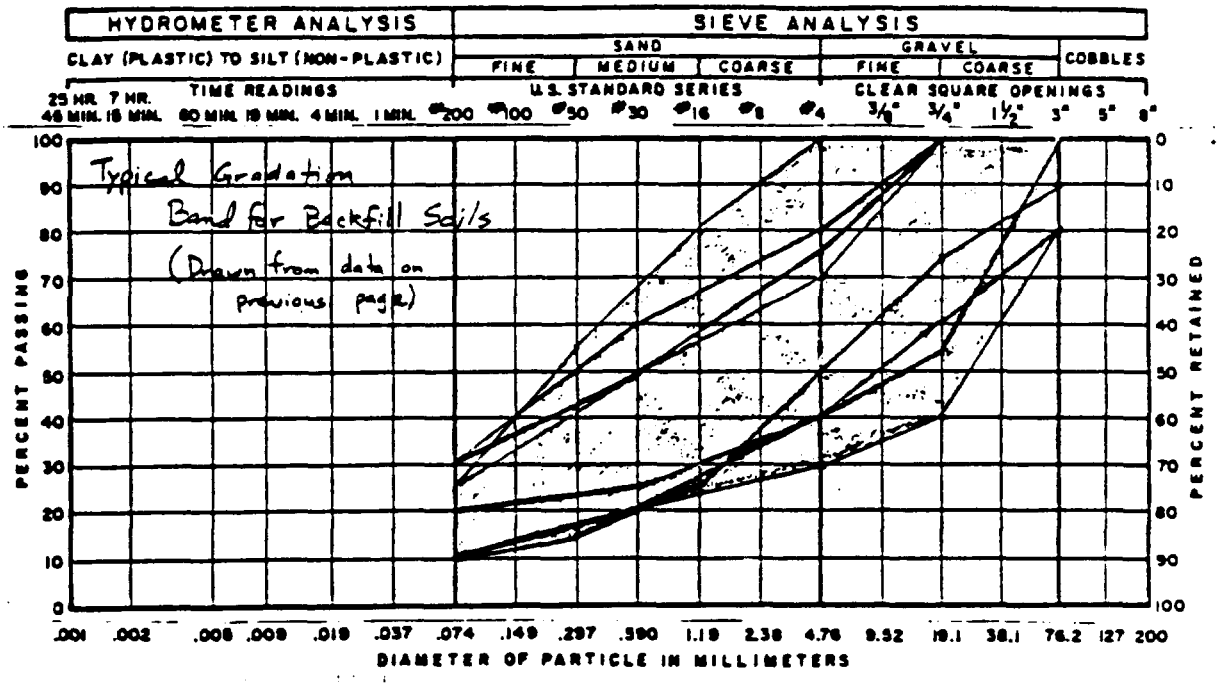
Typical Corp of Engineer's Specified Backfill Gradation (from CASE INT. slide show - Ref. No. 1

U.S. STND SIEVE	% PASSING BY WEIGHT
3"	90-100
3/4"	75-100
#4	50-100
#16	25-80
#50	15-55
#200	10-25

(cont:)

1.3.5 cont:

The above typical gradations are plotted below. A well graded backfill soil falling within the gradation "band" presented below and mixed with an appropriate amount of bentonite slurry is frequently used for a backfill design.



Just how much bentonite is required in a backfill design mix in order that a desired permeability, in this case 1×10^{-7} cm/sec or less, is obtained? In general, according to the CASE notebook (Ref. No. 4), a backfill with at least 20% fines and 1% bentonite, by weight, will stand up to most pollutants. The amount of bentonite added will vary with the percentage of fines and the water content of the premixed backfill soils. The graph on page 12 of 19 (next page) shows permeability of a soil bentonite cutoff wall vs. % bentonite by dry weight with water as a leachate. From the graph, in order to achieve a permeability of 1×10^{-7} cm/sec, one should proportion the bentonite to be a minimum of 1% by dry weight of the backfill materials if the backfill soils are clayey silty sand with 30 to 50% fines, about 2½% if the backfill soils are poorly graded silty sand with 30 to 50% non-plastic fines, and about 3% if the backfill soils are well graded coarse gradations with 10 to 25% non-plastic fines. In summary, what the graph basically shows is that a higher percentage of bentonite is required to acheive a desired permeability if: (1) a soils fines content is lower or (2) the fines are non-plastic rather than plastic in nature.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY M. SCHULTZ DATE 2/28/85 SUBJECT OMC/WAUKEGAN/SUPERFUND SHEET NO. 12 OF 19
CHKD. BY [illegible] DATE 3/1/85 DESIGN ANALYSIS JOB NO. C11837

1.3.5 cont:

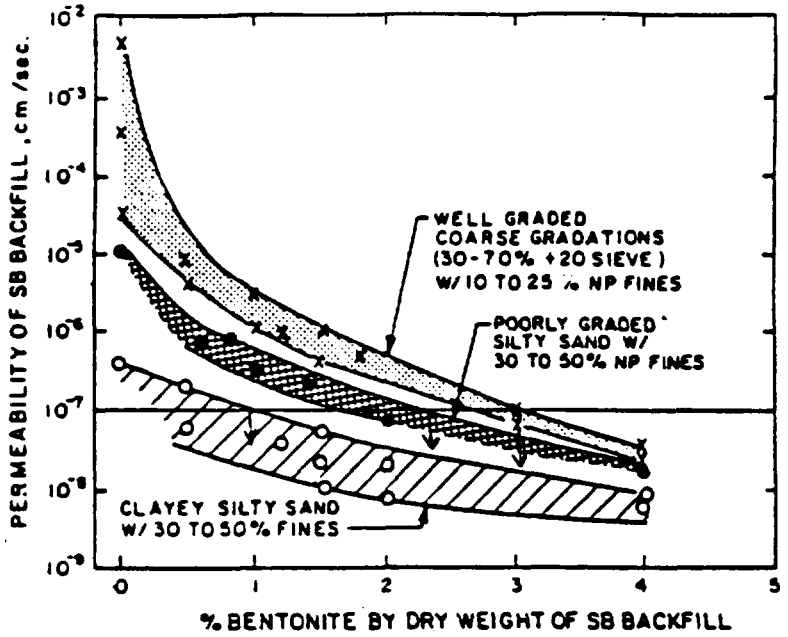


FIG. 19 RELATIONSHIP BETWEEN PERMEABILITY AND QUANTITY OF BENTONITE ADDED TO SB BACKFILL
(WATER AS LEACHATE)
(AFTER D'APPOLONIA AND RYAN 1979) – Ref. No. 5

The graph below also shows that it is important to have the fines in the backfill be plastic in nature. For example, if the % fines in the backfill are 20%, one can achieve a permeability of 1×10^{-7} cm/sec if the fines are plastic, but can not if they are nonplastic. Adding bentonite to increase plasticity is adequate but expensive.

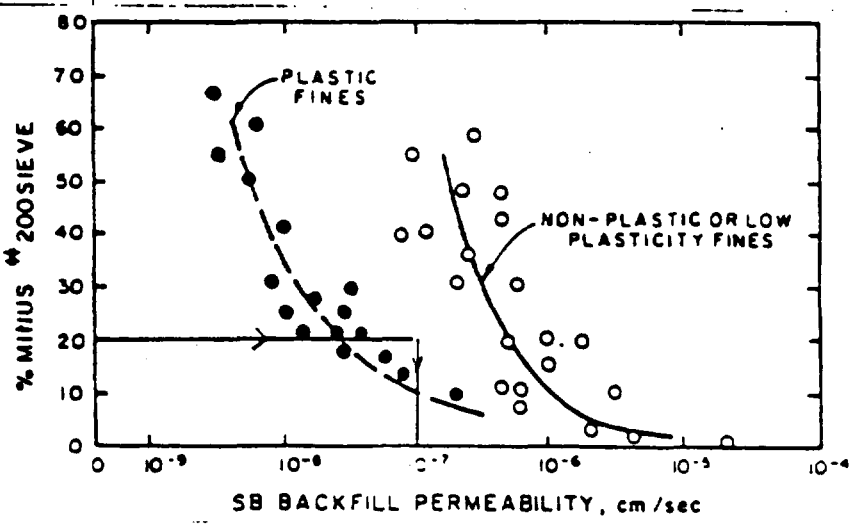


FIG. 18 PERMEABILITY OF SOIL-BENTONITE BACKFILL RELATED TO FINES CONTENT (1% BENTONITE)
(WATER AS LEACHATE)
(AFTER D'APPOLONIA AND RYAN 1979) – Ref. No. 5

1.3.5 cont:

Maximum economy will be attained when the fine fraction is provided by clayey soils, blended with sand and some gravel and then mixed with bentonite slurry. In addition, the use of ordinary clay materials mixed with small quantities of bentonite as soil backfill is preferred over large quantities of bentonite mixed with granular backfill because ordinary clay is significantly less affected by permeation with most chemical and industrial wastes than is bentonite. In summary, based on the gradation band and the two graphs on the preceding page, an adequate concept design backfill mix would contain 25-30% plastic fines, about 2% bentonite, be well graded and exhibit a permeability no larger than 1×10^{-7} cm/sec. It is very important that whatever gradation % fines and % bentonite is chosen for the final backfill design, preconstruction testing should be done to evaluate its suitability to the PCB environment at OMC. Basically, permeability testing with water and compatibility testing to evaluate the long term effects of PCB's should be conducted using the backfill design mix to evaluate whether or not the design permeability of 1×10^{-7} cm/sec can be achieved and maintained. The backfill mix and testing programs are unresolved items.

Other items for consideration during final design of slurry backfill:

1) Mixing and placement of backfill should be limited to days when the average temperature is not less than 25° F.
2) It has been shown that varying the water content of the backfill can affect permeability. CASE Int. (Ref. No. 4) suggests that the water content of the backfill at the time of placement be no more than 30%. This can be best controlled by adding dry bentonite or additional fines.
3) Good grading gives the backfill low compressibility characteristics. If fines portion becomes excessive, it may cause backfill consolidation. (XANTHAKOS)
4) At the Gilson Road Hazardous Waste Disposal Site, the first EPA Superfund Slurry wall site, a permeability of 1×10^{-7} cm/sec was achieved with 2 to 3% bentonite and a total (non-plastic) fines content of 30% during laboratory testing. The final design backfill mix specified not less than 5% bentonite and 30% fines to account for imperfect field mixing. However, field verification testing indicated that the actual % bentonite averaged only about 4% while the % fines averaged 33%, resulting in a field permeability averaging 5×10^{-8} cm/sec. Leachate at Gilson Road was organic solvent in the tenth of a percent range (Ref. No. 6).

Volumes: Components of the in-place backfill materials

Excavated trench volume (pg 7) $5140 yd^3$

Wet weight of backfill (assuming 105 pcf per D. Tillges (Ref. No. 1))

$5140 yd^3 (105 lb/ft^3)(27 ft^3/yd^3) = 14,571,900$ lbs

(cont.)

1.3.5 cont:

Estimate of total weight of bentonite needed for job. (based on Case Estimate)

$$\frac{6\,lb}{ft^2}\left(55{,}500\,ft^2\right) = 333{,}000 \text{ lbs of bentonite}$$

Weight of bentonite used for trenching operation:

Total weight − left in place weight =

333,000 lbs − 220,786 lbs = 112,214 lbs

Case Notebook (Ref. No. 4) states that 90-100 lb/yd³ of bentonite will result in a density of at least 64 lb/ft³ which is the minimum density of fresh slurry that should be allowed in the trench (See 1.3.1a)

Volume of water mixed with bentonite for trenching operation:

$$112{,}214\,lbs\left(\frac{yd^3}{90\,lbs}\right)\left(\frac{27\,ft^3}{yd^3}\right)\left(\frac{7.48\,gal}{ft^3}\right) = 251{,}808\,gal$$

Total Quantities:

Off Site Borrow Soils		3686 yd³
Additional Water	228,931 + 251,808 =	480,739 gal
Bentonite (@ 2% in backfill)	220,786 + 112,214 =	333,000 lbs

1.3.5 cont:

Estimate of total weight of bentonite needed for job. (based on Case Estimate)

$$\frac{6\,lb}{ft^2}\left(55{,}500\,ft^2\right) = 333{,}000 \text{ lbs of bentonite}$$

Weight of bentonite used for trenching operation:

Total weight − left in place weight =

333,000 lbs − 220,786 lbs = 112,214 lbs

Case Notebook (Ref. No. 4) states that 90-100 lb/yd³ of bentonite will result in a density of at least 64 lb/ft³ which is the minimum density of fresh slurry that should be allowed in the trench (See 1.3.1a)

Volume of water mixed with bentonite for trenching operation:

$$112{,}214\,lbs\left(\frac{yd^3}{90\,lbs}\right)\left(\frac{27\,ft^3}{yd^3}\right)\left(\frac{7.48\,gal}{ft^3}\right) = 251{,}808 \text{ gal}$$

Total Quantities:

Off Site Borrow Soils		3686 yd³
Additional Water	228,931 + 251,808 =	480,739 gal
Bentonite (@ 2% in backfill)	220,786 + 112,214 =	333,000 lbs

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY M. SCHULTZ DATE 2/28/85 SUBJECT CMC/WALCERAN/SUPERFUND SHEET NO. 16 OF 19
CHKD BY [illegible] DATE 3/1/85 DESIGN ANALYSIS JOB NO. C1-835

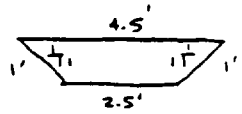
1.4 CLAY CAPPING OF CUTOFF TRENCH

Upon completion of backfill placement and before drying of the backfill can occur, the cutoff trench shall be capped with clay. Capping shall be done southwest of the railroad tracks following details as shown on figure 3, Section A-A; underneath the railroad tracks as shown on figure 5, Section D-D'; and northeast of the railroad tracks as shown on figure 5, Section E-E'. Prior to capping, the slurry wall will need to be excavated as shown on Sections B-B' (figure 4) and C-C' (figure 5). Cutback slopes no steeper than 3:1 should be used. Mr. G. Stallard of I.T. Corp. has seen slurry walls cutback as steep as 1:1 after the backfill materials were allowed to "set up" for several days. 3:1 slopes should therefore be attainable along the top of the wall. (Ref. No. 7)

The clay cap over the slurry wall will be 1 foot thick overlain by 1.5 feet of granular materials and an impermeable membrane southwest of the tracks, 2.0 feet thick beneath the tracks overlain by geotextile and 18" ballast, and about 1.5 feet thick northeast of the tracks overlain by the membrane and 1.5 feet of granular materials. Prior to placement of the clay, the side slopes of the trench should be cut back to at least a 1:1 except under the railroad tracks where cutback slopes should be at least 2:1. Slopes of this nature should help the clay to bear on existing clay and the trench rather than just a clay "plug" bearing on the trench materials alone. This design should also promote some bridging of the clay over the trench. The clay cap should be a wet plastic clay directly over the trench for strain compatability. The clay materials should have a water content slightly above optimum and be compacted by the gentle application of rolling equipment so as to minimize disturbance of the bulk of the backfill.

Volume of Clay Capping Materials:

For rough estimate, assume cuts at 1:1 (Minor portion at 2:1).



Area = ½(2.5+4.5)(1) = 3.5 ft²

Length = 1850 ft ± (Page 7)

Volume = 1850 (3.5) / 27 = 240 yd³

Say 275 yd³ to account for occasional 2:1 cuts beneath RR tracks.

1.5 CLEANUP

Excess slurry shall be spread in thin layers over the disposal areas upon the completion of work and become part of the disposal site. Mixing ponds should be leveled and the area left as found.

1.6 QUALITY CONTROL, TESTS and APPROVALS

The contractor shall maintain his own quality control for the cut-off wall construction under the direction of a qualified engineer. The engineer will also provide additional quality control testing, to verify that performance criteria are met. A testing program to be developed will include the following tests: (a) slurry viscosity; (b) check of slurry hydration time; (c) blending methods and proportions for slurry and backfill; (d) sample in-place backfill for laboratory permeability tests; (e) backfill slump; and (f) verifications of dimensions, continuity and key. Example testing requirements are found in Table 1 attached.

TABLE 1

Example

Materials Quality Control Program

Soil/Bentonite

Slurry Trench Cut-Off Wall

SUBJECT		STANDARD	TYPE OF TEST	MINIMUM FREQUENCY	SPECIFIED VALUES
Materials	Water	-	-pH -Total Hardness (Ca & Mg)	Per water source or as changes occur	As required to properly hydrate bentonite with approved additives
	Additives	-	Manufacturer certificate of compliance with stated characteristics		As approved by Engineer
	Bentonite	API Std 13A	Manufacturer certificate of compliance		Unaltered sodium cacion montmorillonite
	Backfill Soils	-	Selected soils obtained from a borrow area approved by the Engineer		65 to 100% passing 3/8" Sieve 35 to 85% passing #20 Sieve 15 to 35% passing #200 Sieve Roll to 1/8" thread
Slurry	Prepared for Placement into the Trench	API Std 13B	- Unit Weight - Viscosity - Filtrate Loss - pH	1 set per shift or per batch (pond)	Unit Weight $\geq$ 1.03 gm/cc V $\geq$ 15 centipose or 40 sec-Marsh @ 68° Loss $\leq$ 15 cc in 30 min @ 100 psi pH $\geq$ 8
	In Trench	API Std 13B 1	- Unit Weight	1 set per shift at point of trenching	unit weight = 1.03 - 1.36 gm/cc
Backfill Mix	At Trench	ASTM C 143	- Slump - Gradation	1 set per 200 cu yds	Slump 2 to 6 inches 65 to 100% passing 3/8" Sieve 35 to 85% passing #20 Sieve 15 to 35% passing #200 Sieve

M. Schulte 2/28/85 OMC/Waukegan/Superfund Design Analysis C1837 Sheet 12 of 1-75

Rev 3/1/85

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY MNS DATE 2-28-85 SUBJECT OMC SHEET NO. 19 OF 19
CHKD BY CCW DATE 3/1/85 JOB NO. C11337

Summary of References

No. 1 Information obtained from slurry wall slide presentation or subsequent discussions on 2/15/85. Slide presentation given by Mr. Dan Tilloes of CASE International Company, a slurry wall contractor, Roselle, Illinois.

No. 2 Phone conversation memo regarding discussions with Mr. Don Simms of N.L. Baroid on 2/26/85.

No. 3 Text: Xanthakos, Petros P., Slurry Walls, McGraw-Hill, Inc., 1979.

No. 4 Notebook: Case Slurry Wall Notebook, distributed by Case International Comp.

No. 5 Papers: D'Appolonia, David J., "Slurry Trench Cutoff Walls For Hazardous Waste Isolation" from Engineered Construction International, Inc., & Ryan, Christopher R., "Slurry Cut-off Walls, Methods and Applications", from GEO. CON Inc.

No. 6 Abstract: Ayres, J., Lagen, D. and Barvenik, M., "The First EPA Superfund Cutoff Wall; Design and Specifications"

No. 7 Phone conversation memo regarding discussions with Mr. Geoffrey Shallard of I.T. Corp. on 2/22/85.

No. 8 Phone conversation memo regarding discussions with Mr. Bob Martin of Case International Comp. on 3/5/85.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY Mike Schmitt DATE 2/20/85 SUBJECT SMC/WAUKEGAN/SUPERFUND SHEET NO. ____ OF ____
CHKD. BY [illegible] DATE 3/1/85 JOB NO. [illegible]

SOIL BENTONITE SLURRY CUTOFF WALL DETAIL
DIKE CONSTRUCTION FOR SLURRY WALL TRENCHING

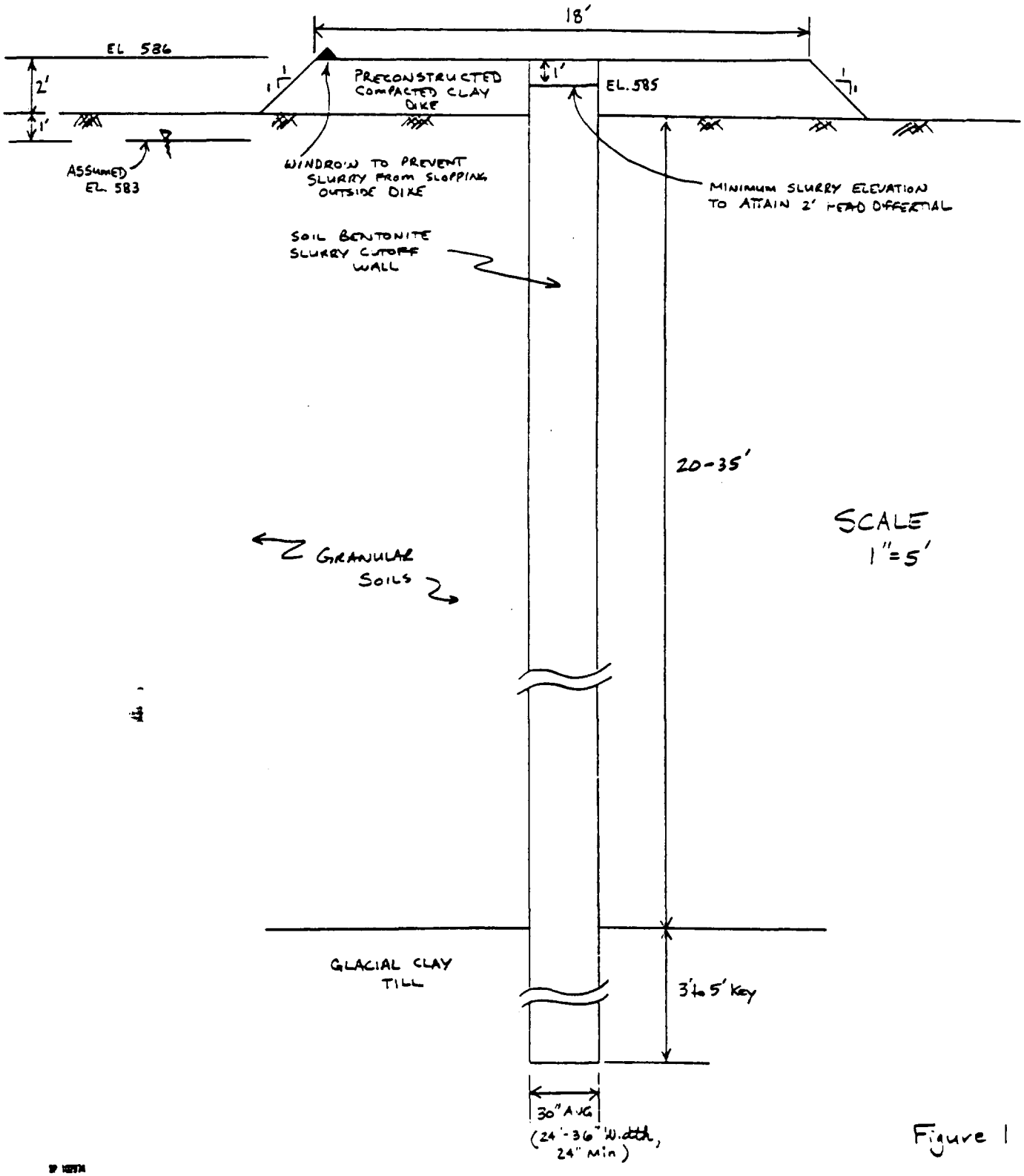
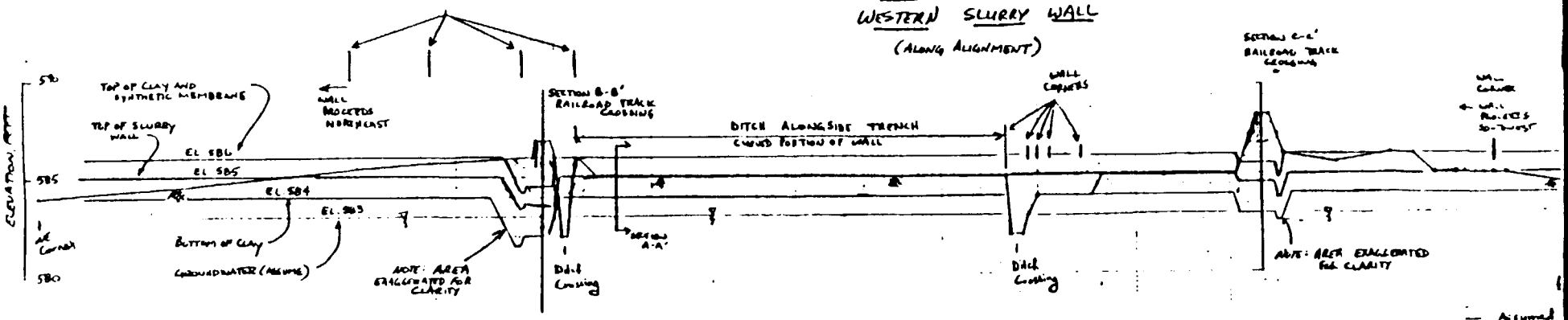


Figure 1

WESTERN SLURRY WALL

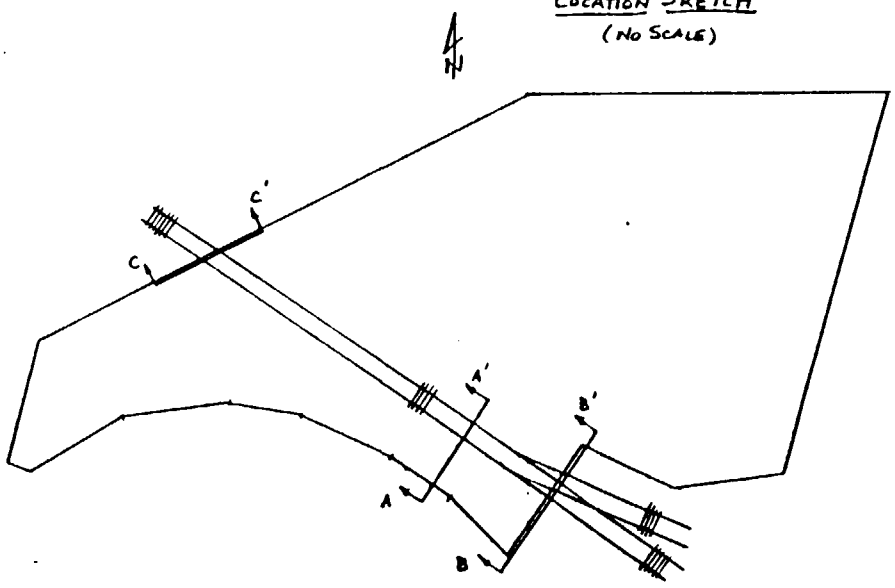
(ALONG ALIGNMENT)

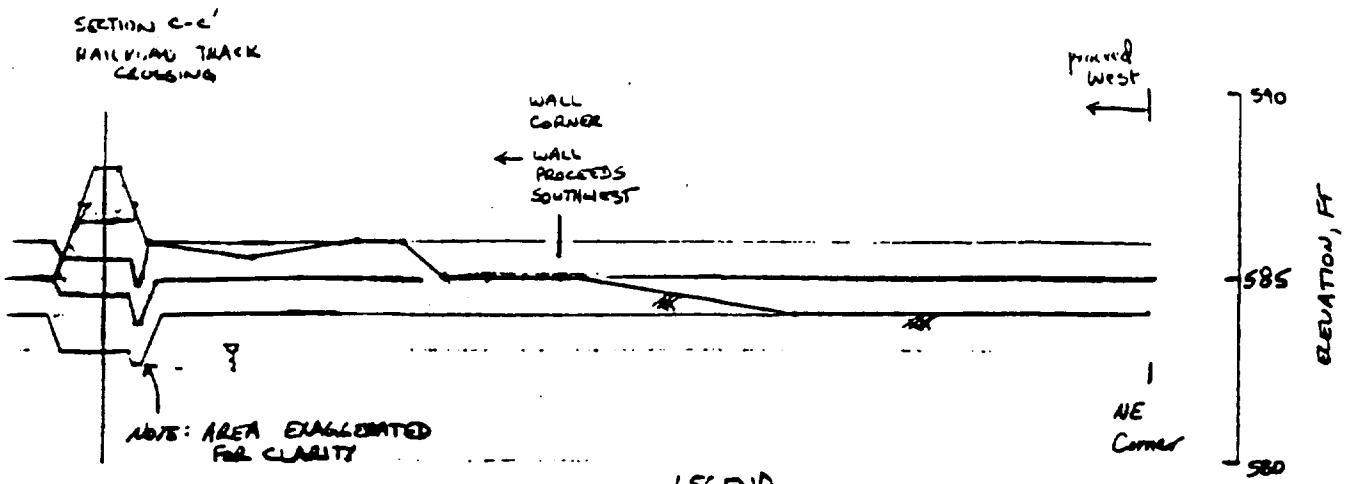


HORIZONTAL SCALE
1" = 100'

LOCATION SKETCH

(NO SCALE)



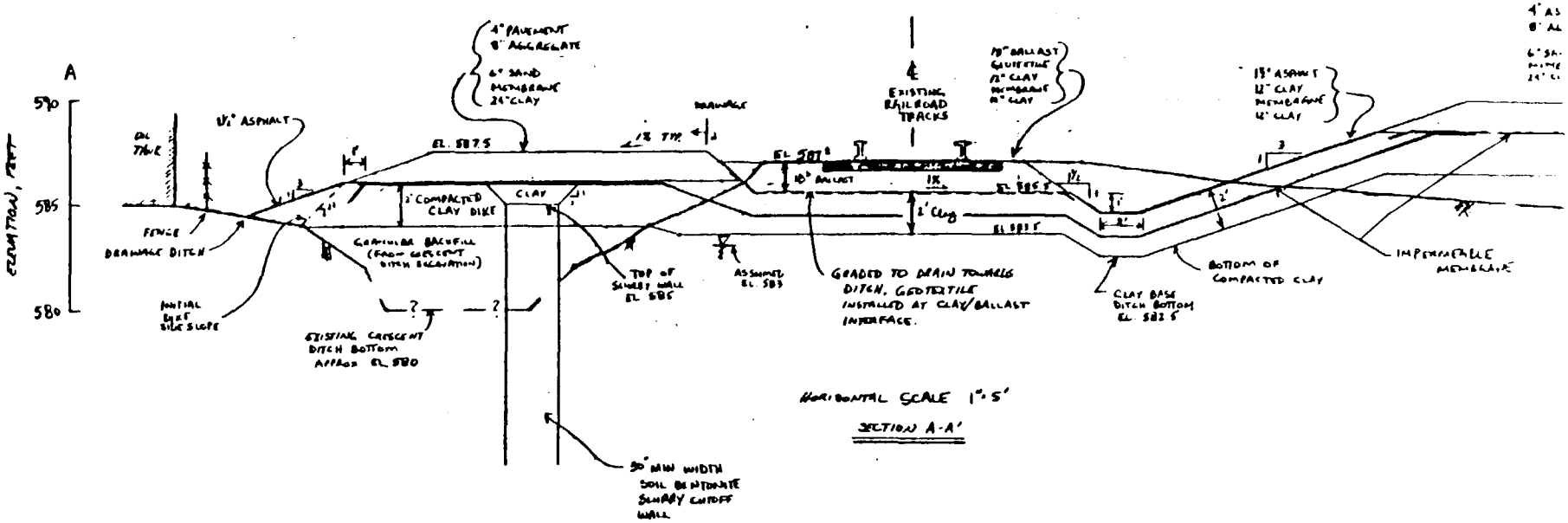


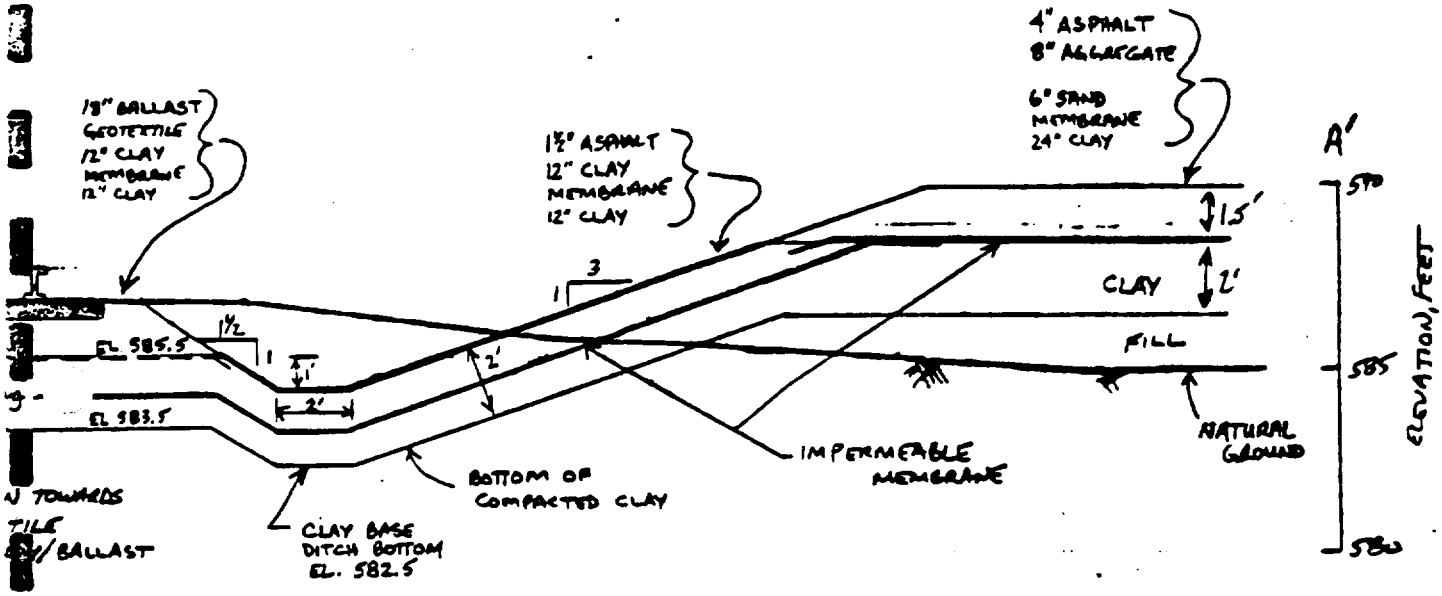
LEGEND

- Assumed Water Surface, EL. 583
- Top of Slurry Wall
- IMPERMEABLE MEMBRANE (TOP OF CLAY)
- RAILROAD BALLAST (18")
- TO BE EXCAVATED & BACKFILLED DURING DIKE CONSTRUCTION
- Natural Ground

OMC/WAUKEGAN/SUPERFUND
C11837 2/24/85 NNS
PROFILE SECTION- SLURRY WALL ALIGNMENT, CRESCENT DITCH OWL LAGOON CONTAINMENT AREA

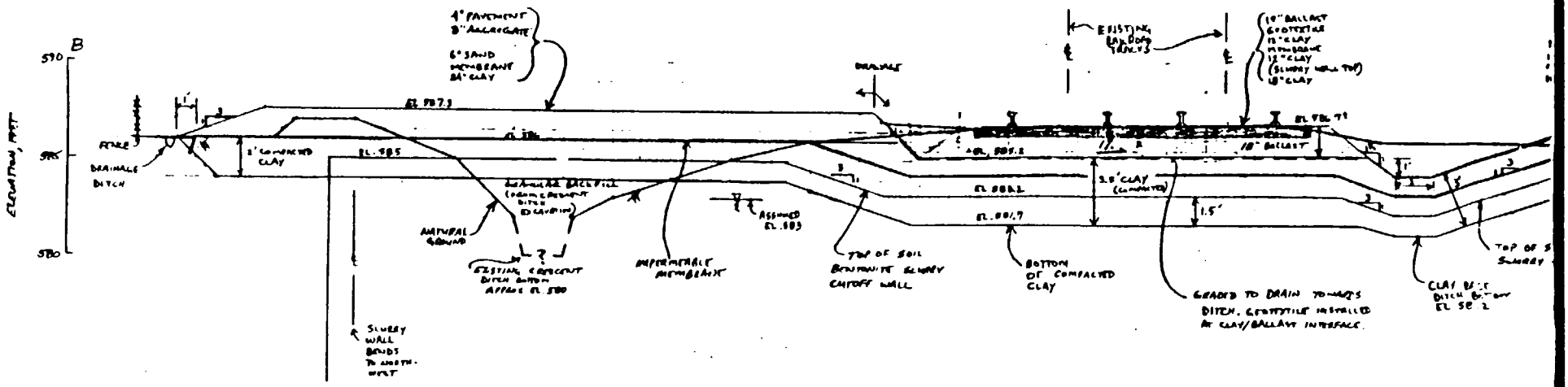
Figure 2


A
590
585
580
ELEVATION, FEET
OIL TANK
FENCE
DRAINAGE DITCH
INITIAL DIKE SIDE SLOPE
1½" ASPHALT
4" PAVEMENT
8" AGGREGATE
6" SAND
MEMBRANE
24" CLAY
EL. 587.5
2' COMPACTED CLAY DIKE
CLAY
GRANULAR BACKFILL (FROM CRESCENT DITCH EXCAVATION)
EXISTING CRESCENT DITCH BOTTOM APPROX EL. 580
TOP OF SLURRY WALL EL. 585
ASSUMED EL. 583
DRAINAGE
1% TYP.
EXISTING RAILROAD TRACKS
EL. 587.5
10" BALLAST
1%
2' Clay
EL. 585.5
EL. 583.5
GRADED TO DRAIN TOWARDS DITCH. GEOTEXTILE INSTALLED AT CLAY/BALLAST INTERFACE.
30' MIN WIDTH SOIL BENTONITE SLURRY CUTOFF WALL
18" BALLAST
GEOTEXTILE
12" CLAY
MEMBRANE
12" CLAY
15" ASPHALT
12" CLAY
MEMBRANE
12" CLAY
CLAY BASE DITCH BOTTOM EL. 582.5
BOTTOM OF COMPACTED CLAY
IMPERMEABLE MEMBRANE
HORIZONTAL SCALE 1" = 5'
SECTION A-A'



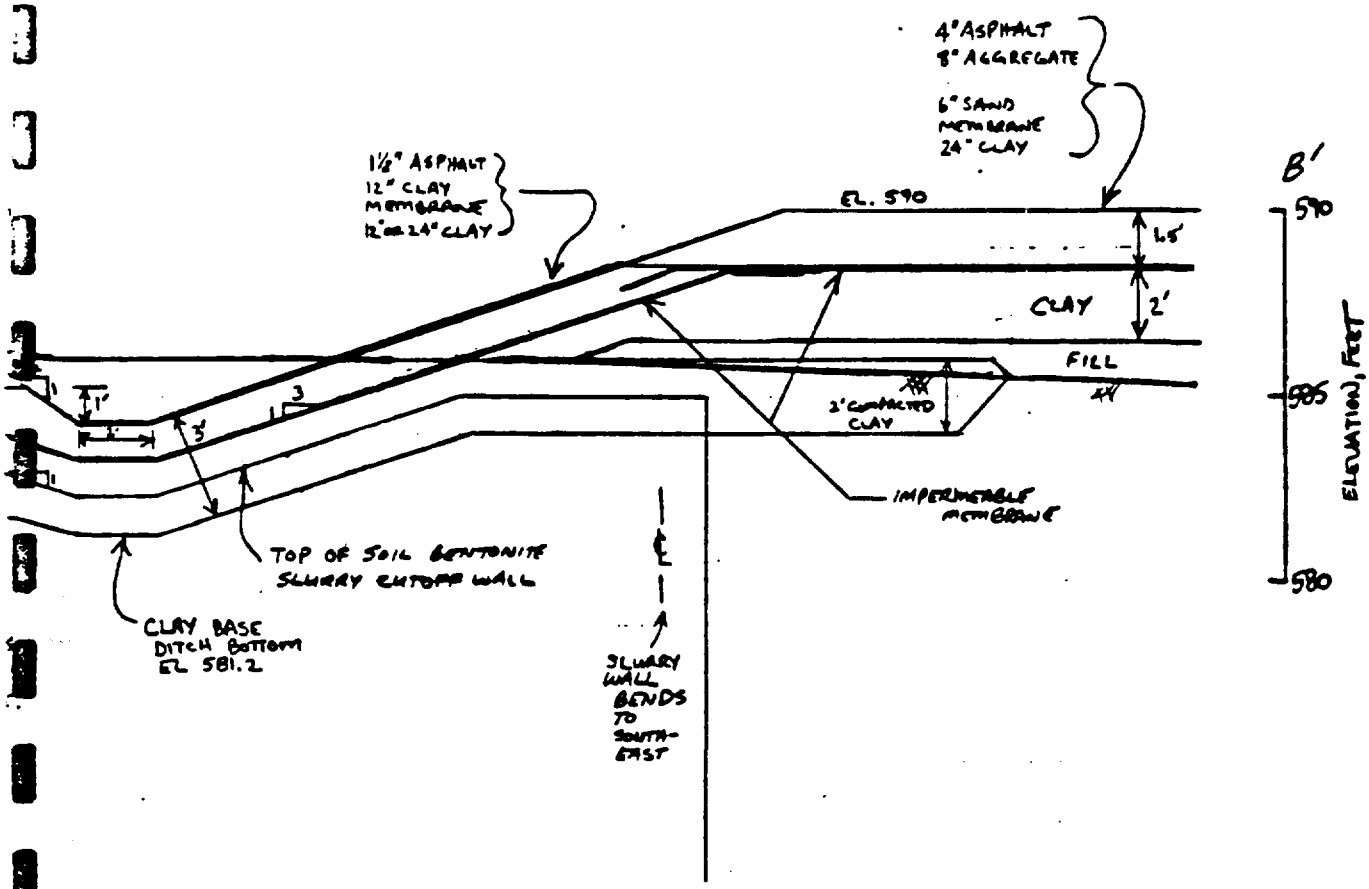
OMC/WAUKEGAN/SUPERFUND
C 11837 2/24/85 MWS
PROPOSED CROSS SECTION
SLURRY WALL, CRESCENT DITCH
OVAL LAGOON CONTAINMENT AREA

Figure 3



HORIZONTAL SCALE 1" = 5'

SECTION B-B'

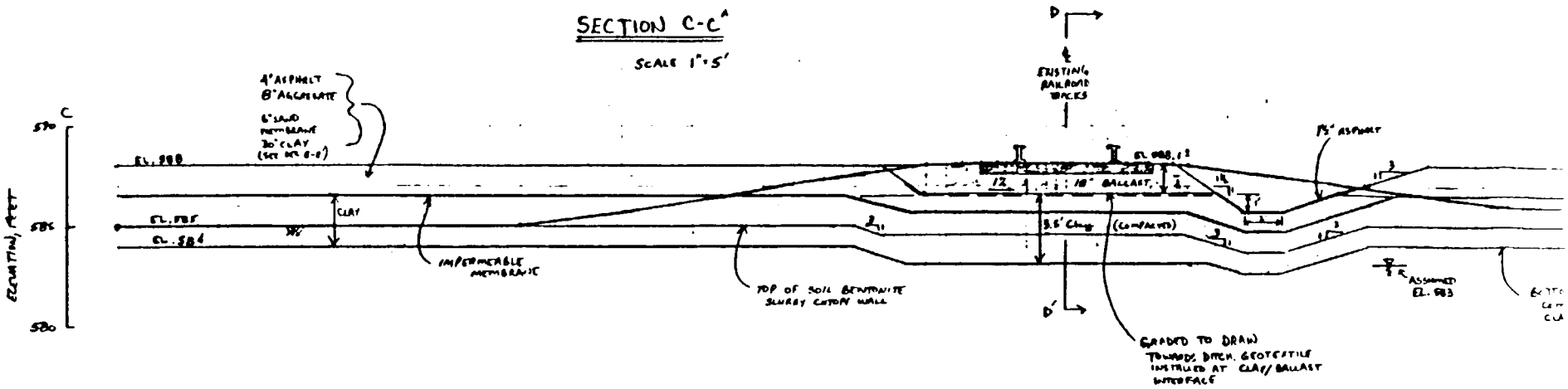


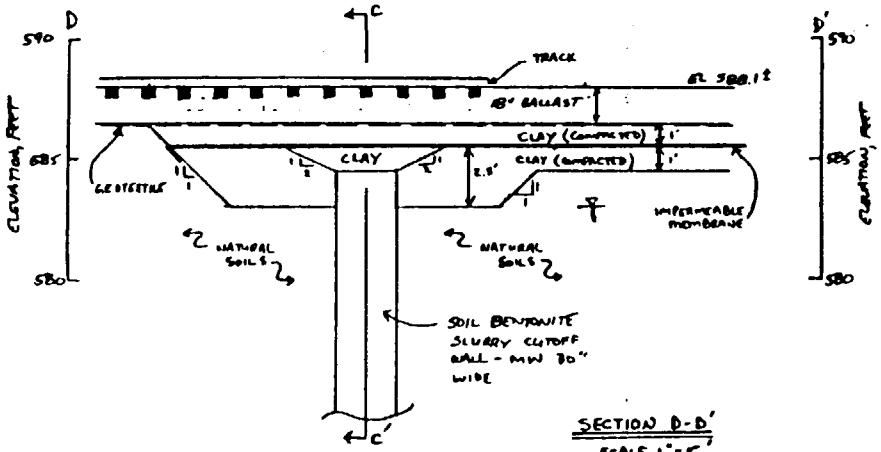
OMC/WAUKEGAN/SUPERFUND
C11837 2/24/85 MNS
PROPOSED CROSS SECTION
SLURRY WALL, CRESCENT DITCH
OVAL LAGOON CONTAINMENT AREA

Figure 4

SECTION C-C'

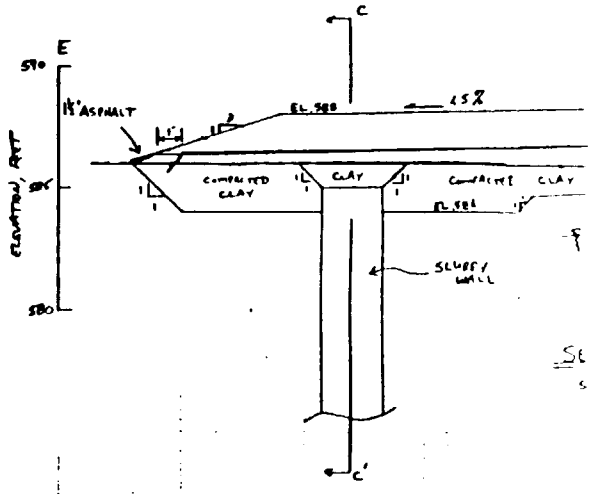
SCALE 1" = 5'

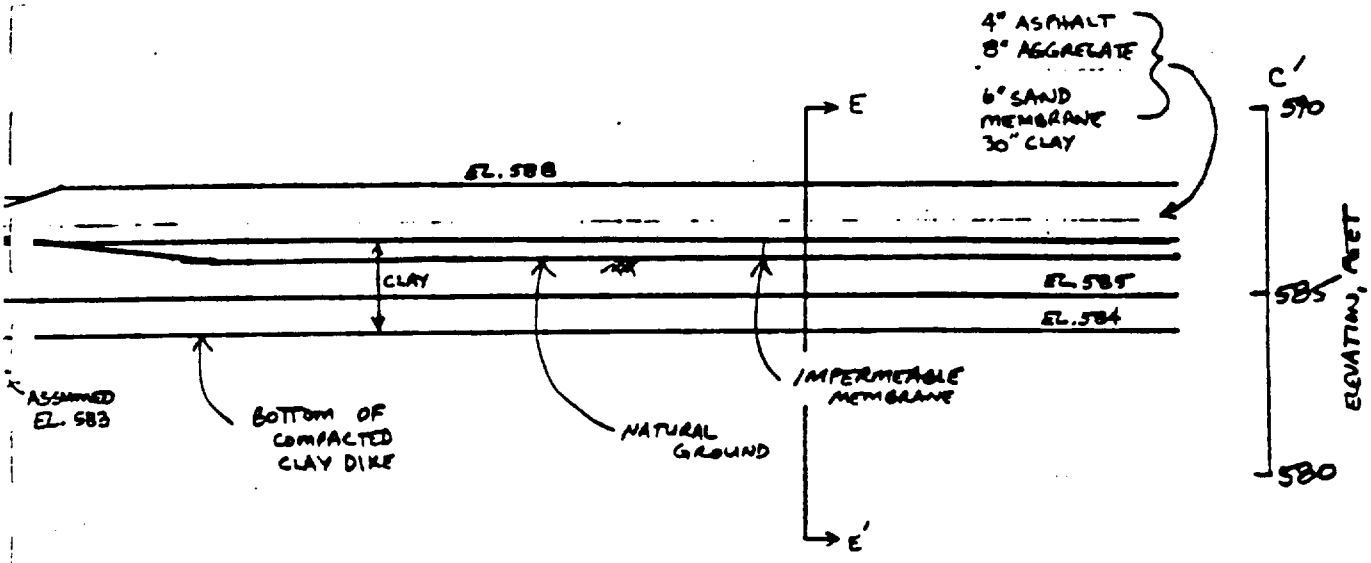


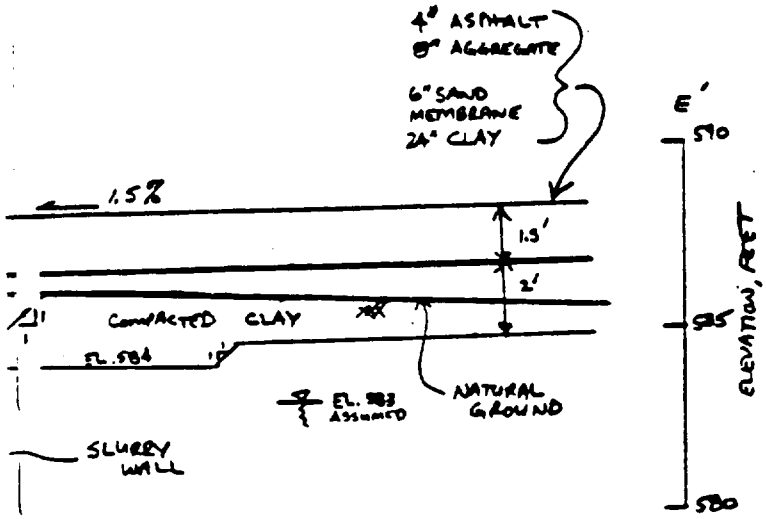


SECTION D-D'

SCALE 1" = 5'







SECTION E-E'

SCALE 1" = 5'

OMC/WAUKEGAN/SUPERFUND
C11837 2/24/85 MNS
PROPOSED CROSS SECTIONS
SLURRY WALL, CRESCENT DITCH
OVAL LAGOON CONTAINMENT AREA

Figure 5

VIII. Crescent Ditch/Oval Lagoon Containment

Site Construction

G. Decontamination Station

The decontamination station defined under the Parking Lot Containment Cell Section will also service the Crescent Ditch/Oval lagoon activities.

MABS/BM5

SITE RESTORATION

WARZYN

VIII.Crescent Ditch/Oval Lagoon Containment

Site Restoration

A. Decontamination of Equipment

Soil removal equipment, site restoration vehicles and all associated equipment will be decontaminated at the parking lot decontamination station prior to leaving the site.

MABS/BM5

SITE RESTORATION

VIII CRESCENT DITCH/OVAL LAGOON

B. FINAL GRADING & PRESSURE VENTING

Final grades consist of 3 to 1 sideslopes up 2-4' to the parking area. Fill volume was to be kept at a minimum; therefore, top slopes are at 1½%. High elevation is 591 and the top of the 3 to 1 is at elevation 588. The total volume between existing grades and final grades is 20,000 cy. After deducting volumes for final cover (see below), 1,200 cy remains. Therefore, 1,200 cy of material excavated for the slurry wall will be contained in the cell in order to attain final grades.

Three pressure vents will be constructed in this containment cell. One will be south of the Railroad and 2 North. See sheet No. 329 for approximate locations. Pressure venting will be further analyzed for the final design.

A pedestrian path to descend from the parking area will also be addressed for final design.

VIII. CRESCENT DITCH / OVAL LAGOON CONTAINMENT

SITE RESTORATION

C. FINAL COVER

ACCORDING TO CH2M HILL CONCEPT DESIGN REPORT DATED SEPT. 14, 1984, PAGE 2-25, "THE TOP OF THE CONTAINMENT AREA WOULD BE CAPPED WITH 3 FT. OF CLAY AND THEN COVERED WITH ASPHALTIC CONCRETE." ACCORDING TO SAME DOCUMENT, FIGURE 2-2, "TYPICAL SECTION THROUGH CRESCENT DITCH AREA" AND "... OVAL LAGOON AREA," THE COVER WILL CONSIST OF "IMPERVIOUS PAVEMENT" OVERLYING "COMPACTED CLAY COVER" OVERLYING "SAND DRAINAGE WITH PERFORATED PIPE." THE COVER WILL OVERLIE THE IN-SITU SAND DEPOSITS.

1. DISCUSSION – DEVELOPMENT OF COVER DETAILS

IT WOULD BE BENEFICIAL TO LIMIT THE OVERALL THICKNESS OF THE COVER AT BOTH THE OVAL LAGOON / CRESCENT DITCH AND PARKING LOT CONTAINMENT CELLS. FIGURE 2-2 OF THE CONCEPT REPORT INDICATES A TYPICAL SECTION THROUGH THE CRESCENT DITCH / OVAL LAGOON WHERE THE TOP OF THE FINAL COVER IS AT GRADE. THIS WOULD REQUIRE EXCAVATION OF THE IN-SITU SAND TO MAKE ROOM FOR THE COVER. THE EXCAVATED SAND WOULD HAVE TO BE TRUCKED AND DISPOSED IN THE PARKING LOT CONTAINMENT CELL INCREASING THAT VOLUME AND RAISING THE FINAL GRADE. EXCAVATION OF SAND IN THE CRESCENT DITCH / OVAL LAGOON AREA WOULD MOST LIKELY REQUIRE SHALLOW DEWATERING SINCE THE GROUNDWATER TABLE IS GENERALLY ONLY 1 TO 2 FT. BELOW THE GROUND SURFACE. BECAUSE OF THE DISPOSAL AND DEWATERING REQUIREMENTS, THE COVER IN THE CRESCENT DITCH / OVAL LAGOON AREA WILL BE PLACED AT GRADE AND THE GRADE RAISED EQUAL TO THE COVER THICKNESS. THE COVER THICKNESS SHOULD BE MINIMIZED TO PREVENT RR AND AUTO TRAFFIC PROBLEMS AT THE PARKING LOT CONTAINMENT CELL, AN OVERHEAD 138 KV TRANSMISSION LINE CROSSES THE AREA. THE GRADES WILL BE RAISED BY LANDFILLING DREDGE SPOILS AND OTHER EARTH FILL REDUCING THE LINE CLEARANCE WHICH, ACCORDING TO COM ED, SAGS TO APPROX. 40 FT. NEAR THE SOUTH SIDE OF THE CONTAINMENT CELL. THE GREATER THE FILL VOLUME AND THE THICKER THE COVER, THE MORE THE LINE CLEARANCE WILL BE REDUCED.

1. CONTINUED

BASED ON THE CONCEPT REPORT, THE COVER IS SUPPOSED TO CONSIST OF PAVEMENT, 3FT. OF CLAY AND A DRAINAGE LAYER. THE PAVEMENT WILL REQUIRE A BASE COURSE AGGREGATE FOR STABILITY AND DRAINAGE - ASSUME TOTAL THICKNESS OF 1 FT. FOR PAVEMENT AND AGGREGATE. THE DRAINAGE LAYER WOULD HAVE TO BE THICK ENOUGH TO CONTAIN DRAIN TILE WITH SOME COVER - ASSUME 1 FT. THICK. TOTAL COVER THICKNESS IS THEN 1+3+1 = 5 FT.

ONE WAY TO REDUCE THE COVER THICKNESS WOULD BE TO REDUCE THE THICKNESS OF THE CLAY PORTION. A DRAFT DOCUMENT BY THE ILLINOIS EPA TITLED "WASTE MANAGEMENT FACILITIES, DESIGN CRITERIA" STATES ON PAGE 7 THAT FOR CLASS I LANDFILL SITES (HAZARDOUS WASTE), "FINAL COVER SHOULD BE A MINIMUM OF 2 FT. OF COVER MATERIAL," AND "ARTIFICIAL CAP LINER SHALL BE INSTALLED." THE IEPA ALSO STATES THAT A VEGETATIVE COVER SHOULD BE PROVIDED. BASED ON IEPA DESIGN CRITERIA, THE CLAY THICKNESS COULD BE REDUCED TO 2FT. BUT A SYNTHETIC LINER SHOULD BE ADDED. THE PAVEMENT WILL SERVE AS THE TOP COVER IN PLACE OF VEGETATION TO PREVENT EROSION.

ANOTHER REFERENCE, "DRAFT RCRA GUIDANCE DOCUMENT, SURFACE IMPOUNDMENTS, LINER SYSTEMS, FINAL COVER AND FREEBOARD CONTROL" ISSUED 7/82, DISCUSSES FINAL COVER DESIGN CRITERIA ON PAGES 24-35. IN THIS DOCUMENT, THE FEDERAL EPA "BELIEVES THAT A 3 LAYER FINAL COVER WILL ADEQUATELY MINIMIZE INFILTRATION OF PRECIPITATION, WHICH IS THE PRIMARY PURPOSE OF THE FINAL COVER... THE TOP LAYER SHOULD HAVE AT LEAST 2 FT. OF SOIL CAPABLE OF SUSTAINING PLANT SPECIES WHICH WILL EFFECTIVELY MINIMIZE EROSION... THE SECOND LAYER OR DRAINAGE LAYER... SHOULD BE AT LEAST 12 IN. THICK TO PROVIDE CAPACITY TO HANDLE WATER FROM MAJOR SUSTAINED STORM EVENTS... DRAINAGE TILES OR OTHER COLLECTION DEVICES ARE NOT CONSIDERED NECESSARY... THE DRAINAGE LAYER SHOULD BE OVERLAIN WITH A GRADUATED GRANULAR OR SYNTHETIC FILTER FABRIC TO PREVENT PLUGGING... THE FUNCTION OF THE BOTTOM LOW PERMEABILITY LAYER IS TO REJECT FLUID TRANSMISSION... IT SHOULD CONSIST OF 2 COMPONENTS. THE UPPER COMPONENT

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 2-26-85 SUBJECT OMC- WAUKEGAN SHEET NO. 3 OF 9
CHKD. BY [illegible] DATE 3-6-85 JOB NO. C11837

1. CONTINUED

SHOULD BE AT LEAST A 20 mil THICK SYNTHETIC MEMBRANE ... THE SECOND COMPONENT SHOULD BE A 2-FT. THICK MINIMUM CLAY LAYER WITH MAXIMUM HYDRAULIC CONDUCTIVITY (PERMEABILITY) OF 1×10^{-7} cm/sec ... THE IMPERMEABLE LAYER SHOULD BE WHOLLY BELOW THE AVERAGE DEPTH OF FROST PENETRATION IN THE AREA."

BASED ON THE ILLINOIS EPA AND RCRA GUIDELINES, THE COVER DETAIL OF THE CONTAINMENT CELLS WILL BE MODIFIED TO CONSIST OF THE FOLLOWING COMPONENTS IN DESCENDING ORDER: ASPHALT, AGGREGATE BASE COURSE, UNIFORM SAND DRAINAGE LAYER, IMPERMEABLE SYNTHETIC MEMBRANE, COMPACTED CLAY. THIS COVER DETAIL CONSISTS OF 4 LAYERS AS OPPOSED TO 3 RECOMMENDED BY EPA IN THE RCRA DOCUMENT (ASPHALT, CLEAN SAND DRAINAGE LAYER, SYNTHETIC MEMBRANE AND CLAY).

2. AND 3. ASPHALT PAVEMENT AND AGGREGATE BASE COURSE

DESIGN FLEXIBLE PAVEMENT BASED ON ARMY COE TM 5-822-5/AFM 88-7, CH. 5 AND TM 5-818-5/AFM 88-6, CH. 4

FROM PAGE 7 5-822-5 - "IN THE DESIGN OF PARKING AREAS, DESIGN INDEX VALUES FOR CATEGORY I TRAFFIC (TABLE 4) WILL NORMALLY BE USED."

FROM PAGE 7 5-822-5, TABLE 4 - ASSUME CLASS A AND DESIGN INDEX = 3 AS MOST CONSERVATIVE CASE. (MAY BE MODIFIED DURING FINAL DESIGN)

ASSUME THE COMPACTED CLAY WILL ACT AS THE SUBGRADE AND CONSIST OF LOW PLASTICITY CLAY (CL) LOCALLY AVAILABLE IN WAUKEGAN AREA. BELOW THE CLAY WILL BE COMPACTED "CONTAMINATED" CLAY FROM DISPOSAL OF THE LAGOON LINER. FROM MANUAL TM 5-818-2/AFM 88-6, CHAP. 4, TABLE 2-1, p. 2-5, ANTICIPATE FROST GROUP F4 FOR CLAY WITH PI < 12. FROM TM 5-818-2, TABLE 4-1, p. 4-5, USE SOIL SUPPORT INDEX = 3.5. FROM TM 5-822-5, FIGURE 3, p. 9, TOTAL THICKNESS OF FLEXIBLE PAVEMENT, BASE COURSE AND SUBBASE COURSE ≃ 17 INCHES.

2. AND 3. CONTINUED

FROM PAGE 5, TABLE 2 TM 5-822-5 – ASSUME BASE COURSE CBR = 80, IF DESIGN INDEX = 3, THEN MINIMUM PAVEMENT THICKNESS IS 1.5 INCHES AND BASE COURSE IS 4 INCHES FOR A TOTAL THICKNESS OF 5.5 INCHES. HOWEVER, SINCE A CLASS A ROAD WAS ASSUMED, MIN. THICKNESS MUST BE 6 INCHES ACCORDING TO NOTE C. THEN THE SUBBASE SHOULD BE 17 − 6 = 11 INCHES. HOWEVER, BASED ON WARZYN'S PREVIOUS EXPERIENCE WITH FLEXIBLE PAVEMENTS, IT IS OUR OPINION THAT A PARKING LOT OF THIS SIZE SHOULD HAVE A MINIMUM TOTAL PAVEMENT THICKNESS OF 3 INCHES AND MINIMUM BASE COURSE OF 8 INCHES.

FOR COMPARISON AND AS A CROSS CHECK, A FLEXIBLE PAVEMENT DESIGN WILL BE PERFORMED USING THE "WISCONSIN ASPHALT PAVEMENT ASSOCIATION DESIGN GUIDE". SINCE THE WISCONSIN CLIMATE IS SIMILAR TO THE WAUKEGAN, ILLINOIS CLIMATE, THE SAME DESIGN GUIDELINES WILL APPLY WITH FROST CONDITIONS CONSIDERED.

A TRAFFIC CLASS 5 (MEDIUM-DUTY) IS ASSUMED FOR PARKING LOTS WITH 50 OR MORE STALLS, UP TO 5 TRUCKS PER DAY AND 500 CARS PER DAY IN THE DESIGN LANE. A TRUCK IS DEFINED AS A 2-AXLE, 6-TIRE VEHICLE HAVING A GROSS VEHICLE WEIGHT OF 20,000 LB OR GREATER. THE LOW PLASTICITY CLAY SUBGRADE IS ASSUMED TO BE A POOR SUBGRADE WITH CBR = 2 TO 5 (CBR = 3.5 USED PREVIOUSLY). BASED ON SECTION V OF THE DESIGN GUIDE, A FLEXIBLE PAVEMENT CONSISTING OF 1.50 INCHES OF BITUMINOUS SURFACE 2.00 INCHES OF BITUMINOUS BASE AND 10 INCHES OF CRUSHED AGGREGATE BASE WILL BE SUFFICIENT. TOTAL THICKNESS = 13.5 IN. THIS DESIGN DOES NOT INCLUDE A SUBBASE COURSE.

CONCEPTUAL RECOMMENDATION FOR FLEXIBLE PAVEMENT DESIGN
A 2.0 IN. THICK BINDER MAY BE CONSIDERED IF COST CUTTING MEASURES ARE NECESSARY.

BASED ON THE 2 ANALYSES, THE FOLLOWING SECTION IS PROPOSED: 1.50" ASPHALT SURFACE, 2.50" ASPHALT BINDER, 8" AGGREGATE BASE AND 6" AGGREGATE SUBBASE; TOTAL THICKNESS = 18" > 17" MIN. BY CORPS DESIGN.

SINCE THE PAVEMENT CONTRACTOR WILL MOST LIKELY BE A LOCAL CONTRACTOR FAMILIAR WITH ILLINOIS DOT SPECIFICATIONS, THE IDOT SPECS WILL BE USED. SECTION 406 DEALS WITH BITUMINOUS CONCRETE BINDER AND SURFACE COURSES. SECTION 301 DEALS WITH AGGREGATE BASE COURSES. (IDOT STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, OCT. 1, 1983)

Volume aggregate = 144,777 sf × 8" ÷ 27 = 3,600 cy Vol. pavement = 1,800 cy

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY R. WEBER DATE 3-3-85
CHKD. BY W. Wilk DATE 3-6-85
SUBJECT OMC - WAUKEGAN, IL
DESIGN ANALYSIS
SHEET NO. 1 OF 1
JOB NO. C11837

IX. EAST-WEST PORTION OF NORTH DITCH AND BYPASS

SITE PREPARATION

C. DEWATERING FOR UTILITY MODIFICATIONS

SEE VIII. CRESCENT DITCH/OVAL LAGOON, SITE PREPARATION, E. DEWATERING FOR UTILITY RELOCATION

B. UTILITIES

1. Electrical

There are no modifications to be done. However, several items shall be protected:

existing overhead transmission lines and power poles
electrically-operated gate
400 watt merc. vapor lamp

2. Gas

The gas main shall be protected. A portion of it may need to be modified.

3. Catch basins

5 catchbasin will be constructed in the area See Drawing Sheet Nos. 531, 532, 535

IX. East-West Portion of North Ditch and Bypass

Site Preparation

B. Utilities-Additional and Modifications

Per the Conceptual Design, the North Ditch stormwater bypass sewer would be constructed to divert surface water flow around the Crescent Ditch and Oval Lagoon and to collect surface water flow from the parking lot area.

The bypass sewer would begin at the existing 36-inch diameter diameter storm drain at the west edge of OMC's property. The bypass sewer will be constructed from the existing 36-inch storm drain, approximately 358 feet north and approximately parallel to the existing North Shore Sanitary District (NSSD) 51-inch sanitary sewer. The bypass sewer will then turn east and cross the existing 51-inch NSSD sewer.

From available record data, the elevation of the existing NSSD 51-inch sanitary sewer appears to conflict with the proposed profile of the North Ditch bypass sewer. A special cast-in-place manhole structure will be constructed over the bypass sewer and the NSSD sewer to deal with this conflict - See Section IX, Site Construction, Article B, and the drawings, for further clarification.

The bypass sewer also crosses a 12 inch high pressure gas main between the 51-inch NSSD sewer crossing and the west end of the east-west portion of the north ditch. Relocation of the existing gas main will probably be required and coordinated with the gas utility.

The location and elevation of these utilities, as well as any additional utilities, must be determined in order to assess their full impact on the proposed bypass sewer. The completion of the site survey and field edit of the base material is necessary for the assessment of all conflicts.

MABS/BJ1

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 2-25-85 SUBJECT OMC DESIGN ANALYSIS SHEET NO. X-1 OF
CHKD. BY [illegible] DATE 3-7-85 JOB NO. U537

SITE PREPARATION

IX EAST-WEST PORTION OF THE NORTH DITCH & BYPASS

A. REMOVAL OF EXISTING SITE FEATURES

Some items will have to be removed for construction purposes. These are: Approximately 500' of fenceline will be removed and salvaged to be replaced after construction, 9 water monitoring wells will be abandoned, 1 U.S.G. & G.S. Gaging station will be removed, 20 foot long foot bridge will be removed.

SITE PREPARATION

WARZYN
ENGINEERING INC

IX EAST-WEST PORTION OF THE NORTH DITCH & BYPASS

WARZYN
ENGINEERING INC

Operation and Maintenance Provisions

VIII. Crescent Ditch/Oval Lagoon Containment

B. Decontamination of Vehicles

All vehicles, equipment, and personnel that come into contact with PCB contaminated materials will require decontamination prior to leaving the site. In general, the decontamination procedures for vehicles and equipment will consist of:

1. Water and detergent wash with scrubbing to remove all sediments from the equipment. Only as much water as necessary should be used, and care must be taken to keep splashing to a minimum.

2. Water rinse.

3. Collect washing and rinse fluids and dispose of properly by discharge to the water treatment plant.

This procedure should provide sufficient decontamination for equipment exiting the site. To ensure that sufficient cleanup has taken place periodic wipe tests should be conducted using the following procedures:

1. Apply an appropriate solvent (hexane), to a piece of 11 cm filter paper (eg. Whatman 40 ashless, or Whatman "50" smear tabs or similar).

2. The moistened filter paper, held with a pair of stainless steel forceps, is used to thoroughly swab a 100 cm^2 area, measured using a sampling template.

3. The filter paper swab is then placed in a pre-cleaned glass jar and stored at 4°C for analysis for PCB's.

Quality assurance must be applied throughout the entire monitoring program. Blank swab samples and spiked samples will be needed to insure the accuracy of the test results.

MABS/BN2

Operations and Maintenance Provisions

VIII. Crescent Ditch/Oval Lagoon Containment

A. Shipment Off-Site and Loading

Highly contaminated hot spots in the Crescent Ditch/ Oval Lagoon area will be dewatered in place, excavated and removed to a licensed landfill. Trucks for removal of this material would be contracted to a licensed landfill (i.e. CECOS). The trucks would be loaded by the excavating back-hoe. The trucks would be secured (covered) and then routed through the parking lot decontamination station and the security/control station. All documents, permits, manifests, etc. would be processed by the contractor prior to leaving the site.

Should the inplace dewatering be inadequate, the material would be fixed. The material would be transported to the batch plant, fixed, cured and then removed to the licensed landfill. This material is expected to have a relatively high solids content and would be handled accordingly at the batch plant and curing cells.

MABS/BL8

SITE OPERATIONS/MAINTENANCE

WARZYN
ENGINEERING INC

G. REMOVAL OF STRUCTURES

The 1590' of 6' Chain Link fence and 3 gates will be removed after completion of final surfaces

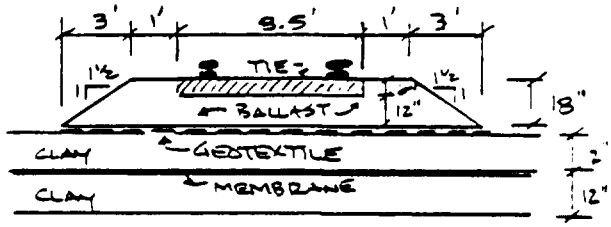
F. RAILROAD REPLACEMENT (SITE RESTORATION)

4. GEOTEXTILE

A GEOTEXTILE IS CONSIDERED NECESSARY IN THE CRESCENT DITCH / OVAL LAGOON CONTAINMENT AREA ONLY TO SEPARATE THE RAILROAD BALLAST OF THE RAIL SPUR FROM THE UNDERLYING FINAL COVER CONSISTING OF 12 INCHES OF CLAY, 40 mil HDPE SYNTHETIC MEMBRANE AND 12 INCHES OF CLAY. SINCE THE PRIMARY PURPOSE OF THE GEOTEXTILE IS SEPARATION AND NOT STABILIZATION OR REINFORCEMENT (THE COMPACTED CLAY IS ANTICIPATED TO BE A FIRM SUBGRADE), BASED ON THE BELOW LISTED REFERENCE, IT IS ANTICIPATED THAT A 10-20 oz/yd² NON-WOVEN, NEEDLE PUNCHED, RESIN DIPPED GEOTEXTILE WILL BE SPECIFIED. THIS WILL BE FURTHER EVALUATED IN FINAL DESIGN. A LIGHTER GEOTEXTILE THAN THAT RECOMMENDED BELOW MAY BE SUITABLE SINCE THE RR TRACK IS ONLY A SPUR.

AN ESTIMATE OF THE AREA OF GEOTEXTILE REQUIRED IS AS FOLLOWS:

WIDTH = 8.5 + 3 + 1 + 1 + 3 = 16.5 FT.



SCALED FROM DRAWINGS —
LENGTH ~ 340 FT.

AREA = 16.5 (340) = 5610 FT² → ROUND UP TO 6000 FT²

ADDITIONAL DISCUSSION

REFERENCE: RAYMOND, G., "GEOTEXTILES FOR RAILROAD BED REHABILITATION," SECOND INTERNATIONAL CONFERENCE ON GEOTEXTILES, LAS VEGAS, 19__.

RECOMMENDATIONS AND CONCLUSIONS:

NON-WOVEN, NEEDLE PUNCHED, RESIN DIPPED
EOS < 40 MICRONS (NO. 400 SIEVE)
BURIED DEPTH MIN. 8", RECOMMENDED 12" BELOW TIE
WEIGHT 20 oz/yd² FOR CONTINUOUS RAIL & 12" DEPTH } VERY HEAVY SECTIONS OF GEOTEXTILE
" 29 oz/yd² BELOW SWITCHES, CROSSINGS, ETC. }
INCREASE WEIGHT 50% IF DEPTH IS 8"

F. RAILROAD REPLACEMENT

The 340' of removed railroad will be replaced to the same lines and grades.

1. Material
   Ballast material will be 3/4" to 1 1/2" Crushed Stone.

2. Ballast
   Refer to section on next page.
   Volume of ballast:
   $$[[(16.5 + 10.5)/2] \times 1.5] - (8.5 \times .5)] \times 340' \div 27 \cong \underline{200 \text{ cy}}$$

3. Clay
   The 63 cy (See Appendix K) excavated during site preparation will be replaced with clay as specified in the Final cover section.

E. DRAINAGE

1. Slopes

Perimeter ditches will completely encircle the containment cell. See print in Appendix F for flow areas and ditch directions. Calculations (see Appendix G) were done based on some ditch assumptions.

Assumptions : V ditch
sideslopes are 2:1
slope of the ditch 0.5%

2. Depths

The largest flow calculated was 4.51 cfs, which gives a depth of water of 0.8'. (See Appendix G)

Due to the elevation of water, the ditches will have to be designed to vary in depth in order to stay above water; however, a minimum of 0.8' will be maintained.

If a storm occurs which exceeds the 25 year event, the ditches will overflow onto surrounding grounds with no detrimental effects

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RHW DATE 3-3-85 SUBJECT GMC - WAUKEGAN, IL SHEET NO. 2 OF 2
CHKD. BY WW DATE 3-6-85 JOB NO. C11837

(CONTINUED)

MONITORING WELLS. THE WELLS WILL BE DEVELOPED FOLLOWING INSTALLATION.

3. INSTALLATION

THE GROUNDWATER WITHDRAWAL WELLS WILL BE INSTALLED JUST PRIOR TO PLACING THE SYNTHETIC MEMBRANE OF THE FINAL COVER. A DETAIL WILL BE DEVELOPED IN FINAL DESIGN FOR A SLEEVE OF MEMBRANE AROUND THE PROTECTIVE WELL CASING TO PREVENT SURFACE INFILTRATION AROUND THE WELL CASING. THE GENERAL CONTRACTOR IS ANTICIPATED TO SUB OUT THE WELL INSTALLATION TO A QUALIFIED DRILLING FIRM.

4. ESTIMATING

FOR ESTIMATING PURPOSES, ASSUME 3 WELLS TO A DEPTH OF 20 FT.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY H. WEBER DATE 3-3-85 SUBJECT OMC - WAUKEGAN, IL SHEET NO. 1 OF 2
CHKD. BY W. Wellman DATE 3-6-85 JOB NO. C11837

VIII. CRESCENT DITCH/OVAL LAGOON CONTAINMENT CELL

SITE RESTORATION

D. INTERNAL GROUNDWATER WITHDRAWAL WELLS (INSIDE CELL)

IT IS PROPOSED TO INSTALL SEVERAL GROUNDWATER WITHDRAWAL WELLS INSIDE THE CD/OL CONTAINMENT CELL. THE PRIMARY PURPOSE OF THE WELLS IS TO MONITOR THE WATER LEVELS INSIDE THE CELL FOR COMPARISON TO THE LEVELS IN WELLS OUTSIDE THE CELL. IF FOR SOME REASON THE FINAL COVER HAS ALLOWED SURFACE WATER TO INFILTRATE THE CELL, THE WITHDRAWAL WELLS COULD BE USED TO DRAW THE WATER LEVEL DOWN AGAIN SO THAT AN OUTWARD GRADIENT DOESN'T EXIST (A POSITIVE GRADIENT MAY PROMOTE A MIGRATION OF PCB CONTAMINATED WATER OUTSIDE THE CELL). THREE GROUNDWATER WITHDRAWAL WELLS ARE CONSIDERED SUITABLE DUE TO THE RELATIVE HIGH PERMEABILITY OF THE SAND (APPROX. 10^{-3} cm/sec).

IF WITHDRAWAL WERE NECESSARY, A SURFACE PUMP WOULD BE ADEQUATE SINCE THE GROUNDWATER TABLE IS RELATIVELY HIGH AND THE SITE GRADES WILL NOT BE RAISED APPRECIABLY. THE EFFLUENT COULD BE TREATED WITH A PORTABLE WATER TREATMENT PLANT, PIPED TO THE NSSD PLANT, OR COLLECTED IN TANK TRUCKS FOR TREATMENT AT A SUITABLE OFF-SITE PLANT (3 OPTIONS).

1. LOCATIONS

3 WELLS WERE LOCATED AS SHOWN ON THE "FINAL GRADES" DRAWING.

2. DETAILS

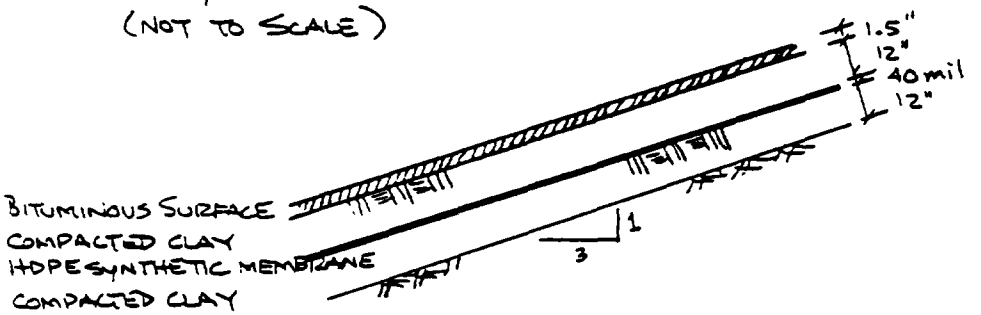
STEEL WELL CASING WILL BE CONSIDERED DURING FINAL DESIGN BECAUSE OF GREATER LONG-TERM DURABILITY

WELLS CONSISTING OF PVC ARE CONSIDERED SUITABLE SINCE THE WELLS WILL NOT BE USED TO MONITOR WATER QUALITY. FOUR INCH DIAMETER WELLS WILL BE USED SINCE THEY WILL HAVE A GREATER FLOW CAPACITY. THE REMAINING WELL DETAILS ARE SIMILAR TO THOSE UNDER VII. LAGOONS, SITE PREPARATION, E. GROUNDWATER

THE PAVEMENT WILL ALSO BE PLACED AS COVER TO THE SHALLOW DITCHES AROUND THE PERIMETER OF THE CONTAINMENT CELL. PAVED DITCHES WILL ALSO OCCUR BETWEEN THE RAILROAD SPUR AND THE FINAL COVER. THE SIDESLOPE PAVING SHOULD NOT COVER THE BASE COURSE OR SAND DRAINAGE LAYER, OTHERWISE THE DRAINAGE PATH WOULD BE BLOCKED!

PLACEMENT OF THE CLAY ON THE SIDESLOPES WOULD OCCUR NOT IN HORIZONTAL LIFTS BUT RATHER BY WORKING UP THE SIDESLOPES. PLACEMENT OF PAVEMENT ON THE SIDESLOPES AND IN DITCHES MAY REQUIRE HAND WORK.

IN SUMMARY, THE FINAL COVER ON THE SIDESLOPES WILL BE AS FOLLOWS:
(NOT TO SCALE)

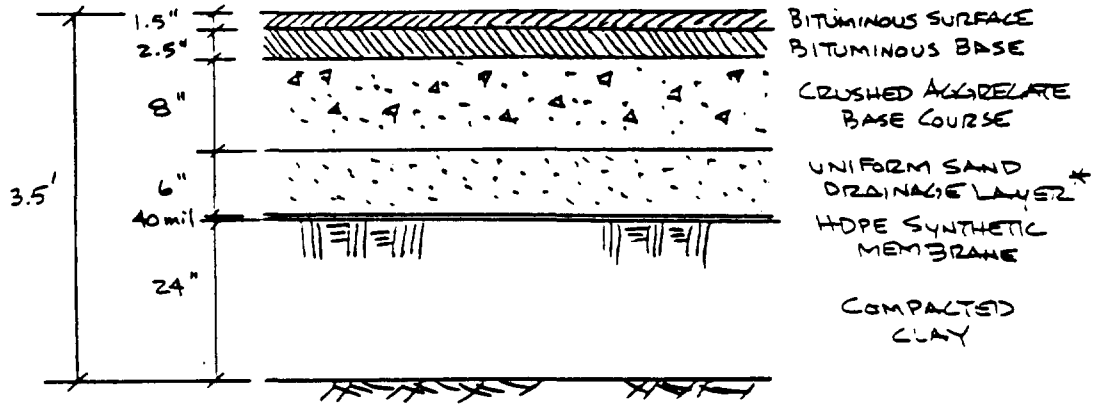


THE SIDESLOPE DETAIL WILL APPLY ONLY WHEN THE EXISTING SURFACE GRADES INSIDE THE CONTAINMENT AREA ARE RAISED PRIOR TO PLACING THE FINAL COVER (e.g. MODIFYING GRADES TO PROMOTE DRAINAGE). OTHERWISE, THE FINAL COVER WILL EXTEND OUT BEYOND THE SLURRY WALL AT THE EXISTING GRADE. COVER DETAILS IN THE VICINITY OF THE SLURRY WALL AND RAILROAD SPUR ARE DISCUSSED AND DEPICTED UNDER THE SLURRY CUTOFF WALL SECTION.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RHW DATE 2-26-85 SUBJECT GMC - WAUKEGAN SHEET NO. 8 OF 9
CHKD. BY WW DATE 3-6-85 JOB NO. C11937

IN SUMMARY, THE FINAL COVER WILL BE AS FOLLOWS (NOT TO SCALE)



* ALSO SERVES AS A SUBBASE LAYER TO PAVEMENT

THE FINAL COVER HAS BEEN REDUCED IN THICKNESS FROM APPROX. 5 FT. AS INDICATED IN THE CH2M HILL CONCEPT REPORT TO 3.5 FT. AS SHOWN, AND IS IN GENERAL CONFORMANCE TO IEPA AND USEPA GUIDELINES

THE ABOVE DETAIL WILL BE MODIFIED WHEN SIDESLOPES ARE REQUIRED SINCE THE UPPER LAYERS OF PAVEMENT, BASE COURSE AND DRAINAGE LAYER WILL NOT BE NECESSARY. A SYNTHETIC MEMBRANE AND 24 INCHES OF CLAY WILL BE NECESSARY HOWEVER AS WELL AS A SURFACE PROTECTION TO MINIMIZE EROSION. THE SIDESLOPES WILL BE DESIGNED FOR 3H:1V. IT IS PROPOSED TO PLACE THE 40 mil HDPE MEMBRANE BETWEEN TWO 12 INCH THICK CLAY LAYERS. THIS PROFILE WOULD MAINTAIN THE REQUIRED 24 INCHES OF CLAY AS WELL AS PROVIDE THE REQUIRED MINIMUM 6 INCHES OF SOIL PROTECTION ABOVE AND BELOW THE MEMBRANE. SINCE THE MEMBRANE IS PROTECTED, A 6 INCH THICK SAND LAYER WILL NOT BE NEEDED. FOR EROSION PROTECTION, IT IS PROPOSED TO COVER THE SIDESLOPES BY PLACING A LAYER OF ASPHALT PAVEMENT DIRECTLY OVER THE CLAY. A GRANULAR BASE COURSE WILL NOT BE NEEDED SINCE THE PAVEMENT WILL NOT BE SUBJECT TO TRAFFIC. THE ASPHALT PAVEMENT THICKNESS MAY ALSO BE REDUCED TO CONSIST OF THE 1.5 INCH THICK BITUMINOUS SURFACE COURSE CONTAINING FINE AGGREGATE THAT IS ANTICIPATED TO HAVE LESS SURFACE VOIDS.

6. CLAY

IN ACCORDANCE WITH THE 1982 RCRA GUIDELINES, THE CLAY LAYER BENEATH THE MEMBRANE WILL BE 24 INCHES (2 FT.) THICK AND BE SPECIFIED TO HAVE A PERMEABILITY NOT MORE THAN 1×10^{-7} cm/sec. THE CLAY WILL SERVE AS THE PROTECTIVE LAYER REQUIRED BENEATH THE MEMBRANE. ADDITIONAL RESTRICTIONS ON THE PHYSICAL PROPERTIES OF THE CLAY MATERIAL WILL BE CONSIDERED DURING PREPARATION OF THE SPECIFICATIONS. THE FOLLOWING RESTRICTIONS ARE CURRENTLY USED BY THE WISCONSIN DEPT. OF NATURAL RESOURCES FOR SPECIFYING CLAY TO BE USED AS LINERS FOR SOLID WASTE LANDFILLS:

PASSING No. 200 SIEVE $\geq$ 50%
CLAY CONTENT $\geq$ 25% (0.002 mm)
PERMEABILITY $\leq 1 \times 10^{-7}$ cm/sec
LIQUID LIMIT $\geq$ 30%
PLASTICITY INDEX $\geq$ 15%
COMPACTION $\geq$ 90% MODIFIED PROCTOR (OR POSSIBLY 95% STANDARD)

THESE SPEC'S WILL BE COMPARED TO AVAILABLE IEPA AND USEPA SPEC'S FOR CLAY. HOWEVER, THE SPEC'S SHOULD NOT BE TOO STRICT SUCH THAT SUITABLE CLAY ISN'T LOCALLY AVAILABLE. FOR EXAMPLE, THE LIQUID LIMIT CRITERIA MAY HAVE TO BE REDUCED. THE CLAY WOULD BE PLACED IN UNIFORM LIFTS (APPROX. 6-12 INCHES) AND COMPACTED TO 90% MODIFIED PROCTOR (POSSIBLE ALTERNATE IS 95% STANDARD PROCTOR) WITH A SHEEPSFOOT ROLLER ON THE "WET" SIDE OF OPTIMUM MOISTURE.

CLAY VOLUME IS: 144,777 sf × 2 ÷ 27 = <u>10,700 cy</u>

5. SYNTHETIC MEMBRANE

THE RCRA GUIDELINES INDICATE THAT AT LEAST A 20 mil THICK SYNTHETIC LINER BE USED (PAGE 27). AT THE DIRECTION OF MR. JACK BRAUN OF THE CHICAGO EPA, A MR. RICK TAYLOR OF SCHLEGEL LINING SYSTEMS VISITED THE WARZYN DESIGN OFFICE TODAY TO PRESENT A DISCUSSION ON THEIR PRODUCT. SCHLEGEL PROMOTES THE USE OF HIGH DENSITY POLYETHYLENE (HDPE) AS A SYNTHETIC MEMBRANE. ACCORDING TO MR. TAYLOR, SCHLEGEL WAS AWARDED A CONTRACT TO PROVIDE A 40 mil HDPE MEMBRANE TO BE INCORPORATED INTO THE FINAL COVER AT AN EPA SITE (LAPARIZI LANDFILL?) IN NEW JERSEY. A SIMILAR EPA PROJECT THAT SCHLEGEL DID NOT GET BUT WHICH A 40 mil HDPE MEMBRANE WAS ALSO USED IN THE FINAL COVER WAS AT LOVE CANAL. BASED ON MANUFACTURERS LITERATURE, HDPE IS HIGHLY RESISTANT TO DEGRADATION BY VARIOUS CHEMICALS.

SINCE 40 mil HDPE HAS BEEN APPROVED BY EPA ON PREVIOUS HAZARDOUS WASTE SITES AND THE THICKNESS IS TWICE THE THICKNESS RECOMMENDED IN THE RCRA GUIDELINES, IT IS CURRENTLY ANTICIPATED THAT A 40 mil HDPE MEMBRANE WILL BE SPECIFIED CONTINGENT UPON MODIFICATION DURING FINAL DESIGN.*

AREA TO BE COVERED IS 144,777 sf (See Appendix F)

*A 20 mil OR 30 mil SYNTHETIC MEMBRANE MAY BE CONSIDERED, IF THE OVERALL ESTIMATED CONSTRUCTION BUDGET EXCEEDS THE CORPS ESTIMATES, AS A COST-SAVING MEASURE.

RICK TAYLOR - REGIONAL SALES MGR. OF ROCKY MOUNTAIN REGION
SCHLEGEL LINING TECHNOLOGY INC.
LITTLETON, COLORADO
(303) 973-3116

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RHW DATE 2-26-85 SUBJECT OMC - WAUKEGAN SHEET NO. 5 OF 9
CHKD. BY WW DATE 3-6-85 JOB NO. C11837

4. DRAINAGE LAYER (SUBBASE)

A CLEAN UNIFORM SAND DRAINAGE LAYER WILL BE PROVIDED BENEATH THE AGGREGATE BASE COURSE TO DRAIN OFF SURFACE INFILTRATION THAT PENETRATES THE ASPHALT AND AGGREGATE BASE COURSE. THE AGGREGATE BASE COURSE ALONE COULD POSSIBLY BE ADEQUATE FOR DRAINAGE IF THE AMOUNT OF FINES WERE RESTRICTED TO SAY LESS THAN 5%. HOWEVER, BASED ON PAGE 27 OF THE 1982 RCRA GUIDELINES, THE UNDERLYING SYNTHETIC LINER MUST "BE PROTECTED FROM DAMAGE BELOW AND ABOVE THE MEMBRANE BY AT LEAST 6 INCHES OF BEDDING MATERIAL NO COARSER THAN USCS SAND (SP) ..." SINCE THE AGGREGATE BASE COURSE WILL CONTAIN GRAVEL AND BE CLASSIFIED AS GRAVEL (GW-GM) IN THE USCS, A CLEAN SAND LAYER (SP) 6 INCHES THICK WILL SERVE FOR DRAINAGE AND PROTECTION OF THE MEMBRANE. THE GRADATION OF THE SAND WILL BE SPECIFIED SUCH THAT IT WILL BE CLASSIFIED AS "SP" BUT STILL SATISFY FILTER REQUIREMENTS TO PREVENT WASHING OUT OF FINES FROM THE AGGREGATE BASE COURSE. THE FILTER CRITERIA AS DESCRIBED ON PAGE 26 OF THE RCRA GUIDELINES ARE AS FOLLOWS:

$$\frac{D_{15}\ \text{BASE COURSE}}{D_{85}\ \text{DRAINAGE LAYER}} \leq 5$$

$$\frac{D_{50}\ \text{BASE COURSE}}{D_{50}\ \text{DRAINAGE LAYER}} \leq 25$$

$$\frac{D_{15}\ \text{BASE COURSE}}{D_{15}\ \text{DRAINAGE LAYER}} = 5 \text{ TO } 20$$

DRAINAGE LAYER SHALL HAVE A PERMEABILITY $\geq 1 \times 10^{-3}$ cm/sec

VOLUME OF SAND NEEDED IS:

144,777 sf (see Appendix F) × 6" ÷ 27 = <u>2,700 cu</u>

SF 102978

SITE CONSTRUCTION

WARZYN
ENGINEERING INC

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 3.5.85 SUBJECT OMC DESIGN ANALYSIS SHEET NO. ____ OF ____
CHKD. BY DJO DATE 3-7-85 JOB NO. 11937

I AIR MONITORING STATIONS

REFER TO THE SITE SPECIFIC SAFETY PLAN (SSSP) FOR DISCUSSION OF AIR MONITORING STATIONS.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY R.M. WEBER DATE 3-4-85 SUBJECT OMC-WAUKEGAN, IL SHEET NO. 1 OF 1
CHKD. BY DATE 3-6-85 JOB NO. C11837

I. PARKING LOT CONTAINMENT CELL

SITE PREPARATION

H. ABANDON EXISTING MONITORING WELLS

THE EXISTING MONITORING WELLS WITHIN THE CONTAINMENT CELL SHOULD BE ABANDONED IN ACCORDANCE WITH THE PROCEDURES OUTLINED UNDER VII. LAGOONS, SITE RESTORATION.

SINCE SITE ACCESS TO DATE HAS NOT BEEN PERMITTED, THE NUMBER OF EXISTING WELLS TO BE EFFECTED ISN'T KNOWN. FOR ESTIMATING PURPOSES, ASSUME 13 WELLS ESTABLISHED AT A DEPTH OF 25 FT.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RHW DATE 3-3-85 SUBJECT CMC-WAUKEGAN, IL SHEET NO. 2 OF 2
CHKD. BY WD DATE 3-6-85 JOB NO. C11837

G. CONTINUED

1. LOCATIONS

THE TEMPORARY WELLS WILL BE LOCATED OPPOSITE THE 5 PERMANENT WELL NESTS LOCATED OUTSIDE THE CONTAINMENT CELL, AS INDICATED ON THE "CONSTRUCTION GRADES" DRAWING.

2. DETAILS

SINCE THE SOLE PURPOSE OF THE WELLS IS TO MONITOR WATER LEVELS UNTIL THE FINAL COVER IS PLACED AND THE PERMANENT GROUNDWATER WITHDRAWAL WELLS INSTALLED THROUGH THE COVER, IT IS PROPOSED TO INSTALL 2-INCH DIAMETER, PVC WELLS WITH A 10 FT. SCREEN LOCATED JUST BELOW THE WATER TABLE. THE WELL SCREEN WILL BE BACKFILLED WITH COARSE SAND (ANNULUS) AND A BENTONITE PLUG PLACED ABOVE THAT. A STEEL PROTECTIVE CASING IS NOT CONSIDERED NECESSARY.* THE WELL WILL BE CAPPED WITH A PVC CAP. THE WELLS CAN BE INSTALLED IN AN AUGERED BOREHOLE WITHOUT TAKING SPT SAMPLES. DRILL CUTTINGS CAN BE LEFT INSIDE THE CELL.

STEEL CASING MAY BE SPECIFIED DURING FINAL DESIGN AS A RELATIVELY INEXPENSIVE SAFETY MEASURE

3. INSTALLATION

THE WELLS SHOULD BE INSTALLED DURING SITE PREPARATION BY A QUALIFIED DRILLING SUBCONTRACTOR.

4. ESTIMATING

ASSUME 5 WELLS AT 15 FT. DEEP.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY D.H. WEBER DATE 3-3-95 SUBJECT OMC - WAUKEGAN, IL SHEET NO. 1 OF 2
CHKD. BY W. Wyatt DATE 3-6-95 JOB NO. C11837

V. PARKING LOT CONTAINMENT CELL

SITE PREPARATION

F. INSTALL PERMANENT GROUNDWATER MONITORING WELLS (OUTSIDE CELL)

1. LOCATIONS

SEE "CONSTRUCTION GRADES" DRAWING

2. DETAILS

SEE VIII. CRESCENT DITCH/OVAL LAGOON CONTAINMENT CELL AND VII. LAGOONS, SITE PREPARATION. TEN WELLS WILL BE INSTALLED AT 5 LOCATIONS (NESTS).

3. INSTALLATION

SEE VII. LAGOONS, SITE PREPARATION, E. GROUNDWATER MONITORING WELLS

4. ESTIMATING

USE 5 WELLS AT 15 FT. AND 5 WELLS AT 30 FT.

G. INSTALL TEMPORARY GROUNDWATER MONITORING WELLS (INSIDE CELL)

IT IS DESIRED TO MONITOR THE GROUNDWATER LEVEL INSIDE THE PARKING LOT SLURRY WALL DURING PLACEMENT OF EARTH FILL MATERIALS TO DETERMINE IF RUNOFF COLLECTED BY THE PERIMETER BERMS AND WATER DRAINING FROM THE EARTH FILL ARE RAISING THE WATER LEVEL HIGHER THAN OUTSIDE THE CELL. IF A HIGHER WATER LEVEL DID OCCUR, A GRADIENT CAUSING OUTWARD MIGRATION WOULD EXIST. IT IS PROPOSED TO INSTALL 5 TEMPORARY MONITORING WELLS JUST INSIDE THE CONTAINMENT BERM FOR THIS PURPOSE.

SP 102976

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 2-22-85 SUBJECT OMC DESIGN ANALYSIS SHEET NO. 1 OF 1
CHKD. BY DJO DATE 3-8-85 CONCEPT SUMMARY JOB NO. 11837
SITE PREPARATION

I PARKING LOT/CONTAINMENT CELL

E. FENCING

Approximately 260' of fenceline from within the containment area will be removed.

Approximately 1500' of security fence will be installed with 2 gates. See Drawing No. 528 for locations

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY R.H. DEBER DATE 3-4-85 SUBJECT OMC-WAUKEGAN IL SHEET NO. 1 OF 1
CHKD. BY [illegible] DATE 3-6-85 JOB NO. C11837

I. PARKING LOT CONTAINMENT CELL

SITE PREPARATION

D. DEWATERING FOR UTILITY MODIFICATIONS

REFER TO VII. CRESCENT DITCH/OVAL LAGOON CONTAINMENT CELL, SITE PREPARATION

WARZYN ENGINEERING INC.
MADISON, WISCONSIN

BY LAB DATE 3-22-85 SUBJECT OMC DESIGN ANALYSIS SHEET NO. 4 OF 4
CHKD. BY DJG DATE 3-8-85 CONCEPT SUBMITTAL JOB NO. 11837
SITE PREPARATION

I PARKING LOT CONTAINMENT CELL

2 Gas - Drawings 530 & 538
Portions of the 12" gas main will have to be removed, abandoned, plugged and rerouted.
- 50' will be removed for slurrywall construction
- Gas line will be disconnected in 8 locations and the line will be plugged and abandoned.
- 995' will be installed around the containment cell.

3. Sanitary - Drawings 529 and 537
Portions of the 8" sanitary line will be disconnected and plugged or removed and rerouting will occur.
- 3 locations will be disconnected and plugged
- 40' will be removed
- 620' of 8" sanitary line will be installed.

4. Storm
Portions of the 18" RCP will be disconnected, plugged and abandoned or removed. Storm will be rerouted.
- 7 locations will be disconnected and plugged
- 40' will be removed
- 630' of 18" RCP will be installed
- 3 manholes & catch basins will be installed
- 2 manholes will be abandoned. Lids will be removed and manholes will be backfilled with clean material. Vol backfill = 4.7 cy.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 2-21-85 SUBJECT OMC DESIGN ANALYSIS SHEET NO. 3 OF 9
CHKD. BY DJC DATE 3-8-85 CONCEPT SUBMITTAL JOB NO. 11837
SITE PREPARATION

I PARKING LOT CONTAINMENT CELL

C. UTILITIES - ADDITIONS & MODIFICATIONS

1. Electrical - Drawings 530 & 538
Some electrical utilities will be abandoned within the containment area. Some will have to be removed for slurry wall construction and additional facilities will have to be constructed.

Overhead Electrical
- Approximately 480' of 12KV OH 3 phase lines will be removed
- 2 12KV OH 3 phase poles will be removed and relocated.

- 460' of 12KV OH 3 phase lines will be installed around the containment cell. 480' of this will be the lines removed from old location and 460' will be new.

Underground Electrical
- Underground electrical will be disconnected in 11 locations and portions within the containment cell will be abandoned.
- 80' of UG electrical will be removed for slurrywall construction
- 840' of UG electrical will be installed and connection to light poles will be done in 7 locations

Light poles
- 5 light poles will be removed and relocated.
- 2 additional poles will be installed

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 3-1-85 SUBJECT GMC DESIGN ANALYSIS SHEET NO. 2 OF 9
CHKD. BY DJC DATE 3-7-85 CONCEPT SUBMITTAL JOB NO. 11837
SITE PREPARATION

I. PARKING LOT CONTAINMENT CELL

2. DRAINAGE

The initial containment berm will contain any surface water from leaving the site. Any water within the cell will be considered contaminated and will be pumped to the treatment plant Piping, sump area, and pump will be needed, and will be addressed in the final design.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 3-1-85 SUBJECT OMC DESIGN ANALYSIS SHEET NO. 1 OF 9
CHKD. BY DJL DATE 3-8-85 CONCEPT SUBMITTAL JOB NO. 11837
SITE PREPARATION

I PARKING LOT CONTAINMENT CELL

A. REMOVAL OF EXISTING FEATURES

Within the containment cell area several items will have to be removed:

5 signs
965' of guard railing
260' of fencing
17,725 sf of pavement to be stockpiled

The remaining pavement (152,650 − 17,725 = 134,925 sf) will be broken up.

B. INITIAL GRADING

The remaining area, (286,965 sf − 152,650 paving area) will be cleared & grubbed. Area is 134,315 sf. See Appendix F for surface area calculations.

1. Berms
Two berms were designed − see Crescent Ditch / Oval Lagoon.

Initial berm volume = 8 ft² × 2,300 = 680 cy
slurry wall const berm vol = 32 ft² × 2,300 = 2,730 cy

Before construction of the slurry wall construction berm, some material will be excavated. Excavated vol = 628 cy
See Appendix K for volume calculation. EXISTING
SURFACE WILL BE SCARIFIED PRIOR TO CONSTRUCTION OF THE BERMS

SITE PREPARATION

WARZYN
ENGINEERING INC

X PARKING LOT CONTAINMENT CELL

WARZYN
ENGINEERING INC

Operations and Maintenance Provisions

IX. East-West Portion of North Ditch and Bypass

B. Decontamination

All vehicles, equipment, and personnel that come into contact with PCB contaminated materials will require decontamination prior to leaving the site. In general, the decontamination procedures for vehicles and equipment will consist of:

1. Water and detergent wash with scrubbing to remove all sediments from the equipment. Only as much water as necessary should be used, and care must be taken to keep splashing to a minimum.

2. Water rinse.

3. Collect washing and rinse fluids and dispose of properly by discharge to the water treatment plant.

This procedure should provide sufficient decontamination for equipment exiting the site. To ensure that sufficient cleanup has taken place periodic wipe tests should be conducted using the following procedures:

1. Apply an appropriate solvent (hexane), to a piece of 11 cm filter paper (eg. Whatman 40 ashless, or Whatman "50" smear tabs or similar).

2. The moistened filter paper, held with a pair of stainless steel forceps, is used to thoroughly swab a 100 cm^2 area, measured using a sampling template.

3. The filter paper swab is then placed in a pre-cleaned glass jar and stored at 4°C for analysis for PCB's.

Quality assurance must be applied throughout the entire monitoring program. Blank swab samples and spiked samples will be needed to insure the accuracy of the test results.

MABS/BN3

Operations and Maintenance Provisions

IX. East-West Portion of the North Ditch and Bypass

Site Construction

A. Spoil Material to Parking Lot.

As indicated in the Conceptual Design, the contaminated material excavated from the east-west portion of the North Ditch for installation of the bypass sewer pipe would be placed and compacted in the parking lot area. The estimated excavation quantity is estimated to be approximately 3,400 cubic yards. If some of the material excavated west of the present ditch location were proven by field testing during construction not to be contaminated, it may not require containment.

MABS/BJ2

SITE OPERATIONS/MAINTENANCE

WARZYN

IX. East-West Portion of the North Ditch and Bypass

Site Restoration

C. Decontamination of Equipment

Soil removal equipment, site restoration vehicles, and all associated equipment will be decontaminated at the Parking Lot Decontamination Station prior to leaving the site.

MABS/BM6

Application of seed shall be as follows.

Class I

Ky. Bluegrass	50 lbs/acre
Perrenial Ryegrass	20
Creeping Red Fescue	10
White Clover	5

4. Fertilizer

Fertilizer appropriate for the topsoil used should be determined and used at an appropriate application rate.
Area to be fertilized is 128,500 sf.

5 Mulch

Seeded areas shall be mulched. Mulch will consist of any hay or straw in an air-dry state, free of noxious weed seeds and other matter according to the State of Illinois Department of Transportation "Standard Specifications for Road and Bridge Construction" manual.
Area to be mulched is 128,500 sf.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 3-6-85 SUBJECT OMC SHEET NO IX-16 OF
CHKD. BY TJLuncu DATE 3-7-85 JOB NO. 11837

SITE RESTORATION

A. FINAL GRADING

1. Fencing

The 500' of fencing that was removed shall be replaced upon completion of construction activities.

2. General

For the first approximately 925' from Grid 638,360 going East along north ditch, final grades slope at 3.5% down from the northern edge over the bypass to the edge of the containment cell. This was done to achieve a greater depth over the bypass pipe. This area will be covered with 2 feet of clay, 6" topsoil, seeded, fertilized & mulched. The remaining 880' will have a 1.5% slope to the pipe and then back up at a 1.5% to grade. Final cover will be the same as stated above. The sewer bypass (western edge) will slope from either side at 1.5% also, but no clay cover is required because area is assumed uncontaminated.

B. FINAL COVER

The area is to have 2' of clay, 6" of topsoil and is to be seeded, fertilized and mulched on the east. The western portion does not require clay.

1. Clay

The clay layer is to be 2' thick. See specification under Crescent Ditch/Oval Lagoon Final Cover. Clay volume = [(75 × 270) + (300 × 135) + (535 × 70) + (400 × 55)] × 2 ÷ 27 = 8,000 cy

2. Topsoil

Topsoil shall be in accordance with the State of Illinois Department of Transportation "Standard Specifications for Road and Bridge Construction" Manual. Topsoil area is (75 × 270) + (20 × 415) + (300 × 135) + (535 × 70) + (400 × 55) equaling 128,500 sf. Volume = 128,500 × .5' ÷ 27 = 2380 cy

3. Seed

Area to be seeded is 128,500 sf (See above for calculation of area. Seed mix shall be Class I according to the State of Illinois Department of Transportation "Standard Specification for Road and Bridge Construction" Manual

SITE RESTORATION

WARZYN
ENGINEERING INC

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAV DATE 3-6-85 SUBJECT Design Analysis SHEET NO. IX-15 OF
CHKD. BY TJL DATE 3-7-85 JOB NO. 11837
GMC/Waukegan Harbor

F. STABILITY of NORTHERN STRUCTURES

Because of the shallowness of the excavation associated with construction of the bypass sewer in the east-west portion of the North ditch, it does not appear that it will impact on the stability of adjacent sheetpile bulkhead or transmission pole foundations.

IX. East-West Portion of the North Ditch and Bypass

Site Construction

E. Decontamination Facility

The Decontamination Station defined under the Parking Lot Containment Cell Section will also service the North Ditch activities.

MABS/BM6

IX. EAST-WEST PORTION OF NORTH DITCH AND BYPASS

SITE CONSTRUCTION

D. DEWATERING

IT IS CURRENTLY PLANNED TO REMOVE ONLY THE MATERIALS FROM THE E-W DITCH AND BYPASS NECESSARY TO INSTALL THE BYPASS STORM SEWER. SINCE AN INVERT ELEVATION OF APPROXIMATELY EL. 580 IS ANTICIPATED, THE INVERT WILL ONLY BE ABOUT 1.5 TO 2.0 FT. BELOW THE WATER LEVEL OF THE E-W DITCH AS SURVEYED AEROMETRICALLY IN AUGUST 1984 (W.L. 581.7). TO AVOID A DEWATERING AND TREATMENT SCHEME, IT IS PROPOSED TO INSTALL THE STORM SEWER BYPASS WITHOUT DEWATERING. PIPE SUBGRADE CONDITIONS CAN BE VISUALLY ASSESSED DURING EXCAVATION FOR PIPE BEDDING. WORK CREWS CAN WEAR HIPBOOTS OR WADERS TO PROTECT THEIR LEGS FROM THE POTENTIALLY CONTAMINATED WATER.

C. EXCAVATION/BACKFILL QUANTITIES

The western area (outside the existing ditch area) is considered clean. Excavated material can be reused and no final clay cover is necessary.

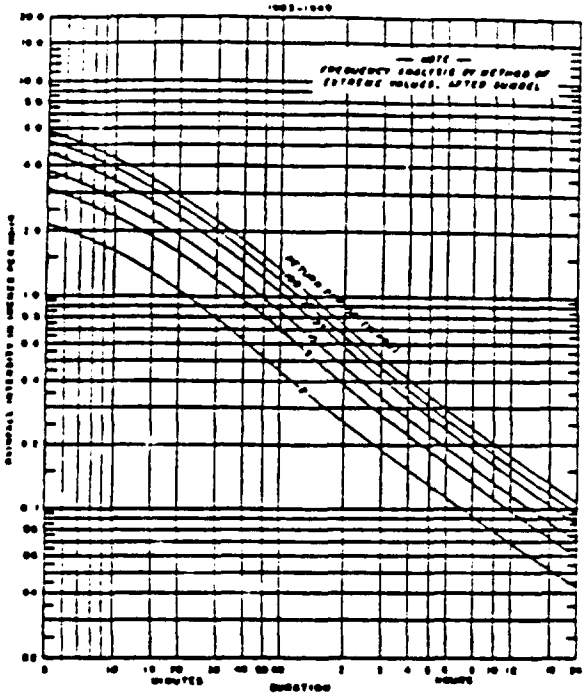
Excavation volume	1,800 cy	Refer to section A
Pipe cover to existing grade	1,200 cy	Refer to Cost Estimate
Cover to grade	520 cy	
Pipe bedding	130 cy	

The East-West portion of the North Ditch is considered contaminated. Excavated material will be disposed of in the Parking Lot containment cell. Two feet of final cover clay and 6" of topsoil will be placed — see Final Cover under Site Restoration.

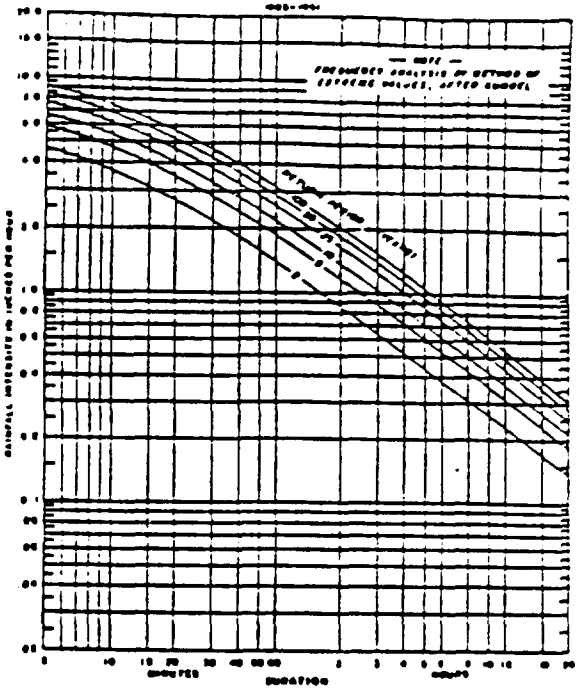
Excavation volume	2,000 cy	Refer to section A
Cover to existing grade	2,055 cy	Refer to Cost Estimate
Existing grade to Final grade	4,520 cy	Refer to Appendix E
Pipe bedding	335 cy	Refer to Cost Estimate

RAINFALL INTENSITY – DURATION – FREQUENCY CURVES

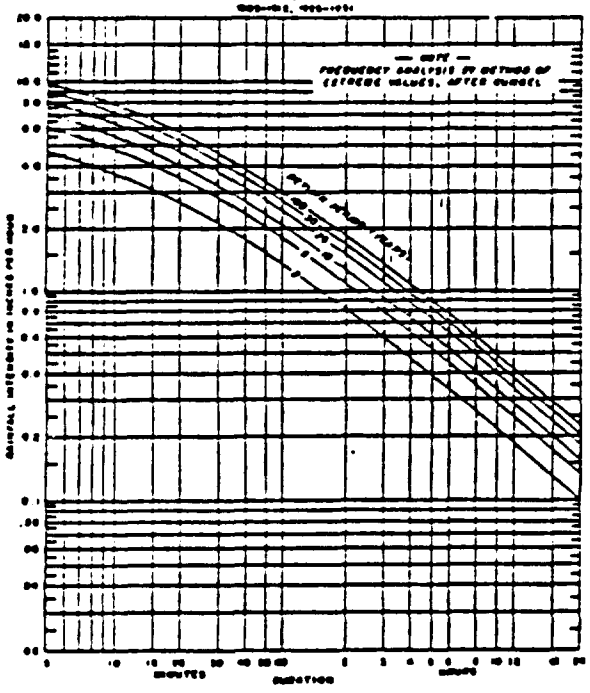
POCATELLO, IDAHO



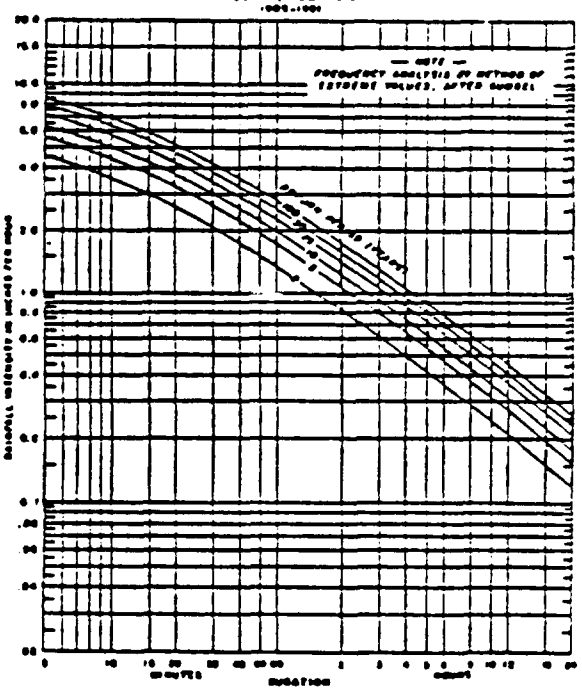
CAIRO, ILLINOIS



CHICAGO, ILLINOIS



PEORIA, ILLINOIS



DONOHUE & ASSOCIATES, INC.
CONSULTING ENGINEERS
SHEBOYGAN, WISCONSIN

CLIENT Warzyn DATE 2-12-85
PROJECT Waukegan BY Scott Salvgerson
PROJECT NO. 13935 PAGE NO. 3 of 3

B. Gravity Flow (Free Discharge)

1. Assume N = 0.013
2. Q req'd = 16.8 MGD
3. Available slope = $\frac{579.95 - 578.8}{2665}$ = 4.4×10^{-4} FT/FT

Per Kutters Formula Slide Rule; $S = \frac{0.04}{1000}$

42" Round pipe = 20.5 cfs = 13.3 MGD < 16.8 req'd
48" Round pipe = 29.0 cfs = 18.7 MGD > 16.8 req'd

∴ 48" Round pipe would handle design flow

However, Ground cover over 48" is Not Adequate

∴ Use 38" x 60" Horizontal Elliptical Reinforced concrete pipe.

DONOHUE & ASSOCIATES, INC.
CONSULTING ENGINEERS
SHEBOYGAN, WISCONSIN

CLIENT WARZYN DATE 2-12-85
PROJECT WAUKEGAN BY Scott Solverson
PROJECT NO. 13935 PAGE NO. 2 of 3

Bypass Sewer Design

A. Pressure Flow:

1. Assuming that Lake Michigan is at its 10 year interval high water elevation, and the head at the inlet of the bypass sewer matches the crown of the 36" storm drain, then:

$$S_o/L = \frac{583.95 - 582.80}{2665} = 4.4 \times 10^{-4} \text{ FT/FT}$$

$$\therefore \text{headloss}/1000' = 0.44 \text{ FEET}$$

Per Hazen-Williams formula, assuming C = 120

42" Round pipe = 13.9 MGD < 16.8 Req'd
48" Round pipe = 19.7 MGD > 16.8 Req'd

∴ 48" Round pipe is OK
38" x 60" horizontal elliptical pipe is approximately equivalent to 48" Round.

∴ Use 38"x60" Horizontal Elliptical Reinforced concrete pipe to obtain minimal earth cover

DONOHUE & ASSOCIATES, INC.
CONSULTING ENGINEERS
SHEBOYGAN, WISCONSIN

CLIENT Warzyn DATE 2-12-85
PROJECT Waukegan BY Scott Solverson
PROJECT NO. 13935 PAGE NO. 1 of 3

North Ditch Bypass - Flow Calculations

GIVEN

1. In the Conceptual Design, page 1-3, The U.S. Dept. of Interior calculated the 5-year storm event of the North Ditch to be 23 cfs.

2. The A/E Instruction Manual, Sub-chap. 3-C states design calculations will be based on a 10-year/1 hour design storm.

Pro-rate to a 10-year/1 hour flow:

Using the attached Rainfall intensity curve, find the ratio between the 10-year and 5-year storm at 1 hour duration (assuming the 23 cfs was based on 1 hour duration)

10 year = 2.05
5 year = 1.80

$$\text{Design flow} = 23 \text{ cfs} \left(\frac{2.05}{1.80}\right) = 26.2 \text{ cfs}$$

Assume:
High invert = 579.95 (USGS)
low invert = 578.80 (USGS)
length ≈ 2665'

Checked BVM 2-27-85

Per the Conceptual Report, the East-West portion of the North Ditch is considered to be contaminated. However, it is being assumed that concerns relative to installing the bypass sewer partially under water can be satisfactorily addressed, and that the pipe foundation can be suitably prepared in a "wet" condition. If this proves false, dewatering inside the ditch area would be required to allow installation of the pipe in a "dry" condition.

It is being assumed that health hazard concerns relative to installing the bypass sewer partially under water can be satisfactorily addressed, and the pipe foundation can be suitably prepared without trench dewatering.

Temporary sheeting will be required to separate the side of the ditch that remains in service from the side receiving the bypass sewer. This sheeting would be driven down approximately 5 feet.

The pipe will be bedded with crushed stone material hauled in to the site. Granular material will be brought in to the site for trench backfill (except as previously discussed under Item A of this section). Backfill will be placed to the rough grade level inside the sheet piling. Upon completion of bypass sewer construction, the remaining half of the ditch will be backfilled with granular material and the sheet piling removed.

MABS/BJ3

storm drain upstream of the bypass sewer as being 580.95 feet (USGS Datum). (To be subsequently verified by the field survey). The bypass sewer invert at the connection to the 36-inch diameter storm drain has been set at 579.95 (USGS Datum) feet to obtain minimal earth cover over the pipe. The bypass sewer outfall invert will be set at 578.80 feet (USGS Datum). The selected pipe slope is 0.044 percent. The design flow used for calculating the bypass sewer size and slope is 26 cfs. This figure is derived from the 23 cfs five year storm flow presented in the Conceptual Design report. The derived figure represents a 10 year, 1 hour storm flow (per the A/E Manual criteria). Based on Kutters Formula, it was determined that a 48-inch round pipe was required to handle this design flow, at the slope indicated. The proposed sewer will handle the 10 year storm flow for all Lake Michigan water levels less than or equal to the 10 year interval high water elevation for Lake Michigan (582.8, USGS Datum) and was found to provide the necessary capacity.

A 38 inch by 60 inch horizontal elliptical pipe, which is hydraulically equivalent to a 48 inch round pipe, was selected in order to provide minimal earth cover.

Cover over the pipe is a significant concern, especially since this area may be considered for a future parking area. Pipe strength calculations will be prepared after determination of final grades and live loads along the sewer alignment.

A concrete headwall will be cast around the pipe at its outfall. Cast-in-place manholes will be constructed along the bypass sewer (or cast-in-place slabs directly on top of the sewer) at the approximate locations shown on the drawings. Several manholes along the bypass sewer alignment will have grate inlets and act as area drains.

A special cast-in-place manhole will be required at the existing 51 inch NSSD sanitary sewer crossing, due to expected elevation conflicts between the two conduits. The manhole would be cast over the existing 51 inch sewer, and the top of the sanitary sewer broken out. This would allow passing the bypass sewer intact over the 51 inch NSSD sewer. No detrimental effect on the flow of the 51 inch sewer is expected.

IX. East-west Portion of the North Ditch and Bypass

Site Construction

A. Excavation-Trenching

The conceptual design stated there would be an estimated 5,500 cubic yards of soil excavated from the east-west portion of the north ditch in order to construct the bypass sewer.

For the 38 inch by 60 inch horizontal elliptical pipe selected, the trench width required would be approximately 8 feet, outside of the existing ditch area. Inside the ditch area, the width required may be greater, due to wet construction. The depth of cut will vary, but is expected to average 7 feet outside the ditch area and 3 feet inside the ditch area.

Bypass sewer construction outside the ditch area would thus yield approximately 1,800 cubic yards of excavated material, and the construction inside the sheet piled area would yield approximately 2,000 cubic yards of excavated material. Therefore, the total quantity of excavated material is estimated at approximately 3,800 cubic yards.

This quantity is less than the Conceptual Design estimate.

Per the Conceptual Design, the soil in the East-West portion of the north ditch is considered contaminated, and would be placed and compacted in the parking lot area. The Conceptual Plan does not clearly state the north/south portion of the bypass sewer alignment is in a contaminated area. If the material excavated is proven (by contractor field testing) not to be contaminated, it could be used for trench backfill and site grading, or disposed of in containment areas.

B. Pipe Installation

A 30 inch by 60 inch horizontal elliptical reinforced concrete pipe would be installed as shown on the North Ditch Storm Sewer Bypass Plans. This assumes that no additional conflicts are discovered. Available information indicates the invert of the 36-inch diameter

SITE CONSTRUCTION

WARZYN
ENGINEERING INC

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 3-1-85 SUBJECT CMC DESIGN ANALYSIS SHEET NO. 1 OF 1
CHKD. BY DJO DATE 3-7-85 JOB NO. 11837

SITE RESTORATION

X PARKING LOT

C. FINAL GRADING & PRESSURE VENTING

Final grades consist of 3 to 1 sideslopes up approximately 16 FT. to the parking area. The parking lot will be sloped at a 1½% to drain to the north. Two entrance/exit ramps will be constructed at an approximate slope of 7%. The elevation of the parking lot ranges from 600' to 604'. Pedestrian access will be discussed in the final design.

Five pressure vents will be constructed in this containment area. See Sheet No. 536 for approximate locations. These will be addressed further in the final design.

X. Parking Lot Containment Cell

Site Restoration

B. Decontamination of Equipment

All excavation and site restoration vehicles and associated equipment will require decontamination prior to leaving the site. Decontamination will take place at the parking lot decontamination station.

All equipment and structures associated with the decontamination station will be removed and properly disposed of by the contractor.

MABS/BM8

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 3-1-85 SUBJECT GMC - WAUKEGAN, IL SHEET NO. 1 OF 1
CHKD. BY [illegible] DATE 3-5-85 JOB NO. C11837
DESIGN ANALYSIS

I. PARKING LOT CONTAINMENT CELL

SITE RESTORATION

A. ABANDON TEMPORARY GROUNDWATER MONITORING WELLS

THE 5 PVC WELLS INSTALLED INSIDE THE TOE OF THE CONTAINMENT BERM (SEE SITE PREPARATION) SHOULD BE ABANDONED PRIOR TO PLACIN THE FINAL COVER. ABANDONMENT CAN CONSIST OF PULLING OUT THE WELLS AND ALLOWING THE BOREHOLE TO COLLAPSE. GROUTING WILL NOT BE REQUIRED. OVERDRILLING WITH HOLLOW STEM AUGERS WILL ONLY BE NECESSARY IF THE WELLS CANNOT BE PULLED OUT.

SITE RESTORATION

WARZYN

X. Parking Lot Containment Cell

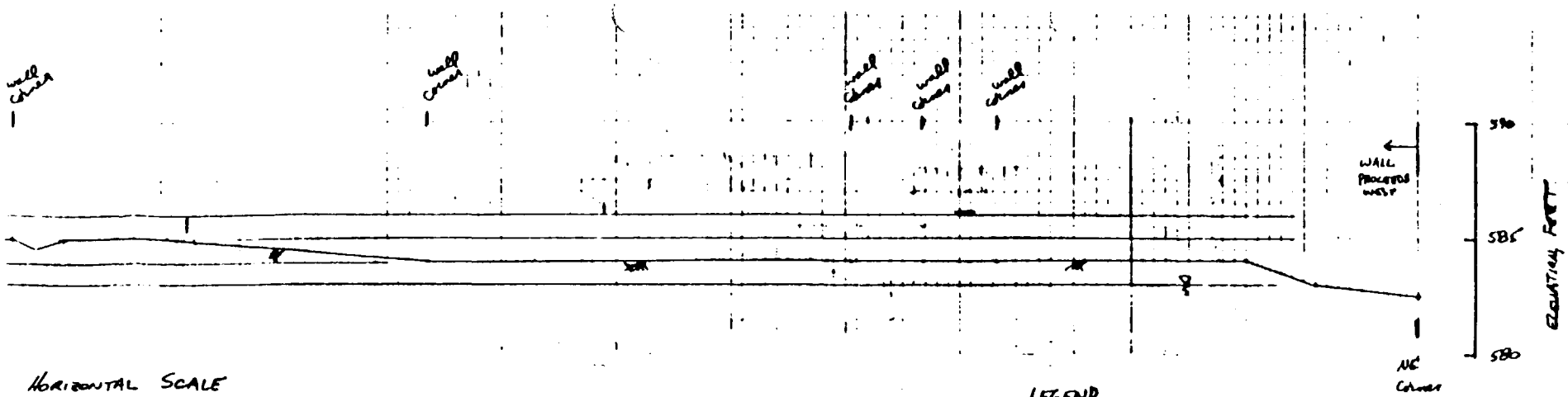
Site Construction

C. Decontamination Station

A single decontamination station will be located in the parking lot/north ditch area to handle all vehicles and equipment associated with the crescent ditch/oval lagoon, north ditch, and parking lot operations. The station will be located at a point of exit from the site, and all vehicles, equipment, and personnel will be required to pass through the decontamination area prior to leaving the site. The station will consist of a concrete pad overlain with a steel grating and surrounded by a small dike or curb. Grating is necessary in order to reduce containment transport via truck tires. The pad will slope into a catch basin where the wash fluids can be contained or piped to the water treatment plant. A personnel decontamination station, with associated emergency equipment, will be located adjacent to the vehicle/equipment decontamination area.

MABS/BM7

Approximately 1,035 ft of curb will be constructed.



HORIZONTAL SCALE
1" = 100'

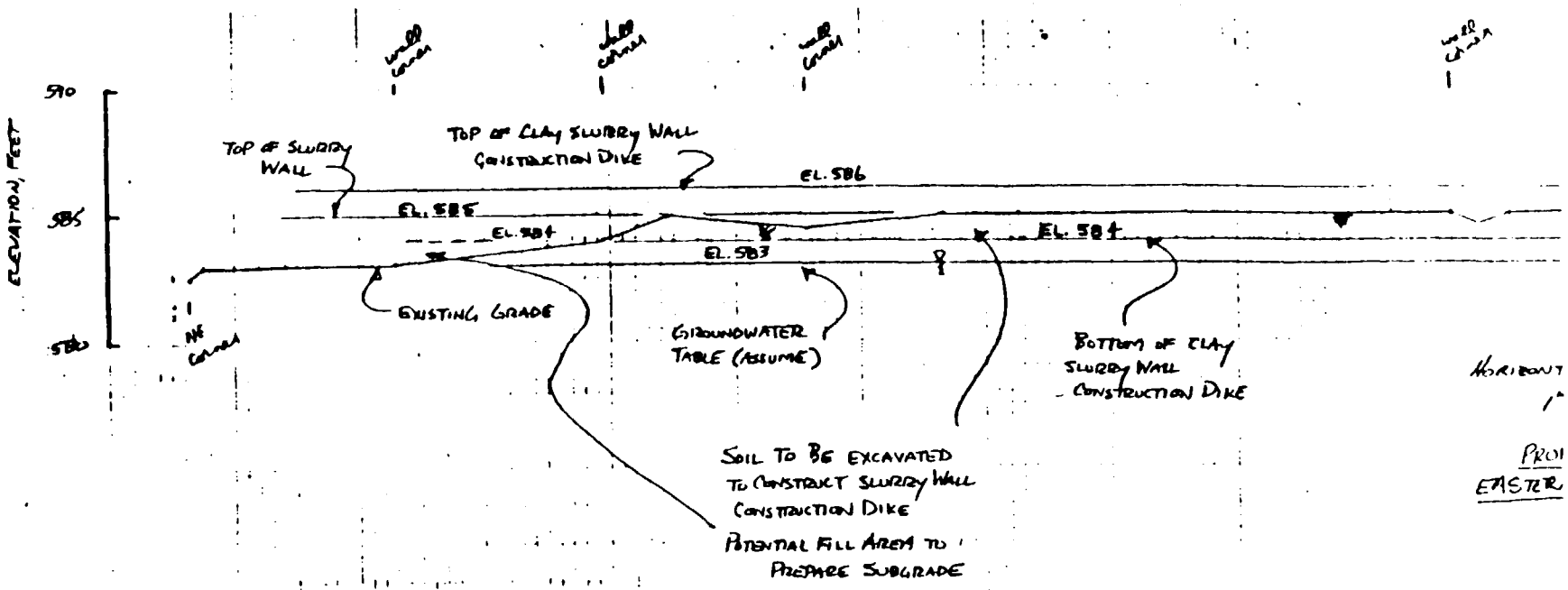
PROFILE SECTION
EASTERN SLURRY WALL

LEGEND

- H_2O
- Top of Slurry Wall
- Impermeable Membrane (TOP OF CLAY)
- Natural Ground
- TO BE EXCAVATED & BACKFILLED DURING DIKE CONSTRUCTION

OMC/WAUKEGAN/SUPERFUND
C11837 2/24/85 RANS
PROFILE SECTION, PARKING
LOT CONTAINMENT AREA

Figure 1



HORIZONT
1"
PROI
EASTER

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RHW DATE 3-1-85 SUBJECT OMC-WAUKEGAN SHEET NO. 4 OF 4
CHKD. BY MNS DATE 3/4/85 JOB NO. C11837

1.4 CLAY CAPPING OF SOIL-BENTONITE SLURRY WALL

VOLUME: REFER TO CALC'S UNDER CD/OL

AREA = 3.5 FT^2 ✓
LENGTH = 2250 FT ± ✓
V = (3.5)(2250) / 27 = 291 YD^3 ✓

1.5 CLEANUP
1.6 QUALITY CONTROL } SEE VIII. CD/OL

* SEE ATTACHED PROFILE ALONG SLURRY WALL ALIGNMENT
* SEE TYPICAL PARKING LOT CONTAINMENT CELL CROSS SECTION UNDER ITEM V., SITE RESTORATION, D. FINAL COVER

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RJW DATE 3-1-85 SUBJECT CMC-WAUKEGAN SHEET NO. 3 OF 4
CHKD. BY MLK DATE 3/4/85 JOB NO. C11837

1.3 CONTINUED

VOLUME OF IMPORTED SOIL (ASSUME IN-PLACE BORROW DENSITY 125 PCF)

$= 17{,}650{,}202\ LB \times \frac{FT^3}{125\ LB} \times \frac{YD^3}{27\ FT^3} = \underline{5230\ YD^3}$

WEIGHT OF WATER IN IMPORTED SOIL = $W_{wet} - W_{dry}$

$= 17{,}650{,}202 - 15{,}348{,}002 = 2{,}302{,}200\ LBS$

VOLUME OF WATER IN IMPORTED SOIL

$= 2{,}302{,}200\ LB \times \frac{FT^3}{62.4\ LB} \times \frac{7.48\ GAL}{FT^3} = 275{,}969\ GAL$

VOLUME OF WATER NEEDED TO ADD TO IMPORTED SOIL = $V_{H_2O\ IN\text{-}PLACE} - V_{H_2O\ IMPORTED}$

$= 600{,}749\ GAL - 275{,}969\ GAL = \underline{324{,}780\ GAL}$

TOTAL WEIGHT OF BENTONITE NEEDED (INCLUDING SLURRY & BACKFILL)

$= (2250\ FT)(35\ FT)(6\ LB/FT^2) = \underline{472{,}500\ LB}$

WEIGHT OF BENTONITE USED FOR SLURRY ($W_{TOTAL} - W_{BACKFILL}$)

$= 472{,}500 - 313{,}225 = 159{,}275\ LB$

VOLUME OF WATER MIXED WITH BENTONITE TO MAKE SLURRY (90-100 LB/YD^3)

$= 159{,}275\ LB \left(\frac{YD^3}{90\ LB}\right)\left(\frac{27\ FT^3}{YD^3}\right)\left(\frac{7.48\ GAL}{FT^3}\right) = \underline{357{,}413\ GAL}$

TOTAL VOLUME OF WATER NEEDED ($V_{BACKFILL} + V_{SLURRY}$)

$= 324{,}780 + 357{,}413 = \underline{682{,}193\ GAL}$

SUMMARY

IMPORTED BORROW SOIL	5230 YD^3
WATER	682,193 GAL
BENTONITE	472,500 LB

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY R. WEBER DATE 3/1/85 SUBJECT OMC - WAUKEGAN SHEET NO. 2 OF A
CHKD. BY MNS DATE 3/4/85 JOB NO. C11837

1.2 CONTINUED

EXCAVATION QUANTITY FOR SLURRY WALL CONSTRUCTION
ASSUME AVG. TRENCH DEPTH = 35 feet ✓ (INCLUDING 2' DIKE)
TRENCH WIDTH = 30 in = 2.5 ft ✓
TRENCH LENGTH = 2250 ft ± ✓ (SCALED FROM DRAWING)

$V = (35)(2.5)(2250)/27 = \underline{\underline{7292\ YD^3}}$ ✓

1.3 MATERIALS — SEE VIII. CD/OL

1.3.5 BACKFILL

VOLUMES: REFER TO SIMILAR CALC'S UNDER CRESCENT DITCH/OVAL LAGOON SLURRY WALL DISCUSSION

EXCAVATION QUANTITY AND BACKFILL VOLUME (PREVIOUSLY CALCULATED ABOVE)
$= \underline{\underline{7292\ YD^3}}$ ✓

TOTAL WET WEIGHT OF BACKFILL (ASSUME IN-PLACE DENSITY 105 PCF)
$= 7292\ YD^3 \times \frac{27\ FT^3}{YD^3} \times \frac{105\ LB}{FT^3} = 20{,}672{,}820\ LB$ ✓ (INCLUDING SOIL AND BENTONITE)

DRY WEIGHT OF BACKFILL (ASSUME IN-PLACE WATER CONTENT 32%)
$= \text{WET WT.}/(1+w) = 20{,}672{,}820/1.32 = 15{,}661{,}227\ LB$ ✓

WEIGHT OF WATER IN BACKFILL $= 20{,}672{,}820 - 15{,}661{,}227 = 5{,}011{,}593\ LB$ ✓

VOLUME OF WATER IN BACKFILL $= 5{,}011{,}593\ LB \times \frac{FT^3}{62.4\ LB} \times \frac{7.48\ GAL}{FT^3} = 600{,}749\ GAL$ ✓

DRY WEIGHT OF BENTONITE IN BACKFILL (ASSUME 2% BY DRY WEIGHT) =
$0.02(15{,}661{,}227) = \underline{\underline{313{,}225\ LB}}$ ✓

DRY WEIGHT OF SOIL IN BACKFILL $= 15{,}661{,}227 - 313{,}225 = 15{,}348{,}002\ LBS$ ✓

WET WEIGHT REQUIRED FOR SOIL IN BACKFILL (ASSUME SOIL BORROW MOISTURE 15%)
$= 15{,}348{,}002(1.15) = 17{,}650{,}202\ LBS$ ✓

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY R.W. WEBER DATE 3/1/85 SUBJECT OMC-WAUKEGAN, IL SHEET NO. 1 OF 4
CHKD. BY M.W. Schutz DATE 3/4/85 JOB NO. C11537
DESIGN ANALYSIS

V. PARKING LOT CONTAINMENT CELL

SITE CONSTRUCTION

B. SLURRY WALL

REFER TO CATEGORY VIII. CRESCENT DITCH/OVAL LAGOON CONTAINMENT CELL - SITE CONSTRUCTION, ITEM E FOR DETAILED DISCUSSION ON SLURRY WALL. IDENTICAL CONSTRUCTION METHODS AND SPECIFICATIONS WILL APPLY TO BOTH SLURRY WALL SITES.

1.1 PREQUALIFICATION OF CONTRACTORS - SEE VIII. CD/OL

1.2 SLURRY TRENCH CUTOFF WALL

FEATURES AFFECTING SLURRY WALL CONSTRUCTION DO NOT INCLUDE RAILROAD SPUR AFFECTING CRESCENT DITCH/OVAL LAGOON WALL. FEATURES DO INCLUDE A 138KV OVERHEAD TRANSMISSION LINE AND THE ASSOCIATED POLES AND POLE FOUNDATIONS. COMMONWEALTH EDISON HAS BEEN CONTACTED REGARDING LINE CLEARANCE AND LATERAL CLEARANCE BETWEEN WALL AND POLE FOUNDATIONS. DETAILS WILL BE WORKED OUT IN FINAL DESIGN. THE PRESENCE OF THE 138KV LINE IS NOT ANTICIPATED TO CAUSE ANY SIGNIFICANT DESIGN ALTERATIONS EXCEPT THAT A "NOTCH" IN THE NORTH LEG OF THE SLURRY WALL BE PROVIDED SO THAT THE EXCAVATION AND FINAL WALL DO NOT AFFECT THE LATERAL CAPACITY OF THE ADJACENT CORNER POLE FOUNDATION. NORTH SHORE GAS COMPANY HAS ALSO BEEN CONTACTED REGARDING RELOCATING THEIR 12 INCH HIGH PRESSURE GAS MAIN. SEE ITEM C UNDER SITE PREPARATION.

VOLUMES:

EXCAVATION QUANTITY TO ESTABLISH GRADE FOR CLAY DIKE CONSTRUCTION (SEE APPENDIX K) = 650 yd^3 ✓

CLAY FILL VOLUME FOR SLURRY WALL DIKE CONSTRUCTION BERM (SEE ITEM B UNDER SITE PREPARATION) = 3410 yd^3 ✓

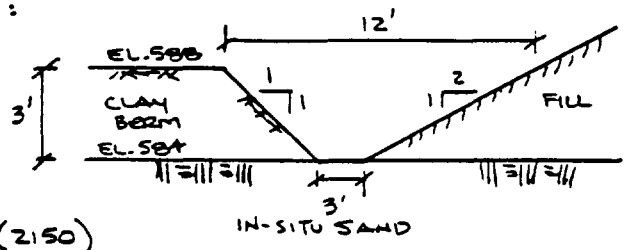
WARZYN ENGINEERING INC.
MADISON, WISCONSIN

BY R.W. DEBER DATE 3-4-85 SUBJECT OMC-WAUKEGAN, IL SHEET NO. 3 OF 3
CHKD. BY WW DATE 3-7-85 JOB NO. C11837

A. CONTINUED

CHECK VOLUME OF PROPOSED DITCH SECTION — VOLUME CONTROLLED BY ELEVATION OF PERIMETER DIKE:

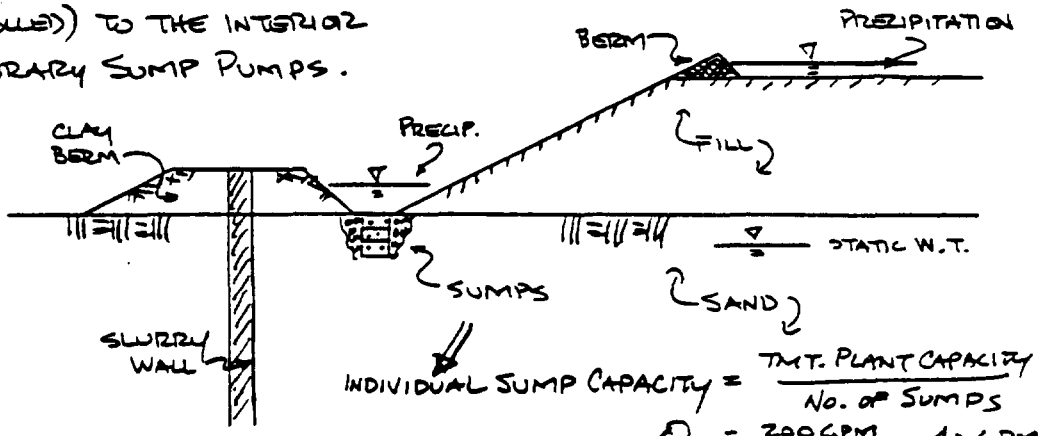
(SKETCH NOT TO SCALE)



$V = \text{AREA} \times \text{LENGTH}$

$$\text{STORAGE } V_{AVAIL} = \tfrac{1}{2}(3+12)(3)(2150)$$
$$= 48{,}375 \text{ FT}^3 \left(\frac{7.48 \text{ GAL}}{\text{FT}^3}\right)$$
$$= 361{,}845 \text{ GAL}$$

SINCE $V_{AVAIL} < V_{REQUIRED}$ FOR STORAGE, THE CONTRACTOR WILL BE REQUIRED TO MAINTAIN A PERIMETER BERM AROUND THE TOP EDGE OF THE FILL AT ALL TIMES TO POND PRECIPITATION. THE BERM SHOULD BE AT LEAST 5.7 IN. HIGH TO STORE THE PRECIPITATION ANTICIPATED FOR A MAJOR 25-YEAR STORM EVENT. A BERM OF 24 IN. HEIGHT MIN. IS CONSIDERED SUITABLE. THE PONDED PRECIPITATION COULD THEN BE EITHER PUMPED DIRECTLY OR ALLOWED TO FLOW DOWN THE SIDESLOPES (CONTROLLED) TO THE INTERIOR TEMPORARY SUMP PUMPS.



$$\text{INDIVIDUAL SUMP CAPACITY} = \frac{\text{TMT. PLANT CAPACITY}}{\text{NO. OF SUMPS}}$$
$$Q = \frac{200 \text{ GPM}}{5} = \underline{\underline{40 \text{ GPM}}}$$

WATER THAT IS COLLECTED SHOULD BE ROUTED TO THE TREATMENT PLANT VIA 6 TO 8 IN. DIAMETER PIPE OR FLEXIBLE HOSE (CONTRACTOR OPTION. IF SUMPS ALL CONNECTED TO SAME PIPE SYSTEM, ESTIMATE APPROX. <u>1800 L.F.</u> OF PIPE NECESSARY.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RWL DATE 3-4-85 SUBJECT OMC- WAUKEGAN, IL SHEET NO. 2 OF 3
CHKD. BY WW DATE 3-7-85 JOB NO. C11837

A- CONTINUED

THE FILLING, THE PIEZOMETRIC LEVEL INSIDE THE CELL SHALL BE LOWERED TO BE AT LEAST EQUAL TO THE OUTSIDE GROUNDWATER LEVEL.

THE FILTERED SUMPS SHALL BE OF SIMILAR DESIGN AS DISCUSSED UNDER VIII. CRESCENT DITCH/OVAL LAGOON CONTAINMENT CELL, SITE CONSTRUCTION, DEWATERING, i.e. PERFORATED BARREL PLACED BELOW THE SHALLOW GROUNDWATER TABLE AND BACKFILLED WITH COARSE AGGREGATE.

ESTIMATE FLOW RATES

FROM APPENDIX G, ILLINOIS STATE WATER SURVEY, TECHNICAL LETTER 13:
25 YEAR STORM EVENT → 5.7 INCHES OF RAINFALL / 24 HR PERIOD

FROM "CONSTRUCTION GRADES" DRAWING, SCALE DIMENSIONS OF AREA INSIDE CONTAINMENT BERM:

$$A = \tfrac{1}{2}(335+510)(325) + 2(\tfrac{1}{2})(140)(55) + (165)(55) = \underline{\underline{235{,}338\ FT^2}}$$

VOLUME OF WATER IN 24 HR PERIOD:

$$V = 5.7\,IN\,(FT/12\,IN)(235{,}338\ FT^2)(GAL/0.1337\ FT^3) = \underline{\underline{836{,}092\ GAL/24\ HR}}$$

FLOW RATE (TOTAL):

$$Q = (836{,}092\ GAL/24\ HRS)(HR/60\ MIN) = \underline{\underline{580\ GPM}}$$

SINCE THE MAXIMUM TREATMENT PLANT CAPACITY IS 200 GPM, A STORAGE CAPACITY IS NEEDED INSIDE THE CONTAINMENT CELL. STORAGE WILL BE NEEDED FOR 24 HRS. ASSUME 75% OF TREATMENT PLANT CAPACITY IS AVAILABLE:

$$\text{STORAGE } V_{REQ'D} = [580\,GPM - 0.75(200\,GPM)](60\,min)(24\,hrs)$$
$$= \underline{\underline{619{,}200\ GAL}}$$

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY R. WEBER DATE 3-4-85 SUBJECT OMC-WAUKEGAN, IL SHEET NO. 1 OF 3
CHKD. BY WWmill DATE 3-7-85 JOB NO. C11837
DESIGN ANALYSIS

I. PARKING LOT CONTAINMENT CELL

SITE CONSTRUCTION

A. DEWATERING OF SURFACE INFILTRATION

AFTER THE CONTAINMENT BERM AND SLURRY CUTOFF WALL ARE INSTALLED, WATER FROM INFILTRATION OF PRECIPITATION AND FROM FREE WATER, IF ANY, DRAINING FROM THE DREDGE FILL WILL BE CONTAINED WITHIN THE CONTAINMENT CELL.

TO MINIMIZE A HEAD BUILD-UP INSIDE THE CELL WHICH COULD POTENTIALLY CAUSE OUTWARD MIGRATION OF PCB CONTAMINATED WATER THROUGH THE SLURRY WALL, SEVERAL FILTERED SUMPS WILL BE INSTALLED JUST INSIDE THE TOE OF THE CONTAINMENT BERM FOR WATER WITHDRAWAL.

IT WILL BE SPECIFIED THAT THE EXISTING ASPHALT PAVEMENT INSIDE THE SLURRY WALL CONTAINMENT CELL BE BROKEN UP TO ALLOW INFILTRATION AND PREVENT PONDING. THEREFORE, THE SURFACE IS INITIALLY ANTICIPATED TO BE RELATIVELY POROUS OVER THE ENTIRE FILL AREA. AS DREDGE SPOILS ARE BROUGHT IN AND PLACED OVER THE AREA, THE RELATIVE PERMEABILITY OF THE SURFACE IS ANTICIPATED TO DECREASE SINCE THE DREDGE SPOILS (PRIMARILY MUCK) ARE FINER GRAINED THAN THE IN-SITU SAND. PRECIPITATION IS ANTICIPATED TO POND ON THE DREDGE SPOILS.

IT IS PROPOSED TO MAINTAIN A 3 FT. WIDE DITCH AROUND THE INSIDE OF THE BERM WITH 5 FILTERED SUMPS SPACED TO COLLECT THE PRECIPITATION AND FREE WATER FROM THE DREDGE SPOILS. THE SUMPS WOULD BE LOCATED INBETWEEN THE FIVE TEMPORARY PVC MONITORING WELLS INSIDE THE DIKE TOE. THE PIEZOMETRIC LEVEL INSIDE THE CONTAINMENT CELL SHALL NOT EXCEED MORE THAN 1 FT. HIGHER THAN THE GROUNDWATER LEVEL OUTSIDE THE CELL AS MEASURED IN THE 5 PERMANENT WELL NESTS. UPON COMPLETION OF

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 2/28/95 SUBJECT OMC-WAUKEGAN SHEET NO. 1 OF 3
CHKD. BY W. Wallner DATE 3/1/95 JOB NO. C1337
DESIGN ANALYSIS

I. PARKING LOT CONTAINMENT CELL

SITE RESTORATION

D. FINAL COVER

1. GENERAL

SEE ITEM "VIII. CRESCENT DITCH / OVAL LAGOON CONTAINMENT CELL - SITE RESTORATION, C. FINAL COVER" FOR DISCUSSION AND JUSTIFICATION OF FINAL COVER DETAILS. FINAL COVER WILL CONSIST OF 1.5 INCHES BITUMINOUS CONCRETE SURFACE COURSE, 2.5 INCHES OF BITUMINOUS CONCRETE BASE, 8 INCHES OF CRUSHED AGGREGATE BASE COURSE, 6 INCHES OF SAND DRAINAGE LAYER, 40 mil HDPE SYNTHETIC MEMBRANE AND 24 INCHES OF COMPACTED CLAY FOR A TOTAL FINAL COVER THICKNESS AT THE TOP OF THE FILL AREA OF 3.5 FEET. AS DISCUSSED PREVIOUSLY, THE SIDESLOPE COVER WILL CONSIST OF THE 40 mil HDPE SANDWICHED BETWEEN TWO 12 INCH THICK CLAY LAYERS.

A VARIATION FROM THE CRESCENT DITCH / OVAL LAGOON SIDESLOPE DETAIL OCCURS FOR THE EROSION PROTECTION LAYER. SINCE THE PARKING LOT CONTAINMENT AREA WILL BE SUBJECT TO FILLING, THE FINAL GRADE IS ANTICIPATED TO BE RAISED ON THE ORDER OF 16 FT. PAVING THE SIDESLOPES IS ANTICIPATED TO BE DIFFICULT AND EXPENSIVE (3H:1V). THEREFORE, THE SLOPES WILL BE PROTECTED BY PLACING A GEOTEXTILE OVER THE CLAY COVER FOLLOWED BY A LAYER(S) OF RIPRAP.

THE 12 INCH THICK CLAY LAYERS ON THE SIDESLOPES WILL BE PLACED OVER THE FILL BY WORKING PARALLEL TO THE FILL SURFACE (UP THE SLOPE). THE CLAY IS ANTICIPATED TO BE PROPERLY COMPACTED (90% MODIFIED) AND BE RELATIVELY FIRM. IT IS PROPOSED TO PLACE DREDGE FILL AND OTHER CONTAMINATED SOILS INSIDE THE CONTAINMENT CELL SUCH THAT THE CONTAMINATED SOIL CEMENT AND UPPER CLAY LAYER FROM THE DEWATERING LAGOONS WILL BE PLACED OVER THE DREDGE FILL MATERIALS AND PROVIDE A FIRM SUBGRADE FOR CLAY COVER PLACEMENT. SINCE THE COMPACTED CLAY COVER AND COVER SUBGRADE WILL BE RELATIVELY FIRM, A GEOTEXTILE IS NEEDED ONLY FOR SEPARATION OF THE RIPRAP FROM THE CLAY COVER, NOT FOR STABILIZATION OR REINFORCEMENT. AS SUCH, A 5 OUNCE FABRIC IS CONSIDERED SUITABLE TO HAVE A PUNCTURE

P 12976

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RHD DATE 2/28/85 SUBJECT OMC SHEET NO. 2 OF 3
CHKD. BY WWD DATE 3/1/85 JOB NO. C11937

D. CONTINUED

STRENGTH ABLE TO WITHSTAND PLACEMENT OF RIPRAP. AN ULTRAVIOLET PROTECTED MEMBRANE IS NOT CONSIDERED NECESSARY SINCE IT WILL BE COVERED BY RIPRAP. DETAILED SPEC'S WILL BE DEVELOPED FOR THE GEOTEXTILE AT FINAL DESIGN.

THE RIPRAP DETAILS ARE DISCUSSED UNDER ITEM G. OF THIS HEADING. THE RIPRAP ON THE SIDESLOPES NOT EXPOSED TO THE LAKE WILL CONSIST OF 12 INCHES OF GRADED CRUSHED STONE, APPROXIMATE GRADATION 1 TO 6 INCHES. ON THE LAKE EXPOSED SIDESLOPES, THE GRADED RIPRAP WILL BE OVERLAIN BY AN ADDITIONAL 18 INCHES OF LARGER RIPRAP (QUARRY STONE), APPROXIMATE GRADATION 9 TO 18 INCHES. A TYPICAL SECTION FOLLOWS.

2. QUANTITIES

FINAL COVER QUANTITIES ARE AS FOLLOWS:

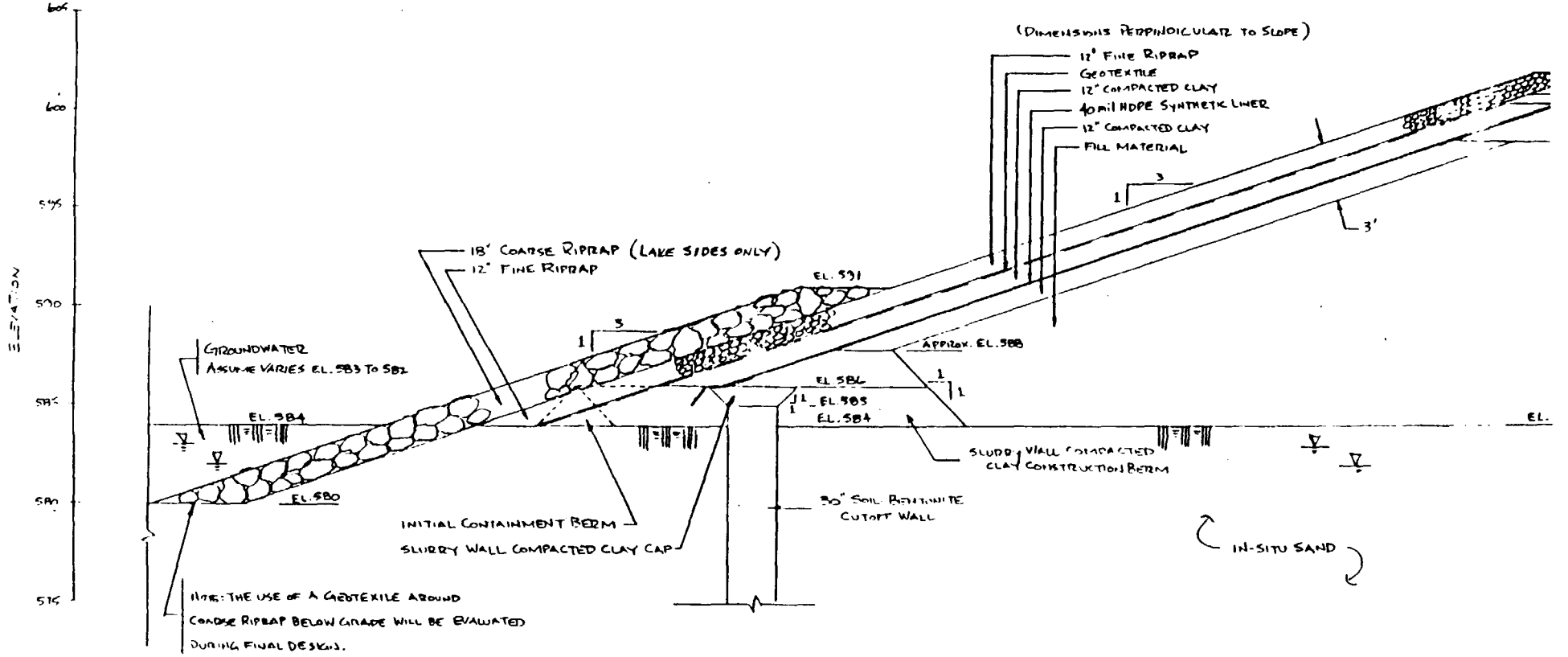
CLAY	13,300 CY	PAVED AREA
	8,000	SIDESLOPES
SAND	3,300	
AGGREGATE	4,400	
BITUM	2,200	
GEOTEXTILE	107,893 SF	
MEMBRANE	179,072 SF	

FOR VOLUMES, REFER TO APPENDIX E
FOR AREAS, REFER TO APPENDIX F.

MADISON WISCONSIN

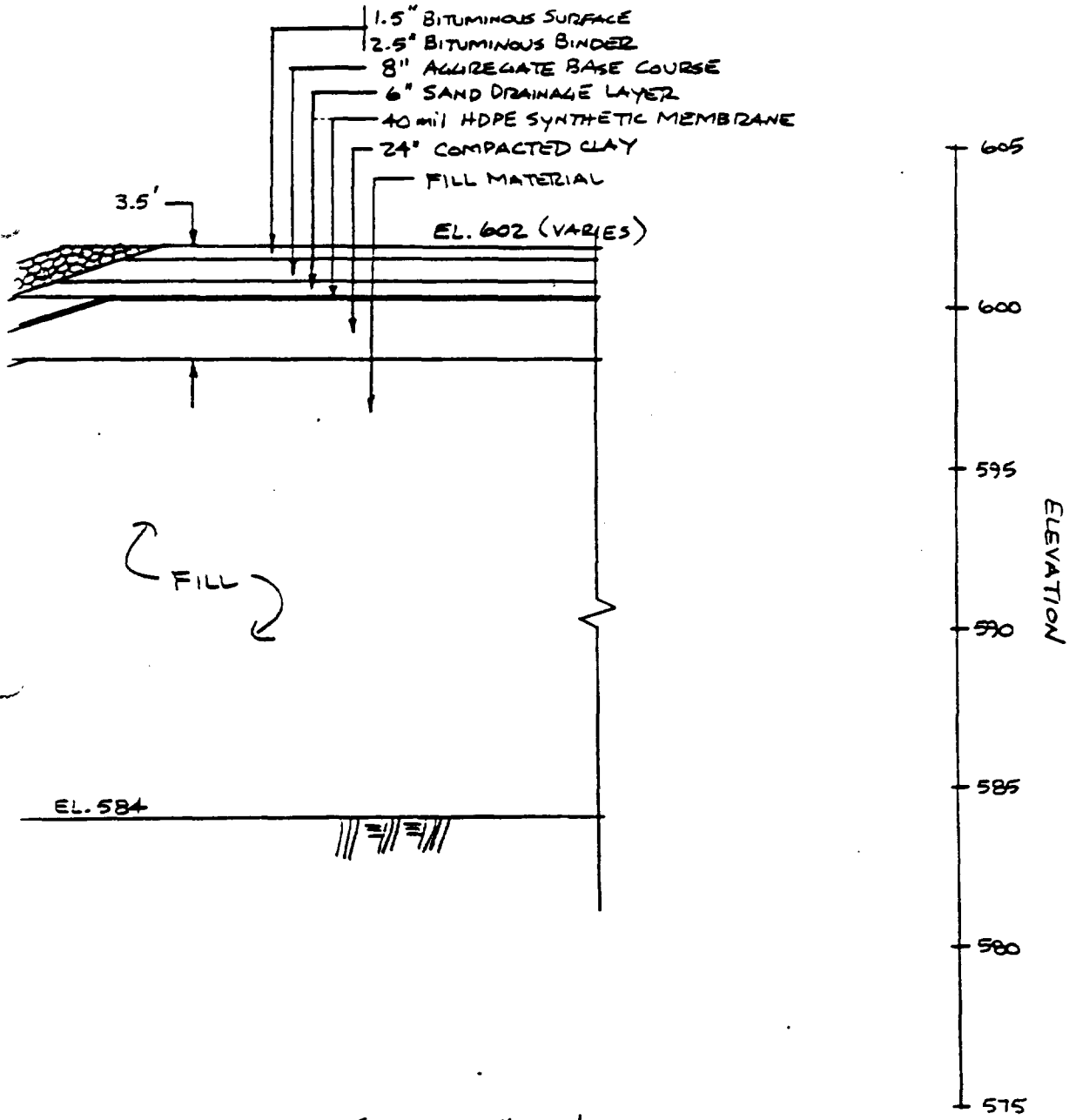
BY JWJ DATE 7/29/85 SUBJECT CITY OF WAUKEGAN SHEET NO 3 OF IV DATE SUBJECT SHEET NO OF IV
CHKD BY WWS DATE 8/1/85 JOB NO C11837 CHKD BY DATE JOB NO CHKD BY
DESIGN ANALYSIS

TYPICAL SECTION
PARKING LOT CONTAINMENT CELL



WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

DATE 2/29/85 SUBJECT OMC SHEET NO. 3 OF 3
DATE JOB NO. 11527



SCALE: 1" = 5'

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 3-4-85 SUBJECT GMC - WAUKEGAN, IL SHEET NO. 1 OF 1
CHKD. BY [illegible] DATE 3-6-85 JOB NO. C11837
DESIGN ANALYSIS

V. PARKING LOT CONTAINMENT CELL

SITE RESTORATION

E. INTERNAL GROUNDWATER WITHDRAWAL WELLS

SEE SIMILAR DISCUSSION UNDER VIII. CRESCENT DITCH / OVAL LAGOON CONTAINMENT CELL, SITE RESTORATION AND VII. LAGOONS, SITE PREPARATION, E. GROUNDWATER MONITORING WELLS.

FOUR GROUNDWATER WITHDRAWAL WELLS ARE CONSIDERED SUITABLE DUE TO THE RELATIVE HIGH PERMEABILITY OF THE SAND AQUIFER. IF WITHDRAWAL IS NECESSARY, SUBMERSIBLE PUMPS MAY BE NECESSARY SINCE THE SITE GRADES WILL BE RAISED APPROXIMATELY 14 TO 18 FEET. A 4-INCH WELL WILL BE USED TO ACCOMODATE THE SUBMERSIBLE PUMPS, IF NECESSARY.

1. LOCATIONS

4 WELLS WERE LOCATED AS SHOWN ON THE "FINAL GRADES" DRAWING.

2. DETAILS
3. INSTALLATION

SEE VIII. CRESCENT DITCH / OVAL LAGOON, SITE RESTORATION

4. ESTIMATING

ASSUME 4 WELLS TO A DEPTH OF 35 FT.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 2/29/95 SUBJECT OMC-WAUKEGAN SHEET NO. 1 OF 2
CHKD. BY Wm W. [illegible] DATE 3/6/95 JOB NO. C1937
DESIGN ANALYSIS

I. PARKING LOT CONTAINMENT CELL

SITE RESTORATION

F. RIPRAP

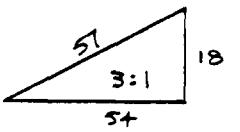
THE FINAL COVER OF THE PARKING LOT CONTAINMENT CELL WILL HAVE RIPRAP PLACED ON THE SIDESLOPES FOR EROSION PROTECTION. ALL SIDESLOPES WILL HAVE A "FINE RIPRAP" COVER. SIDESLOPES CLOSEST TO THE LAKE WILL HAVE AN OUTER "COARSE RIPRAP" PART WAY UP THE SIDESLOPE.

THE PURPOSE OF THE FINE AGGREGATE IS ESSENTIALLY EROSION PROTECTION FROM RAINFALL DIRECTLY ON THE SIDESLOPES AND RUNOFF FROM THE TOP PAVED COVER. A 12-INCH THICK LAYER OF FINE RIPRAP IS PROPOSED. A GRADATION FROM APPROXIMATELY 1 TO 6 INCHES IS CONSIDERED SUITABLE.

ESTIMATE "FINE RIPRAP" VOLUME:

FROM APPENDIX F OF DESIGN ANALYSIS –
AREA OF SIDESLOPES ~ 107,893 FT^2

VOLUME = 107,893 × 1 = 107,893 FT^3
V = 3996 YD^3



THE PURPOSE OF THE "COARSE RIPRAP" IS TO TO PROVIDE AN ADDITIONAL SAFETY FACTOR AGAINST LAKE EROSION DURING A MAJOR STORM. FROM THE DRAWINGS, THE LAKE SHORE (AS IT WAS IN AUGUST 1984) WILL BE APPROXIMATELY 200 FT. AWAY FROM THE TOE OF THE FILL SIDESLOPES AT THE CLOSEST POINT. BASED ON THE CONTOUR MAPS, SAND PILES TO APPROX. EL. 590 AND A "SEAWALL" (DETAILS UNKNOWN) EXIST BETWEEN THE LAKE AND THE PROPOSED CONTAINMENT CELL. THESE FEATURES ARE ANTICIPATED TO DISSIPATE MOST IF NOT ALL OF THE

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 2/28/85 SUBJECT OMC SHEET NO. 2 OF 2
CHKD. BY [illegible] DATE 3/6/85 JOB NO. C11837

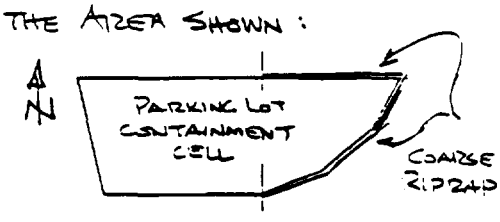
F. CONTINUED

ENERGY CREATED BY STORM WAVES. THEREFORE, THE "COARSE RIPRAP" IS AN EXTRA PRECAUTION. POTENTIAL RECESSION OF THE LAKE SHORELINE IS ANTICIPATED TO OCCUR OVER A PERIOD OF SEVERAL WEEKS AT MOST, AND MORE LIKE SEVERAL MONTHS OR YEARS. SINCE THERE IS CURRENTLY 200 FT. MINIMUM SEPARATION DISTANCE AND FEATURES TO RESIST RECESSION, ENOUGH WARNING TIME WILL BE AVAILABLE TO IMPLEMENT REMEDIAL MEASURES SHOULD DISRUPTION OF THE SIDESLOPE INTEGRITY APPEAR IMMINENT (LONG-TERM MAINTENANCE ITEM).

AFTER SCANNING VOLUMES I AND II OF THE US ARMY CORPS OF ENGINEERS "SHORE PROTECTION MANUAL", 1984, A DETAILED RIPRAP DESIGN AS INDICATED IN THE DESIGN EXAMPLES WAS NOT CONSIDERED NECESSARY DUE TO THE SEPARATION DISTANCE AND EXISTING SITE FEATURES. SOMEWHAT ARBITRARILY, AN 18-INCH THICK "COARSE RIPRAP" LAYER WAS CHOSEN. A GRADATION IN THE RANGE OF 9 TO 18 INCHES IS CONSIDERED SUITABLE. IT IS PROPOSED TO PLACE THE COARSE RIPRAP FROM ONE TO TWO FEET BELOW THE GROUNDWATER TABLE AS AN EXTENSION OF THE FILL SLOPE (3:1) BELOW THE SIDESLOPE TOE TO A LEVEL APPROXIMATELY EQUAL TO THE EXISTING SAND PILES — SAY FROM EL. 580 TO EL. 591.

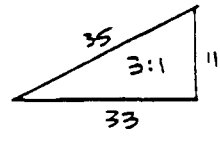
ESTIMATE "COARSE RIPRAP" VOLUME:

THE COARSE RIPRAP WILL BE PLACED IN THE AREA SHOWN:



FROM APPENDIX F OF DESIGN ANALYSIS –
AREA OF SIDESLOPE ~ 30,500 FT^2

VOLUME = 30,500 x 1.5 = 45,750 FT^3
V = 1694 YD^3



SP 102978

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 3-22-85 SUBJECT OMC DESIGN ANALYSIS SHEET NO. 1 OF 2
CHKD. BY DJD DATE 3-3-85 CONCEPT SUBMITTAL JOB NO. 11837
SITE RESTORATION

I PARKING LOT CONTAINMENT CELL

G. REMOVAL OF STRUCTURES

Upon completion of final surfaces, the 1500 ft of security fencing and 2 gates will be removed.

H. ACCESS ROAD

Two access ramps will be constructed.

1 Slope

Access ramps will have a slope of 7% per the Architect Engineer Instruction Manual, Subchapter 3C, page 2.

2 Paving

The paving for the access ramps will consist of 8" of aggregate and 4" of bituminous paving. See Final Surfaces in this section for complete design.

I. DRAINAGE

1 Slopes

Perimeter ditches were designed using design assumptions: V-ditch, sideslopes of 2:1, slope of the ditch of a 5%. See Appendix F for Flow areas for perimeter, as well as curb line flows.

2 Depths

The largest flow calculated (See Appendix G) for perimeter ditch is 5.4 cfs. Using the Manning equation, ditch depth will be at a minimum of 1.0'. The plateau will drain to a curb. Calculations were done to size the curb. The curb depth shall be 6". Refer to Appendix G for calculations, and Drawing Sheet No. 536.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY DJD DATE 3-6-85 SUBJECT DMC DESIGN ANALYSIS SHEET NO. 2 OF 2
CHKD BY LAB DATE 3-8-85 CONCEPT SUBMITTAL JOB NO. 11837
PARKING LOT CONTAINMENT

I DRAINAGE (CONTINUED)

IF THE PERIMETER DRAINAGE SWALE EXCEEDS ITS CAPACITY STORM WATER WILL FLOW ON TO ADJACENT AREAS WHERE THE WATER WILL POND AND EITHER PERCOLATE INTO THE SOIL, OR BE STORED UNTIL THE FLOW IN THE SWALE DIMINISHES.

IF THE CURB AT THE TOP OF THE CONTAINMENT CELL IS UNABLE TO CONTAIN ADDITIONAL STORM FLOW, THE WATER WILL SHEET FLOW DOWN THE RIP RAP SIDE SLOPE OF THE CONTAINMENT CELL.

SITE OPERATIONS/MAINTENANCE

WARZYN

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 3-6-85 SUBJECT OHC DESIGN ANALYSIS SHEET NO. 1 OF 3
CHKD BY DJP DATE 3-8-85 CONCEPT SUBMITTAL JOB NO. 11837
PARKING LOT CONTAINMENT CELL

OPERATIONS / MAINTENANCE

A. PLACEMENT OF MATERIAL

1. QUANTITIES

TOTAL AIR SPACE (between existing & final grades)	143,500 cy
LESS FINAL COVER VOLUMES	31,200 cy
NET AIR SPACE (CAPACITY)	112,300 cy

SEE APPENDIX E FOR CALCULATIONS

THIS VOLUME, 112,300 cy IS THE CAPACITY OF THE CELL GIVEN THE FINAL GRADES AS SHOWN ON SHEET NO. 536.

ACTUAL VOLUME TO BE CONTAINED WILL CONSIST OF THE FOLLOWING:

AREA B (1000 x 1.20 BATCHING)	1,200 cy
AREA C (28,300 @ 40% solids)	23,000 cy
EAST-WEST PORTION OF N. DITCH	4,000 cy
SLURRY WALL (CRESCENT DITCH)	5,200 cy
SLURRY WALL (PARKING LOT)	7,300 cy
VOLATILIZATION CONTROL SLUDGE	1,300 cy
LAGOON LINER MATERIAL	21,000 cy
LAGOON SOIL/CEMENT	10,500 cy
CURING CELL LINER	2,800 cy
CURING CELL SOIL/CEMENT	1,400 cy
FIXATION AREA LINER	2,800 cy
FIXATION AREA SOIL/CEMENT	1,400 cy
CONTAMINATED PAVING - TREATMENT	1,000 cy
CONTAMINATED PAVING - PARKING LOT	1,700 cy
BERM VOLUMES - PARKING LOT	4,000 cy
	88,000 cy

THESE CONTAINED VOLUMES MAY CHANGE. AN ADDITIONAL 63,000 cy MAY BE CONTAINED IF THE BASE CLAY & GRANULAR LAYER FROM THE UNDERDRAIN SYSTEM IN THE TREATMENT AREA

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 3-6-85 SUBJECT CMC DESIGN ANALYSIS SHEET NO. 2 OF 3
CHKD BY DLC DATE 3-8-85 CONCEPT SUBMITTAL JOB NO 11837
PARKING LOT CONTAINMENT CELL

IS CONTAMINATED. FOR FINAL DESIGN, CONTAINED VOLUMES WILL BE EVALUATED FURTHER AND FINAL GRADES WILL BE ADJUSTED ACCORDINGLY.

2. PHASES & VOLUMES

Volumes will be compacted in the containment cell in three (3) phases as specified below:

phase 1

Parking lot pavement	1,700 cy
Construction - berms	4,000 cy
E-W portion of N. Ditch excavation	4,000 cy
Slurry wall Excavation - Pkng lot	7,300 cy
" " Crescent Ditch	5,200 cy
Area B	1,200 cy
Volitilization Control Sludge	1,300 cy
	24,700 cy

phase 2

Fixation Volumes	4,200 cy
Curing Cell Volume	4,200 cy
Contam Paving - Treatment	1,000 cy
Lagoon 2 - ½ material	11,500 cy
	20,900 cy

phase 3

Lagoon 2 - ½ material	11,500 cy
Lagoon Liner, etc.	31,500 cy
	43,000 cy

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY R.H. WEBER DATE 3-8-85 SUBJECT DMC DESIGN ANALYSIS SHEET NO. 3 OF 3
CHKD. BY DJD DATE 3-8-85 CONCEPT SUBMITTAL JOB NO. 11837
PARKING LOT CONTAINMENT CELL

3 COMPACTION

AT THE PRESENT TIME, IT ISN'T KNOWN WHAT THE PHYSICAL PROPERTIES AND HANDLEABILITY OF THE DREDGE SPOILS (PRIMARILY MUCK) WILL BE WHEN THEY ARE REMOVED FROM THE DEWATERING LAGOONS FOR PLACEMENT IN THE PARKING LOT CONTAINMENT CELL. THIS TOPIC WILL BE FURTHER EVALUATED DURING FINAL DESIGN.

IT IS CURRENTLY ANTICIPATED THAT A MAXIMUM MOISTURE CONTENT WILL BE SPECIFIED FOR THE DREDGE SPOILS [i.e. DREDGE SPOILS SHALL BE REDUCED TO A MAXIMUM MOISTURE CONTENT OF X % (DRY WEIGHT BASIS)] PRIOR TO REMOVAL FROM THE LAGOON AND PLACEMENT IN THE PARKING LOT CURING CELL. TO EVALUATE WHAT THIS MAXMUM MOISTURE CONTENT SHOULD BE, A MOISTURE-DENSITY RELATIONSHIP WILL BE DEVELOPED BY PROCTOR METHODS.

THE DREDGE SPOILS WITH A MAXIMUM MOISTURE CONTENT OF X % WILL BE NON-FLOWABLE SUCH THAT THEY CAN BE SPREAD, LEVELLED AND COMPACTED WITH CONVENTIONAL EARTHWORK EQUIPMENT. IT IS CURRENTLY FELT THAT, BY SPECIFYING A MAXIMUM MOISTURE CONTENT OF DREDGE SPOILS, A COMPACTION SPEC WILL BE WRITTEN AS A PROCEDURAL SPEC WHEREBY A MINIMUM NUMBER OF PASSES OF A SPECIFIC PIECE OF CONSTRUCTION EQUIPMENT (e.g. ROLLER, RUBBER TIRED ROLLER, ETC.) WOULD BE SPECIFIED RATHER THAN A PERFORMANCE SPEC WHERE A MINIMUM COMPACTION DENSITY WOULD BE SPECIFIED (e.g. 90% MODIFIED PROCTOR).