Kansas Citys, Missouri and Kansas
Flood Damage Reduction Feasibility Study
(Section 216 – Review of Completed Civil Works Projects)
Engineering Appendix to the Interim Feasibility Report

Chapter A-9

GEOTECHNICAL ANALYSIS NORTH KANSAS CITY - LOWER (HARLEM AREA)

CHAPTER A-9
GEOTECHNICAL ANALYSIS
NORTH KANSAS CITY – LOWER
(HARLEM AREA)

A-9.1 INTRODUCTION

This chapter presents the geotechnical evaluation results for the Harlem area of the North Kansas City - Lower Unit, which was determined to have a high enough probability of failure under the existing level of protection to warrant further study. This determination relies on historical borings and soil test information combined with recent subsurface borings and soil test information.

A-9.2 SOURCES OF EXISTING LEVEE DESIGN INFORMATION

The primary sources of information for this geotechnical analysis include the references listed in the References section of this chapter.

A-9.3 DESCRIPTION OF THE LEVEE UNIT

Refer to Section A-4.3.9 for a detailed description of the North Kansas City – Lower Unit.

A-9.4 LEVEE DESIGN FEATURES

A-9.4.1 Existing Levee and Floodwall Sections

The North Kansas Unit is a Federal protection system. It consists of the Airport Section and the Lower Section, as explained by the General chapter of this appendix. The unit was originally constructed as a non-Federal levee, but was removed and replaced using Federal standards in 1947. The final contract for construction of the project was completed in 1955.

Upper reach of the Lower Section - The section of the North Kansas City levee known as the Lower Section includes Stations 0+00 to 70+40 and Stations 210+40 to 469+17. The upper reach of the Lower Section consists of a levee section with one stoplog gap. The levee was constructed with a 1V on 3H riverside slope and 1V on 4H landside slope. No underseepage control measures were constructed in the upper reach due to the low height of the levee and thick blanket conditions.

Lower reach of the Lower Section - The lower reach consists of a levee section with one sandbag gap and two stoplog gaps. The levee was constructed with a 1V on 4H riverside slope and 1V on 3H landside slope. The underseepage control measure consists of landside seepage berm in open areas. Industry restricted the lateral extent of underseepage berm in the Harlem area (no berm constructed) and the National Starch area (partial berm constructed). Very large berms in excess of 1,000 feet landward of the primary levee toe were constructed between Stations 280+00 to 400+00.

A plan view of the North Kansas City Unit and typical sections are provided in the Supplemental Exhibits section as Exhibits A-9.1 through A-9.7.

A-9.4.2 Future Flood Protection Concerns

This levee unit is not recommended for a raise based on the hydraulic analysis of the Missouri and Kansas River flows. During the 1993 flood, Station 210+40 to Station 275+00 was reported to have serious flood fighting. Property owners reported excessive water pressures below pavement and building slabs. That pressure resulted in uncontrolled piping of silt foundation blanket materials. Their flood fight efforts consisted of sandbag ring dikes with temporary sand fill placement inside the seepage areas. In one building foundation near National Starch, a standpipe was constructed to offset the excessive head and reduce the piping potential. In another location inside of the National Starch property, sewer piping collapsed resulting in multiple sinkholes inside the protected area.

The 1993 flood did not reach the top of levee in these problem areas. A full head to the top of the levee may have lead to catastrophic underseepage failure of this area and all contiguous area inside the North Kansas City protection unit.

A-9.4.3 Area Site Characterization

Boring information provided by Exhibits A-9.8 through A-9.35 supports characterization of the foundation between Station 210+00 (Broadway Bridge) and Station 275+00 (Paseo Bridge). The borings were located in the as-built drawings listed in the references. One new boring, AD-1008 (completed in 2001), supplemented the prior borings. The foundation profile has been developed below stations 210+00 to 240+00. In subsequent studies, the foundation profile was developed below stations 240+00 to 275+00. That reach is discussed in Chapter 10 of this appendix.

A-9.4.4 Underseepage Analyses

Stations 210+00 to 240+00 are identified as having underseepage concerns under the interim feasibility portion of the study. The reach from Stations 210+00 to 240+00 experienced excessive uplift pressure during the 1993 flood below the existing access road and adjacent structural foundations. The underseepage analysis was modeled after consideration of the types of soils landward of the levee, the consistency of the thickness of the soil blanket clays or silts, the thickness of the sand deposit below the levee blanket materials, the lateral extent of the blanket landside and riverward of the levee, the effects of the location of the Missouri River, and the height of the existing levee. All of these variables were considered during the development of the model to characterize the representative reaches along the alignment of the levee.

These reaches were considered separately to determine the landside resistance to upward gradient pressures which could initiate piping of the blanket materials. This could lead to subsequent piping of sand grains toward the river entrance, leading to ultimate collapse of the levee section due to the foundation voids caused by piping. Soil begins moving in the blanket when the pressure change in a vertical column of material exceeds the weight of the material bearing on the location where the pressure change occurs. Because pressure typically decreases from depth to the surface, a diagram of the change in pressure typically produces a sloping line or “gradient”. The underseepage design aims to assure that the weight of the soil column at any depth exceeds the upward gradient by a safety factor.

The safety factor for checking the materials at the landside toe of the North Kansas City levee is 1.1. An additional design requirement is to provide underseepage control when the safety factor with respect to critical gradient is less than 1.5 with the design water surface 3 feet below the top of levee. Usually the 1.5 safety factor controls the required underseepage design. If the 1.1 safety factor or secondary check of 1.5 is not satisfied, the underseepage control is designed to meet a safety factor of 1.5 for the berm design, the buried collector design, and the pressure relief well design.

Berm design was considered only when the area landside of the levee was available for construction. If area for a berm was not available, a buried collector system was considered. In areas that exhibited a blanket thickness of less than 5 feet, relief wells were considered appropriate to provide the underseepage control. The safety factor was set midway between wells to a minimum of 1.5. The pressures at the base of the blanket at the midpoint between wells will reach a maximum, and initiation of soil grain movement will begin at these locations.

Permeability parameters were assigned to the blanket materials based on the content of silt, clay or sand. Only areas that contained a blanket thickness of at least ¼ the height of the levee were considered meaningful in the underseepage model. For thin blanket areas, pressure relief wells are considered appropriate for underseepage control.

The existing safety factor in the underseepage analysis was calculated using water at the top of levee. The relative magnitude of the permeability ratios of the clean foundation sands to the blanket materials was set after observation of boil activity from the 1951 flood. The Kansas City District method of estimating the underseepage gradient and the required safety factors deviates somewhat from the method presented in the EM-1110-2-1913. The Kansas City District's traditional empirical approach has been used since the 1960's and has proven effective in providing adequate underseepage control for most reaches within the North Kansas City Unit. This method is based on conclusions of a Corps of Engineers conference, held in Omaha in November, 1962. The excellent historical performance of the levees during the 1993 flood event on the Missouri River demonstrates the effectiveness of this procedure. The traditionally assumed permeability ratios for blanket materials are shown in Table A-9.1.

TABLE A-9.1
Permeability Ratios for Blanket Materials

Blanket Material	Assigned Permeability Ratio
SM : Silty Sand	100
ML : Silt	200-400
ML-CL : Silt/Clay	400
CL: Lean Clay	400-600
CH: Fat Clay	800-1000

The calculations of the underseepage factors of safety that were used in the underseepage analysis are as follows:

The gradient piping factor of safety is defined as:

$FSi = ic / io$

where io = actual gradient and ic = critical gradient

$ic = \gamma b / \gamma w$ when soils particles movement can begin at the toe

and $\gamma b = \gamma sat - \gamma w$ where γsat = saturated unit weight of the soil and

γw = unit weight of water

io = upward gradient through the blanket = change in head from the base of the blanket to the top of the blanket. The reference datum is set at the top of the blanket because the movement of the soil grain will begin at the top of the blanket.

Δh = gradient head calculated at the base of the blanket measure from the reference datum, the top of the blanket. This gradient calculation procedure is provided in the Geotechnical Analysis – Existing Conditions chapter of this appendix with defined equations and illustrative nomenclature.

zbl = the thickness of the blanket

$io = \Delta h / zbl$

then $FSi = ic / io = (\gamma b / \gamma w) / (\Delta h / zbl) = (\gamma b * zbl) / (\Delta h * \gamma w)$

The underseepage analysis is provided in Exhibits A-9.36 through A-9.52 in the Supplemental Exhibits section, showing the factor of safety with respect to gradient. Two distinct reaches were characterized, Stations 210+00 to 230+00 and Stations 230+00 to 240+00.

The original designers considered underseepage berms, buried collector, and relief wells for the area being considered. No underseepage control measures were adopted due to marginal safety concerns. The constructed levee section did include a riverside cutoff trench through any unknown upper sand lense layers and a landside sand blanket above the existing ground surface to control any underseepage infiltrating beyond the riverside cutoff trench. The area was to be monitored closely during high water, and future consideration for underseepage control measures were to be based on the monitoring of these reaches. The City of Kansas City, Missouri Water Services Department presented some improvement recommendations for the Harlem area in a 1998 Storm Drainage

Master Plan. That report is included as Exhibit A-9.53 in the Supplemental Exhibits section.

Kansas City District underseepage design history indicates that, in areas with very thin to no thickness in blanket materials present, relief wells were the system chosen to control underseepage. The thinnest blanket used in the analysis was 5 feet. It is expected that the blanket thickness will vary from 5 to 10 feet.

Alternate underseepage control measures were considered for Stations 210+00 to 240+00. The underseepage controls considered were flood fighting, underseepage berms, buried collector system, and pressure relief wells. The alternatives vary with respect to the methodology to remove the underseepage water. The preliminary design does not require evacuation of the underseepage water in order to keep the levee from failing. The interior will flood due to underseepage flow containment in the Harlem area. As a minimum design consideration, the flows from the wells or buried collector system can be collected in manholes during high water. The sponsors will be responsible for setting up portable pumps and discharges lines to dispose of the underseepage water back to the river source by carrying the flow up and over the levee through temporary piping systems (also provided by the sponsor). The recommended pumping facilities requirements are discussed in the Civil Design chapter of this appendix.

The present recommended plan for controlling underseepage and reducing the uplift at the toe of the levee, Stations 210+00 to 240+00 is a buried collector system.

A-9.4.5 Reassessment of Existing Risk and Uncertainty

The existing conditions analysis (refer to Geotechnical Anaylsis – Existing Conditions chapter) was provided as a limited initial evaluation of the North Kansas City Unit's underseepage risk. This chapter indicates that the Harlem area is an area of concern based on recent discovery of the flood fighting efforts inside of levee Stations 257+00 to 272+00. An additional risk and uncertainty analysis is provided for the specified stations in the next chapter. Additional characterization of the reach from Stations 210+00 to 240+00 has resulted in a revised risk and uncertainty for that reach. The results are provided for consideration in Table A-9.2.

TABLE A-9.2
Existing Conditions Risk and Uncertainty Results

Station 210+00 to 240+00	
Height of Water on Levee, feet	Probability of Unsatisfactory Performance
1.0	0.0000
2.0	0.0000142
4.0	0.00295
6.0	0.0278
8.0	0.0935
10.0	0.1954
14.5 (1993)	0.4643
16.0	0.5453
18.0 (top of levee)	0.6400

The assessment of the existing conditions includes observations that led to the selection of a satisfactory performance with respect to underseepage using a factor of safety of 0.7. Historical observations concluded that a factor of safety of 0.55 represents impending failure of the toe of the levee. The observations in 1993 did not lead to total failure of the levee toe for the level of water on the levee. The levee from Stations 210+00 to 240+00 experienced large uplift forces, while the levee from Stations 257+00 to 273+00 included flood fighting to save the foundation of an existing processing building (landside of the toe in excess of 500 feet). ETL 1110-2-556 indicates the use of a factor of 1.0 in the underseepage analysis. The North Kansas City levee experienced a factor of safety lower than 1.0 and did not fail for that water level during the flood of 1993. The observations and calculations indicate a factor of safety near 0.7 may be representative. A higher river level most likely would result in an even lower factor of safety. For a factor of safety of 0.7, the probability of a catastrophic underseepage failure was calculated to be greater than 60% for Stations 210+00 to 240+00. A buried collector system is recommended for Stations 210+00 to 240+00. The system is to be designed in accordance with Corps of Engineers' manuals in order to strengthen the weak sections of the levee and eliminate the serious risk of underseepage failure.

A-9.5 REFERENCES

1. North Kansas City Levee Unit, Definite Project Report, December 1943.

2. North Kansas City Levee Unit, Analysis of Design, Levee and Floodwall, May 1945.

3. North Kansas City Levee Unit, Supplement on Interior Drainage, June 1945.

4. North Kansas City Levee Unit, Supplement on Seepage Control, January 1946.

5. North Kansas City Levee Unit, Supplement on Interior Drainage, May 1947.

6. North Kansas City Levee Unit, Record Drawings for Levee, Floodwall and Appurtenances, December 1950.

7. North Kansas City Levee Unit, Analysis of Design - Burlington Pump Plant, January 1951.

8. North Kansas City Levee Unit, Analysis of Design – Howell Pump Plant, January 1951.

9. North Kansas City Levee Unit, Analysis of Design – Rock Creek Pump Plant, April 1951.

10. North Kansas City Levee Unit, Supplement on Interior Drainage, June 1951.

11. North Kansas City Levee Unit, Record Drawings – Structures, Appendix I, May 1953.

12. North Kansas City Levee Unit, Record Drawings, Pump Plants, Appendix IV, July 1951.

13. North Kansas City Levee Unit, Analysis of Design – Station 94+18.5 Pump Plant, October 1958.

14. North Kansas City Levee Unit Periodic General Inspection No. 1, July 1970.

15. North Kansas City Levee Unit, Periodic General Inspection No. 2, March 1976.

16. North Kansas City Levee Unit, Operations and Maintenance Manual Volume I, January 1978.

17. North Kansas City Levee Unit, Operations and Maintenance Manual Volume II, January 1978.

18. Geotechnical Engineering Report for National Starch & Chemical Company, Packing Line #3 and Blending Bin Expansion Project, North Kansas City, Missouri,
February 24, 2004.

19. Modified Version, NKC, Fall 1993, Vol 5, No. 4, National Starch Information Pamphlet.

20. The C.W. Mofsinger Company Letter to Mr. Don Janiak, Plant Supervisor, National Starch and Chemical Company, Regarding Adhesive Loading Pit Inspection, August 10, 1993, 2 pages.

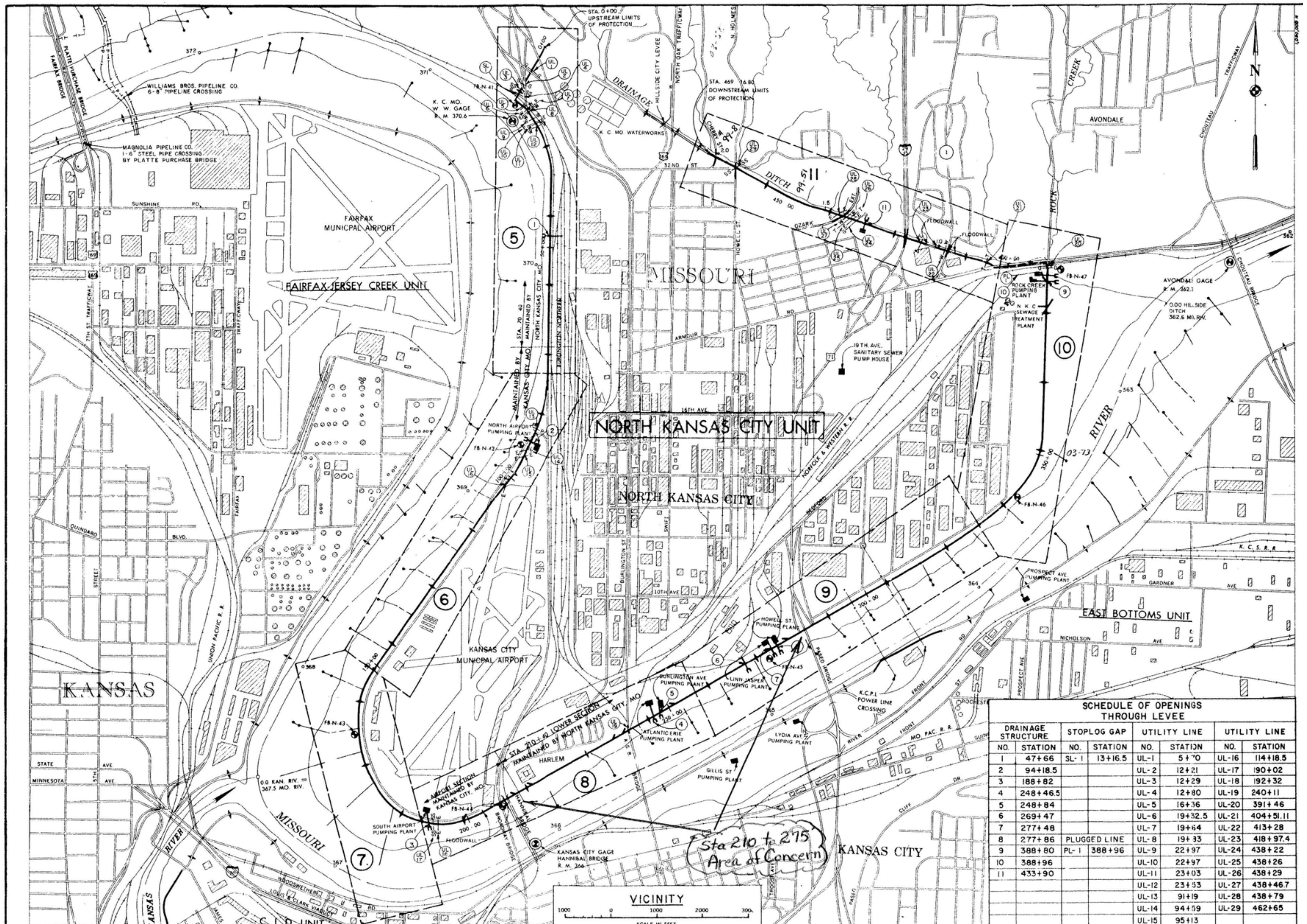
21. The C.W. Mofsinger Company Letter to Mr. Louis J. Jones, Mechanical Supervisor, National Starch and Chemical Company, August 10, 1993, 5 pages.

22. The C.W. Mofsinger Company Letter to Mr. Don Janiak, Mechanical Supervisor, National Starch and Chemical Company, Regarding Adhesive Building Joint Inspection, August 10, 1993, 2 pages.

23. The C.W. Mofsinger Company Letter to Mr. Fred Kidd, Construction & Utilities Supervisor, National Starch and Chemical Company, Regarding Structural Concerns at National Starch, August 9, 1993, 6 pages.

A-9.6 SUPPLEMENTAL EXHIBITS

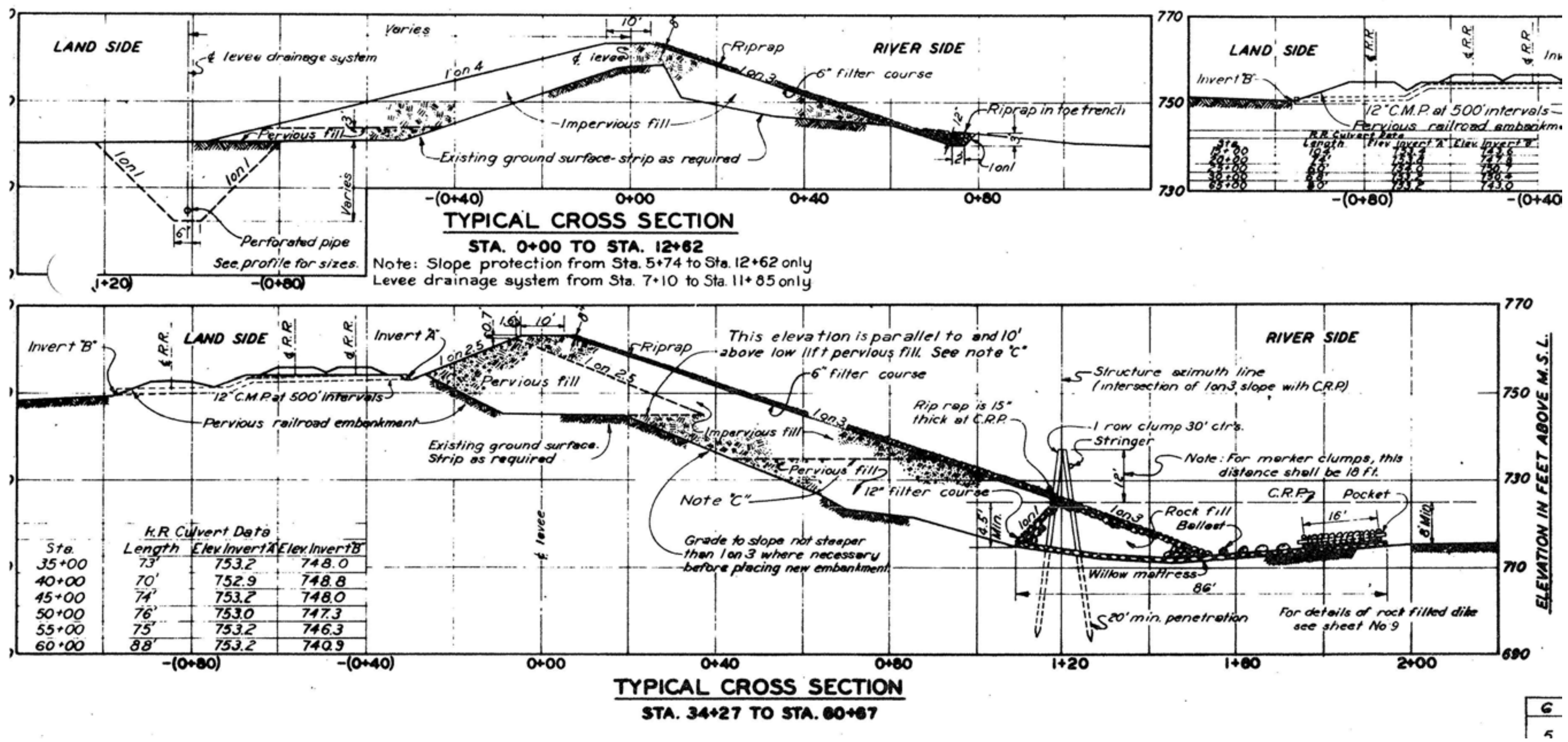
EXHIBIT A-9.1



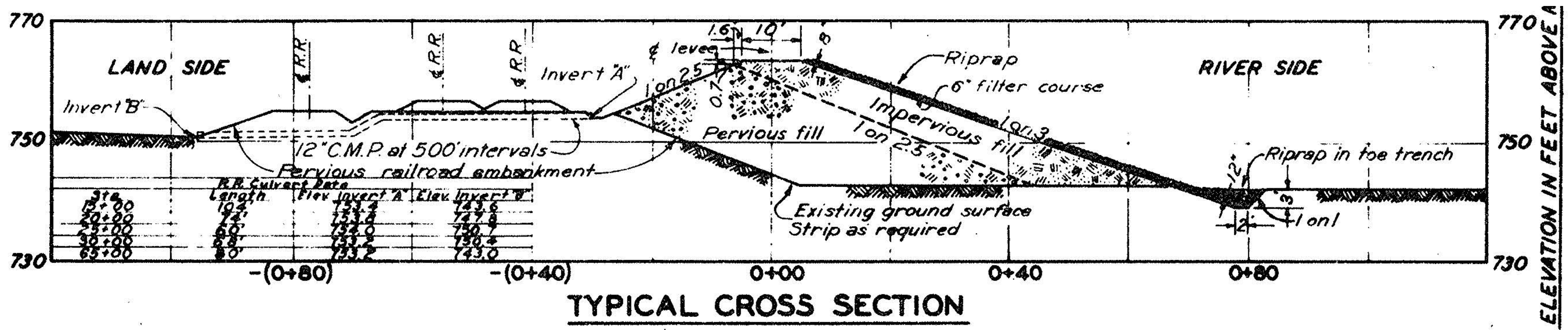
SCHEDULE OF OPENINGS THROUGH LEVEE

DRAINAGE STRUCTURE		STOPLOG GAP		UTILITY LINE		UTILITY LINE	
NO.	STATION	NO.	STATION	NO.	STATION	NO.	STATION
1	47+66	SL-1	13+16.5	UL-1	5+70	UL-16	114+18.5
2	94+18.5			UL-2	12+21	UL-17	190+02
3	188+82			UL-3	12+29	UL-18	192+32
4	248+46.5			UL-4	12+80	UL-19	240+11
5	248+84			UL-5	16+36	UL-20	391+46
6	269+47			UL-6	19+32.5	UL-21	404+51.11
7	277+48			UL-7	19+64	UL-22	413+28
8	277+86	PLUGGED LINE		UL-8	19+33	UL-23	418+97.4
9	388+80	PL-1	388+96	UL-9	22+97	UL-24	438+22
10	388+96			UL-10	22+97	UL-25	438+26
11	433+90			UL-11	23+03	UL-26	438+29
				UL-12	23+53	UL-27	438+46.7
				UL-13	91+19	UL-28	438+79
				UL-14	94+59	UL-29	462+65
				UL-15	95+13		

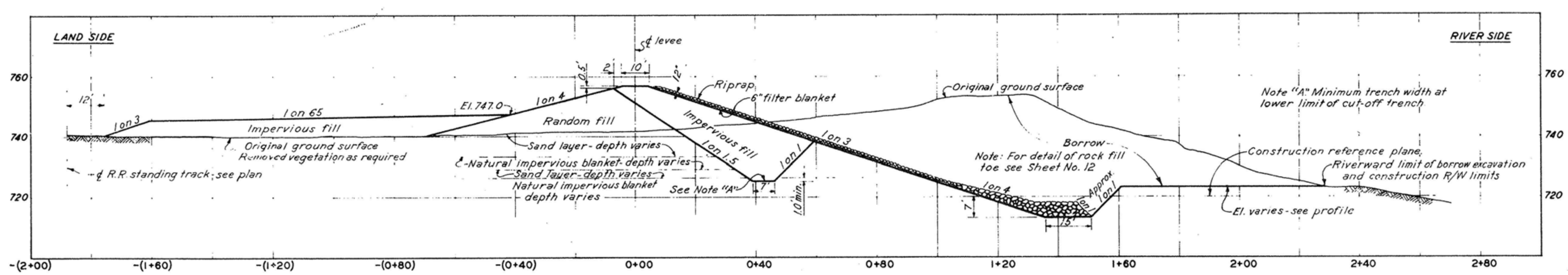
EXHIBIT A-9.2



LAND SIDE
RIVER SIDE
Varies
10'
℄ levee drainage system
1 on 4
℄ levee
Riprap
1 on 3
6" filter course
Riprap in toe trench
Pervious fill
Impervious fill
Existing ground surface- strip as required
1 on 1
Perforated pipe
See profile for sizes.
-(0+40)
0+00
0+40
0+80
770
750
730
TYPICAL CROSS SECTION
STA. 0+00 TO STA. 12+62
Note: Slope protection from Sta. 5+74 to Sta. 12+62 only
Levee drainage system from Sta. 7+10 to Sta. 11+85 only
Invert 'B'
12" C.M.P. at 500' intervals
Pervious railroad embankment
-(0+80)
Invert 'A'
1 on 2.5
This elevation is parallel to and 10' above low lift pervious fill. See note 'C'
Structure azimuth line (intersection of 1 on 3 slope with C.R.P.)
Rip rap is 15" thick at C.R.P.
1 row clump 30' ctrs.
Stringer
Note: For marker clumps, this distance shall be 18 ft.
Existing ground surface. Strip as required
Note 'C'
12" filter course
Rock fill
Ballast
C.R.P.
Pocket
16'
Grade to slope not steeper than 1 on 3 where necessary before placing new embankment
Willow mattress
86'
20' min. penetration
For details of rock filled dike see sheet No 9
R.R. Culvert Data
Sta. | Length | Elev Invert 'A' | Elev Invert 'B'
35+00 | 73' | 753.2 | 748.0
40+00 | 70' | 752.9 | 748.8
45+00 | 74' | 753.2 | 748.0
50+00 | 76' | 753.0 | 747.3
55+00 | 75' | 753.2 | 746.3
60+00 | 88' | 753.2 | 740.9
1+20
1+60
2+00
710
690
ELEVATION IN FEET ABOVE M.S.L.
TYPICAL CROSS SECTION
STA. 34+27 TO STA. 60+67

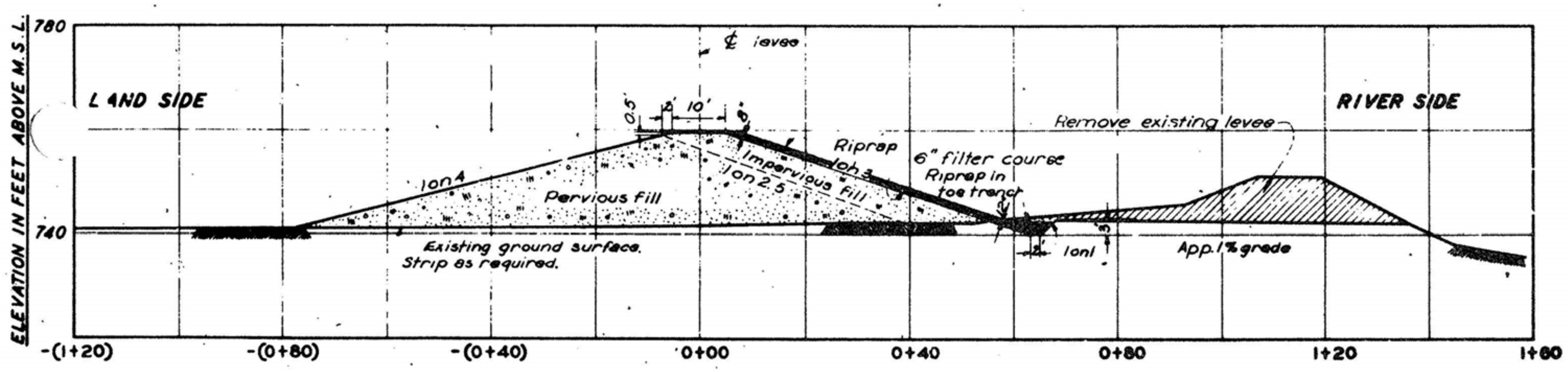


TYPICAL CROSS SECTION
STA. 13+37 TO STA. 34+27
STA. 60+67 TO STA. 71+18



TYPICAL CROSS SECTION
STA. 257+00 TO STA. 271+00

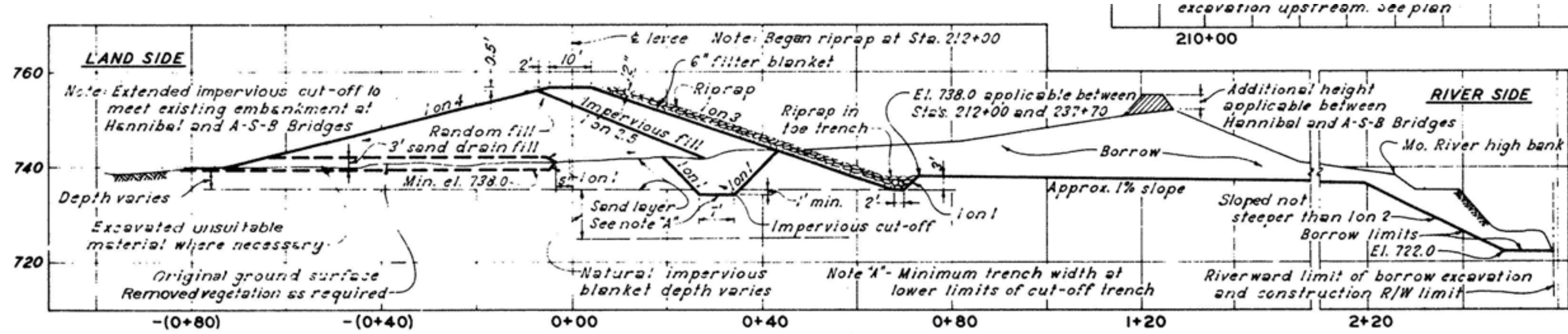
EXHIBIT A-9.4



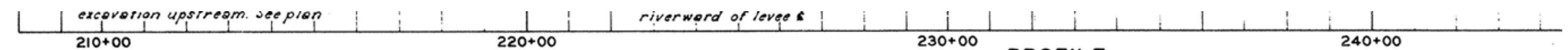
TYPICAL CROSS SECTION

STA. 210+40 TO STA. 239+95

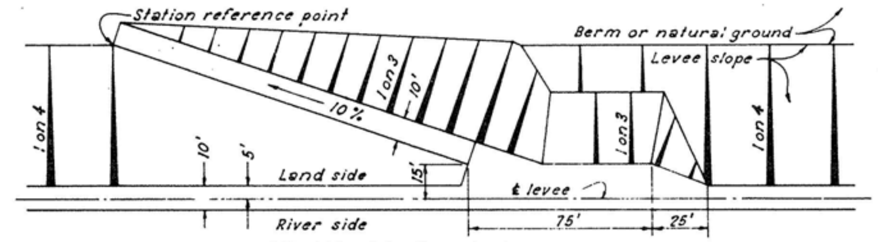
EXHIBIT A-9.5



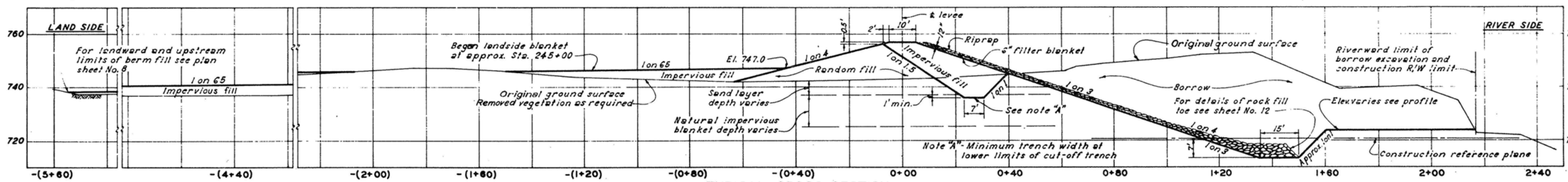
TYPICAL CROSS SECTION
STA. 210+40 TO STA. 242+80



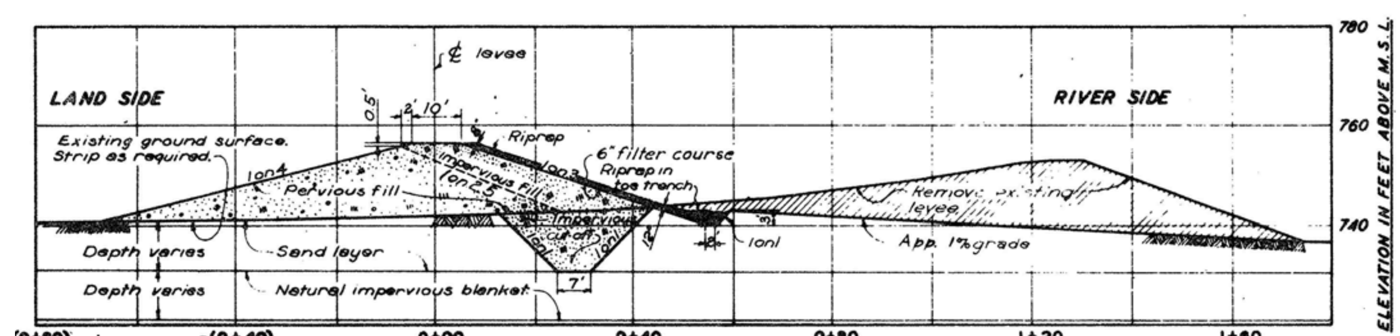
PROFILE



STANDARD RAMP DETAIL
Not to Scale



TYPICAL CROSS SECTION
STA. 242+80 TO STA. 257+00

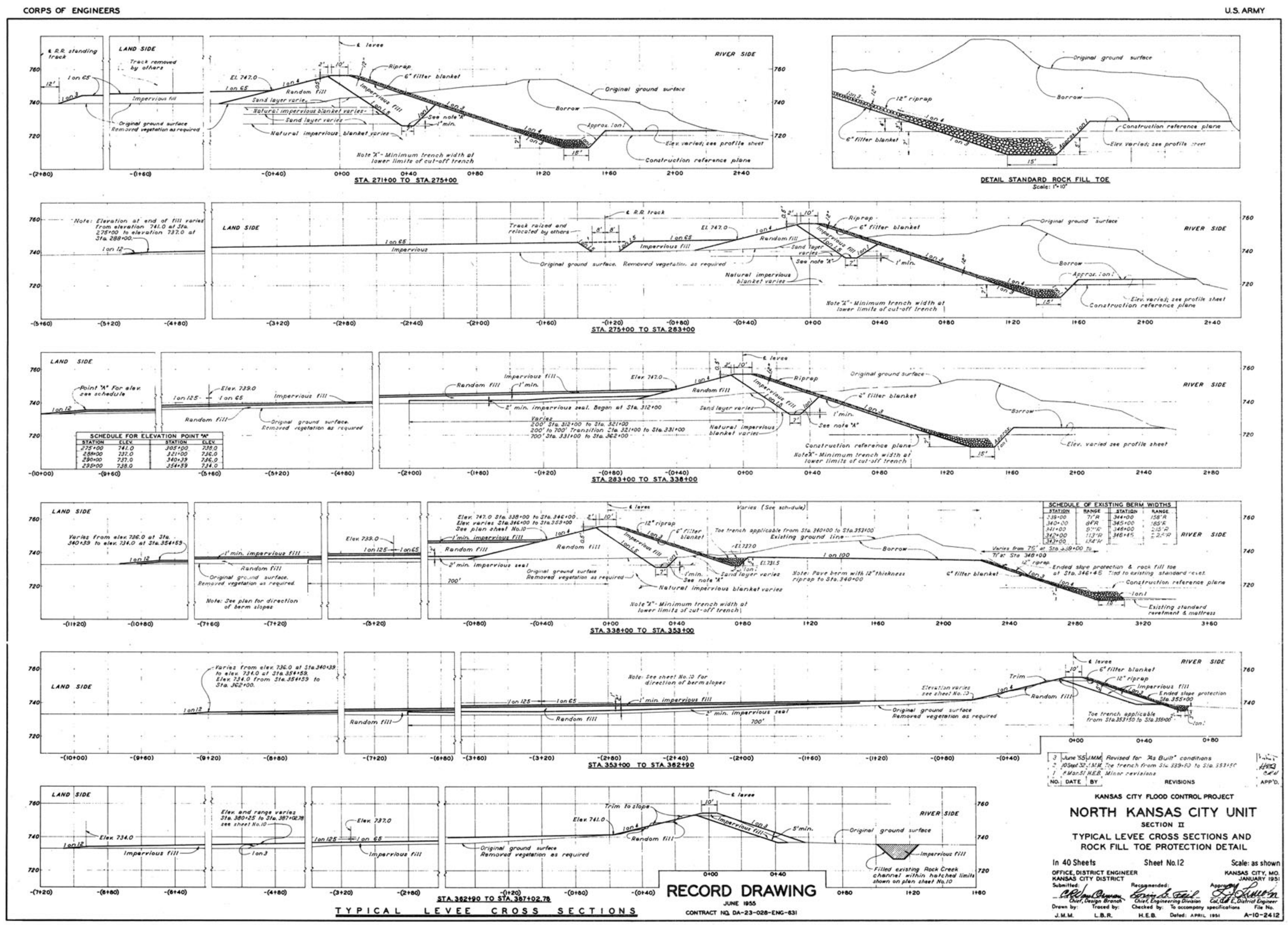


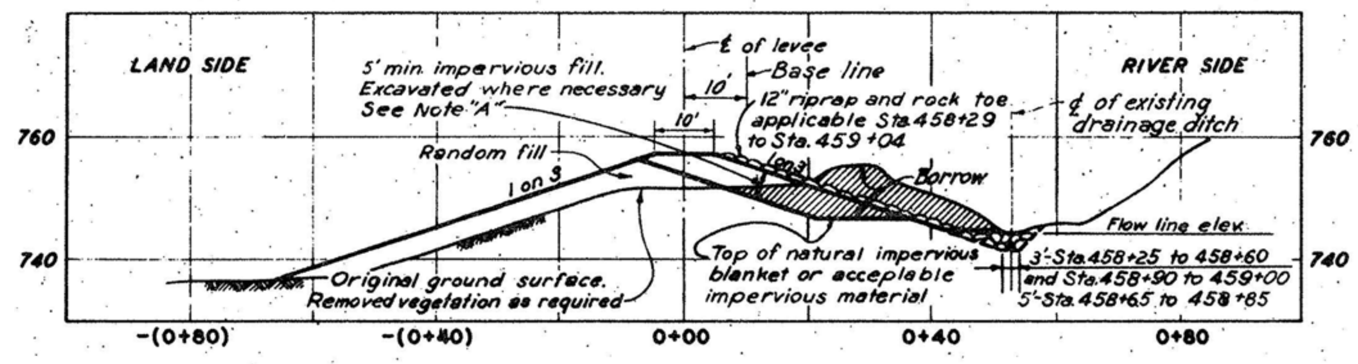
Note: Impervious cut-off trench to end at Sta. 308+00

TYPICAL CROSS SECTION
STA. 241+40 TO STA. 308+00

NOTES
Plan projected on Mercator plane coor[illegible]
North American datum.

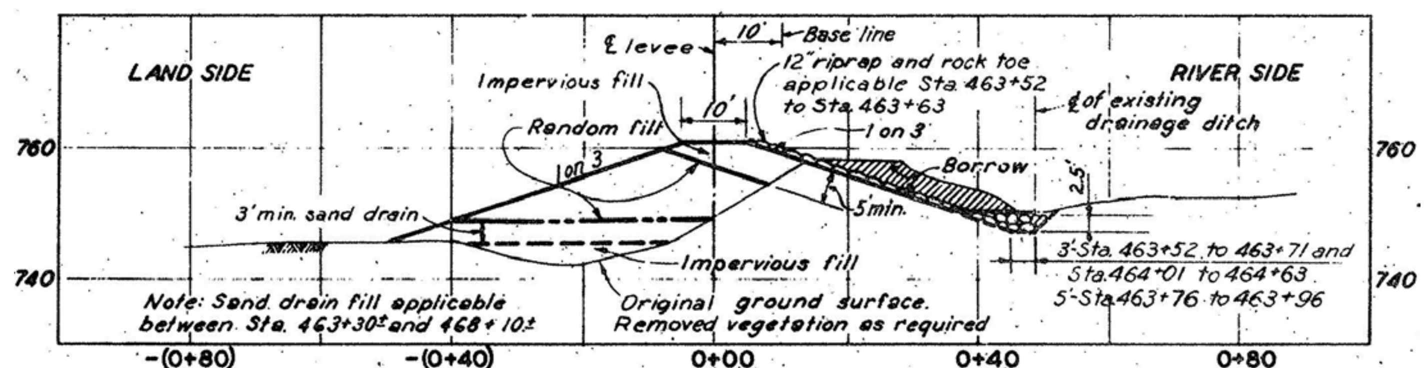
EXHIBIT A-9.6


CORPS OF ENGINEERS
U.S. ARMY
STA. 271+00 TO STA. 275+00
DETAIL STANDARD ROCK FILL TOE
STA. 275+00 TO STA. 283+00
STA. 283+00 TO STA. 338+00
STA. 338+00 TO STA. 353+00
STA. 353+00 TO STA. 362+90
STA. 362+90 TO STA. 387+02.78
TYPICAL LEVEE CROSS SECTIONS
RECORD DRAWING
JUNE 1955
CONTRACT NO. DA-23-028-ENG-831
KANSAS CITY FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
SECTION II
TYPICAL LEVEE CROSS SECTIONS AND ROCK FILL TOE PROTECTION DETAIL
In 40 Sheets
Sheet No. 12
Scale: as shown
OFFICE, DISTRICT ENGINEER KANSAS CITY DISTRICT
KANSAS CITY, MO. JANUARY 1951
A-10-2412
O. & M. M. PLATE NO. 27



TYPICAL CROSS SECTION

STA. 418+40 TO STA. 461+00



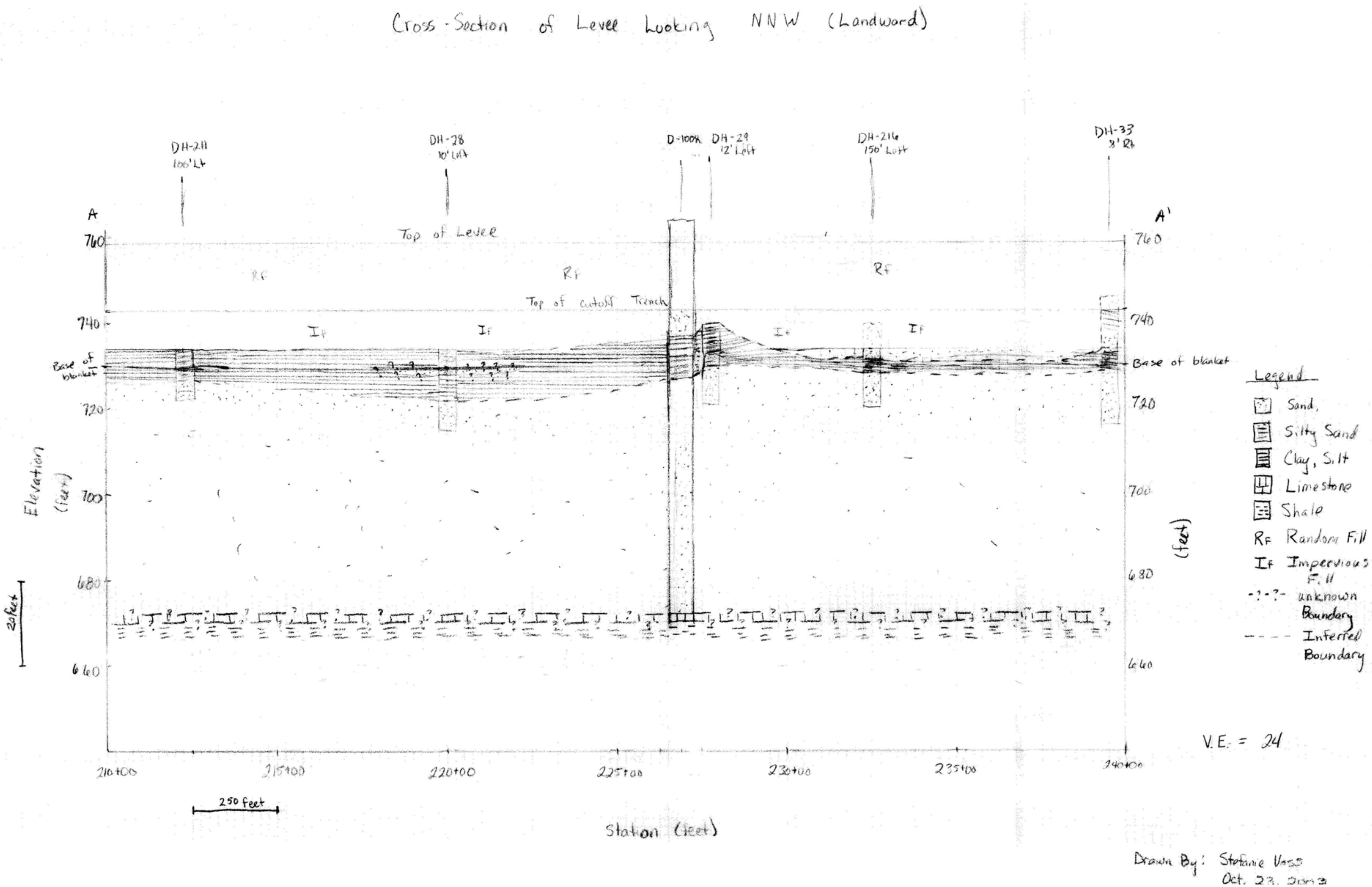
TYPICAL CROSS SECTION

STA. 461+00 TO STA. 469+16.80

NOTE

Site Characterization Maps and Boring Information

EXHIBIT A-9.8



Cross-Section of Levee Looking NNW (Landward)
DH-211 100' Lt
DH-28 10' Lft
D-1008
DH-29 12' Left
DH-216 150' Left
DH-33 3' Rt
A
A'
Top of Levee
RF
Top of cutoff Trench
IF
Base of blanket
Elevation (feet)
(feet)
760
740
720
700
680
660
20 feet
Legend
Sand
Silty Sand
Clay, Silt
Limestone
Shale
RF Random Fill
IF Impervious Fill
-?-?- unknown Boundary
- - - - Inferred Boundary
V.E. = 24
210+00
215+00
220+00
225+00
230+00
235+00
240+00
250 feet
Station (feet)
Drawn By: Stefanie Voss
Oct. 23, 2003

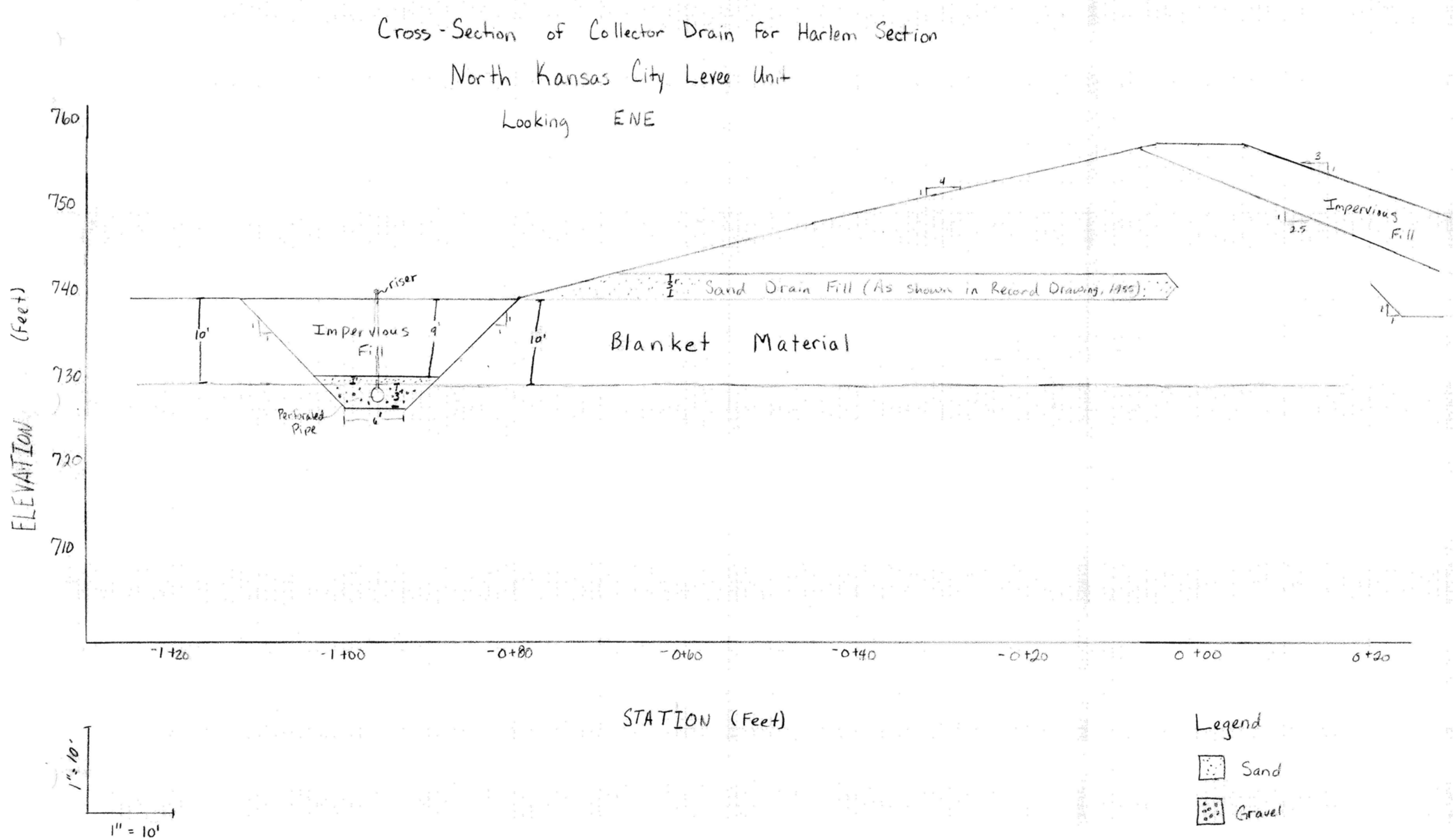

Cross-Section of Collector Drain For Harlem Section
North Kansas City Levee Unit
Looking ENE
760
750
740
730
720
710
ELEVATION (Feet)
riser
Impervious Fill
10'
9'
10'
Perforated Pipe
6'
Sand Drain Fill (As shown in Record Drawing, 1955)
Blanket Material
Impervious Fill
4
3
2.5
-1+20
-1+00
-0+80
-0+60
-0+40
-0+20
0+00
0+20
STATION (Feet)
1" = 10'
1" = 10'
Legend
Sand
Gravel

EXHIBIT A-9.10

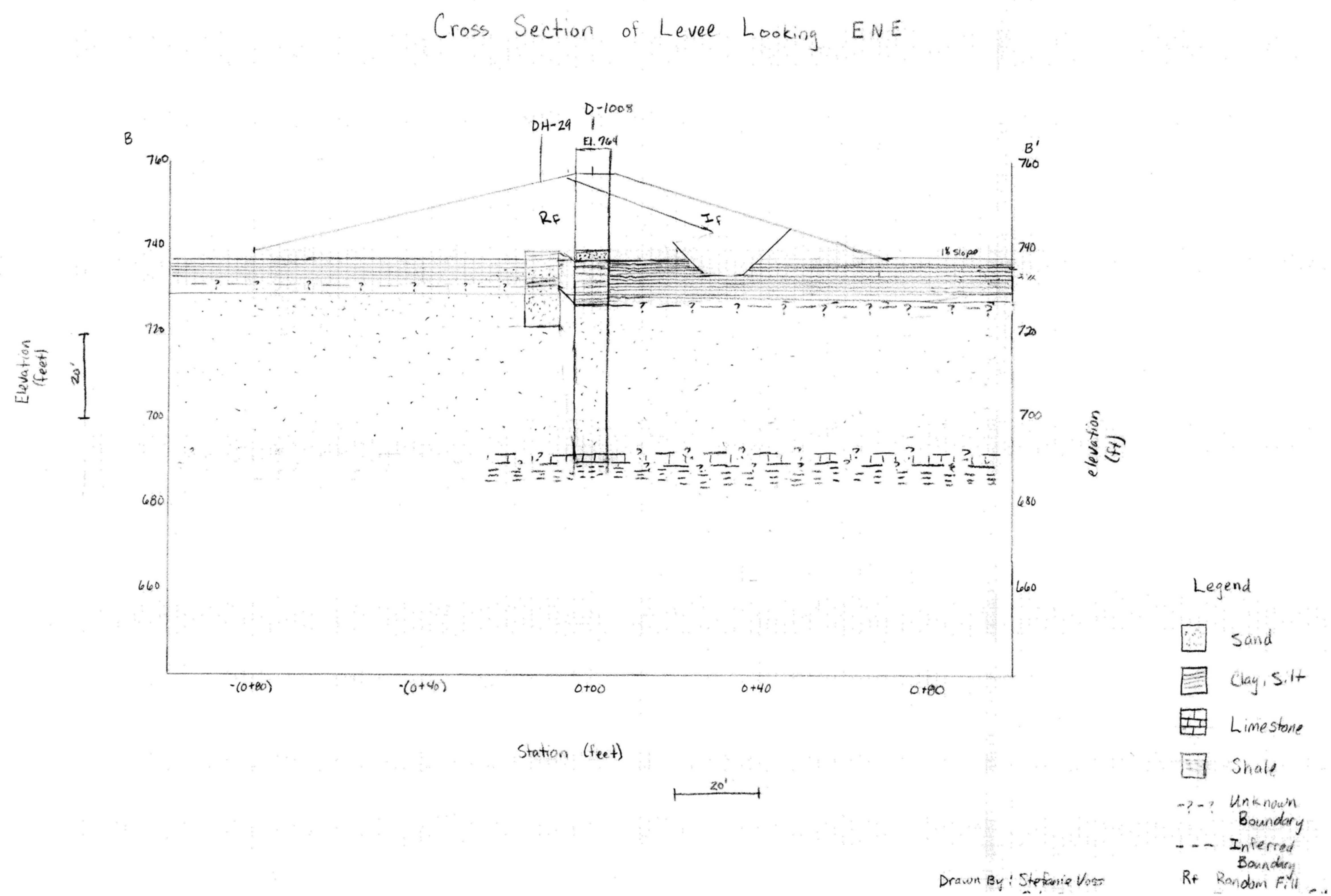
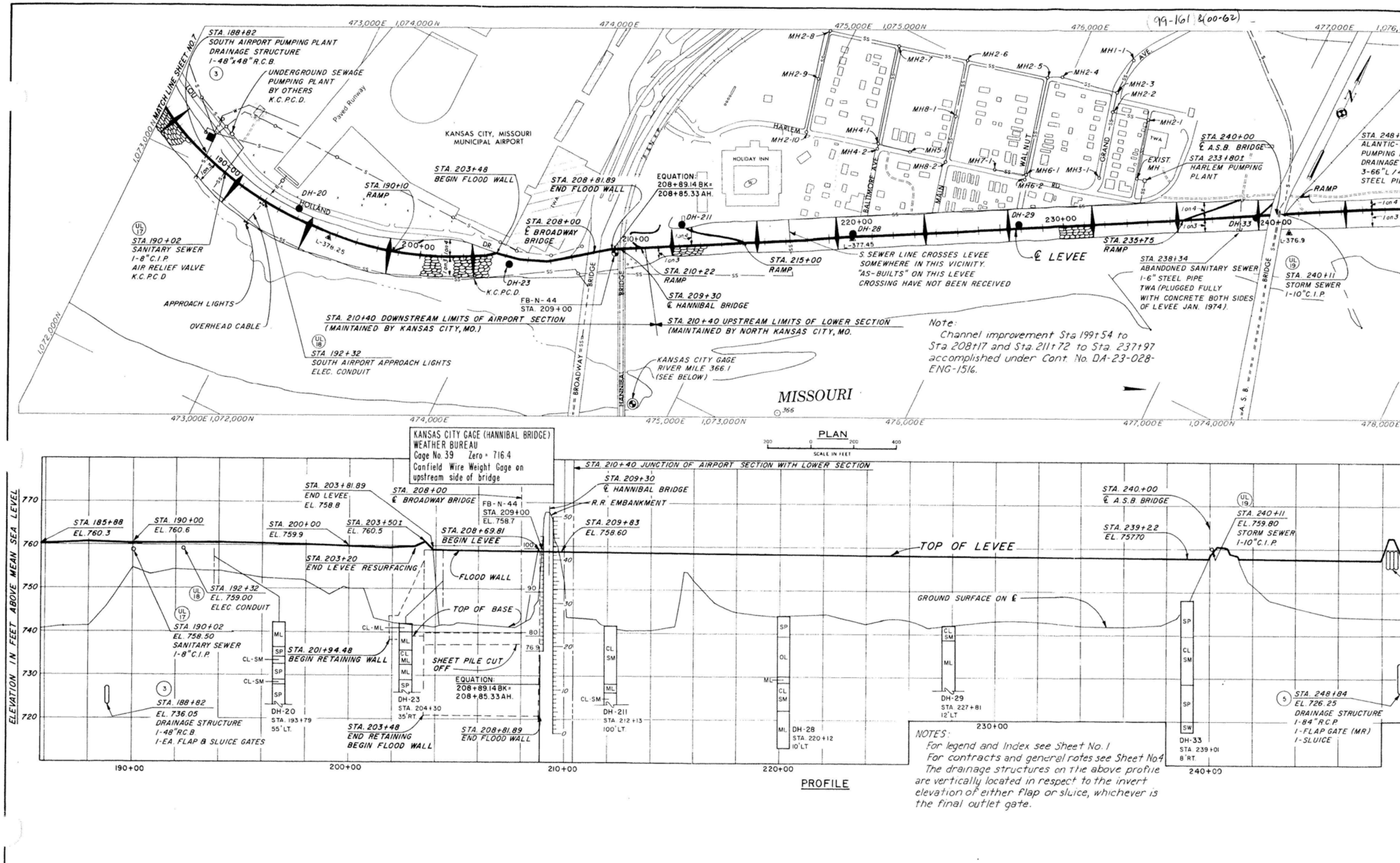
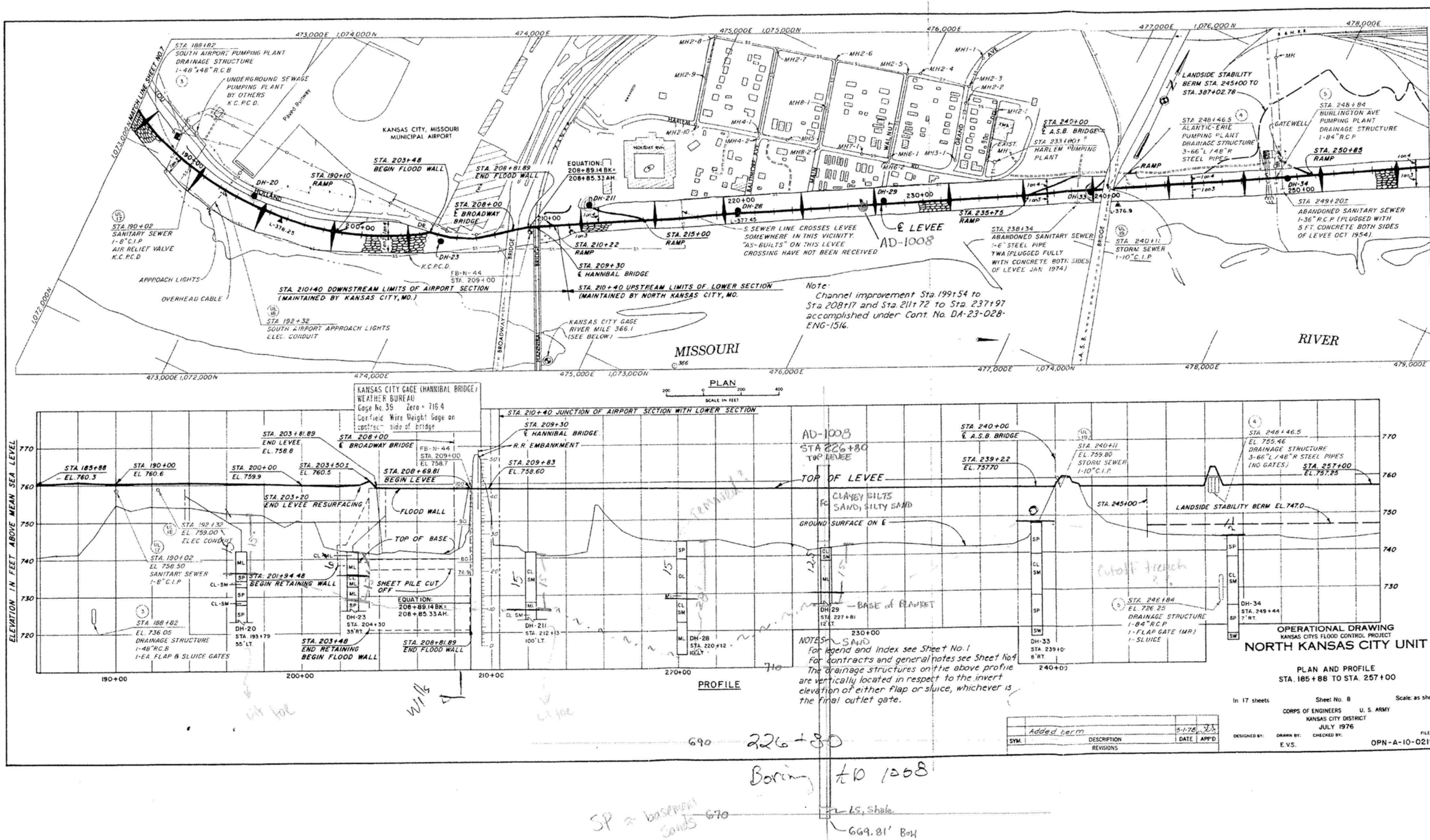


EXHIBIT A-9.11




OPERATIONAL DRAWING
KANSAS CITYS FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
PLAN AND PROFILE
STA. 185+88 TO STA. 257+00
PLAN
PROFILE
MISSOURI
RIVER
KANSAS CITY, MISSOURI MUNICIPAL AIRPORT
AD-1008
STA 226+80
TOP LEVEE
TOP OF LEVEE
CLAYEY SILTS
SAND, SILTY SAND
GROUND SURFACE ON ℄
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
Note:
Channel improvement Sta.199+54 to Sta 208+17 and Sta.211+72 to Sta. 237+97 accomplished under Cont. No. DA-23-028-ENG-1516.
NOTES:
For legend and index see Sheet No.1
For contracts and general notes see Sheet No.4
The drainage structures on the above profile are vertically located in respect to the invert elevation of either flap or sluice, whichever is the final outlet gate.
In 17 sheets
Sheet No. 8
Scale: as shown
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
JULY 1976
OPN-A-10-0219.1
Added berm
Boring AD 1008
669.81' BoH

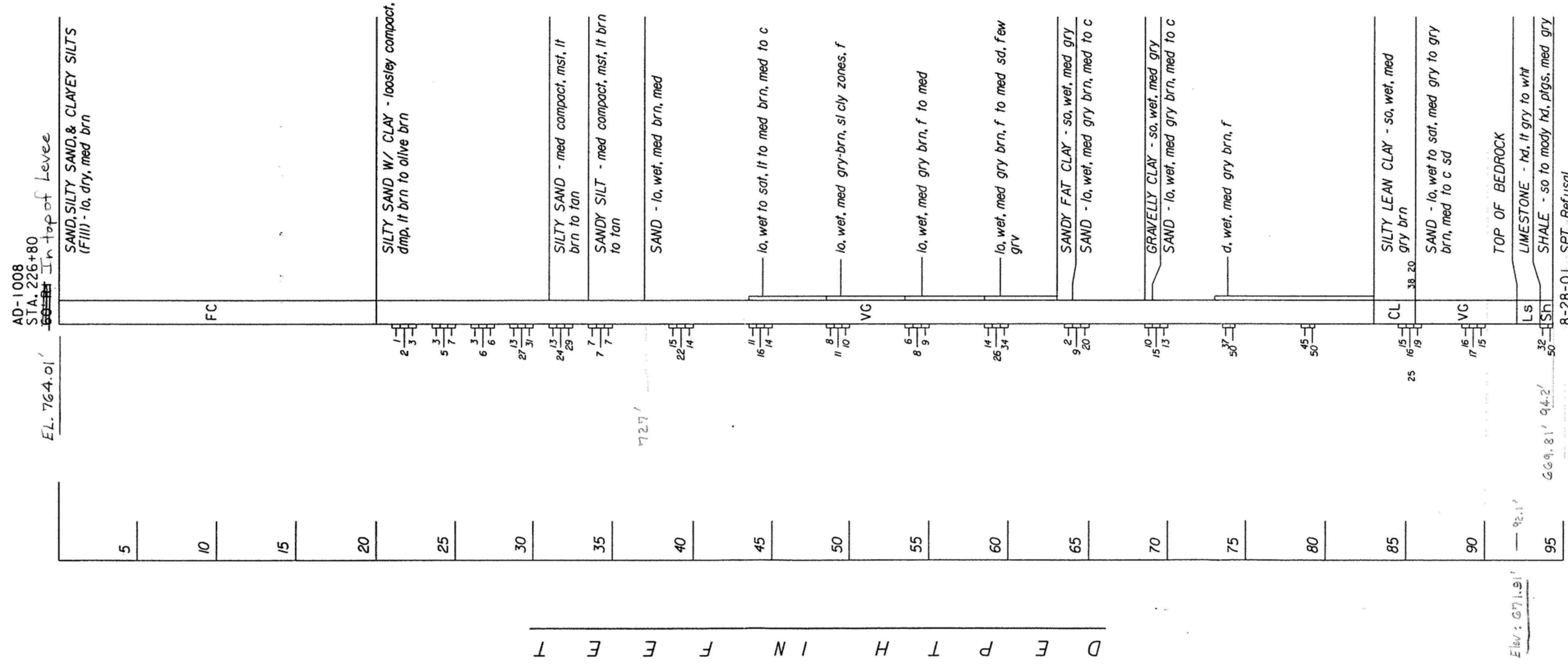

AD-1008
STA. 226+80
In top of Levee
EL. 764.01'
SAND, SILTY SAND, & CLAYEY SILTS (FIII) - lo, dry, med brn
FC
SILTY SAND W/ CLAY - loosley compact, dmp, lt brn to olive brn
SILTY SAND - med compact, mst, lt brn to tan
SANDY SILT - med compact, mst, lt brn to tan
SAND - lo, wet, med brn, med
lo, wet to sat, lt to med brn, med to c
lo, wet, med gry-brn, sl cly zones, f
lo, wet, med gry brn, f to med
lo, wet, med gry brn, f to med sd, few grv
VG
SANDY FAT CLAY - so, wet, med gry
SAND - lo, wet, med gry brn, med to c
GRAVELLY CLAY - so, wet, med gry
SAND - lo, wet, med gry brn, med to c
d, wet, med gry brn, f
SILTY LEAN CLAY - so, wet, med gry brn
CL
SAND - lo, wet to sat, med gry to gry brn, med to c sd
VG
TOP OF BEDROCK
LIMESTONE - hd, lt gry to wht
Ls
SHALE - so to mody hd, ptgs, med gry
Sh
SPT Refusal
8-28-01
7", & 1 3/8"
727'
669.81' 94.2'
92.1'
Elev: 671.91'
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
DEPTH IN FEET

EXHIBIT A-9.14

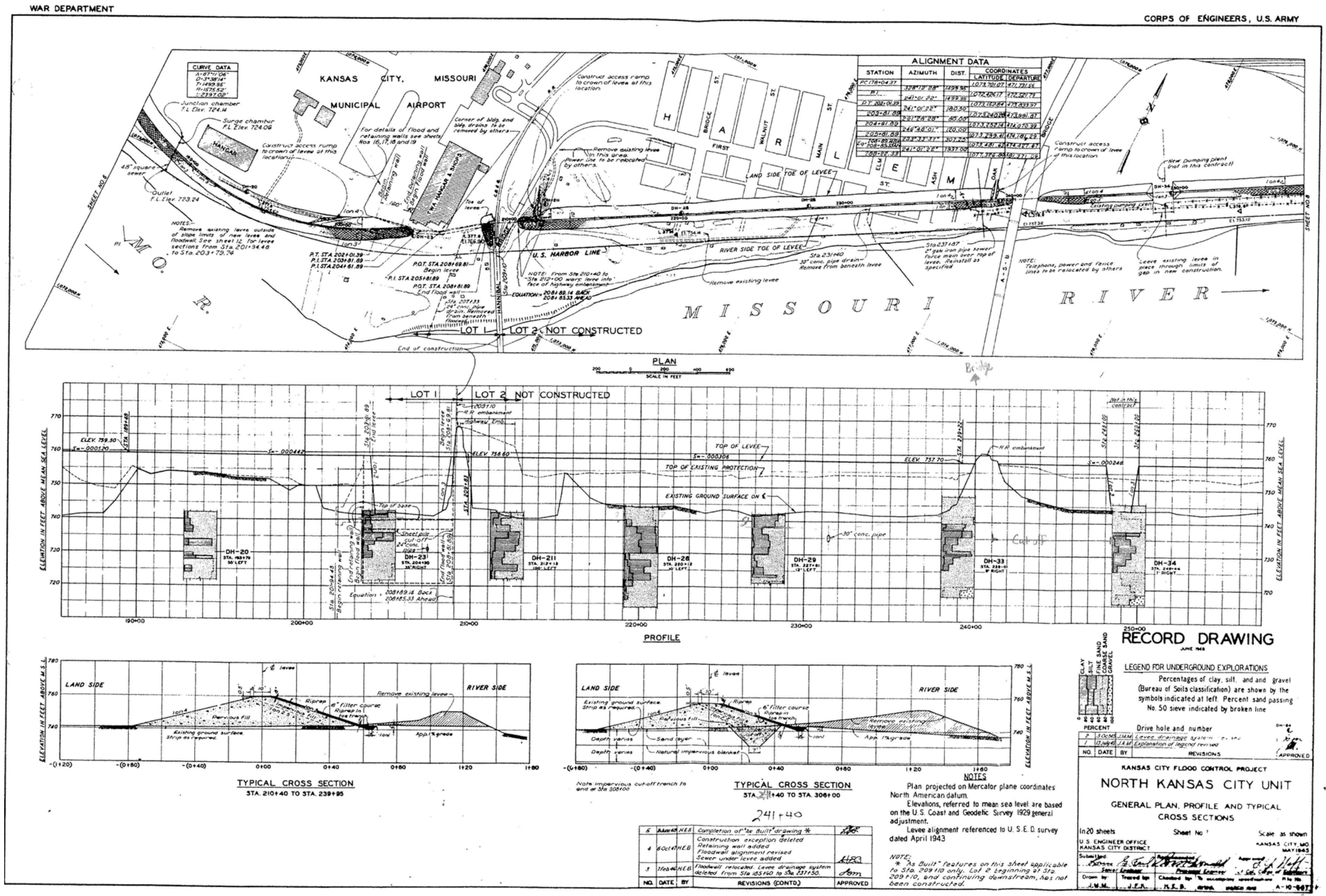
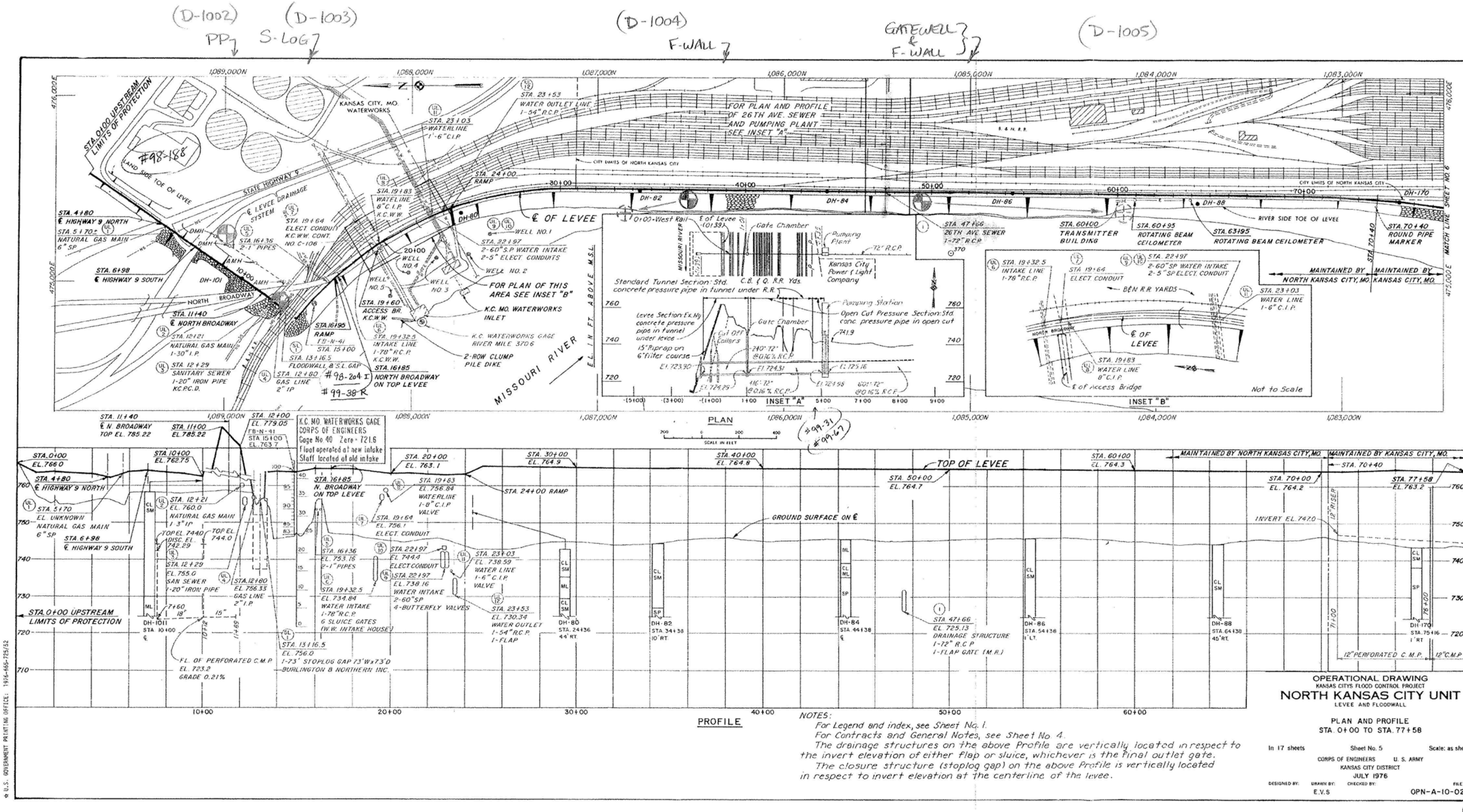
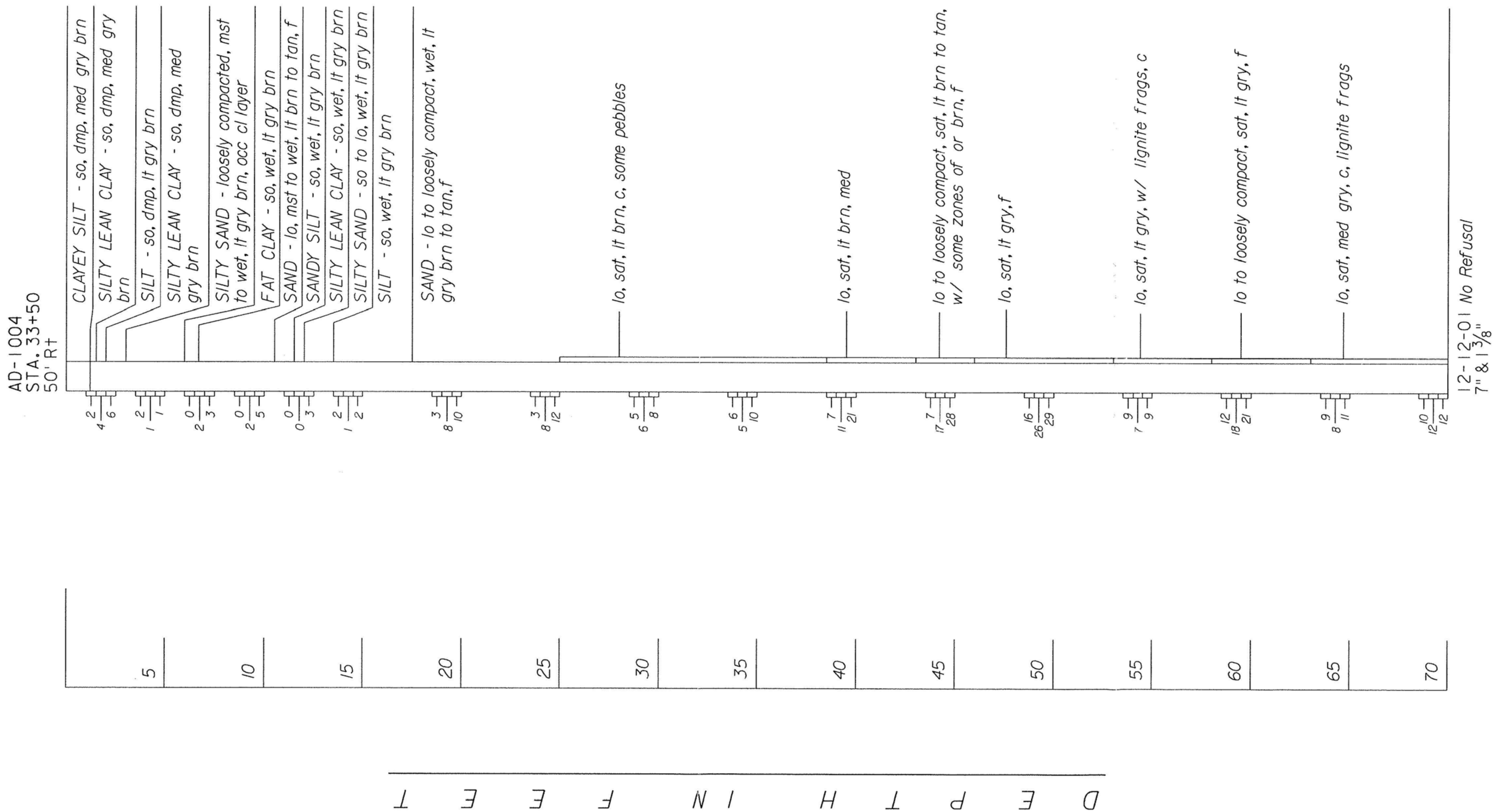


EXHIBIT A-9.15




AD-1004
STA. 33+50
50' RT
CLAYEY SILT - so, dmp, med gry brn
SILTY LEAN CLAY - so, dmp, med gry brn
SILT - so, dmp, lt gry brn
SILTY LEAN CLAY - so, dmp, med gry brn
SILTY SAND - loosely compacted, mst to wet, lt gry brn, occ cl layer
FAT CLAY - so, wet, lt gry brn
SAND - lo, mst to wet, lt brn to tan, f
SANDY SILT - so, wet, lt gry brn
SILTY LEAN CLAY - so, wet, lt gry brn
SILTY SAND - so to lo, wet, lt gry brn
SILT - so, wet, lt gry brn
SAND - lo to loosely compact, wet, lt gry brn to tan, f
lo, sat, lt brn, c, some pebbles
lo, sat, lt brn, med
lo to loosely compact, sat, lt brn to tan, w/ some zones of or brn, f
lo, sat, lt gry, f
lo, sat, lt gry, w/ lignite frags, c
lo to loosely compact, sat, lt gry, f
lo, sat, med gry, c, lignite frags
12-12-01 No Refusal
7" & 1 3/8"
2 4 6
2 1 1
0 2 3
0 2 5
0 0 3
2 1 2
3 8 10
3 8 12
5 6 8
6 5 10
7 11 21
7 17 28
16 26 29
9 7 9
12 18 21
9 8 11
10 12 12
5
10
15
20
25
30
35
40
45
50
55
60
65
70
DEPTH IN FEET

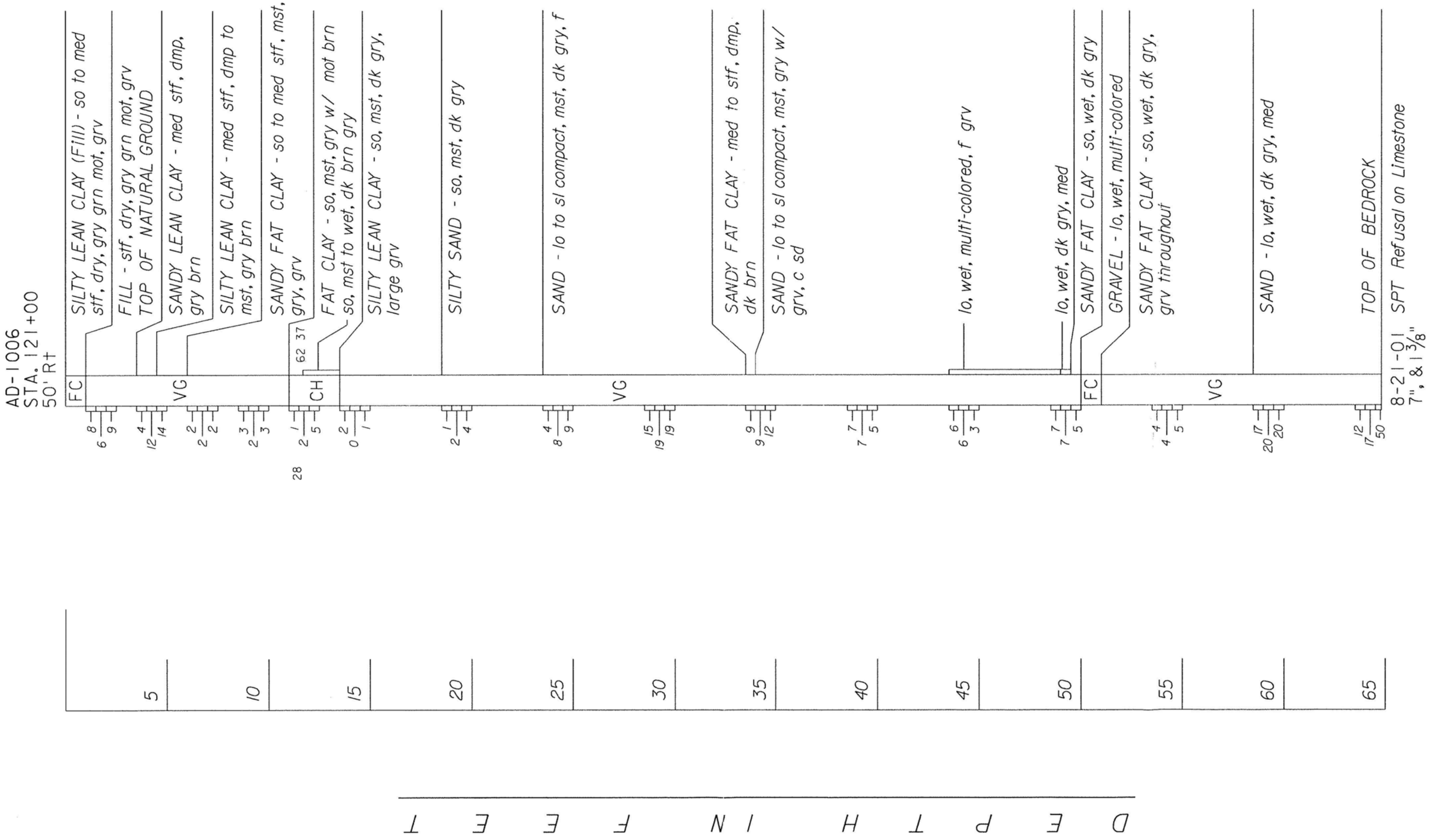
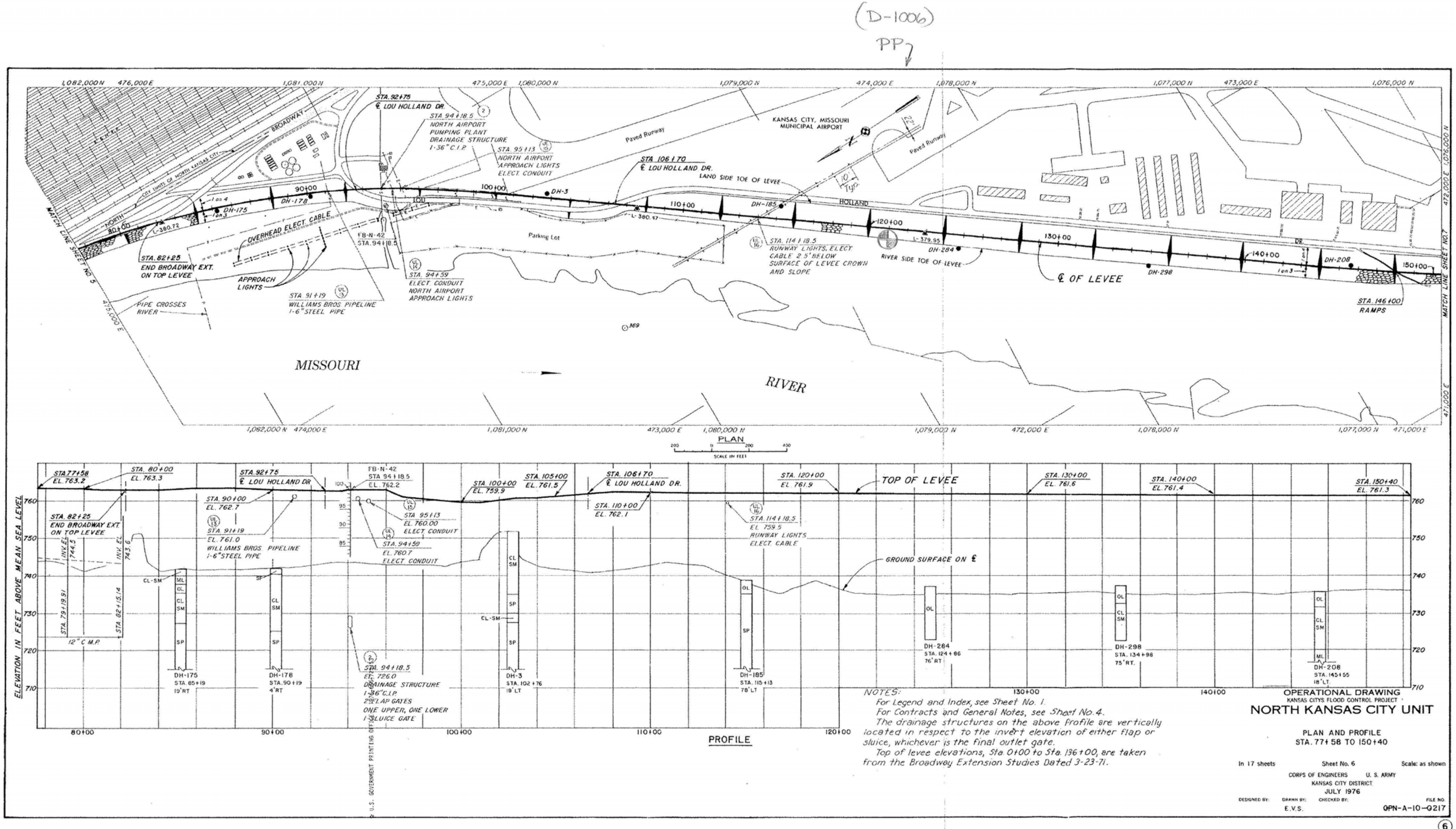

AD-1006
STA. 121+00
50' R+
SILTY LEAN CLAY (Fill) - so to med stf, dry, gry grn mot, grv
FILL - stf, dry, gry grn mot, grv
TOP OF NATURAL GROUND
SANDY LEAN CLAY - med stf, dmp, gry brn
SILTY LEAN CLAY - med stf, dmp to mst, gry brn
SANDY FAT CLAY - so to med stf, mst, gry, grv
FAT CLAY - so, mst, gry w/ mot brn
so, mst to wet, dk brn gry
SILTY LEAN CLAY - so, mst, dk gry, large grv
SILTY SAND - so, mst, dk gry
SAND - lo to sl compact, mst, dk gry, f
SANDY FAT CLAY - med to stf, dmp, dk brn
SAND - lo to sl compact, mst, gry w/ grv, c sd
lo, wet, multi-colored, f grv
lo, wet, dk gry, med
SANDY FAT CLAY - so, wet, dk gry
GRAVEL - lo, wet, multi-colored
SANDY FAT CLAY - so, wet, dk gry, grv throughout
SAND - lo, wet, dk gry, med
TOP OF BEDROCK
SPT Refusal on Limestone
8-21-01
7", & 1 3/8"
FC
VG
CH
62 37
28
5
10
15
20
25
30
35
40
45
50
55
60
65
DEPTH IN FEET

EXHIBIT A-9.18



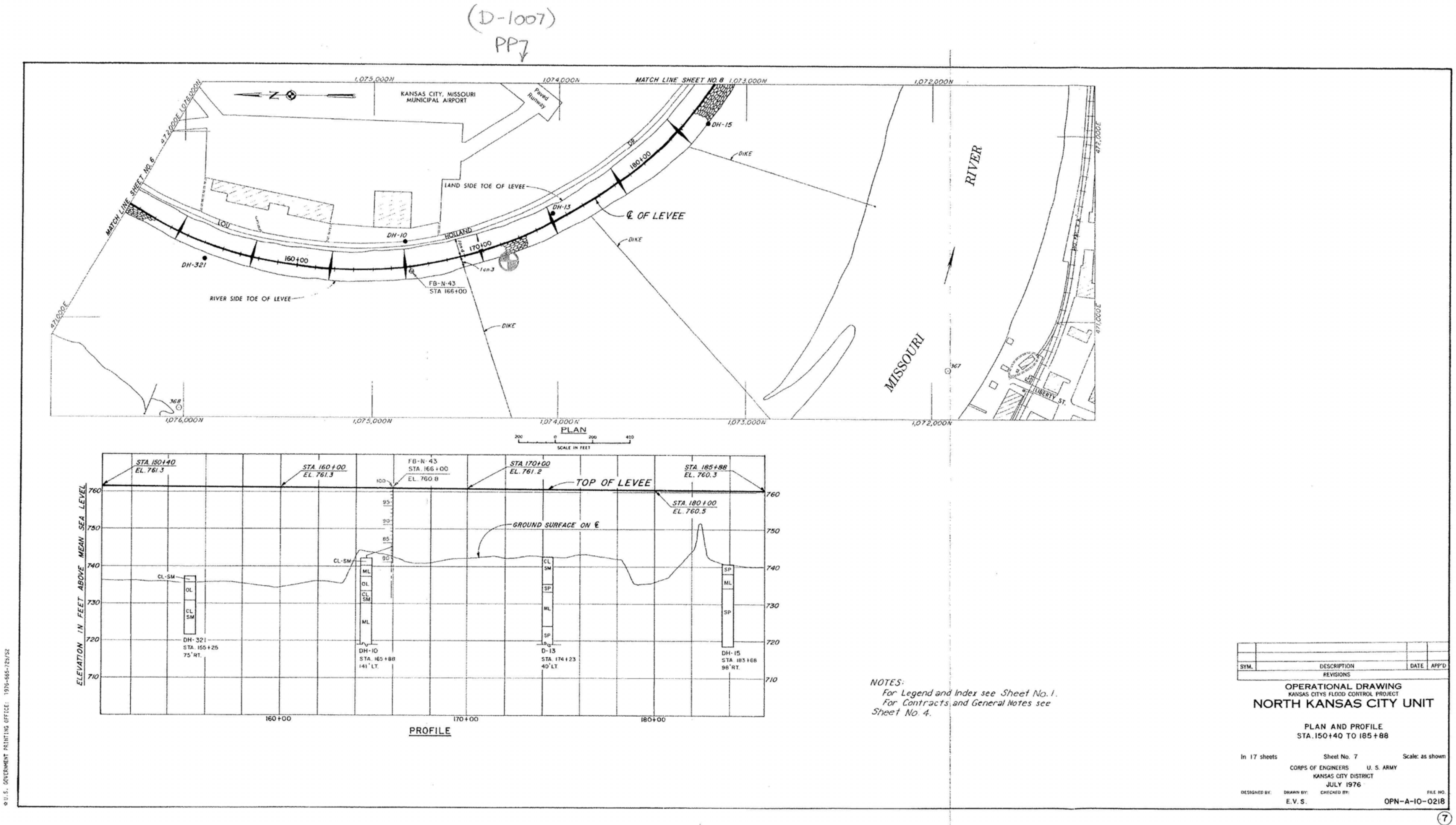

(D-1007)
PP7
KANSAS CITY, MISSOURI MUNICIPAL AIRPORT
MATCH LINE SHEET NO. 8
MATCH LINE SHEET NO. 6
LAND SIDE TOE OF LEVEE
RIVER SIDE TOE OF LEVEE
℄ OF LEVEE
DIKE
MISSOURI
RIVER
LIBERTY ST.
PLAN
PROFILE
TOP OF LEVEE
GROUND SURFACE ON ℄
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
STA. 150+40 EL. 761.3
STA. 160+00 EL. 761.3
FB-N-43 STA. 166+00 EL. 760.8
STA. 170+00 EL. 761.2
STA. 180+00 EL. 760.5
STA. 185+88 EL. 760.3
DH-321 STA. 155+25 75' RT.
DH-10 STA. 165+88 141' LT.
D-13 STA. 174+23 40' LT.
DH-15 STA. 183+66 98' RT.
NOTES:
For Legend and Index see Sheet No. 1.
For Contracts and General Notes see Sheet No. 4.
OPERATIONAL DRAWING
KANSAS CITYS FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
PLAN AND PROFILE
STA. 150+40 TO 185+88
In 17 sheets
Sheet No. 7
Scale: as shown
CORPS OF ENGINEERS
U. S. ARMY
KANSAS CITY DISTRICT
JULY 1976
E.V.S.
OPN-A-10-0218
7

EXHIBIT A-9.20

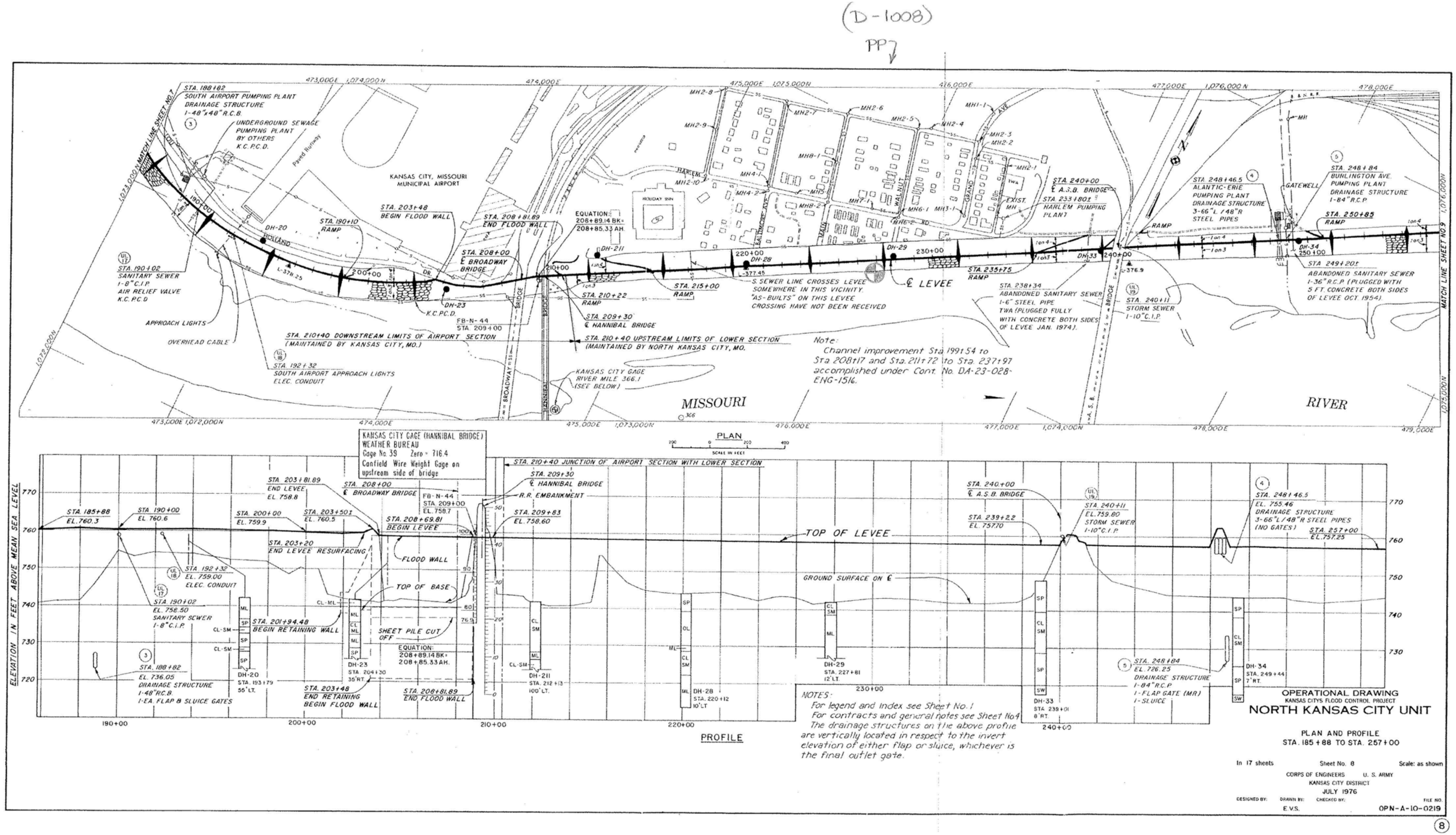
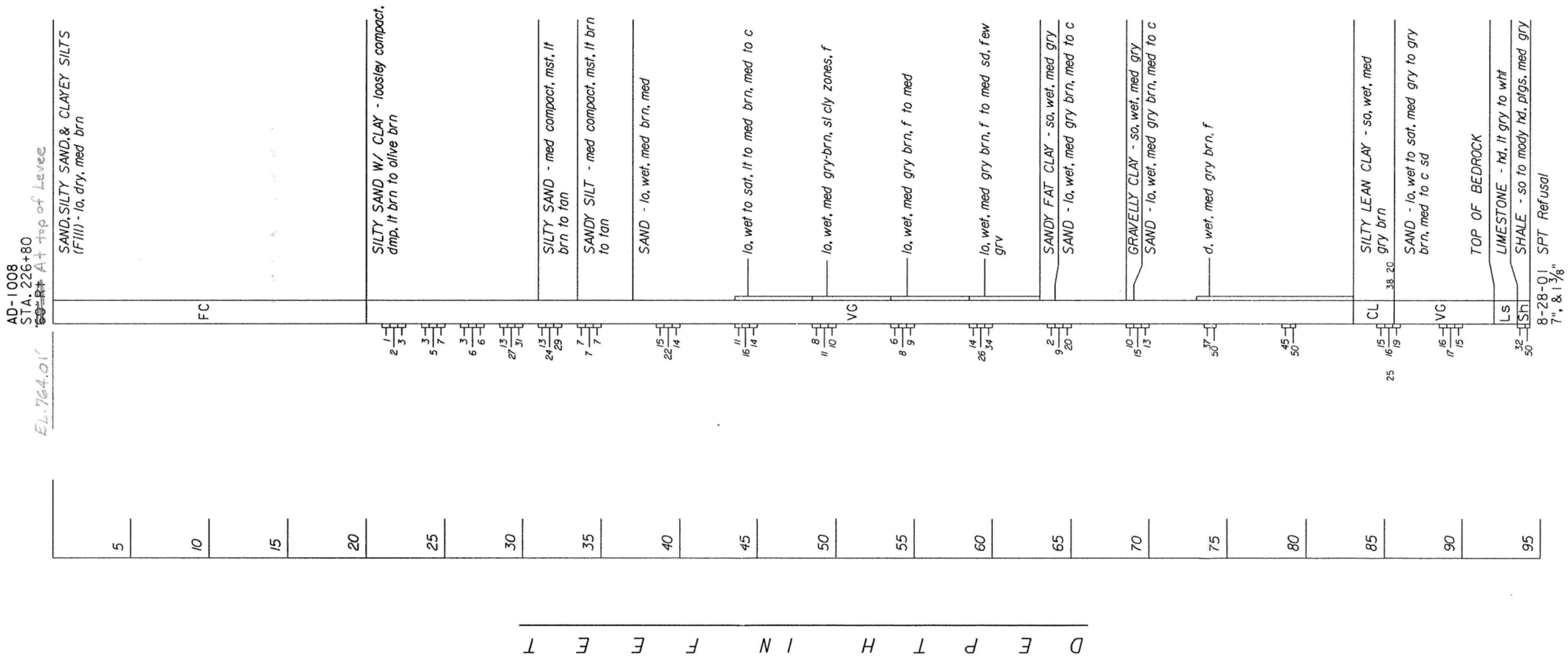


EXHIBIT A-9.21



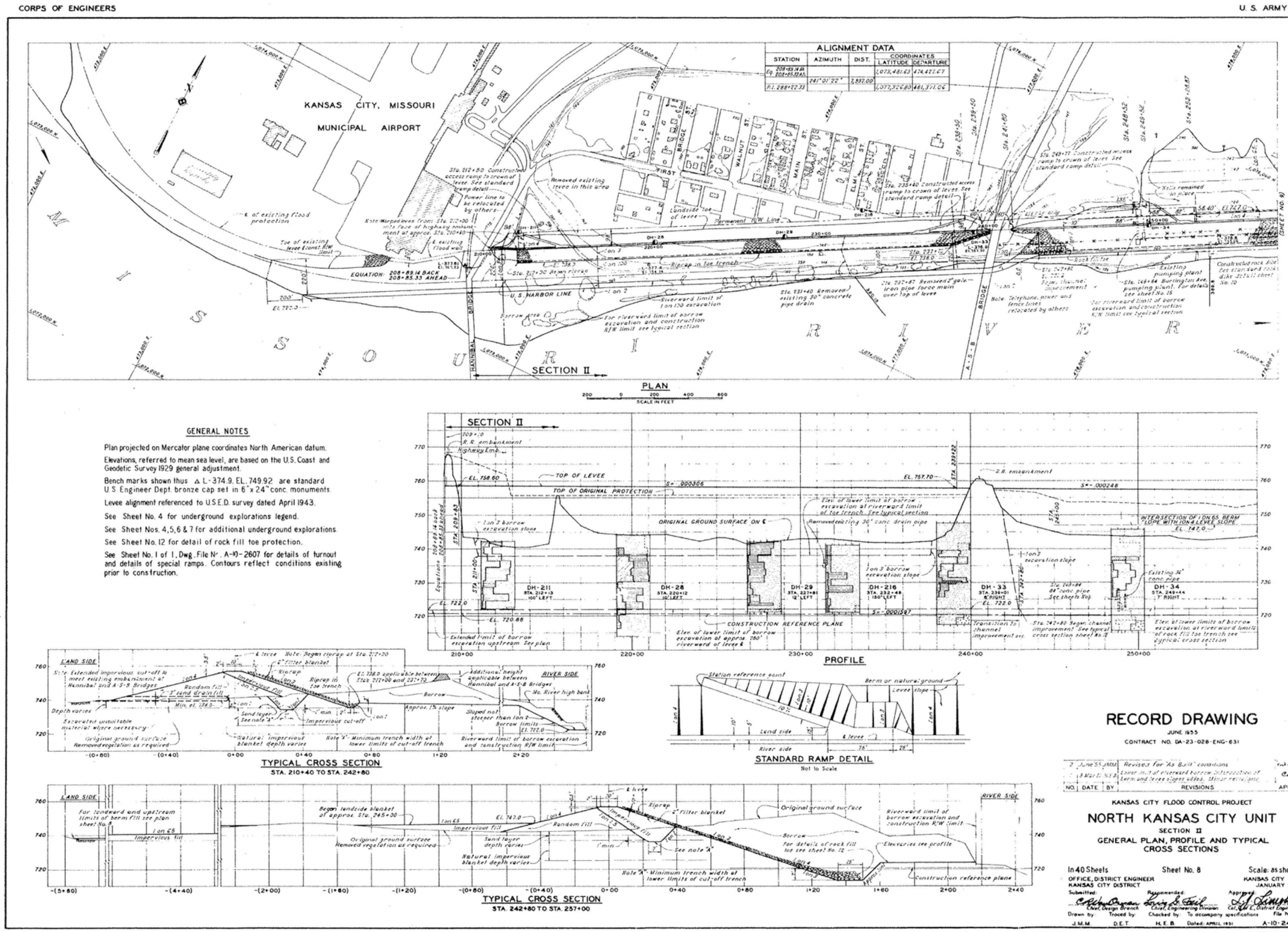

CORPS OF ENGINEERS
U. S. ARMY
ALIGNMENT DATA
KANSAS CITY, MISSOURI
MUNICIPAL AIRPORT
SECTION II
PLAN
GENERAL NOTES
Plan projected on Mercator plane coordinates North American datum.
Elevations, referred to mean sea level, are based on the U.S. Coast and Geodetic Survey 1929 general adjustment.
Bench marks shown thus Δ L-374.9, EL. 749.92 are standard U.S. Engineer Dept. bronze cap set in 6"x 24" conc. monuments.
Levee alignment referenced to U.S.E.D. survey dated April 1943.
See Sheet No. 4 for underground explorations legend.
See Sheet Nos. 4, 5, 6 & 7 for additional underground explorations.
See Sheet No. 12 for detail of rock fill toe protection.
See Sheet No. 1 of 1, Dwg. File No. A-10-2607 for details of turnout and details of special ramps. Contours reflect conditions existing prior to construction.
PROFILE
TYPICAL CROSS SECTION
STA. 210+40 TO STA. 242+80
STANDARD RAMP DETAIL
Not to Scale
TYPICAL CROSS SECTION
STA. 242+80 TO STA. 257+00
RECORD DRAWING
JUNE 1955
CONTRACT NO. DA-23-028-ENG-631
KANSAS CITY FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
SECTION II
GENERAL PLAN, PROFILE AND TYPICAL CROSS SECTIONS
In 40 Sheets
Sheet No. 8
Scale: as shown
OFFICE, DISTRICT ENGINEER
KANSAS CITY DISTRICT
KANSAS CITY MO.
JANUARY 1951
A-10-2408
O. & M.M. PLATE NO. 23

EXHIBIT A-9.23

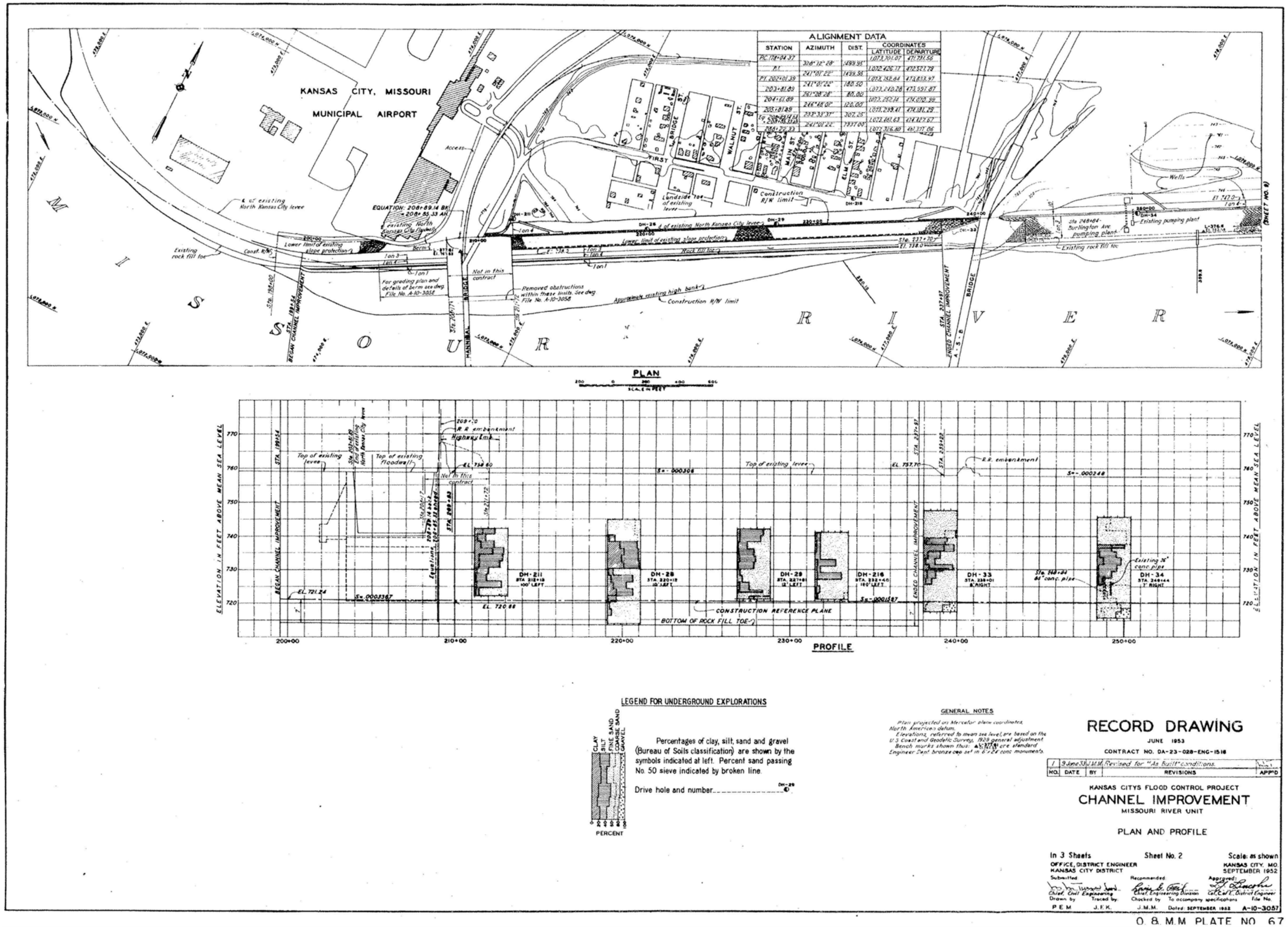
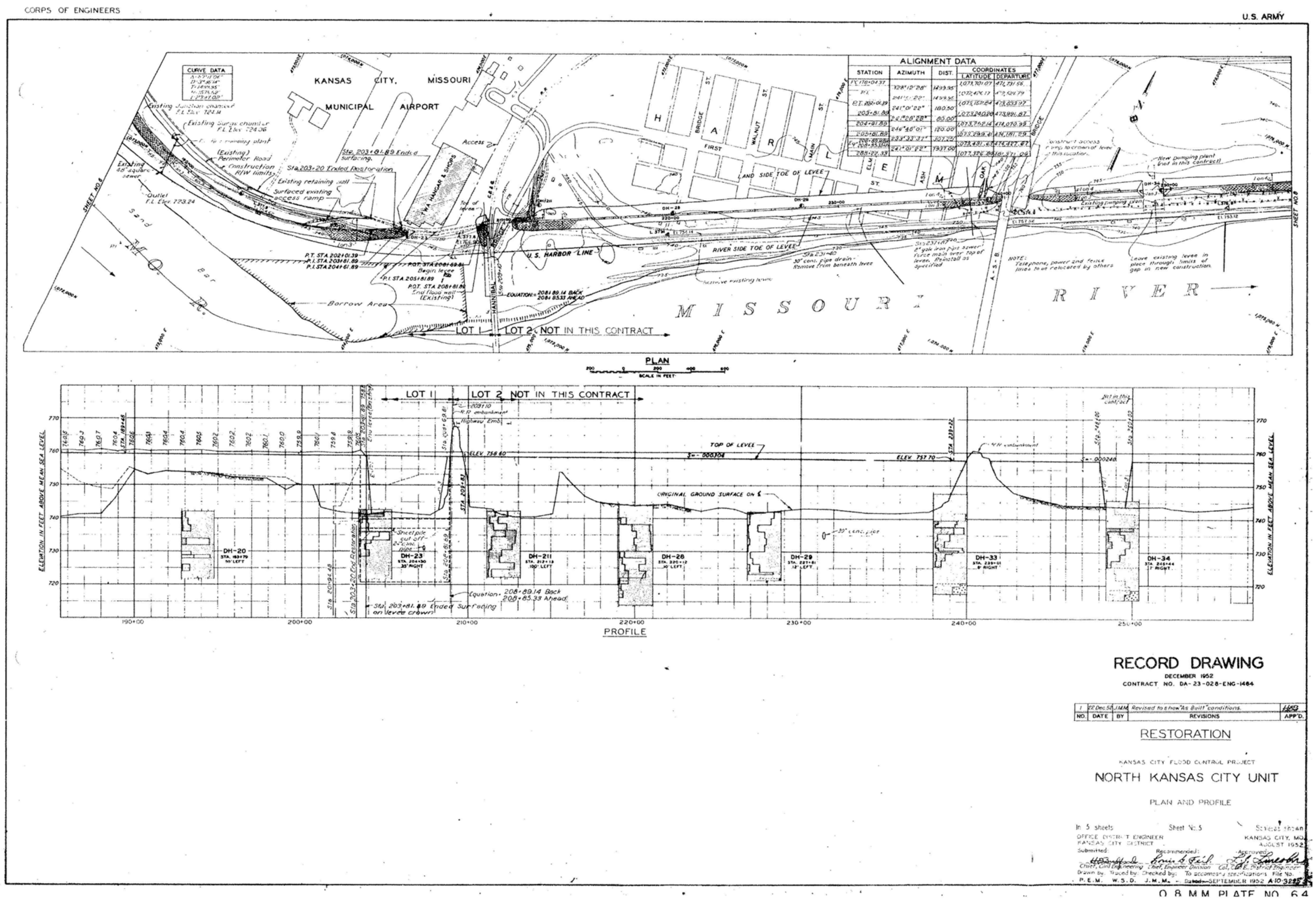
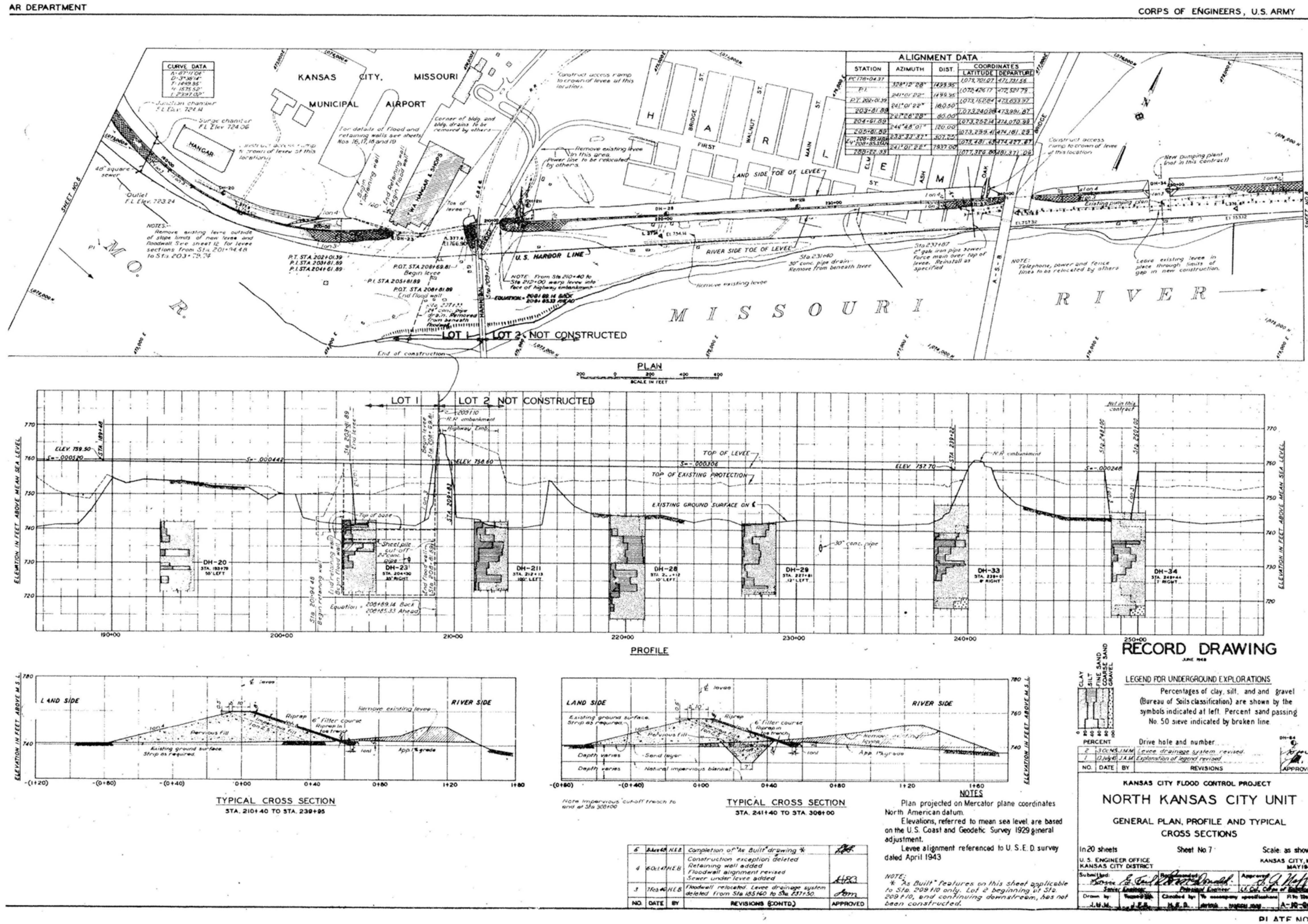


EXHIBIT A-9.24




WAR DEPARTMENT
CORPS OF ENGINEERS, U.S. ARMY
KANSAS CITY, MISSOURI
MUNICIPAL AIRPORT
HANGAR
ALIGNMENT DATA
MISSOURI RIVER
U.S. HARBOR LINE
LOT 1 LOT 2 NOT CONSTRUCTED
PLAN
PROFILE
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
TOP OF LEVEE
TOP OF EXISTING PROTECTION
EXISTING GROUND SURFACE ON ℄
RECORD DRAWING
LEGEND FOR UNDERGROUND EXPLORATIONS
Percentages of clay, silt, and sand gravel (Bureau of Soils classification) are shown by the symbols indicated at left. Percent sand passing No. 50 sieve indicated by broken line.
Drive hole and number
LAND SIDE
RIVER SIDE
TYPICAL CROSS SECTION
STA. 210+40 TO STA. 239+95
TYPICAL CROSS SECTION
STA. 241+40 TO STA. 306+00
NOTES
Plan projected on Mercator plane coordinates North American datum.
Elevations, referred to mean sea level, are based on the U.S. Coast and Geodetic Survey 1929 general adjustment.
Levee alignment referenced to U.S.E.D. survey dated April 1943
KANSAS CITY FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
GENERAL PLAN, PROFILE AND TYPICAL CROSS SECTIONS
In 20 sheets
Sheet No. 7
Scale: as shown
U.S. ENGINEER OFFICE KANSAS CITY DISTRICT
KANSAS CITY, MO. MAY 1945
PLATE NO. 5

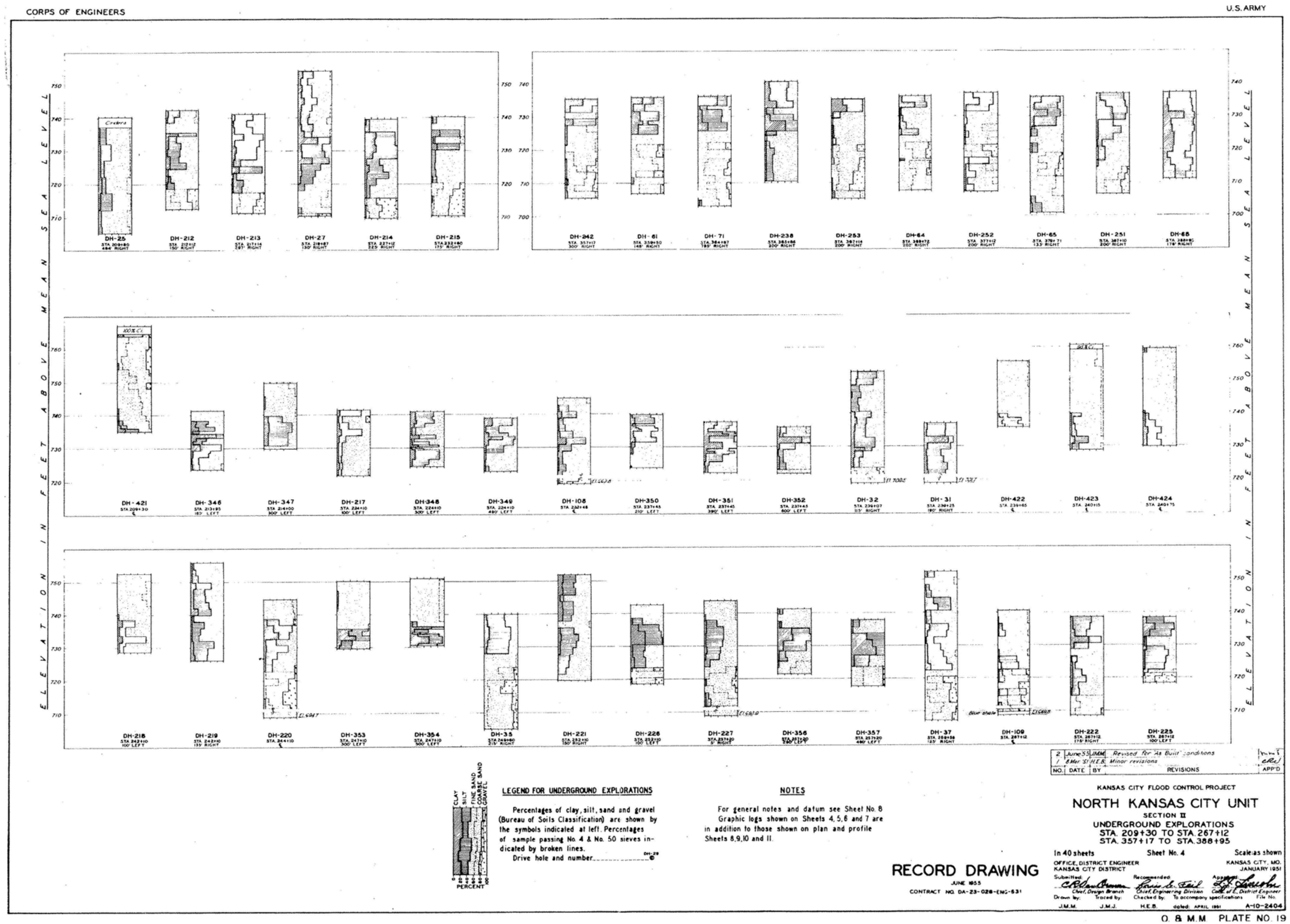

CORPS OF ENGINEERS
U.S. ARMY
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DH-25
DH-212
DH-213
DH-27
DH-214
DH-215
DH-242
DH-61
DH-71
DH-238
DH-253
DH-64
DH-252
DH-65
DH-251
DH-68
DH-421
DH-346
DH-347
DH-217
DH-348
DH-349
DH-108
DH-350
DH-351
DH-352
DH-32
DH-31
DH-422
DH-423
DH-424
DH-218
DH-219
DH-220
DH-353
DH-354
DH-35
DH-221
DH-226
DH-227
DH-356
DH-357
DH-37
DH-109
DH-222
DH-225
Blue shale
CLAY
SILT
FINE SAND
COARSE SAND
GRAVEL
PERCENT
LEGEND FOR UNDERGROUND EXPLORATIONS
Percentages of clay, silt, sand and gravel (Bureau of Soils Classification) are shown by the symbols indicated at left. Percentages of sample passing No. 4 & No. 50 sieves indicated by broken lines.
Drive hole and number
NOTES
For general notes and datum see Sheet No. 8
Graphic logs shown on Sheets 4, 5, 6 and 7 are in addition to those shown on plan and profile Sheets 8, 9, 10 and 11.
RECORD DRAWING
JUNE 1955
CONTRACT NO. DA-23-028-ENG-631
2 June '55 JMM Revised for "As Built" conditions
1 8 Mar '51 H.E.B. Minor revisions
NO. DATE BY REVISIONS APP'D
KANSAS CITY FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
SECTION II
UNDERGROUND EXPLORATIONS
STA. 209+30 TO STA. 267+12
STA. 357+17 TO STA. 388+95
In 40 sheets
Sheet No. 4
Scale: as shown
OFFICE, DISTRICT ENGINEER
KANSAS CITY DISTRICT
KANSAS CITY, MO.
JANUARY 1951
Submitted:
Recommended:
Approved:
Chief, Design Branch
Chief, Engineering Division
Col. C. of E., District Engineer
Drawn by: J.M.M.
Traced by: J.M.J.
Checked by: H.E.B.
To accompany specifications dated: APRIL 1951
File No. A-10-2404
O. & M.M. PLATE NO. 19

EXHIBIT A-9.27

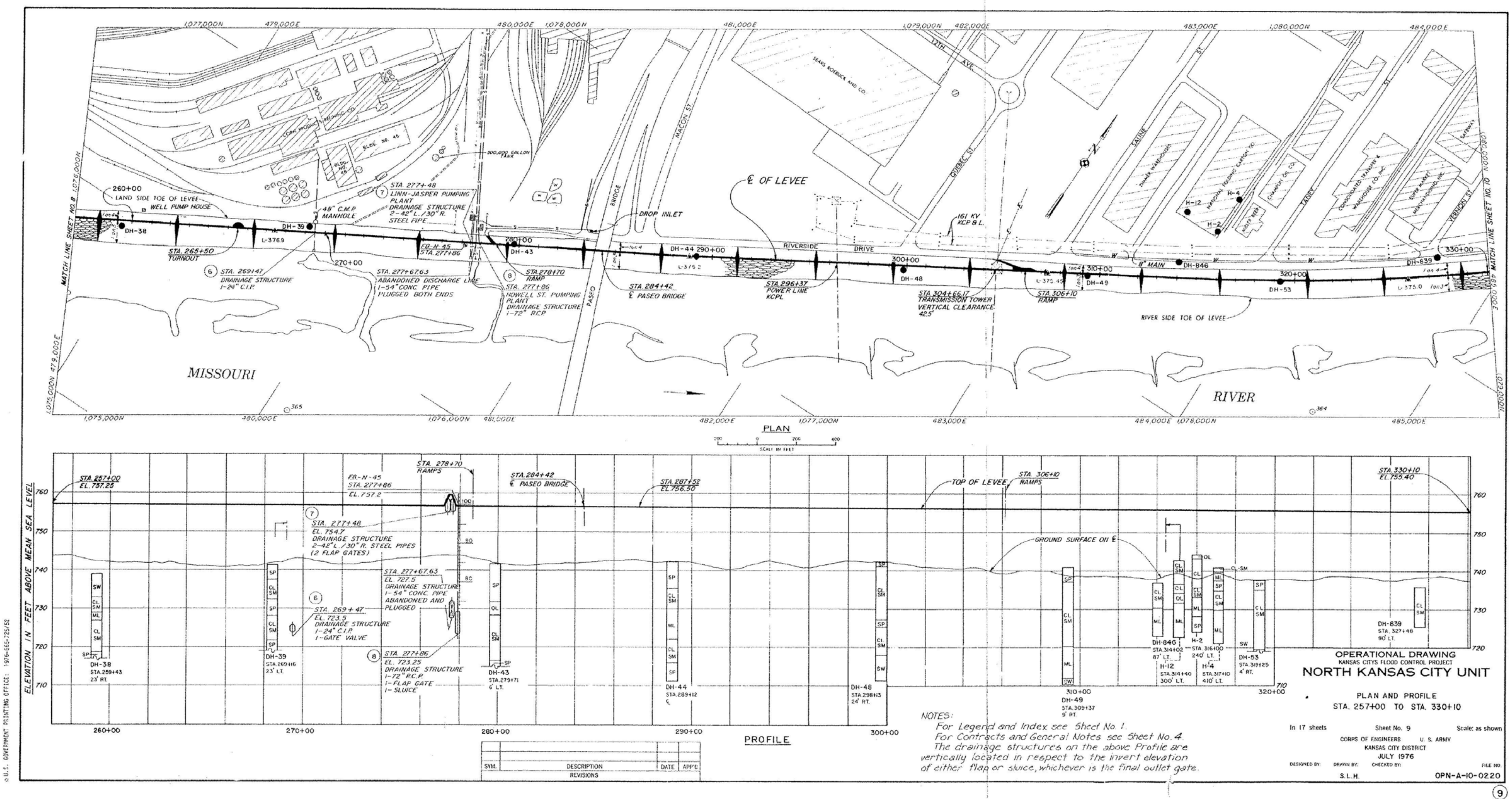
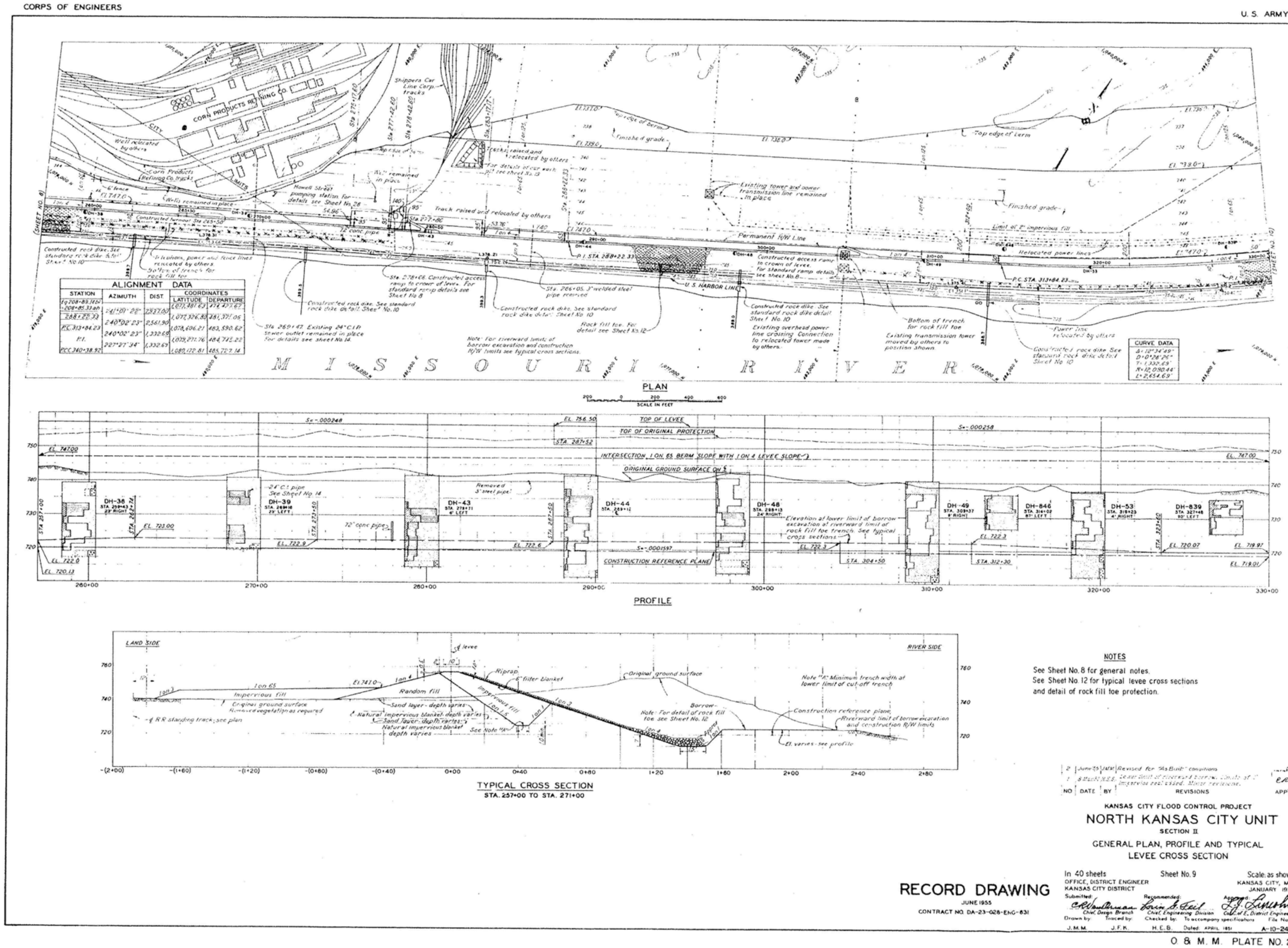
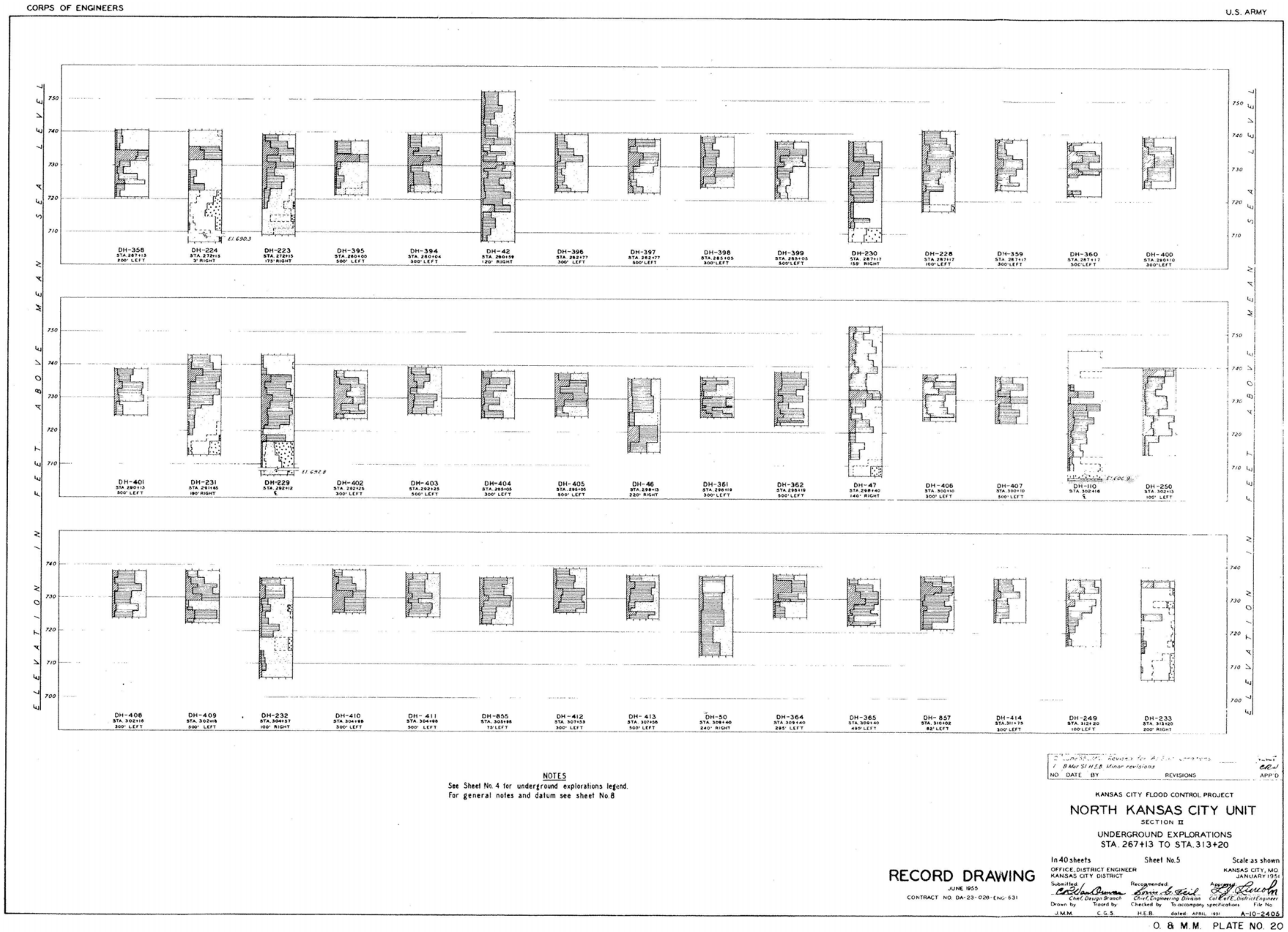
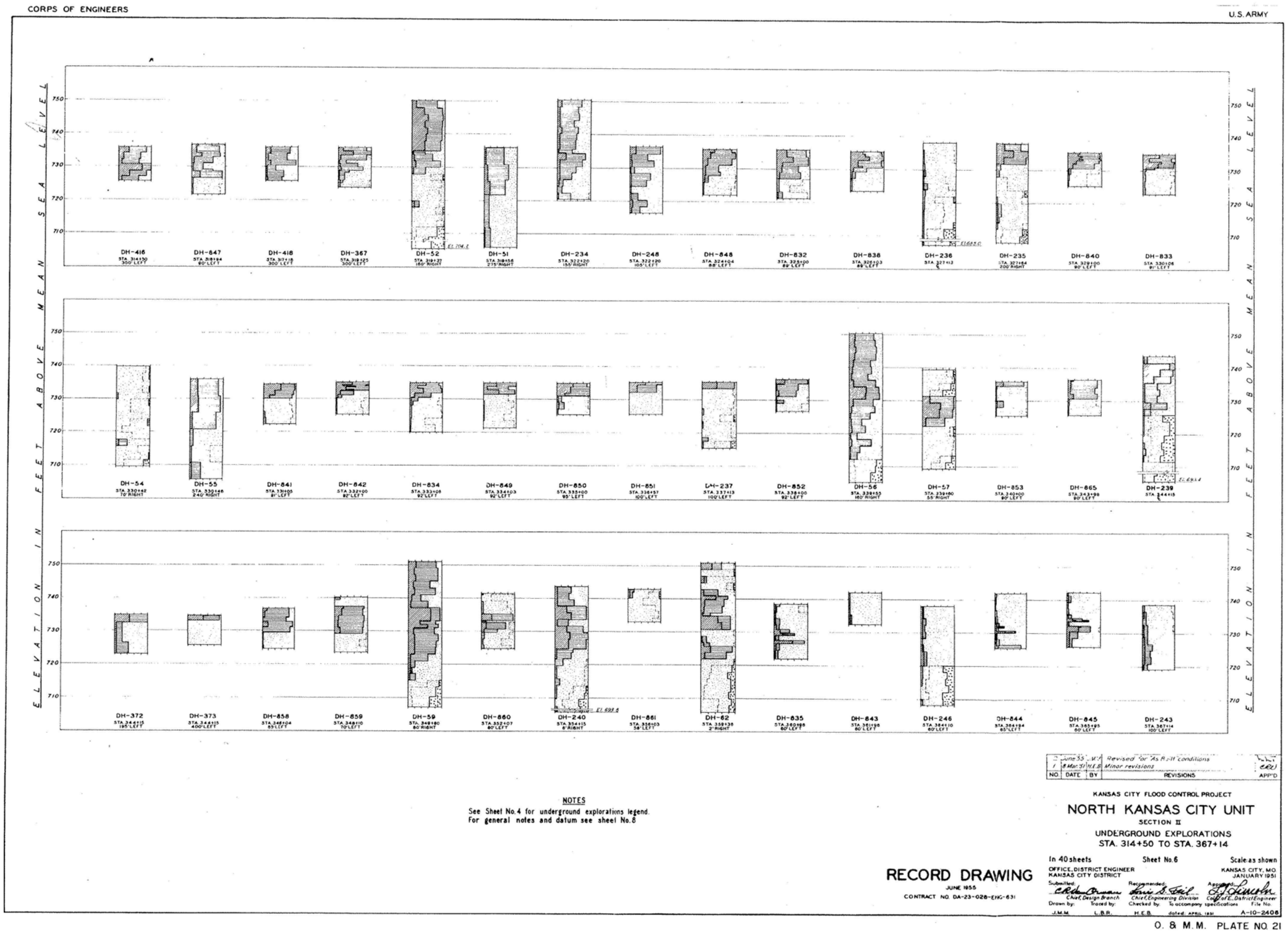
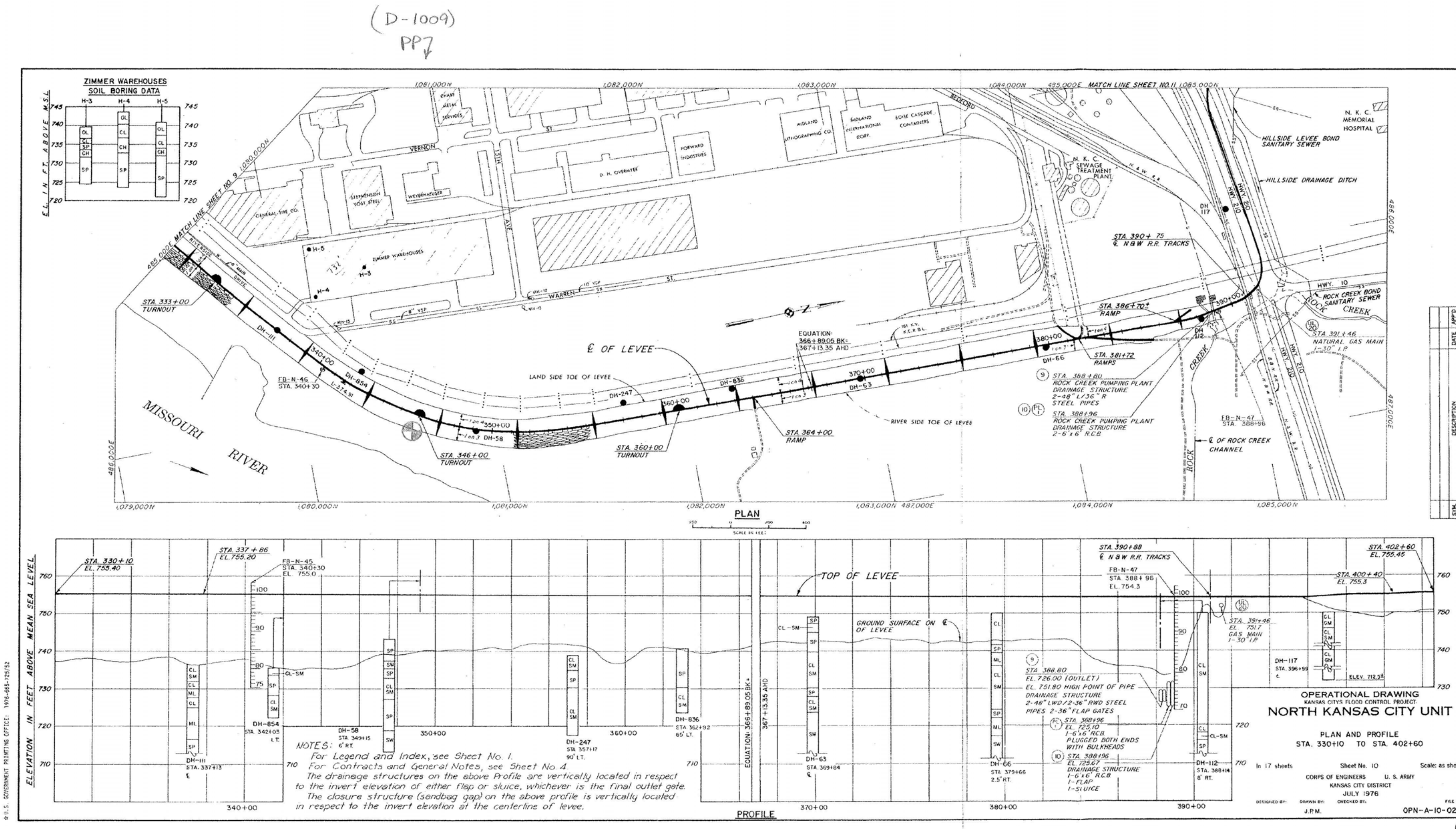


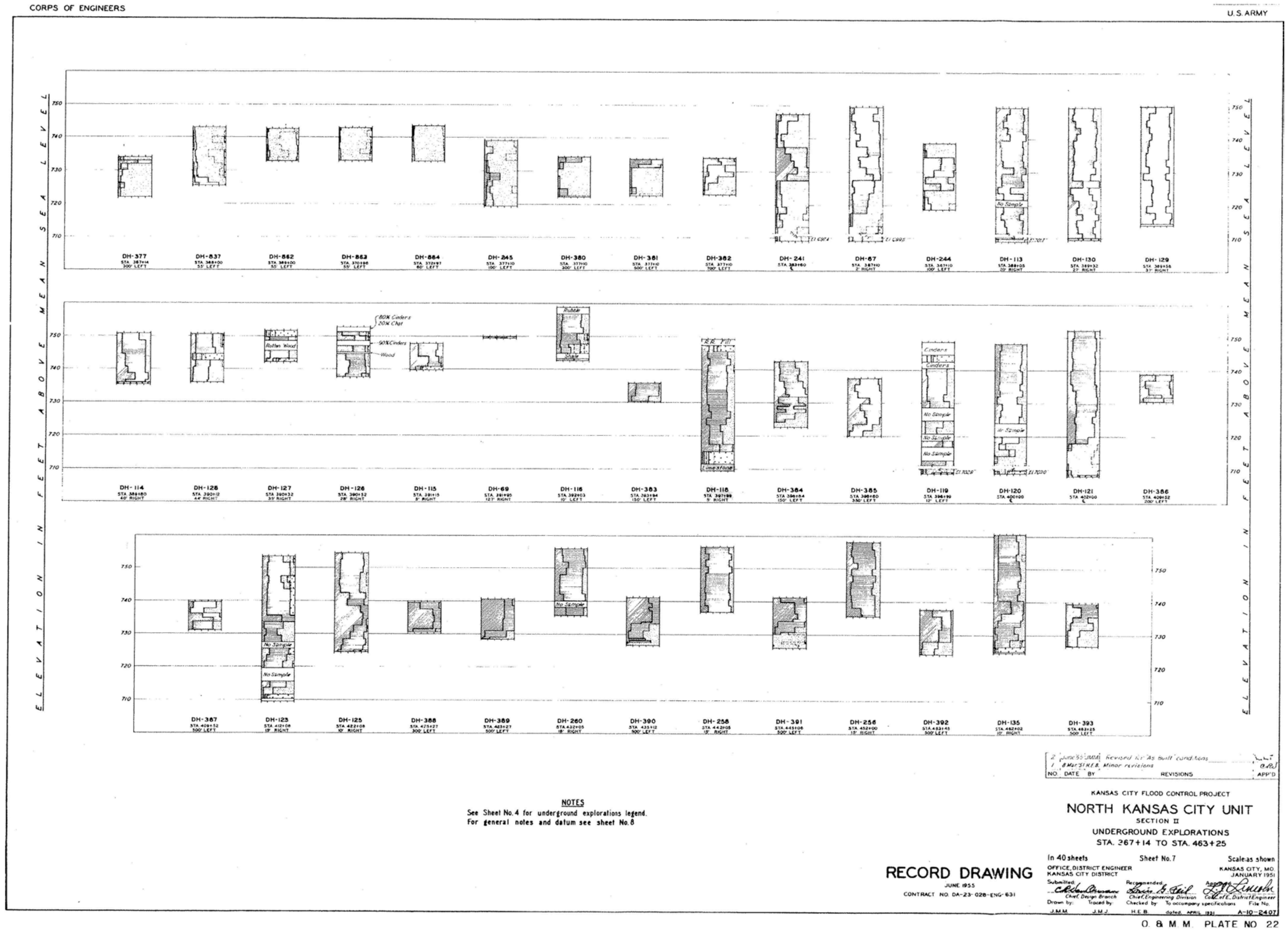
EXHIBIT A-9.28




CORPS OF ENGINEERS
U.S. ARMY
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DH-358
DH-224
DH-223
DH-395
DH-394
DH-42
DH-396
DH-397
DH-398
DH-399
DH-230
DH-228
DH-359
DH-360
DH-400
DH-401
DH-231
DH-229
DH-402
DH-403
DH-404
DH-405
DH-46
DH-361
DH-362
DH-47
DH-406
DH-407
DH-110
DH-250
DH-408
DH-409
DH-232
DH-410
DH-411
DH-855
DH-412
DH-413
DH-50
DH-364
DH-365
DH-857
DH-414
DH-249
DH-233
NOTES
See Sheet No. 4 for underground explorations legend.
For general notes and datum see sheet No. 8
NO DATE BY REVISIONS APP'D
KANSAS CITY FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
SECTION II
UNDERGROUND EXPLORATIONS
STA. 267+13 TO STA. 313+20
In 40 sheets
Sheet No. 5
Scale as shown
OFFICE, DISTRICT ENGINEER
KANSAS CITY DISTRICT
KANSAS CITY, MO
JANUARY 1951
RECORD DRAWING
JUNE 1955
CONTRACT NO. DA-23-028-ENG-531
A-10-2405
O. & M.M. PLATE NO. 20

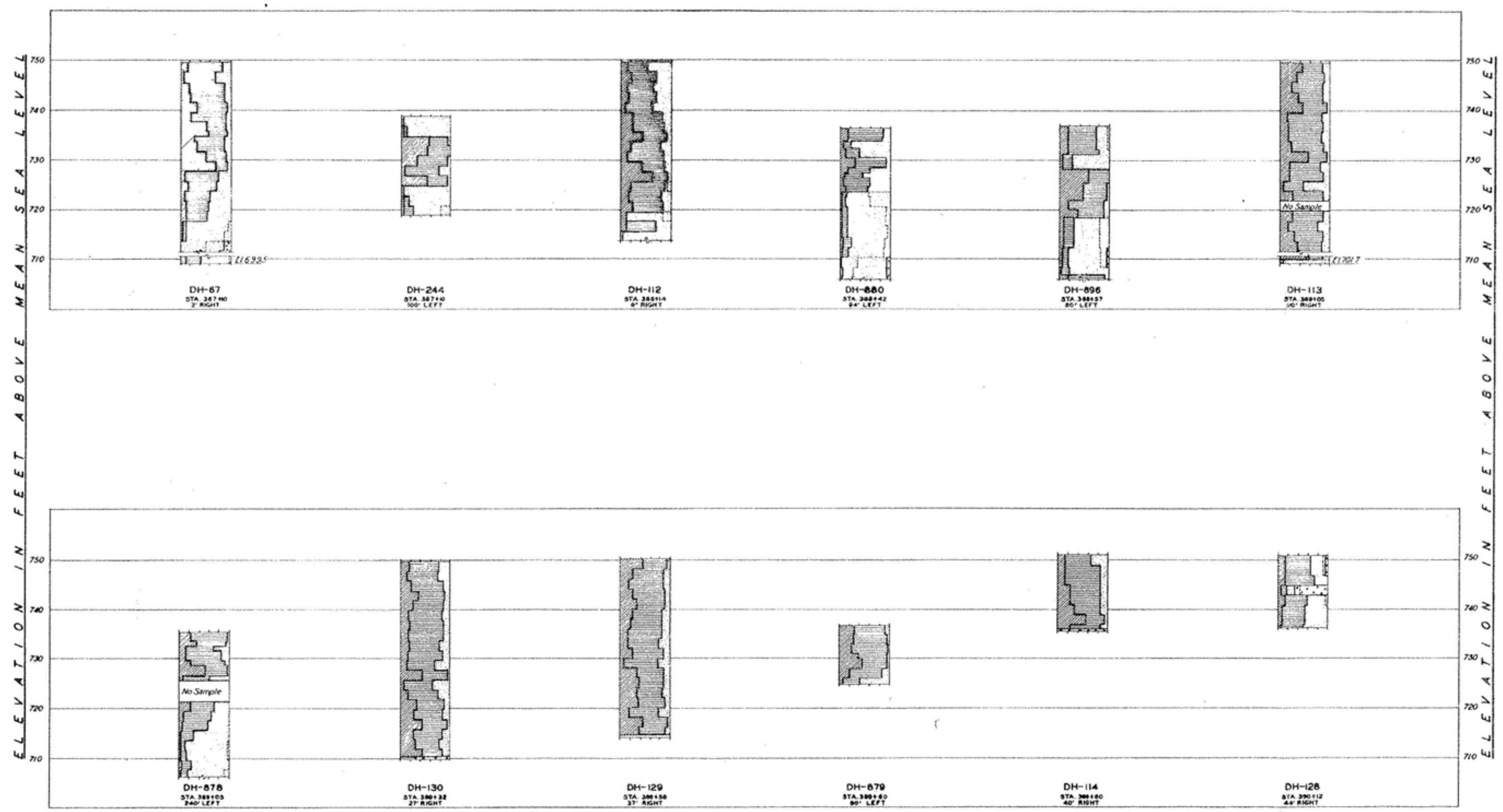

CORPS OF ENGINEERS
U.S. ARMY
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DH-416
DH-847
DH-418
DH-367
DH-52
DH-51
DH-234
DH-248
DH-848
DH-832
DH-838
DH-236
DH-235
DH-840
DH-833
DH-54
DH-55
DH-841
DH-842
DH-834
DH-849
DH-850
DH-851
DH-237
DH-852
DH-56
DH-57
DH-853
DH-865
DH-239
DH-372
DH-373
DH-858
DH-859
DH-59
DH-860
DH-240
DH-861
DH-62
DH-835
DH-843
DH-246
DH-844
DH-845
DH-243
NOTES
See Sheet No.4 for underground explorations legend.
For general notes and datum see sheet No.8
Revised for As Built conditions
8 Mar. 51 H.E.B. Minor revisions
NO. DATE BY REVISIONS APP'D
KANSAS CITY FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
SECTION II
UNDERGROUND EXPLORATIONS
STA. 314+50 TO STA. 367+14
In 40 sheets
Sheet No.6
Scale as shown
OFFICE, DISTRICT ENGINEER
KANSAS CITY DISTRICT
KANSAS CITY, MO.
JANUARY 1951
Submitted:
Recommended:
Approved:
Chief, Design Branch
Chief, Engineering Division
Col. of E., District Engineer
Drawn by: J.M.M.
Traced by: L.B.R.
Checked by: H.E.B.
To accompany specifications dated: APRIL 1951
File No. A-10-2406
RECORD DRAWING
JUNE 1955
CONTRACT NO. DA-23-028-ENG-631
O. & M.M. PLATE NO. 21

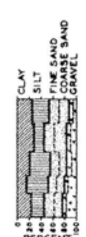

(D-1009)
PP7
ZIMMER WAREHOUSES
SOIL BORING DATA
MISSOURI RIVER
PLAN
PROFILE
TOP OF LEVEE
NOTES: For Legend and Index, see Sheet No. 1.
For Contracts and General Notes, see Sheet No. 4.
The drainage structures on the above Profile are vertically located in respect to the invert elevation of either flap or sluice, whichever is the final outlet gate.
The closure structure (sandbag gap) on the above profile is vertically located in respect to the invert elevation at the centerline of levee.
OPERATIONAL DRAWING
KANSAS CITYS FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
PLAN AND PROFILE
STA. 330+10 TO STA. 402+60
In 17 sheets
Sheet No. 10
Scale: as shown
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
JULY 1976
J.P.M.
OPN-A-10-0221


CORPS OF ENGINEERS
U.S. ARMY
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DH-377
DH-837
DH-862
DH-863
DH-864
DH-245
DH-380
DH-381
DH-382
DH-241
DH-87
DH-244
DH-113
DH-130
DH-129
DH-114
DH-128
DH-127
DH-126
DH-115
DH-69
DH-118
DH-383
DH-118
DH-384
DH-385
DH-119
DH-120
DH-121
DH-386
DH-387
DH-123
DH-125
DH-388
DH-389
DH-260
DH-390
DH-258
DH-391
DH-256
DH-392
DH-135
DH-393
No Sample
NOTES
See Sheet No. 4 for underground explorations legend.
For general notes and datum see sheet No. 8
NO. DATE BY REVISIONS APP'D
KANSAS CITY FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
SECTION II
UNDERGROUND EXPLORATIONS
STA. 267+14 TO STA. 463+25
In 40 sheets
Sheet No. 7
Scale:as shown
OFFICE, DISTRICT ENGINEER
KANSAS CITY DISTRICT
KANSAS CITY, MO.
JANUARY 1951
RECORD DRAWING
JUNE 1955
CONTRACT NO. DA-23-028-ENG-631
Submitted:
Recommended:
Approved:
Chief, Design Branch
Chief, Engineering Division
Col. C of E, District Engineer
Drawn by: J.M.M.
Traced by: J.M.J.
Checked by: H.E.B.
To accompany specifications dated APRIL 1951
File No. A-10-2407
O. & M. M. PLATE NO 22

CORPS OF ENGINEERS

U. S. ARMY





LEGEND FOR UNDERGROUND EXPLORATIONS

Percentages of clay, silt, sand and gravel (Bureau of Soils Classification) are shown by the symbols indicated at left. Percentages of sample passing No. 4 & No. 50 sieves indicated by broken lines.

Drive hole and number............... DH-87

NOTES:

For location of underground explorations see sheet No. 3.

A hole located 82 feet landward of Sta. 389+12 was probed to refusal 31.4 feet below ground surface elevation of 734.8.

RECORD DRAWING

AUGUST 1954

CONTRACT NO. DA-23-028-ENG-633

KANSAS CITY FLOOD CONTROL PROJECT

NORTH KANSAS CITY UNIT

ROCK CREEK PUMPING PLANT

UNDERGROUND EXPLORATIONS

In 16 sheets | Sheet No. 2 | Scale: as shown

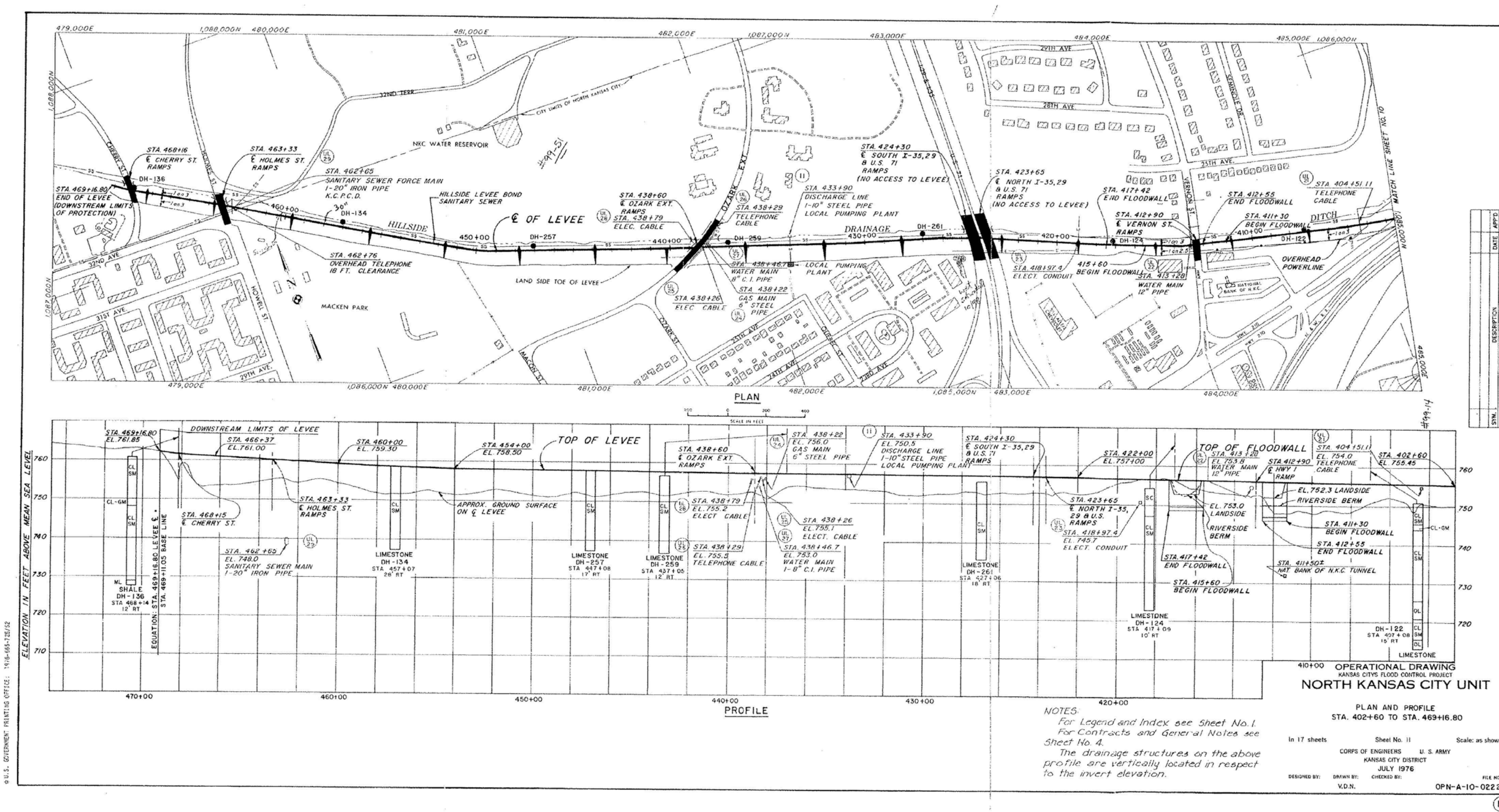
OFFICE, DISTRICT ENGINEER, KANSAS CITY DISTRICT | KANSAS CITY, MO | FEBRUARY 1951

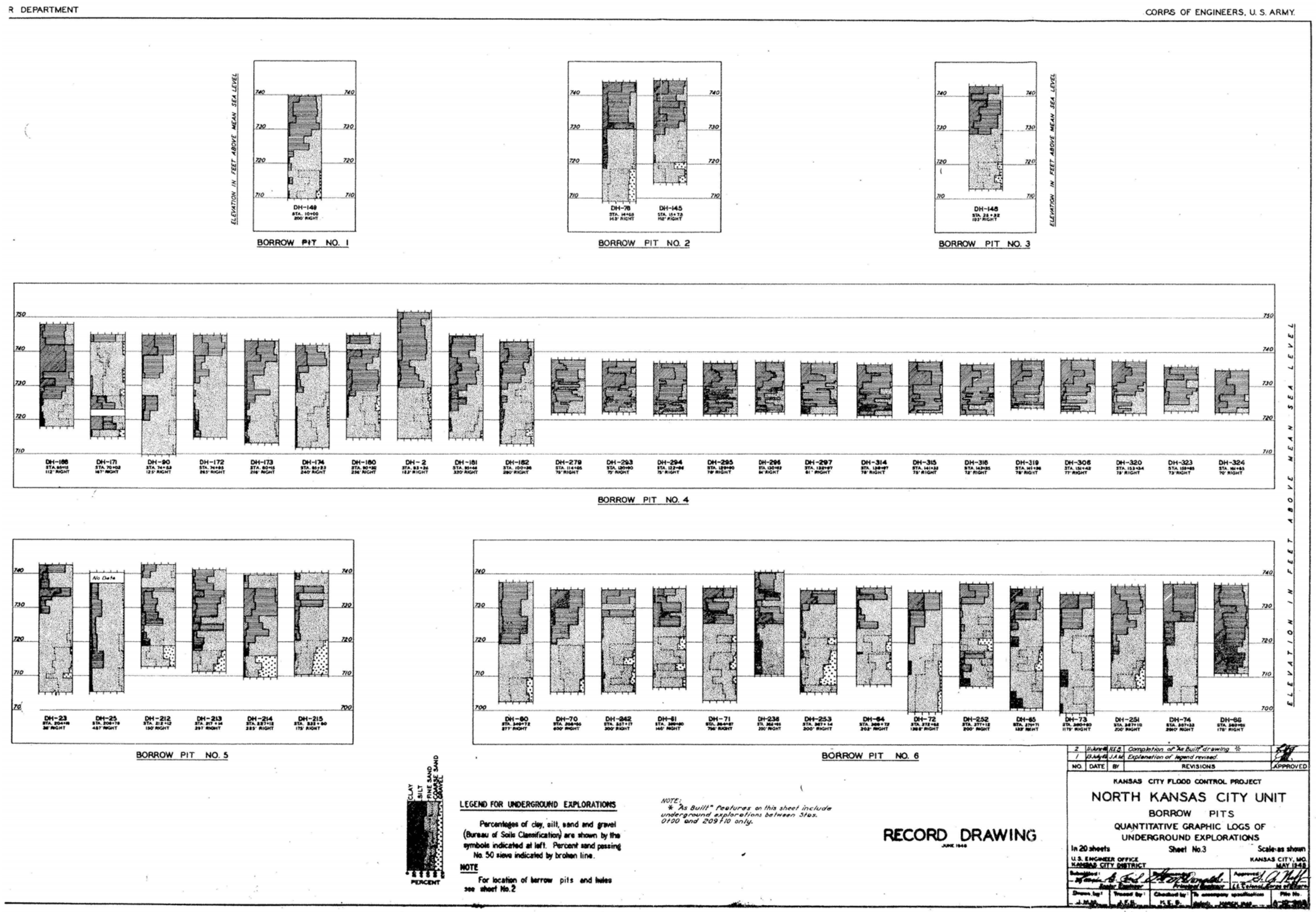
Submitted: Chief, Design Branch | Recommended: Chief, Engineering Division | Approved: Col. C. of E., District Engineer

Drawn by: C.L.W. | Traced by: C.L.W. | Checked by: R.L.G. | To accompany specifications Dated: APRIL 1951 | File No. A-10-2482

O. & M.M. PLATE NO. 66

EXHIBIT A-9.34




R DEPARTMENT
CORPS OF ENGINEERS, U. S. ARMY.
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DH-149
BORROW PIT NO. 1
DH-78
DH-145
BORROW PIT NO. 2
DH-148
BORROW PIT NO. 3
DH-188
DH-171
DH-90
DH-172
DH-173
DH-174
DH-180
DH-2
DH-181
DH-182
DH-279
DH-293
DH-294
DH-295
DH-296
DH-297
DH-314
DH-315
DH-318
DH-319
DH-306
DH-320
DH-323
DH-324
BORROW PIT NO. 4
No Data
DH-23
DH-25
DH-212
DH-213
DH-214
DH-215
BORROW PIT NO. 5
DH-80
DH-70
DH-242
DH-81
DH-71
DH-238
DH-253
DH-64
DH-72
DH-252
DH-65
DH-73
DH-251
DH-74
DH-66
BORROW PIT NO. 6
CLAY
SILT
FINE SAND
COARSE SAND
GRAVEL
PERCENT
LEGEND FOR UNDERGROUND EXPLORATIONS
Percentages of clay, silt, sand and gravel (Bureau of Soils Classification) are shown by the symbols indicated at left. Percent sand passing No. 50 sieve indicated by broken line.
NOTE
For location of borrow pits and holes see sheet No. 2
NOTE:
* "As Built" features on this sheet include underground explorations between Stas. 0+00 and 209+10 only.
RECORD DRAWING
2 | Completion of "As Built" drawing *
1 | Explanation of legend revised.
NO. | DATE | BY | REVISIONS | APPROVED
KANSAS CITY FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
BORROW PITS
QUANTITATIVE GRAPHIC LOGS OF
UNDERGROUND EXPLORATIONS
In 20 sheets
Sheet No. 3
Scale-as shown
U. S. ENGINEER OFFICE
KANSAS CITY DISTRICT
KANSAS CITY, MO.
MAY 1948
Submitted:
Senior Engineer
Principal Engineer
Approved:
Lt. Colonel, Corps of Engineers
Drawn by:
Traced by:
Checked by:
To accompany specification
File No.

Geotechnical Calculations

EXHIBIT A-9.36

Loehr, Scott A NWK

From: Shumate, Eric D NWK
ıt: Friday, July 02, 2004 11:12 AM
Loehr, Scott A NWK
Subject: RE: NKC info needed for report

The 1993 WSEL elevation from our calibrated 1993 RAS model is 754.7 at NKC Station 231+00 (RM 365.73). Using your method with the actual peak gage reading of 48.87 results in 754.67 which is in agreement with the RAS model number.

Eric D. Shumate
Hydraulic Engineer
USACE-CENWK-EC-HH
Tel: 816-983-3117
eric.d.shumate@usace.army.mil

-----Original Message-----
From: Walker, Matthew M NWK
Sent: Thursday, July 01, 2004 3:51 PM
To: Shumate, Eric D NWK
Subject: FW: NKC info needed for report

Can you field this question?

-----Original Message-----
From: Loehr, Scott A NWK
Sent: Thursday, July 01, 2004 3:50 PM
To: Walker, Matthew M NWK
Subject: NKC info needed for report

Could you please tell me what the elevattn of the water was in 1993 peak at Station 231of the NKC unit ? I calculate 753.8 if I use gage of 48 plus 706.4 - 1'/mile fall for 3200 feet. What do you think ?

Scott A. Loehr, P.E.
Geotechnical Branch
Phone: (816) 983-3601
Fax: (816) 426-5462
601 E 12th Street, Room 824
Kansas City, MO 64106

Underseepage Berm Design for
the Harlem Section
North Kansas City Levee Unit
Station 210+00 to 240+00

Written By: Stefanie Voss
Date: October 24, 2003

The Kansas City District underseepage design practice is based on a developed criteria somewhat varying from the USACE EM. The KCD model uses permeability ratios of foundation to blanket thickness based on less conservative assumptions than the USACE model in the EM. This judgment was based service records form the 1951 and 1993 flood experience on existing Kansas City levees.

Before using the spreadsheet established for berm design, hand calculations were performed for the designer to become familiar with the design formulas for underseepage berm requirements. For the Harlem area, stations 210+00 to 240+00, the blanket was assigned a thickness of 10 feet and permeability ratio of 300. Once the underseepage design was calculated by hand, the same numbers were entered into the Excel spreadsheet. The spreadsheet results were compared to the hand calculations, which mostly matched. Any differences were attributed to rounding of the results in the spreadsheet or formulas.

The next calculations considered a thinner blanket based on the review of existing cross-sections. Stations 230+00 to 240+00 were considered to have blanket material thinner than 10 feet. This reach was modeled using a thickness of 5 feet. This reflected the only change in the numbers for calculation. Factors of Safety were lower than the required 1.1 and 1.5 for full and reduced head respectively. To compensate, a berm of greater thickness and width was assigned. The width was extended to 350 feet to achieve a Berm Toe Factor of Safety to 1.1. A berm thickness of 4.2 feet was required to meet the factor of safety of 1.5 at the primary levee toe. A required minimum 5 feet thick berm was assigned. This is required in EM 1110-2-1913, design and Construction of Levees, dated 20 April 2000.

The spreadsheet results were compared to land use maps and aerial photographs to determine the berm alternative cost. While the thickness of the blanket is modeled as uniform in the existing as built records of the cross section through the levee, the thickness appears to decrease, as it gets closer to the Heart of America Bridge. One of the borings, DH-216, was shown as 150 feet landside away from the crown of the levee. Additional subsurface information should be obtained during PED to further refine the underseepage berm limits. At this time conservative lengths of berms will be used for the development of quantities for the berm alternative.

KCKMOS – North Kansas City Unit
Harlem Section (Stations 210+00 to 240+00)

Demolition Plan for the Addition of Berms

- Determine area extent of demolition for affected section.
- Find utilities that would require removal from KCD data.
- Determine what utilities are present in the area from N. Kansas City.
- Find property value data for the buildings within the demolition area from Real Estate.
- Cost estimate the removal or relocation of buildings, streets, utilities, and other items within the demolition boundaries.
- Perform a subsurface investigation to confirm existing conditions are present.
- Determine buyout costs for the affected property owners.
- Meet with property owners to determine if they will accept this alternative.
- If accepted, meet with North Kansas City to plan for traffic rerouting and road and utility relocation.
- If not accepted, move on to different alternative.

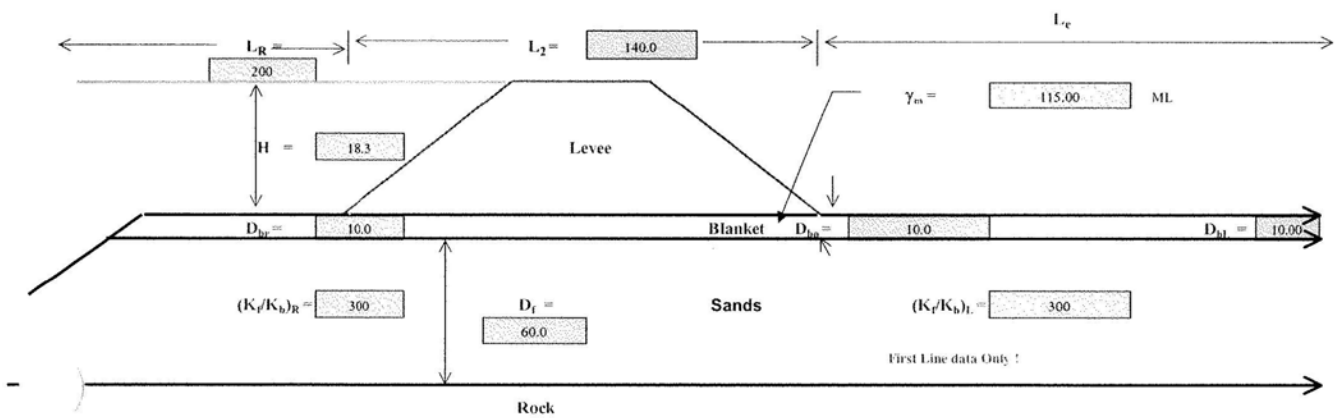
From a driving tour of the area, a few owners have property that back up to the levee toe. While this does not make the alternative infeasible, it will add to the cost of relocating these businesses and individuals. Other alternatives such as relief wells or collector drains may release the seepage pressures, while allowing those individuals to remain in their current property locations.

UNDERSEEPAGE ANALYSIS

Note : This spreadsheet analysis should be used only if the blanket thickness is at least 1/4 of the height of the levee.

KCMOKS Harlem

Designed By: Stefanie Voss | Date : 10/23/2003
Checked By: Loehr | 11/17/2003
Case 1 : Cutoff trench and berm
Revised for Design Flood Hydraulics



Recommended Permeability Ratio
For Foundation Blanket Materials
Chapter Underseepage Revision dated Oct 1998

Blanket Material	Assumed Permeability Ratio, (Kf/Kb)
SM	100
ML	200 to 400
ML-CL	400
CL	400 to 600
CH	800 to 1000

NOMENCLATURE

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height
$H(W_T)$ = head above tailwater at end of underseepage berm
$H(W_T) = H * (W_{T/2}) / (e^{(WT/(2*C)})$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm
$= H * (Le / (L1 + L2 + W_{T/2} + Le))$
W_T = berm width
i_o = seepage gradient
C_r = riverside effective length coefficient
C_L = landside effective length coefficient
where $C = [(Kf/Kb) * Df * Db]^{1/2}$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR C-1)}) / (e^{(2LR C+1)})$
L_2 = levee base width
L_e = landside effective length
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

t' = required Berm thickness at toe
Sc = calc'd slope of underseepage berm
q = seepage /unit Length
Q = cummulated seepage
$FS_i = i_c / i_o$
Shape factor = D_f / L_t or D_f / L'_t

Input Parameters

First row is tied to above graphs! Change Graphics only!

Station	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL}	D_{bo}	D_{br}	D_f	L_R	H	Remarks
Example	300	300	10.0	10.0	10.0	60.0	200	18.3	
210+00 to 240+00	300	300	10.0	10.0	10.0	60.0	200	18.3	Harlem Stretch
Used Borings : D-1008, DH-29									
230+00 to 240+00	300	300	5.0	5.0	5.0	60.0	200	18.3	Harlem Stretch blanket layer is less
Used Borings: DH-216, DH-33									
210+00 to 230+00	300	300	10.0	10.0	10.0	60.0	200	18.3	Harlem Stretch with 10' blanket for portion

Analysis of Without Berm Conditions

C_R Feet	C_L Feet	L_1 Feet	L_2 Feet	L_e Feet	L_t Feet	h_o Feet	i_o Ft/Ft	i_c Ft/Ft	Check #1 Full Head Toe FS_i (need 1.1)	Check #1 Reduced Head Toe FS_i (need 1.5)	Remarks
424	424	186	140	424	751	10.34	1.03	0.84	0.81	0.97	
424	424	186	140	424	751	10.34	1.03	0.84	0.81	0.97	
300	300	175	140	300	615	8.93	1.79	0.85	0.48	0.57	
424	424	186	140	424	751	10.34	1.03	0.85	0.82	0.98	

KCMOKS | Feasibility | Harlem Area | NKC Sta 210+00 to 240+00

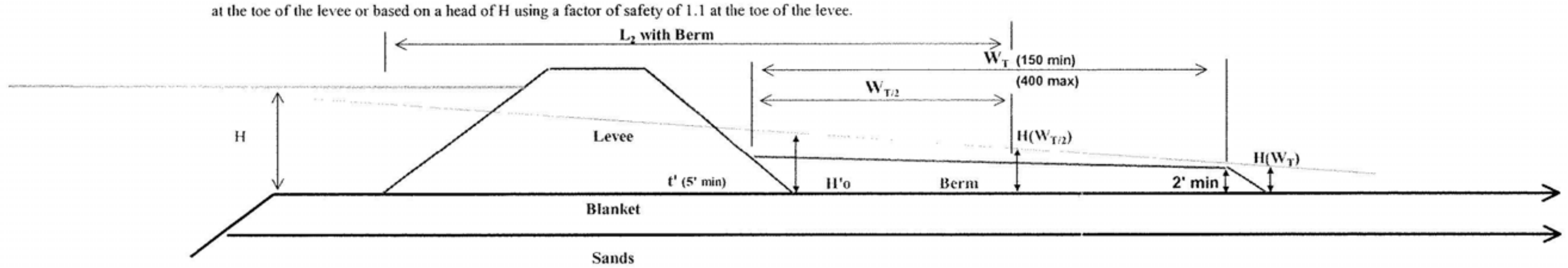
Designer : Name : Stephanie Voss Date : 10/23/2003

Checked : Name : Scott Loehr Date : 11/17/2003

General Notes

Analysis of Existing Conditions : This portion uses full head for the check #1 for FS_i = 1.1 and Full Head less 3 feet for the Check #2 for FS_i = 1.5.
If either of these two columns indicate that the required FS_i is not met then the underseepage berm design is needed.

Berm Design Information : The Excessive head columns provides the designer with a feel for which check case control.
The design of the berm at the toe of the levee requires a FS_i of at least 1.5 for the controlling case. using the reduced head (87% of full head).
The design of the extension of the berm is controlled using full head and a required FS_i of 1.1 at the toe of the berm.
If the FS_i = 1.1 is not met with the width = 400 feet minimum, then the 400 feet is used . The berm thickness required at the toe of the levee is controlled using an H'o at the levee toe set based on FS_i = 1.1, projecting back to the width less than 400 feet, with no adjustment made to H'o.
If the trail width is less than 400 feet, no adjustment to H'o is made. The minimum berm thickness is 5 feet (EM 1110-2-1913). The calculated berm thickness will be based on full head less 3 feet using a Factor of safety of 1.5 at the toe of the levee or based on a head of H using a factor of safety of 1.1 at the toe of the levee.



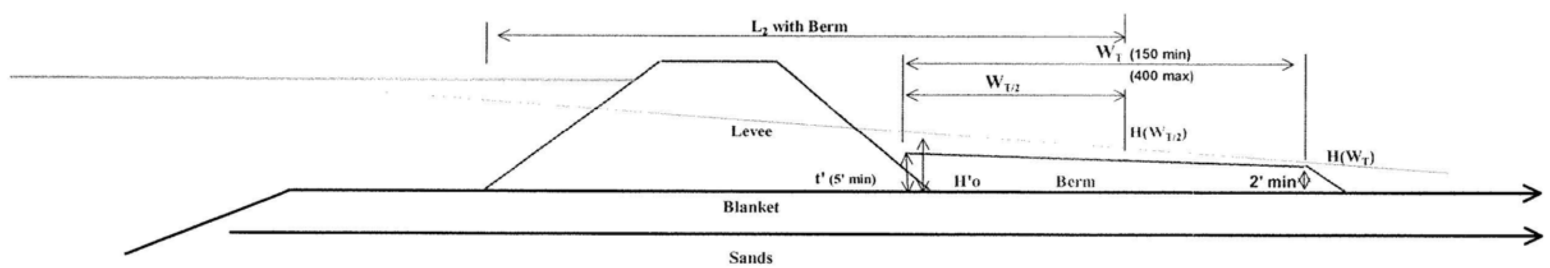
Berm Design Information

Station	Berm Width Design: Excessive Head Control (Feet)		Trial Width	Effective Length	Mid Berm Head, ft	H(WT) Feet	Berm Toe Gradient	Safety Factor	Berm Thickness Design: H'o at Levee Toe	Trial Minimum Berm Thickness	Levee Toe Gradient	Safety Factor Check at Levee Toe	
	FS_i = 1.1	FS_i = 1.5	W_T	L'_t	$H(W_{T/2})$		I_{Berm}	Berm Toe	Feet	t'	I'o	For 1.5	For 1.1
Example	2.68	3.03	**0**	NA	NA	NA	NA	**NA**	NA	**0**	NA	NA	
								Okay	NA	**0**	NA		NA
210+00 to 240+00	2.71	3.05	**200**	851	9.1	7.2	0.72	**1.16**	9.43	**2.5**	0.55	1.52	
								Okay	11.28	**2.1**	0.76		1.11
230+00 to 240+00	5.07	4.63	**350**	790	7.0	3.9	0.78	**1.10**	9.20	**4.2**	0.54	1.56	
								Okay	11.01	**4.2**	0.74		1.15
210+00 to 230+00	2.62	2.98	**200**	851	9.1	7.2	0.72	**1.18**	9.43	**2.5**	0.55	1.53	
								Okay	11.28	**2.1**	0.76		1.12

UNDERSEEPAGE ANALYSIS

	KCMOKS	Feasibility	Harlem Area	NKC Sta 210+00 to 240+00
Designer :	Name :	Stephanie Voss	Date :	10/23/2003
Checked :	Name :	Scott Loehr	Date :	11/17/2003

Revised to reflect criteria developed for L-142



Recommended Final Berm Thickness, Width and Flow Analysis

Begin Station	End Station	Increase in t' for shrinkage settlement and design	Recommended t' (5 feet minimum required)	Recommended W_T	Sc	Shape	k_f	q	q	Length	Q	Berm Quantity	Head (feet)	Spring Point, Y_L (ft) LDSD	Spring Point, Y_R (ft) LDSD
Feet	Feet	Includes 25% Feet	Feet	Feet	Ft/Ft	Factor	(gpd/sq.ft)	(gpd/ft)	(cfs/ft)	Feet	(cfs)	Cubic Yards			
0.00		0.00	**0.0**	**0**	NA	0.0799	2400	3510.52	0.0054	#VALUE!	#VALUE!	0			
21000.00	24000.00	3.13	**5.0**	**200**	67	0.0705	2400	3097.84	0.0048	3000.00	14.4	85556	18.3		NA
23000.00	24000.00	5.25	**5.0**	**350**	117	0.0760	2400	3336.39	0.0052	1000.00	5.2	49907	18.3		NA
21000.00	23000.00	3.13	**5.0**	**200**	67	0.0705	2400	3097.84	0.0048	2000.00	9.6	57037	18.3		NA
										Trial 2 & 3 Total Yards		106944	Cubic Yards		

Total Underseepage :	14.8	CFS

EXHIBIT A-9.42

Gradient

UNDERSEEPAGE ANALYSIS

Date :

Revised purple alignment for baseline
Crest width (feet)
Horizontal to vertical slope ratio

K-r = riverside permeability
K-L = landside permeability
Dbr = riverside blanket thickness
DbL = landside blanket thickness
Df = thickness of pervious foundation
Lr = length of riverside blanket
Ll = length of landside blanket

H = max head or levee height
Hwt = head above tailwater at berm end
H'wt = head above tailwater at 1/2 berm
H'o = head above tailwater at levee toe (w/ berm)
i-c = critical seepage gradient
Wt = berm width
i-o = seepage gradient
Cr = riverside effective length coefficient
Cl = landside effective length coefficient
L1 = riverside effective length

L2 = levee base width
Le = landside effective length
Lt = total effective length
t' = underseepage berm thickness at toe
Sc = calculated slope of underseepage berm
tu = used thickness of underseepage berm
Su = used slope of underseepage berm
kf = permeability of aquifer
q = sepage /unit length
Q = cummulated seepage

Station	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety Factor	L't	Hwt	H'wt	i-o	Cr	Cl	L1	L2	Le	Lt	H'o	t'	Sc	Shape Factor	kf gpd/sq ft)	q (gpd/ft)	q (cfs/ft)	Length (ft)	Q (cfs)
NKC Sta 234	100	100	5	5	5	85	15	0.84	200	0	0.67	491	6.3	6.3	1.26	206	206	154	130	206	491	NA	NA	NA	0.1733	2120	5510.51	0.0085	700.00	6.0
top of levee	300	300	10	10	10	85	15	0.84	200	0	0.92	825	9.2	9.2	0.92	505	505	190	130	505	825	NA	NA	NA	0.1030	2120	3275.83	0.0051	700.00	3.5

x	Hx
25	5.584255
50	4.946515
100	3.881213
125	3.437965
150	3.045338
175	2.697551
200	2.389481
225	2.116595
250	1.874873

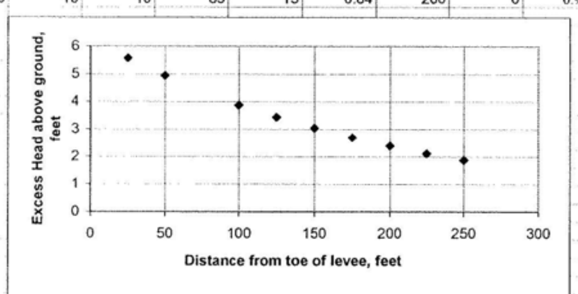
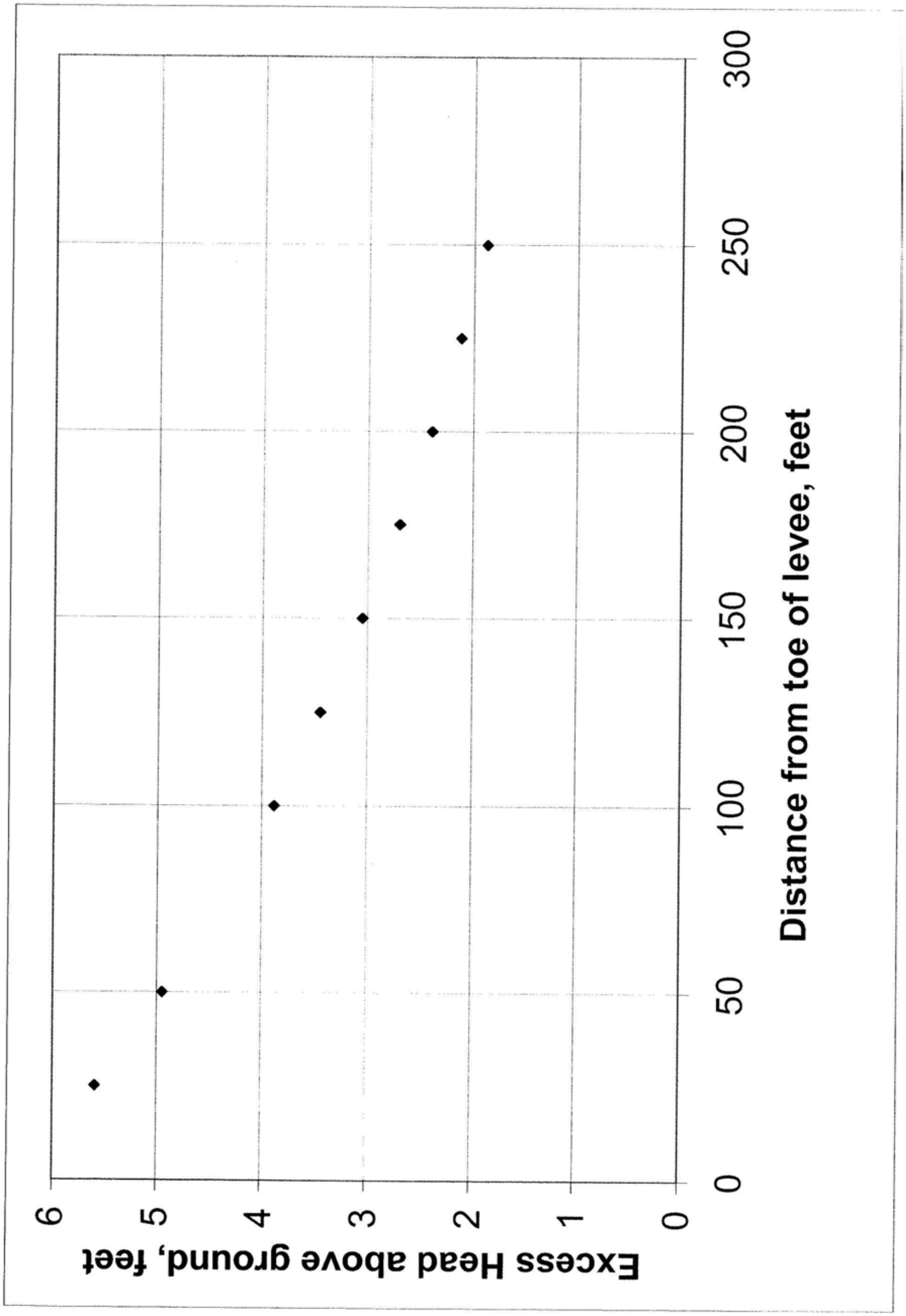
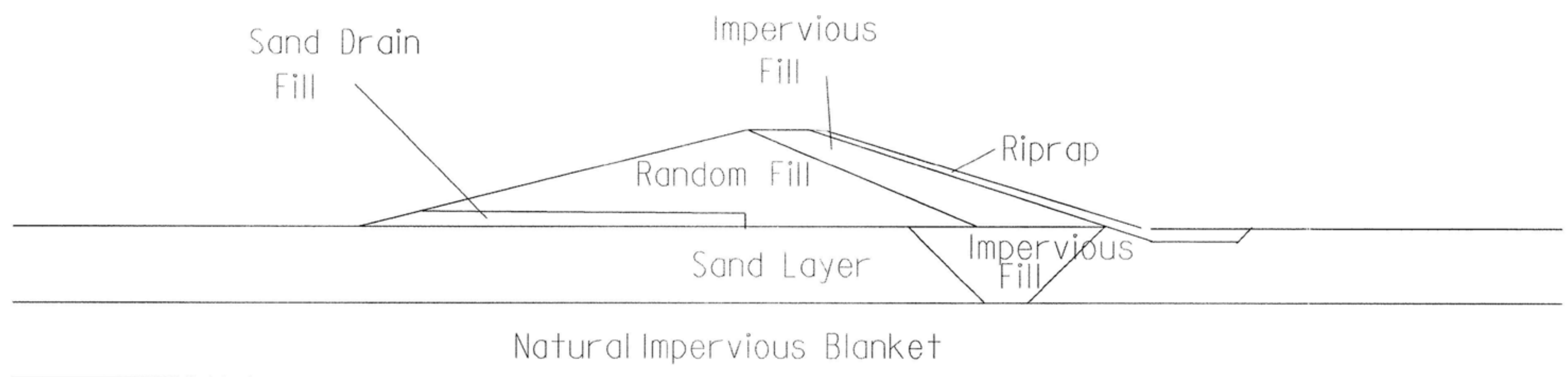


EXHIBIT A-9.43





North Kansas City

Station 235+00

Existing Conditions

UNDERSEEPAGE ANALYSIS				Reliability
North Kansas City			Loehr :	EC-GD
Missouri			Date :	6-Jul-04
Station 230 to 240			Peer review :	RSK 30 July 04
Crest width (feet)		10.00		

Using River Mile 365.7

RM 365.6 100-yr = 748.7'
500-yr = 754.3'

RM 365.84 100-yr = 748.8'
500-yr = 754.5'

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe $= H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm $= H*L_e/L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

use ic=0.86/0.7= 1.23
observed uplift no boils

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where $C = [(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

MEAN UNDER SEEPAGE VALUES

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
230 to 240	300	300	5.00	5.00	5.00	90.0	0.10	1.230	350.00	30.00	134.72	773	0.05	0.05	0.01	367	367	272	118	367	758	0.05
230 to 240	300	300	5.00	5.00	5.00	90.0	4.00	1.230	350.00	30.00	3.37	773	1.90	1.83	0.37	367	367	272	118	367	758	1.98
230 to 240	300	300	5.00	5.00	5.00	90.0	8.00	1.230	350.00	30.00	1.68	773	3.80	3.65	0.73	367	367	272	118	367	758	3.96
230 to 240	300	300	5.00	5.00	5.00	90.0	10.00	1.230	350.00	30.00	1.35	773	4.76	4.57	0.91	367	367	272	118	367	758	4.95
230 to 240	300	300	5.00	5.00	5.00	90.0	14.50	1.230	350.00	30.00	0.93	773	6.90	6.62	1.32	367	367	272	118	367	758	7.18
230 to 240	300	300	5.00	5.00	5.00	90.0	18.00	1.230	350.00	30.00	0.75	773	8.56	8.22	1.64	367	367	272	118	367	758	8.91

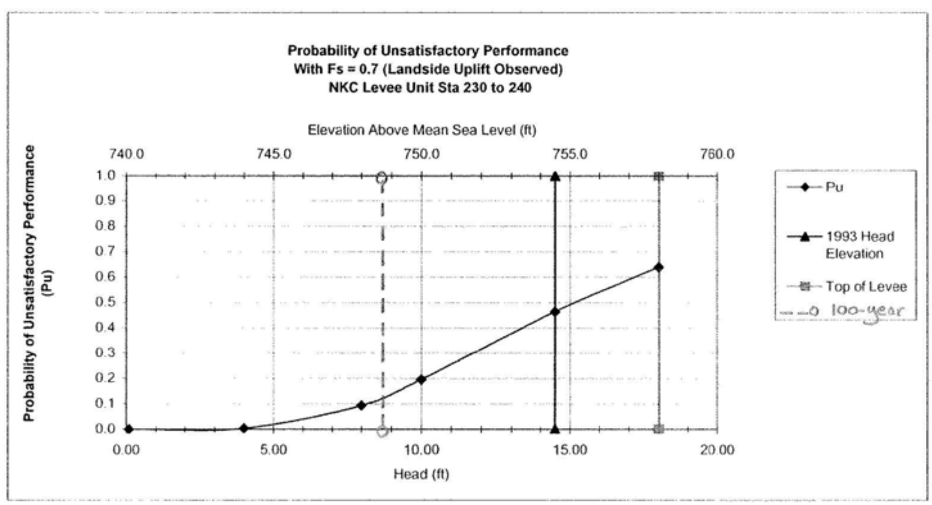


Table 1 : Random Variables for the NKC Levee Unit

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.00	2.50	50.00
Perm Ratio	300	120.00	40.00
Fdn Sand d	90.0	18.00	20.00

Head (ft)	Pu	Elevation (ft)	
0.10	0.0000000	740.10	
4.00	0.0029509	744.00	
8.00	0.0934795	748.00	
10.00	0.1954115	750.00	
14.50	0.4642784	754.50	1993
18.00	0.6396525	758.00	top Levee

UNDERSEEPAGE ANALYSIS			Reliability
North Kansas City		Loehr	EC-GD
Missouri		Date :	6-Jul-04
Station 230 to 240			
Crest width (feet)	10.00		

RSK 7/30/04

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe
$= H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm
$= H*L_e/L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where $C = [(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 1

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
230 to 240	**300**	**300**	**5.00**	**5.00**	**5.00**	**90.00**	**0.10**	**1.230**	**350.00**	**30.00**	**134.72**	**773**	**0.05**	**0.05**	**0.01**	**367**	**367**	**272**	**118**	**367**	**758**	**0.05**
230 to 240	**180**	**180**	**5.00**	**5.00**	**5.00**	**90.00**	**0.10**	**1.230**	**350.00**	**30.00**	**149.74**	**657**	**0.04**	**0.04**	**0.01**	**285**	**285**	**240**	**118**	**285**	**642**	**0.05**
230 to 240	**420**	**420**	**5.00**	**5.00**	**5.00**	**90.00**	**0.10**	**1.230**	**350.00**	**30.00**	**125.59**	**858**	**0.05**	**0.05**	**0.01**	**435**	**435**	**290**	**118**	**435**	**843**	**0.05**
230 to 240	**300**	**300**	**2.50**	**2.50**	**2.50**	**90.00**	**0.10**	**1.230**	**350.00**	**30.00**	**77.71**	**620**	**0.04**	**0.04**	**0.02**	**260**	**260**	**227**	**118**	**260**	**605**	**0.04**
230 to 240	**300**	**300**	**7.50**	**7.50**	**7.50**	**90.00**	**0.10**	**1.230**	**350.00**	**30.00**	**185.70**	**876**	**0.05**	**0.05**	**0.01**	**450**	**450**	**293**	**118**	**450**	**861**	**0.05**
230 to 240	**300**	**300**	**5.00**	**5.00**	**5.00**	**72.00**	**0.10**	**1.230**	**350.00**	**30.00**	**141.12**	**720**	**0.05**	**0.04**	**0.01**	**329**	**329**	**259**	**118**	**329**	**705**	**0.05**
230 to 240	**300**	**300**	**5.00**	**5.00**	**5.00**	**108.00**	**0.10**	**1.230**	**350.00**	**30.00**	**129.69**	**818**	**0.05**	**0.05**	**0.01**	**402**	**402**	**282**	**118**	**402**	**803**	**0.05**

	Kf/Kb	D_{bo}	D_f	$L_e = C$	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	300	5.00	90.0	367	390	0.05	0.01		
	180	5.00	90.0	285	358	0.04	0.01	0.0000006	2.8426
	420	5.00	90.0	435	408	0.05	0.01		
	300	2.50	90.0	260	345	0.04	0.02	0.0000212	96.485
	300	7.50	90.0	450	411	0.05	0.01		
	300	5.00	72.0	329	377	0.04	0.01	0.0000001	0.6724
	300	5.00	108.0	402	400	0.05	0.01		
							Total	0.0000220	100

E[I] =	0.009130098
Var[I]=	2.19545E-05
sigma[I]=	0.004685563
COV(I) =	0.513199657
I crit =	1.230

E[ln I] =	-4.81307
sigma [ln I] =	0.483514
ln(I crit) =	0.20701

BETA	10.38250279
Pu	0.0000000

F(z) =	1.00000
Pu(%) =	0.00000

Table 1 : Random Variables for the NKC Levee Unit			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.00	2.50	50.00
Perm Ratio	300	120.00	40.00
Fdn Sand d	90.0	18.00	20.00

Head	Pu
0.10	0.0000000
0.10	0.0000000
0.10	0.0000000
0.10	0.0000000
0.10	0.0000000
0.10	0.0000000
0.10	0.0000000

UNDERSEEPAGE ANALYSIS
North Kansas City
Missouri

Reliability
Loehr : EC-GD
Date : 6-Jul-04

Crest width (feet) 10.00

RSK 7/30/04

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe
$= H(W_T/2) * e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm
$= H*L_e/L'_1$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where $C = [(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 2

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
230 to 240	300	300	5.00	5.00	5.00	90.00	4.00	1.230	350.00	30.00	3.37	773	1.90	1.83	0.37	367	367	272	118	367	758	1.98
230 to 240	180	180	5.00	5.00	5.00	90.00	4.00	1.230	350.00	30.00	3.74	657	1.73	1.64	0.33	285	285	240	118	285	642	1.82
230 to 240	420	420	5.00	5.00	5.00	90.00	4.00	1.230	350.00	30.00	3.14	858	2.03	1.96	0.39	435	435	290	118	435	843	2.10
230 to 240	300	300	2.50	2.50	2.50	90.00	4.00	1.230	350.00	30.00	1.94	620	1.68	1.58	0.63	260	260	227	118	260	605	1.77
230 to 240	300	300	7.50	7.50	7.50	90.00	4.00	1.230	350.00	30.00	4.64	876	2.05	1.99	0.26	450	450	293	118	450	861	2.12
230 to 240	300	300	5.00	5.00	5.00	72.00	4.00	1.230	350.00	30.00	3.53	720	1.82	1.74	0.35	329	329	259	118	329	705	1.91
230 to 240	300	300	5.00	5.00	5.00	108.00	4.00	1.230	350.00	30.00	3.24	818	1.97	1.90	0.38	402	402	282	118	402	803	2.04

	Kf/Kb	D_{bo}	D_f	$L_e = C$	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	300	5.00	90.0	367	390	1.83	0.37		
	180	5.00	90.0	285	358	1.64	0.33	0.0009985	2.8426
	420	5.00	90.0	435	408	1.96	0.39		
	300	2.50	90.0	260	345	1.58	0.63	0.0338925	96.485
	300	7.50	90.0	450	411	1.99	0.26		
	300	5.00	72.0	329	377	1.74	0.35	0.0002362	0.6724
	300	5.00	108.0	402	400	1.90	0.38		
							Total	0.0351272	100

E[I] =	0.365203929
Var[I]=	0.035127205
sigma[I]=	0.187422531
COV(I) =	0.513199657
I crit =	1.230

E[ln I] =	-1.12419
sigma [ln I] =	0.483514
ln(I crit) =	0.20701

BETA	2.753190881
Pu	0.0029509
F(z) =	0.99705
Pu(%) =	0.29509

Table 1 : Random Variables for the NKC Levee Unit

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.00	2.50	50.00
Perm Ratio	300.00	120.00	40.00
Fdn Sand d	90.00	18.00	20.00

Head	Pu
4.00	0.0029509
4.00	0.0029509
4.00	0.0029509
4.00	0.0029509
4.00	0.0029509
4.00	0.0029509
4.00	0.0029509

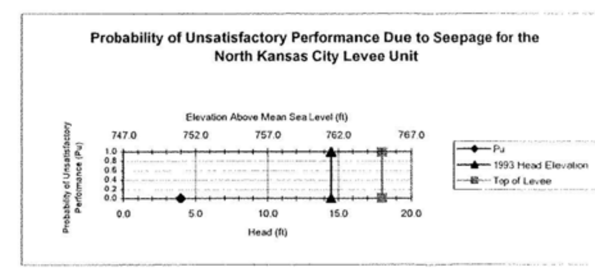


EXHIBIT A-9.48

UNDERSEEPAGE ANALYSIS
North Kansas City
Missouri

Crest width (feet) 10.00

Reliability
Loehr : EC-GL
Date : 6-Jul-04

RSK 7/30/04

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe $= H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm $= H*L_e/L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where C = $[(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 3

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
230 to 240	300	300	5.00	5.00	5.00	90.00	8.00	1.230	350.00	30.00	1.68	773	3.80	3.65	0.73	367	367	272	118	367	758	3.96
230 to 240	180	180	5.00	5.00	5.00	90.00	8.00	1.230	350.00	30.00	1.87	657	3.46	3.29	0.66	285	285	240	118	285	642	3.65
230 to 240	420	420	5.00	5.00	5.00	90.00	8.00	1.230	350.00	30.00	1.57	858	4.06	3.92	0.78	435	435	290	118	435	843	4.20
230 to 240	300	300	2.50	2.50	2.50	90.00	8.00	1.230	350.00	30.00	0.97	620	3.35	3.17	1.27	260	260	227	118	260	605	3.55
230 to 240	300	300	7.50	7.50	7.50	90.00	8.00	1.230	350.00	30.00	2.32	876	4.11	3.97	0.53	450	450	293	118	450	861	4.25
230 to 240	300	300	5.00	5.00	5.00	72.00	8.00	1.230	350.00	30.00	1.76	720	3.65	3.49	0.70	329	329	259	118	329	705	3.82
230 to 240	300	300	5.00	5.00	5.00	108.00	8.00	1.230	350.00	30.00	1.62	818	3.94	3.79	0.76	402	402	282	118	402	803	4.08

	Kf/Kb	D_{bo}	D_f	L_e = C	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	300	5.00	90.0	367	390	3.65	0.73		
	180	5.00	90.0	285	358	3.29	0.66	0.0039940	2.8426
	420	5.00	90.0	435	408	3.92	0.78		
	300	2.50	90.0	260	345	3.17	1.27	0.1355700	96.485
	300	7.50	90.0	450	411	3.97	0.53		
	300	5.00	72.0	329	377	3.49	0.70	0.0009448	0.6724
	300	5.00	108.0	402	400	3.79	0.76		
							Total	0.1405088	100

E[I] =	0.730407858
Var[I]=	0.14050882
sigma[I]=	0.374845062
COV(I) =	0.513199657
I crit =	1.230

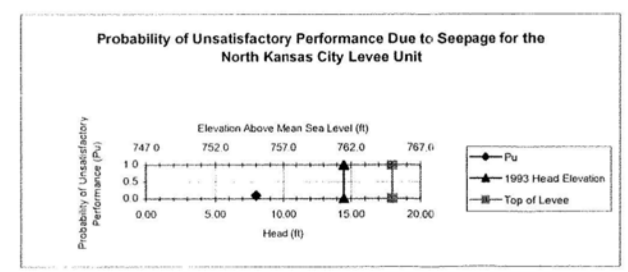
E[ln I] =	-0.43105
sigma [ln I] =	0.483514
ln(I crit) =	0.20701

BETA	1.319629252
Pu	0.0934795
F(z) =	0.90652
Pu(%) =	9.34795

Table 1 : Random Variables for the NKC Levee Unit

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.00	2.50	50.00
Perm Ratio	300	120.00	40.00
Fdn Sand d	90.0	18.00	20.00

Head	Pu
8.00	0.0934795
8.00	0.0934795
8.00	0.0934795
8.00	0.0934795
8.00	0.0934795
8.00	0.0934795
8.00	0.0934795



UNDERSEEPAGE ANALYSIS
North Kansas City
Missouri

Reliability
Loehr : EC-GL
Date : 6-Jul-04

Crest width (feet) 10.00

RSK 7/30/04

Probability of Levee Failure Due to Underseepage

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe $= H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm $= H*L_e/L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where C = $[(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 4

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
230 to 240	300	300	5.00	5.00	5.00	90.00	10.00	1.230	350.00	30.00	1.35	773	4.76	4.57	0.91	367	367	272	118	367	758	4.95
230 to 240	180	180	5.00	5.00	5.00	90.00	10.00	1.230	350.00	30.00	1.50	657	4.33	4.11	0.82	285	285	240	118	285	642	4.56
230 to 240	420	420	5.00	5.00	5.00	90.00	10.00	1.230	350.00	30.00	1.26	858	5.07	4.90	0.98	435	435	290	118	435	843	5.24
230 to 240	300	300	2.50	2.50	2.50	90.00	10.00	1.230	350.00	30.00	0.78	620	4.19	3.96	1.58	260	260	227	118	260	605	4.43
230 to 240	300	300	7.50	7.50	7.50	90.00	10.00	1.230	350.00	30.00	1.86	876	5.14	4.97	0.66	450	450	293	118	450	861	5.31
230 to 240	300	300	5.00	5.00	5.00	72.00	10.00	1.230	350.00	30.00	1.41	720	4.56	4.36	0.87	329	329	259	118	329	705	4.77
230 to 240	300	300	5.00	5.00	5.00	108.00	10.00	1.230	350.00	30.00	1.30	818	4.92	4.74	0.95	402	402	282	118	402	803	5.11

	Kf/Kb	D_{bo}	D_f	$L_e = C$	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	300	5.00	90.0	367	390	4.57	0.91		
	180	5.00	90.0	285	358	4.11	0.82	0.0062407	2.8426
	420	5.00	90.0	435	408	4.90	0.98		
	300	2.50	90.0	260	345	3.96	1.58	0.2118281	96.485
	300	7.50	90.0	450	411	4.97	0.66		
	300	5.00	72.0	329	377	4.36	0.87	0.0014763	0.6724
	300	5.00	108.0	402	400	4.74	0.95		
							Total	0.2195450	100

E[I] =	0.913009822
Var[I]=	0.219545032
sigma[I]=	0.468556327
COV(I) =	0.513199657
I crit =	1.230

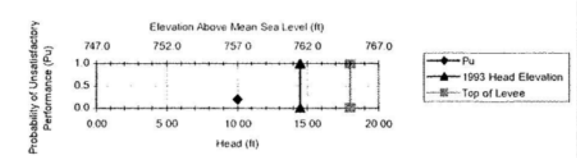
E[ln I] =	-0.20790
sigma [ln I] =	0.483514
ln(I crit) =	0.20701

BETA	0.858125488
Pu	0.1954115
F(z) =	0.80459
Pu(%) =	19.54115

Table 1 : Random Variables for the NKC Levee Unit

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.00	2.50	50.00
Perm Ratio	300	120.00	40.00
Fdn Sand d	90.0	18.00	20.00

Probability of Unsatisfactory Performance Due to Seepage for the North Kansas City Levee Unit



Head	Pu
10.00	0.1954115
10.00	0.1954115
10.00	0.1954115
10.00	0.1954115
10.00	0.1954115
10.00	0.1954115
10.00	0.1954115

EXHIBIT A-9.50

UNDERSEEPAGE ANALYSIS
North Kansas City
Missouri

Crest width (feet) 10.00

Reliability
Loehr : EC-GD
Date : 6-Jul-04

RSK 7/30/04

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe $= H(W_T/2) \cdot e^{(-WT/(2 \cdot CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm $= H \cdot L_e / L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where $C = [(Kf/Kb) \cdot Df \cdot Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C \cdot (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 1993

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
230 to 240	300	300	5.00	5.00	5.00	90.00	14.50	1.230	350.00	30.00	0.93	773	6.90	6.62	1.32	367	367	272	118	367	758	7.18
230 to 240	180	180	5.00	5.00	5.00	90.00	14.50	1.230	350.00	30.00	1.03	657	6.28	5.96	1.19	285	285	240	118	285	642	6.61
230 to 240	420	420	5.00	5.00	5.00	90.00	14.50	1.230	350.00	30.00	0.87	858	7.35	7.10	1.42	435	435	290	118	435	843	7.60
230 to 240	300	300	2.50	2.50	2.50	90.00	14.50	1.230	350.00	30.00	0.54	620	6.08	5.74	2.30	260	260	227	118	260	605	6.43
230 to 240	300	300	7.50	7.50	7.50	90.00	14.50	1.230	350.00	30.00	1.28	876	7.45	7.20	0.96	450	450	293	118	450	861	7.70
230 to 240	300	300	5.00	5.00	5.00	72.00	14.50	1.230	350.00	30.00	0.97	720	6.61	6.32	1.26	329	329	259	118	329	705	6.92
230 to 240	300	300	5.00	5.00	5.00	108.00	14.50	1.230	350.00	30.00	0.89	818	7.14	6.88	1.38	402	402	282	118	402	803	7.40

	Kf/Kb	D_{bo}	D_f	$L_e = C$	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	300	5.00	90.0	367	390	6.62	1.32		
	180	5.00	90.0	285	358	5.96	1.19	0.0131210	2.8426
	420	5.00	90.0	435	408	7.10	1.42		
	300	2.50	90.0	260	345	5.74	2.30	0.4453685	96.485
	300	7.50	90.0	450	411	7.20	0.96		
	300	5.00	72.0	329	377	6.32	1.26	0.0031039	0.6724
	300	5.00	108.0	402	400	6.88	1.38		
							Total	0.4615934	100

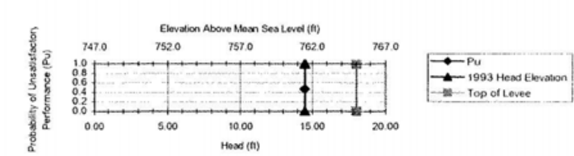
E[I] =	1.323864242
Var[I]=	0.461593429
sigma[I]=	0.679406674
COV(I) =	0.513199657
I crit =	1.230

E[ln I] =	0.16366
sigma [ln I] =	0.483514
ln(I crit) =	0.20701

BETA	0.089660619
Pu	0.4642784
F(z) =	0.53572
Pu(%) =	46.42784

Table 1 : Random Variables for the NKC Levee Unit			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.00	2.50	50.00
Perm Ratio	300	120.00	40.00
Fdn Sand d	90.0	18.00	20.00

Probability of Unsatisfactory Performance Due to Seepage for the North Kansas City Levee Unit



1993 Flood	
Head	Pu
14.50	0.4642784
14.50	0.4642784
14.50	0.4642784
14.50	0.4642784
14.50	0.4642784
14.50	0.4642784
14.50	0.4642784

UNDERSEEPAGE ANALYSIS
North Kansas City
Missouri

Reliability
Loehr : EC-GD
Date : 6-Jul-04

Crest width (feet) 10.00

RSK 7/30/04

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe
$= H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm
$= H*L_e/L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where $C = [(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 5

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
230 to 240	300	300	5.00	5.00	5.00	90.00	18.00	1.230	350.00	30.00	0.75	773	8.56	8.22	1.64	367	367	272	118	367	758	8.91
230 to 240	180	180	5.00	5.00	5.00	90.00	18.00	1.230	350.00	30.00	0.83	657	7.79	7.39	1.48	285	285	240	118	285	642	8.20
230 to 240	420	420	5.00	5.00	5.00	90.00	18.00	1.230	350.00	30.00	0.70	858	9.12	8.81	1.76	435	435	290	118	435	843	9.44
230 to 240	300	300	2.50	2.50	2.50	90.00	18.00	1.230	350.00	30.00	0.43	620	7.55	7.12	2.85	260	260	227	118	260	605	7.98
230 to 240	300	300	7.50	7.50	7.50	90.00	18.00	1.230	350.00	30.00	1.03	876	9.25	8.94	1.19	450	450	293	118	450	861	9.55
230 to 240	300	300	5.00	5.00	5.00	72.00	18.00	1.230	350.00	30.00	0.78	720	8.21	7.84	1.57	329	329	259	118	329	705	8.59
230 to 240	300	300	5.00	5.00	5.00	108.00	18.00	1.230	350.00	30.00	0.72	818	8.86	8.54	1.71	402	402	282	118	402	803	9.19

	Kf/Kb	D_{bo}	D_f	$L_e = C$	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	300	5.00	90.0	367	390	8.22	1.64		
	180	5.00	90.0	285	358	7.39	1.48	0.0202198	2.8426
	420	5.00	90.0	435	408	8.81	1.76		
	300	2.50	90.0	260	345	7.12	2.85	0.6863230	96.485
	300	7.50	90.0	450	411	8.94	1.19		
	300	5.00	72.0	329	377	7.84	1.57	0.0047831	0.6724
	300	5.00	108.0	402	400	8.54	1.71		
							Total	0.7113259	100

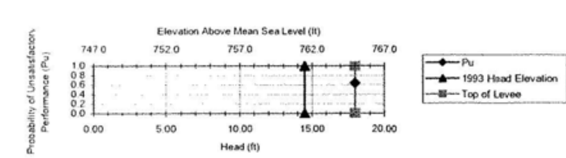
E[I] =	1.64341768
Var[I]=	0.711325903
sigma[I]=	0.843401389
COV(I) =	0.513199657
I crit =	1.230

E[ln I] =	0.37989
sigma [ln I] =	0.483514
ln(I crit) =	0.20701

BETA	-0.357530338
Pu	0.6396525
F(z) =	0.36035
Pu(%) =	63.96525

Table 1 : Random Variables for the NKC Levee Unit			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.00	2.50	50.00
Perm Ratio	300	120.00	40.00
Fdn Sand d	90.0	18.00	20.00

Probability of Unsatisfactory Performance Due to Seepage for the North Kansas City Levee Unit



Head	Pu
18.00	0.6396525
18.00	0.6396525
18.00	0.6396525
18.00	0.6396525
18.00	0.6396525
18.00	0.6396525
18.00	0.6396525

EXHIBIT A-9.52
Missouri River Existing Conditions Water Surface Elevations

Reach	Controlling Discharge	HEC-RAS River Mile	Profile Frequency Percent	Year	Q Total (cfs)	Water Surface Elevation (ft)	Energy Grade Elevation (ft)	Energy Grade Slope (ft/ft)	Average Channel Velocity (ft/s)	Flow Area (sq ft)	Top Width (ft)	Channel Froude #
Lower	Lower Missouri	365.43	0.5%	200	454,000	750.3	751.9	0.00027	10.4	47,633	1,412	0.28
Lower	Lower Missouri	365.43	0.2%	500	530,000	753.4	755.3	0.00029	11.3	52,105	1,456	0.30
Lower	Lower Missouri	365.43	0.133%	750	565,000	754.7	756.7	0.00030	11.7	53,944	1,474	0.30
Lower	Lower Missouri	365.43	0.100%	1,000	590,000	755.6	757.7	0.00030	11.9	55,335	1,485	0.31
Lower	Lower Missouri	365.43	0.080%	1,250	610,000	756.4	758.5	0.00030	12.1	56,436	1,493	0.31
Lower	Lower Missouri	365.43	0.067%	1,500	625,000	756.9	759.1	0.00031	12.3	57,234	1,508	0.31
Lower	Lower Missouri	365.521*	10%	10	245,000	739.4	740.2	0.00019	7.1	35,076	1,403	0.22
Lower	Lower Missouri	365.521*	1%	100	401,000	748.4	749.6	0.00021	8.9	47,910	1,458	0.25
Lower	Lower Missouri	365.521*	0.5%	200	454,000	750.7	752.1	0.00022	9.5	51,392	1,473	0.26
Lower	Lower Missouri	365.521*	0.2%	500	530,000	753.9	755.5	0.00023	10.3	56,116	1,508	0.27
Lower	Lower Missouri	365.521*	0.133%	750	565,000	755.2	756.9	0.00024	10.6	58,065	1,530	0.27
Lower	Lower Missouri	365.521*	0.100%	1,000	590,000	756.1	757.9	0.00024	10.8	59,538	1,547	0.28
Lower	Lower Missouri	365.521*	0.080%	1,250	610,000	756.9	758.7	0.00024	11.0	60,708	1,564	0.28
Lower	Lower Missouri	365.521*	0.067%	1,500	625,000	757.4	759.3	0.00025	11.2	61,560	12,976	0.28
Lower		365.53	Heart of America Bridge									
Lower	Lower Missouri	365.56	10%	10	245,000	739.5	740.2	0.00017	6.9	36,350	1,430	0.21
Lower	Lower Missouri	365.56	1%	100	401,000	748.5	749.7	0.00019	8.6	49,486	1,484	0.24
Lower	Lower Missouri	365.56	0.5%	200	454,000	750.9	752.2	0.00020	9.2	53,055	1,499	0.25
Lower	Lower Missouri	365.56	0.2%	500	530,000	754.1	755.6	0.00021	9.9	57,892	1,529	0.26
Lower	Lower Missouri	365.56	0.133%	750	565,000	755.4	757.0	0.00022	10.2	59,869	1,552	0.26
Lower	Lower Missouri	365.56	0.100%	1,000	590,000	756.4	758.0	0.00022	10.5	61,375	1,569	0.26
Lower	Lower Missouri	365.56	0.080%	1,250	610,000	757.1	758.8	0.00023	10.6	62,569	1,588	0.27
Lower	Lower Missouri	365.56	0.067%	1,500	625,000	757.7	759.4	0.00023	10.8	63,440	1,599	0.27
Lower		365.57	ASB Bridge		Bridge							
Lower	Lower Missouri	365.6	10%	10	245,000	739.7	740.3	0.00013	6.3	39,284	1,327	0.19
Lower	Lower Missouri	365.6	1%	100	401,000	748.7	749.7	0.00016	8.1	51,678	1,398	0.21
Lower	Lower Missouri	365.6	0.5%	200	454,000	751.1	752.3	0.00017	8.7	55,049	1,411	0.22
Lower	Lower Missouri	365.6	0.2%	500	530,000	754.3	755.7	0.00019	9.4	59,613	1,442	0.24
Lower	Lower Missouri	365.6	0.133%	750	565,000	755.6	757.1	0.00020	9.8	61,488	1,470	0.24
Lower	Lower Missouri	365.6	0.100%	1,000	590,000	756.6	758.1	0.00020	10.0	62,915	1,482	0.24
Lower	Lower Missouri	365.6	0.080%	1,250	610,000	757.3	758.9	0.00020	10.2	64,045	1,491	0.25
Lower	Lower Missouri	365.6	0.067%	1,500	625,000	757.9	759.5	0.00021	10.3	64,863	1,497	0.25
Lower	Lower Missouri	365.84	10%	10	245,000	739.8	740.6	0.00020	7.1	35,206	1,365	0.22
Lower	Lower Missouri	365.84	1%	100	401,000	748.8	750.0	0.00022	8.9	48,066	1,467	0.25
Lower	Lower Missouri	365.84	0.5%	200	454,000	751.2	752.6	0.00023	9.4	51,626	1,553	0.25
Lower	Lower Missouri	365.84	0.2%	500	530,000	754.5	756.0	0.00024	10.2	56,684	1,569	0.26
Lower	Lower Missouri	365.84	0.133%	750	565,000	755.8	757.4	0.00025	10.5	58,720	1,572	0.27
Lower	Lower Missouri	365.84	0.100%	1,000	590,000	756.7	758.5	0.00025	10.7	60,250	1,575	0.27
Lower	Lower Missouri	365.84	0.080%	1,250	610,000	757.5	759.3	0.00026	10.9	61,453	1,582	0.27
Lower	Lower Missouri	365.84	0.067%	1,500	625,000	758.0	759.9	0.00026	11.0	62,326	1,587	0.28
Lower	Lower Missouri	366.06	10%	10	245,000	739.9	740.9	0.00026	8.1	31,392	1,350	0.25
Lower	Lower Missouri	366.06	1%	100	401,000	748.9	750.4	0.00028	10.0	43,902	1,416	0.28
Lower	Lower Missouri	366.06	0.5%	200	454,000	751.3	753.0	0.00029	10.6	47,301	1,424	0.29
Lower	Lower Missouri	366.06	0.2%	500	530,000	754.5	756.5	0.00031	11.4	51,893	1,434	0.30
Lower	Lower Missouri	366.06	0.133%	750	565,000	755.8	757.9	0.00032	11.8	53,747	1,439	0.30
Lower	Lower Missouri	366.06	0.100%	1,000	590,000	756.8	758.9	0.00032	12.0	55,139	1,442	0.31
Lower	Lower Missouri	366.06	0.080%	1,250	610,000	757.5	759.7	0.00032	12.2	56,236	1,445	0.31
Lower	Lower Missouri	366.06	0.067%	1,500	625,000	758.1	760.3	0.00033	12.4	57,028	1,446	0.31
Lower	Lower Missouri	366.121*	10%	10	245,000	739.9	741.0	0.00028	8.4	30,334	1,350	0.27
Lower	Lower Missouri	366.121*	1%	100	401,000	749.0	750.6	0.00030	10.3	42,894	1,432	0.29
Lower	Lower Missouri	366.121*	0.5%	200	454,000	751.4	753.1	0.00031	10.9	46,335	1,440	0.30
Lower	Lower Missouri	366.121*	0.2%	500	530,000	754.6	756.6	0.00033	11.7	50,994	1,451	0.31

STA 210 to 24

EXHIBIT A-9.53

NOTE: THIS REPORT WAS DONE FOR THE KANSAS CITY, MO WATER SERVICES DEPARTMENT – IT WAS NOT DONE AS PART OF THE COE FEASIBILITY STUDY. PHASE 1, PHASE 2, AND NORTHEAST INDUSTRIAL DISTRICT DESIGNATIONS AS PRESENTED IN THIS EXHIBIT ARE VALID FOR THIS EXHIBIT ONLY.

KANSAS CITY, MISSOURI
WATER SERVICES DEPARTMENT

STORM DRAINAGE MASTER PLAN
FOR
PHASE 2
NORTHEAST INDUSTRIAL DISTRICT

JULY 1998

96-252-4

100% EMPLOYEE-OWNED
Burns & McDonnell
ENGINEERS · ARCHITECTS · CONSULTANTS

The separate storm sewer system upstream of the detention basin adjacent to I-29 and I-35 would be developed to collect the stormwater runoff from the 10-year design storm in the area bounded by 10th Street to the south, Woodland Avenue to the east, Missouri Avenue to the north, and Tracy Avenue to the west. This is an area of approximately 95 acres. The storm sewer system would consist of pipes ranging in diameter from 30-inches to 96-inches with a total estimated length of 7700 feet.

The separate storm sewer system upstream of the detention basin in Maple Park would be developed to collect the stormwater runoff from the 10-year design storm in the area bounded by Missouri Avenue to the south, Garfield Avenue to the east, Pendleton Avenue to the north, and Highland Avenue to the west. This is an area of approximately 40 acres. The storm sewer system would consist of pipes ranging in diameter from 30-inches to 42-inches with a total estimated length of 3350 feet.

The separate storm sewer system upstream of the detention basin at Cliff Drive would be developed to collect the stormwater runoff from the 10-year design storm in the area bounded by Lexington Avenue to the south, Wabash Avenue to the east, Cliff Drive to the north, and Garfield Avenue to the west. This is an area of approximately 50 acres. The storm sewer system would consist of pipes ranging in diameter from 30-inches to 60-inches with a total estimated length of 5550 feet.

5. <u>HARLEM AREA</u>

Improvements to the Harlem area have been developed to address the concerns associated with seepage through the Missouri River Flood Protection Levee during high stages of the Missouri River and to provide a drainage system for the Harlem area for a 10-year storm event. These improvements were designed considering future redevelopment of the area with commercial and industrial land uses, even though a comprehensive plan is not in effect for this area. The area serviced by Burlington Railroad's drainage system (i.e., that area generally north and east of the Chicago, Burlington and Quincy railroad tracks in the northern section of the Harlem area) was not included in the plan for improvements for Harlem. Evaluation of alternatives for improvement included an assessment of utilizing the existing system for North Kansas City located adjacent to Harlem.

Although the North Kansas City drainage system is located near the Harlem area, there are several drawbacks associated with the utilization of this system in connection with improvements to the Harlem area. In order to connect to the existing system at Atlantic and the Chicago, Burlington & Quincy railroad tracks, the Harlem improvements would have to cross active railroad tracks in at least two locations. This alternative would not be a cost effective plan for improvement. This existing drainage system is located in and owned by North Kansas City. Connection to the system would require an agreement between the two municipalities, as well as the North Kansas City Levee District. In addition, it is unknown whether or not the Atlantic-Erie pumping station was designed to include the Harlem area as part of its tributary area. The station was constructed in the 1960's and review of the available records from that project did not contain information relating to the design of the station.

The recommended improvements for the Harlem area can be separated into two distinct phases. Phase 1 improvements are intended to capture the seepage through the levee and discharge the water back to the Missouri River. Phase 2 improvements would be completed in conjunction with the redevelopment of the area and would include the construction of a drainage system for conveyance of the 10-year storm. For this analysis, it was assumed that street reconstruction would be completed during redevelopment of the Harlem area (i.e., no costs have be allocated for road reconstruction in this plan for improvements). A preliminary plan view of these improvements for Harlem is included in Figure IV-7.

The design of the improvements is based on field observations and on a hydrologic analysis of the Harlem area. The seepage rate of 7 cfs was roughly estimated from observations during the 1993 floods where water was flowing over Harlem Road at a depth of approximately $^1/_{16}$ of an inch. For design of the improvements, this seepage rate should be validated based on the design of the levee system. A HEC-1 model was developed to determine the 10-year runoff hydrograph from the area generally south of Burlington Railroad (an area of 77 acres). The resulting hydrograph was used to estimate the required storage volume of the detention basin assuming a constant outflow rate of 10 cfs from the pumping station. Additionally, the peak discharges to the gravity storm sewers were estimated from rational method and the conduits were sized given a maximum friction slope along the length of the system to the detention basin of roughly 0.2 %.

Phase 1 improvements include:

- 24-inch perforated CMP subsurface drain along the toe of the levee to intercept seepage through the levee.
- 24-inch RCP connecting the subsurface drain to the drainage system at Harlem Road and Grand Avenue.
- 4 ft x 6.5 ft RCB and a 4 ft x 10 ft RCB gravity storm sewer along Grand Avenue to the site of the future detention basin.
- Pumping station with two 10 cfs pumps
- 16-inch force main discharging to the Missouri River.

Phase 2 improvements include:

- Gravity sewer system within Harlem consisting of 4 ft x 4.5 ft RCB and 4 ft x 5.5 ft RCB
- Detention Basin with a total estimated volume of 18.5 acre-feet. Detention basin would have a maximum water depth of 5 feet during the 10-year storm event.

D. COST ESTIMATES

The preliminary cost estimates for each system, excluding the separate storm sewer systems upstream of the detention basins, are summarized in Table IV - 5. The itemized preliminary construction cost estimates for each of the recommended improvements are included at the end of this section in Tables IV - 6 to IV - 10. The supplemental costs of the separate storm sewer systems for the Main Street and Lydia Avenue systems are shown at the end of Tables IV-6 and IV - 9. The costs shown are reported in March 1997 dollars and do not include any allowances for the acquisition of permanent drainage easements. Land acquisition costs are included for construction of the proposed detention facilities; all sites identified in the Lydia Avenue system are currently owned by the City of Kansas City, Missouri.

TABLE IV-5

SUMMARY OF PRELIMINARY COST ESTIMATES

(Excluding the separate storm sewer improvements upstream of detention basins)

System	Construction	20% Contingency	Engineering Design	Land & Conting	Total Cost
Main Street	$2,207,511	$441,502	$397,352	$1,193,000	$4,239,365
Holmes Street	$1,154,423	$230,885	$207,796	$0	$1,593,104
Gillis Street	$2,832,005	$566,401	$509,761	$0	$3,908,167
Lydia Avenue	$755,246	$151,049	$135,944	$0	$1,042,239
Harlem - Phase 1	$842,905	$168,581	$151,723	$300,000	$1,463,209
Harlem - Phase 2	$1,284,225	$256,845	$231,161	$0	$1,772,231
TOTAL					**$14,018,315**

Equivalent fourth quarter 1990 Preliminary construction cost estimate is $11,775,380 based on the ENR Construction Cost Index of 4764 (i.e., an adjustment factor of 0.84).