P-004-2013

cc: M. McGregor
S. Ross
S. Gutti
T. Higdon
M. Pelfrey
S. Dikes

M E M O R A N D U M

TO: Keith Damron, P.E.
Division of Planning

BY: Bart Asher, P.E., P.L.S.
Geotechnical Branch Manager

DATE: July 29, 2013

SUBJECT: **Livingston County**
US 60 Bridge Replacement Study over
Cumberland River
Item # 1-1142
Mars # 8658308P
Preliminary Geotechnical Assessment

The Division of Planning is conducting a bridge replacement study for the subject project. This project is located in Livingston County, KY Where US 60 passes over the Cumberland River just north of Smithland and east of the confluence of the Cumberland and Ohio Rivers (as depicted on the site map). This abbreviated review will discuss some general geotechnical concerns with the area.

The approximate coordinates for the center of this site is site are: 37.148475 degrees North and -88.399527 degrees West. The site is located in the Smithland (657) Geologic Quadrangle which is in the Mississippian Plateau or Pennyrile Physiographic Region.

Mapping indicates that the study area is surrounded by a number of geologic faults. The Latrobe Fault is inferred to be just north of the current bridge location. That fault has, in places, been mined commercially for fluorspar. Aggregate has been mined commercially in the area. The Reed Quarry, one of the largest producers of crushed rock in the world, is located approximately 2 ½ miles to the north of the site.

The available mapping indicates the overburden material around the bridge to be alluvium and Loess. It appears that the mapping indicates that the overburden materials are underlain by Tar Springs Sandstone. The mapping also indicates that there could be some karst features in the quadrangle but none appear to be close to the proposed bridge location.

Plans pertaining to this site with the following drawing numbers are available in the KYTC Bridge office: 5347, 7646, 8464, 10375, 18180, 23409. 18180 involved extensive foundation rehabilitation of Pier B and Pier NP1. Those sheets were viewable but for the most part were not accessible to be included in this report due to problems with the microfilm scanner. Borings from some of the original plans are included.

Foundations for the existing bridge (see attached profile) appear to be:

SA (South abutment) – Spread Footing on Solid Rock
SP4 – Spread Footing on Solid Rock
SP3 – Spread Footing on Solid Rock

SP2 – Concrete piles (could be friction or rock bearing)
SP1 – Concrete piles (could be friction or rock bearing)
Pier A (main span over river) – Spread footings on cemented gravel
Pier B (main span over river) – Spread footings on cemented gravel and H-piles driven to rock (rehab)
NP1 – Spread footings on sand and clay and H-piles driven to rock (rehab)
NP2 – Spread footings on sand and clay
NP3 – Concrete friction piles
NP3 – Concrete friction piles
NP4 – Concrete friction piles
NP5 – Concrete friction piles
NP6 – Concrete friction piles
NP7 – Concrete friction piles
NP8 – Concrete friction piles
NA (North Abutment) – Concrete friction piles

One of the proposed alternates is to reuse the existing foundations for a new superstructure. This does not appear to be desirable from a geotechnical standpoint. It is difficult to analyze the in-place capacity and remaining service life of piles with unknown lengths. Main span pier A does not appear to be founded on bedrock and pier B and NP1 have had a major retrofit and appears to be at least partially founded on bedrock. Additionally, discussions with District personnel and a review of archived plans revealed that numerous retrofits have taken place on this bridge. District personnel indicated some of these retrofits were due to movement of the bridge. The cause of the movement is unknown. Reuse of any substructures will require an in-depth investigation and analysis.

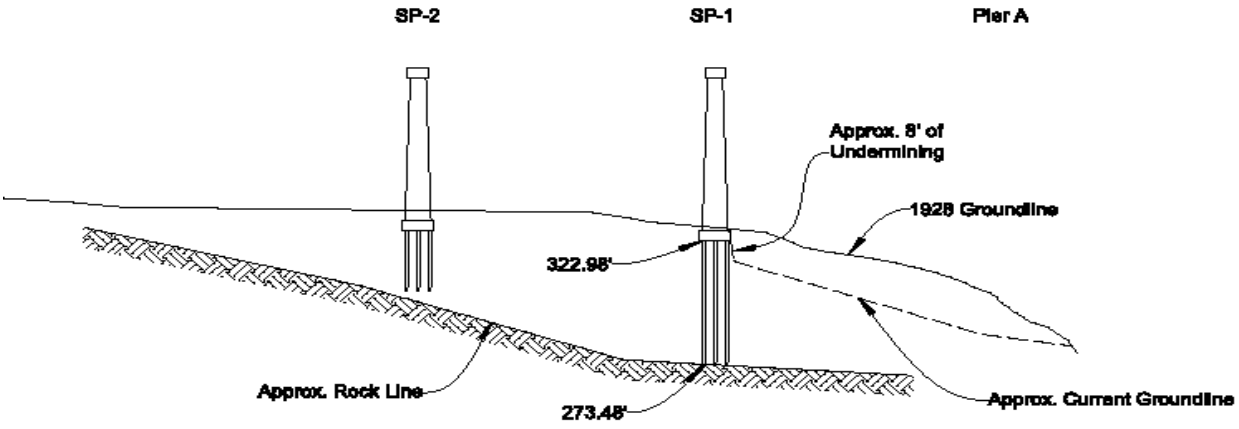
Foundations for a new bridge in this area could be spread footing foundations on bedrock, drilled shafts extended into bedrock, piles driven to bedrock or friction piles founded in the overburden soils. It is likely that the main span would be required to be founded in bedrock with drilled shafts as the preferred foundation type. Upon further study of the hydraulics of a new bridge it is likely that all foundations will be required to extend to bedrock. Evaluation of the proper seismic parameters based on what is found during the field investigation phase will be critical for design of a new bridge. The potential for barge impact could factor into the design of the bridge foundations.

Soils in the area are generally suitable for embankment construction. Generally, embankments built from the native soils can be constructed to a height of 60 feet with 2H:1V sideslopes if the foundation is suitable and proper compaction methods are used. Soil cuts over approximately 10 feet often require analyses to design proper sideslopes. In no case should soil cuts be steeper than 2H:1V. Suitable rock for embankment construction and rock roadbed is readily available in this area of the state. Soils in the area are considered erodible.

A review of aerial mapping indicates that there could be some ponded, wet or potentially swampy areas in some of the proposed corridors (most notably the most eastern alternate where a blue line stream heads toward the Cumberland River). These areas would require site specific investigations in order to determine suitability for design of the embankments. Additional structures may be required.

The Cumberland River, in this area, has some stream bank stability/scour issues. The Division of Maintenance and this office has recently evaluated the bank in the vicinity of the bridge. Piling has reportedly been exposed and a remediation measures have been developed (Call No. 100 Contract ID 132981). At the time of this report these measures had not been constructed. Loss of material appears to have been a concern in previous work on the bridge as well. The evaluation of scour and the erosion potential of the site soils will be critical in the design of any new structure.

View looking at South Bank of Cumberland River.



Approximate Profile of bank, South Side Cumberland River (from Division of Maintenance)

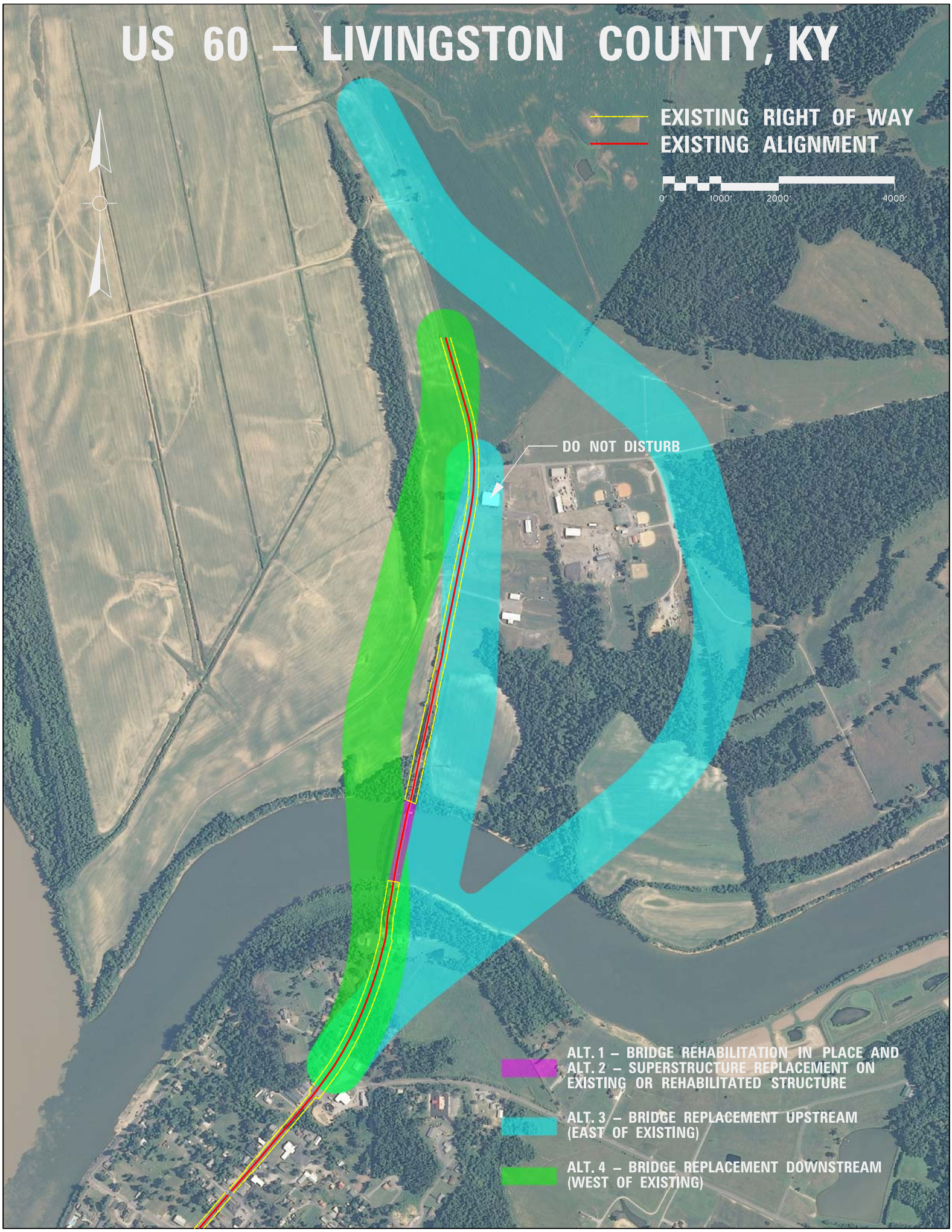
California Bearing Ratio (CBR) values used in pavement design generally range from 2-4 for soils subgrades in the area. Chemical modification of subgrade or the use of rock roadbed is sometimes used in the area. Wet areas could require undercutting and replacement of soils.

Site specific Geotechnical investigations are critical in this region for design.

Please feel free to contact this office for additional information.

Attachments:

Proposed corridor map
GQ Site Map
Select plan sheets from various bridge plans


US 60 – LIVINGSTON COUNTY, KY
EXISTING RIGHT OF WAY
EXISTING ALIGNMENT
0'
1000'
2000'
4000'
DO NOT DISTURB
ALT. 1 – BRIDGE REHABILITATION IN PLACE AND ALT. 2 – SUPERSTRUCTURE REPLACEMENT ON EXISTING OR REHABILITATED STRUCTURE
ALT. 3 – BRIDGE REPLACEMENT UPSTREAM (EAST OF EXISTING)
ALT. 4 – BRIDGE REPLACEMENT DOWNSTREAM (WEST OF EXISTING)

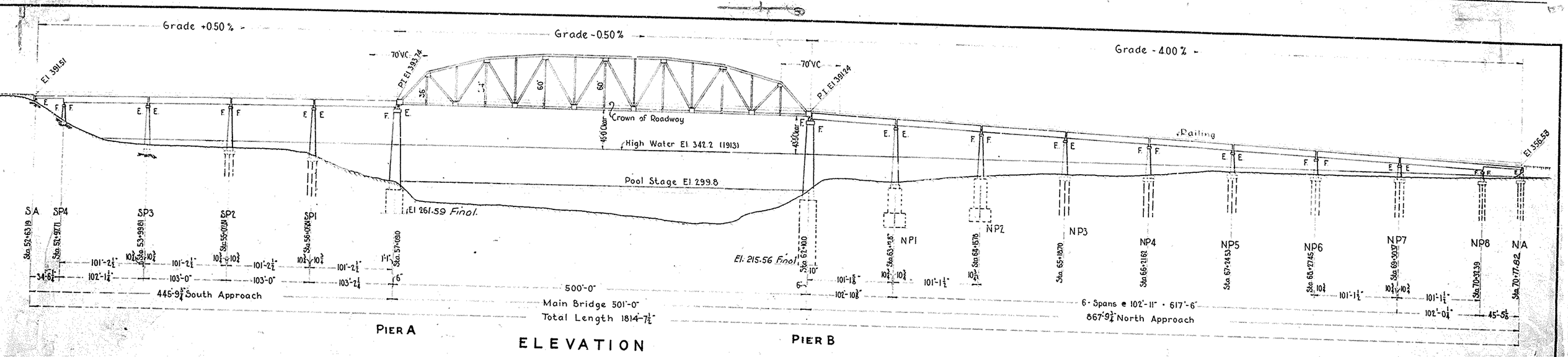
N

Smithland

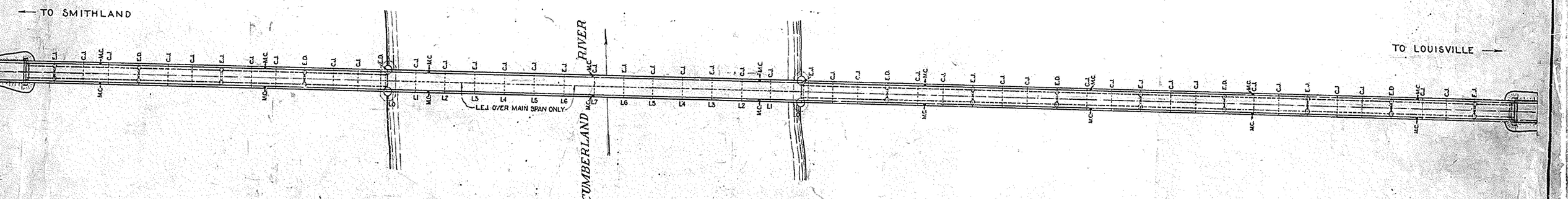
Legend

US Highways		Msg	Ste. Genevieve Limestone
State Roads		Ql	Loess
Local Roads		Qt	Terrace deposits
Mts	Tar Springs Sandstone	QTc	Continental deposits
Km	McNairy Formation	Qal	Alluvium

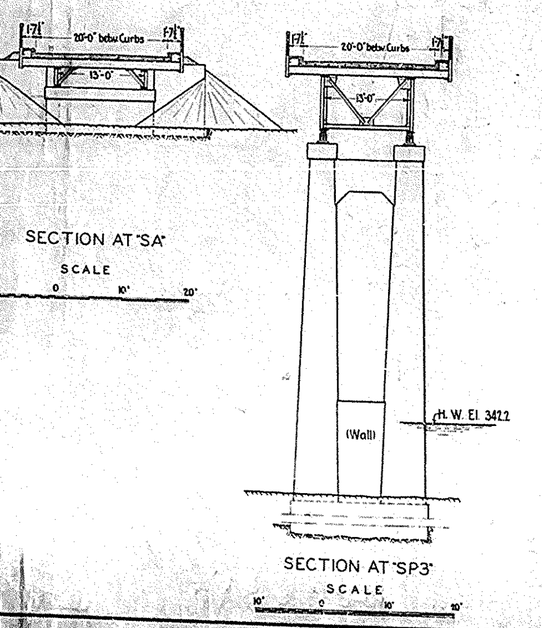
0 600 1,200 2,400 Feet

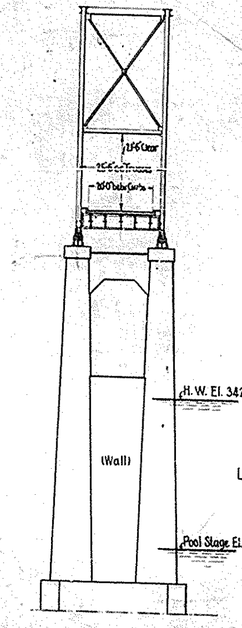


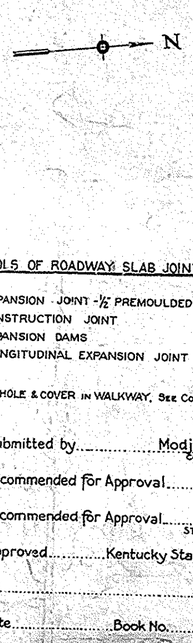
ELEVATION



PLAN







SYMBOLS OF ROADWAY SLAB JOINTS

E.J - EXPANSION JOINT - ½" PREMOULDED FILLER
C.J. - CONSTRUCTION JOINT
E.D. - EXPANSION DAMS
L.E.J. - LONGITUDINAL EXPANSION JOINT

M.C. - MANHOLE & COVER IN WALKWAY. SEE CONTRACT No. 2, DRAWING No. 7.

Submitted by ..... Modjeski & Masters, CONSULTING ENGINEERS

Recommended for Approval ..... BRIDGE ENGINEER.

Recommended for Approval ..... STATE HIGHWAY ENGINEER.

Approved ..... Kentucky State Highway Commission.

By ..... CHAIRMAN

Date ..... Book No. ..... Page .....

LIST OF DRAWINGS

CONTRACT No. 1
SUBSTRUCTURE

Sheet No.	Title
1	General Plan & Elevation
2	Masonry Plan
3	Substructure - Main Bridge
4	Substructure - Approaches

CONTRACT No. 2
SUPERSTRUCTURE

Sheet No.	Title
1	General Plan & Elevation
2	Masonry Plan
3	Stress Sheet
4	Typical Details 500' Span
5	Typical Details 500' Span
6	Typical Details Approach Steelwork
7	Details of Roadway
8	Navigation Lights

CONTRACT No. 1
SUPPLEMENTARY DRAWINGS

Sheet No.	Title
1	Contour Map and Foundation Data.
2	Foundation Data. River Hydrograph.
SK-31	River Bottom and Pier Location - May 1931.

APPROVED
Chief Engineer
F. M. Masters
CONSULTING ENGINEERS

Design Sht. # 5
Dr. # 7646

COMMONWEALTH OF KENTUCKY
STATE HIGHWAY DEPARTMENT

CUMBERLAND RIVER BRIDGE
AT SMITHLAND, KY.

GENERAL PLAN & ELEVATION

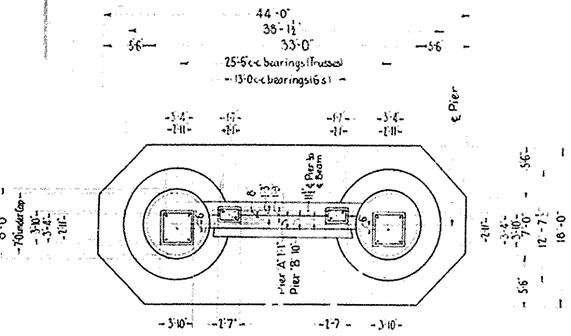
SCALE IN FEET
10 0 20 40 60 80 100

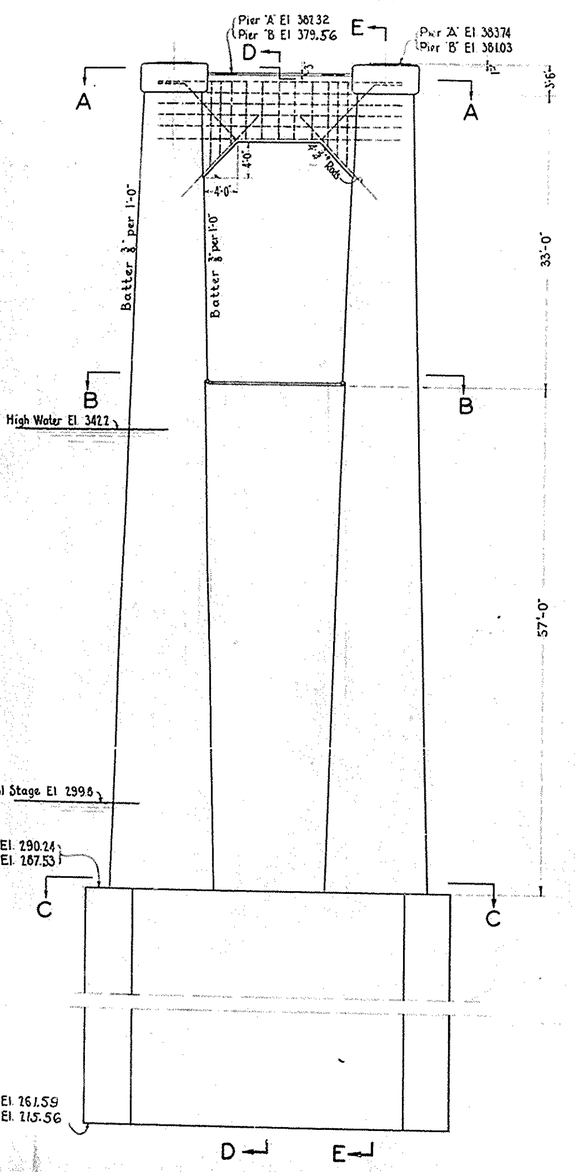
MAY 1929
DRAWING NO. 1
CONTRACT NO. 1&2

MODJESKI AND MASTERS
ENGINEERS

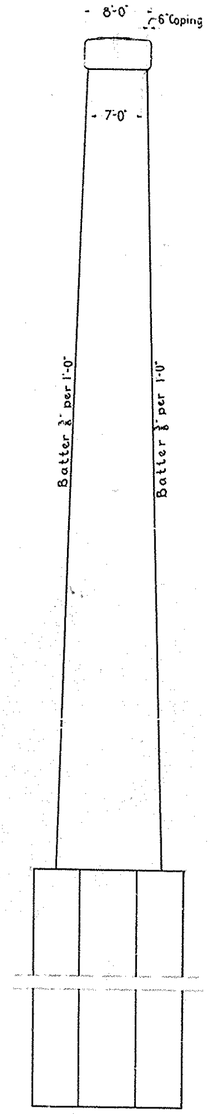
MP 70-70-1

Revised Jan. 15, 1930 - Crown of Roadway revised [illegible]

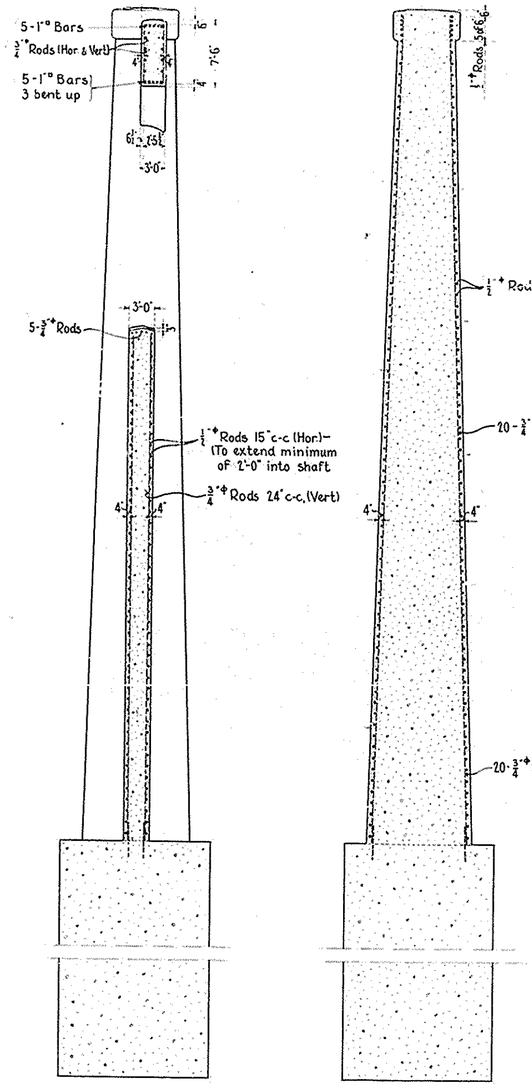




FRONT ELEVATION



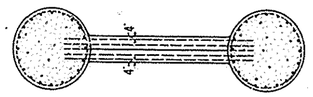
END ELEVATION



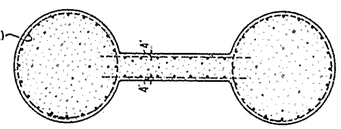
SECTION D-D

SECTION E-E

SECTION A-A



SECTION B-B



SECTION C-C

Class "A" Concrete.

APPROVED

Rudolph Modjeski

F. M. Masters

Sht. # 7
Dr. # 7646

COMMONWEALTH OF KENTUCKY
STATE HIGHWAY DEPARTMENT

CUMBERLAND RIVER BRIDGE

AT SMITHLAND, KY

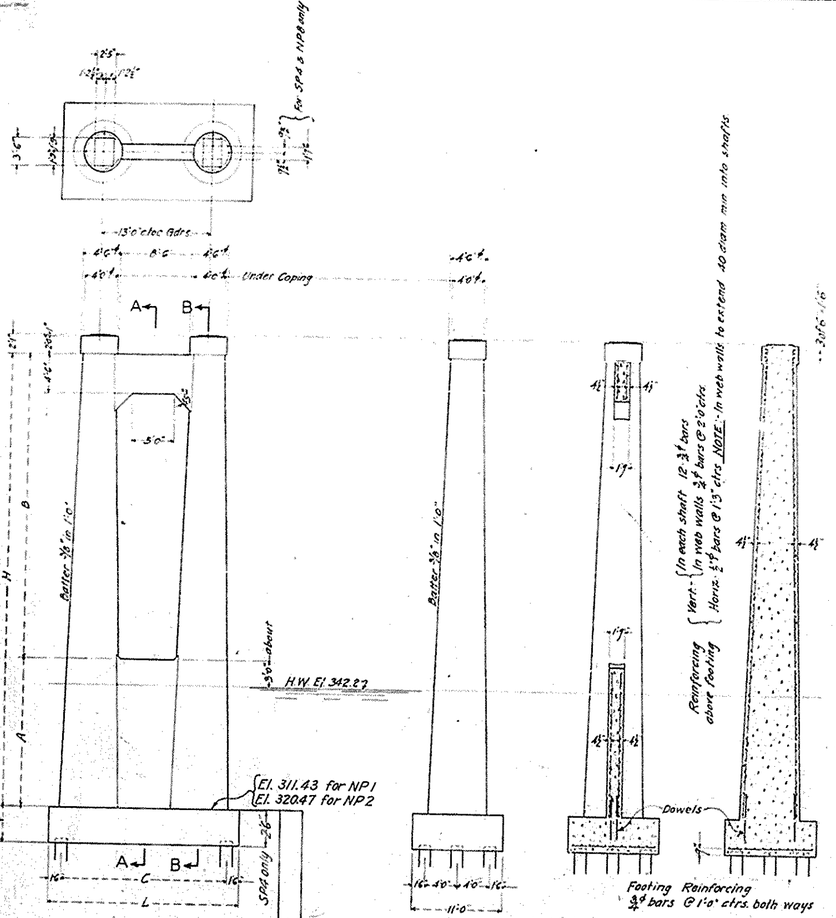
SUBSTRUCTURE - MAIN BRIDGE

SCALE IN FEET
1 0 2 4 6 8 10 12

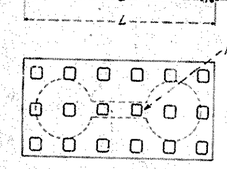
MAY 1929

DRAWING NO. 3
CONTRACT NO. 1

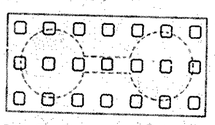
MODJESKI AND MASTERS
ENGINEERS



END ELEVATION SECTION A-A SECTION B-B



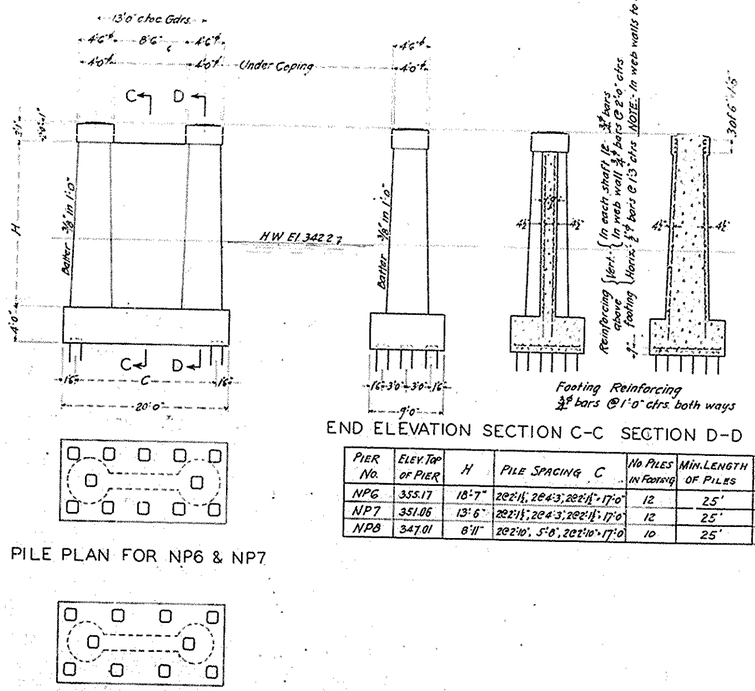
PILE PLAN FOR NP3 & NP4



PILE PLAN FOR NP5

PIER No.	ELEV. Top of PIER	A	B	H	L	PILE SPACING C	No. PILES IN FOOTING	MIN. LENGTH OF PILE	Length Driven
NP1 ①	381.89	18'-3"	34'-7"	52'-11"	23'-0"	5 @ 4'-0" = 20'-0"	18	40'	50'-0"
NP2	381.38	13'-3"	34'-1"	47'-4"	23'-0"	5 @ 4'-0" = 20'-0"	18	25'	25'-0"
NP3	380.86	14'-3"	33'-7"	47'-10"	21'-0" + 8'-0 wide (Bearing on Rock)		–	–	—
NP4	380.36	0'-0"	0'-0"	16'-10"	19'-6" x 6'0 wide (Bearing on Rock)		–	–	—
NP1 ①	375.76	33'-9"	28'-6"	62'-3"	— — — — — —		— —	— —	— —
NP2	371.64	24'-9"	24'-8"	49'-1"	— — — — — —		— —	— —	— —
NP3 ①	367.52	19'-3"	20'-3"	39'-6"	23'0"	5 @ 4'-0" = 20'-0"	18	25'	50'-0"
NP4	363.41	17'-10"	16'-1"	33'-11"	23'-0"	5 @ 4'-0" = 20'-0"	17	25'	50'-0"
NP5 ①	357.29	10'-9"	12'-0"	22'-9"	36'-0	6 @ 4'-6" = 27'-0"	21	25'	40'-0"

① Indicates that one pile shall be driven as a test pile.

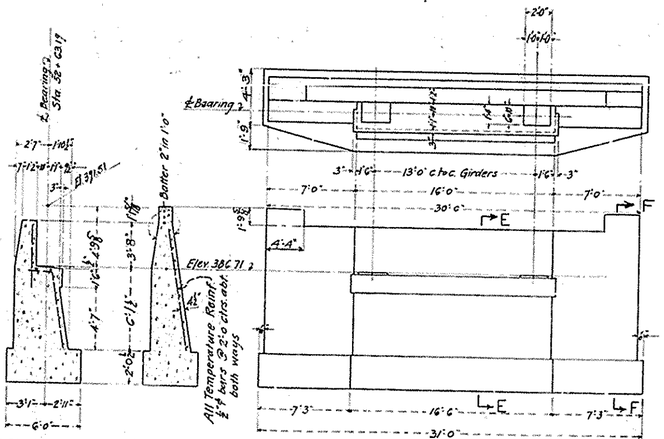


END ELEVATION SECTION C-C SECTION D-D

PILE PLAN FOR NP6 & NP7

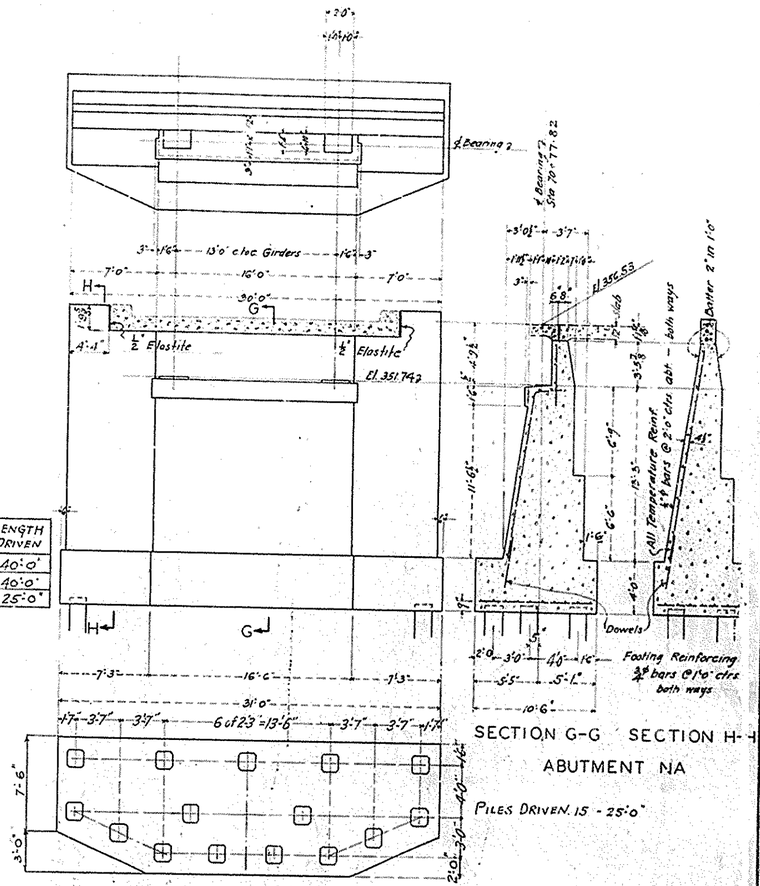
PILE PLAN FOR NP8

PIER No.	ELEV. Top of PIER	H	PILE SPACING C	No. PILES IN Footing	MIN. LENGTH OF PILES	LENGTH DRIVEN
NP6	355.17	18'-7"	2@2'-1½", 2@4'-3", 2@2'-1½" = 17'-0"	12	25'	40'-0"
NP7	351.06	13'-6"	2@2'-1½", 2@4'-3", 2@2'-1½" = 17'-0"	12	25'	40'-0"
NP8	347.01	8'-11"	2@2'-10", 5'-8", 2@2'-10" = 17'-0"	10	25'	25'-0"



SECTION E-E SECTION F-F

ABUTMENT SA

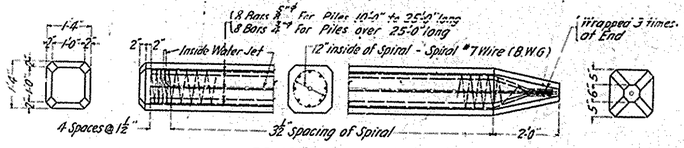


SECTION G-G SECTION H-H

ABUTMENT NA

PILES DRIVEN 15 - 25'0"

PILE PLAN



CONCRETE PILE

Sht. # 8
Dr. # 7646

COMMONWEALTH OF KENTUCKY
STATE HIGHWAY DEPARTMENT

CUMBERLAND RIVER BRIDGE

AT SMITHLAND, KY.

SUBSTRUCTURE – APPROACHES

APPROVED
Rudy Menjou
J. M. Martin

SCALE IN FEET
1 0 1 2 3 4 5 10 15
1 0 5 10 15 20

MAY 1929
DRAWING NO. 4
CONTRACT NO. 1
MODJESKI AND MASTERS
ENGINEERS

Class "D" concrete in piles
all other concrete Class "A"

B.J.D.

Contours 2 ft. intervals

Contours 5 ft. intervals

Contours 2 ft intervals

RIVER

CUMBERLAND

Boring No.1 · Boring No.2 · Boring No.3 · Boring No.4 · Boring No.5 · Boring No.6 · Boring No.7 · Boring No.8 · Boring No.9 · Boring No.10 · Boring No.11 · Boring No.12 · Boring No.13 · Boring No.14 · Boring No.15 · Boring No.16 · Boring No.18

Shore Line Nov. 14, 1928

Base Line

Proposed ℄ of Bridge

500'

301'-6"

300'-0"

90°

80°

← To Smithland

To Louisville & U.S. Route 60

Sta. 53+00 · Sta. 54+00 · Sta. 55+00 · Sta. 56+00 · Sta. 57+09 · Sta. 58+00 · Sta. 59+00 · Sta. 60+00 · Sta. 61+00 · Sta. 62+00 · Sta. 62+09 · Sta. 62+48 · Sta. 63+00 · Sta. 64+00 · Sta. 65+00 · Sta. 65+10.5 · Sta. 66+00 · Sta. 67+00 · Sta. 68+10.5

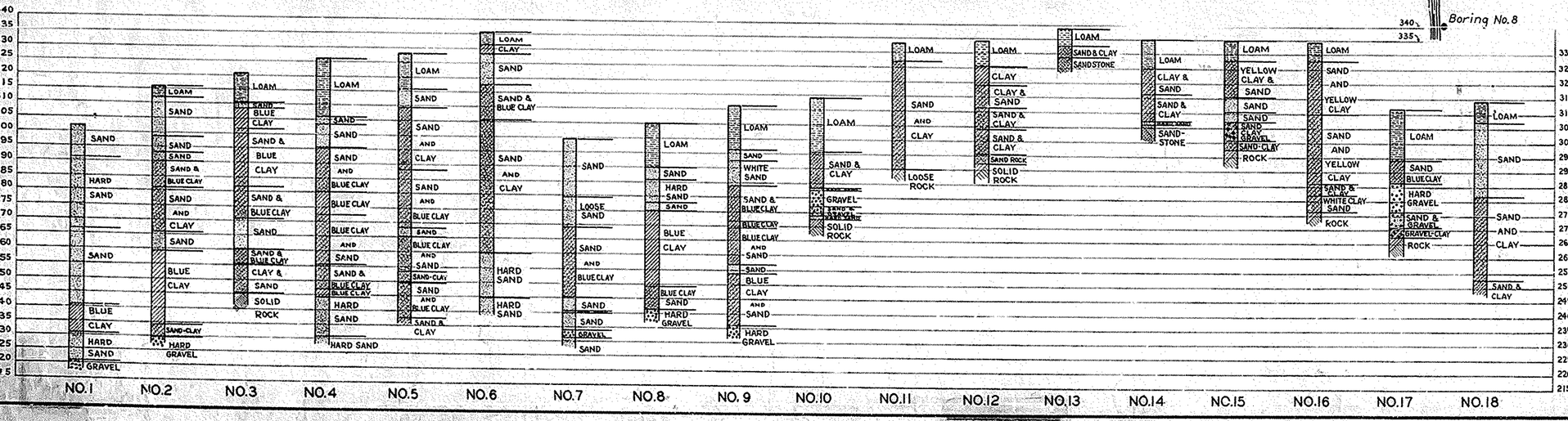
Extreme High Water Elev. 342.2 (1913)

OHIO RIVER POOL NO.52 ELEV. 298.8

Ground Line

PROFILE - RIVER BOTTOM ON ℄ OF PROPOSED BRIDGE

Cumberland River Datum U.S.B.M. #192; 1889 Construction Datum Elev. 341.898, Smithland, Ky.
B.M. Elev. referred to Ohio River Datum Elev. 344.148
Ohio River or Sea Level Datum 2.25 ft higher than Cumberland River Datum.



Sht. # 15
Dr.# 7646

COMMONWEALTH OF KENTUCKY
STATE HIGHWAY DEPARTMENT

CUMBERLAND RIVER SURVEY FOUNDATION DATA

SCALE
40 20 0 40 80

NOVEMBER 1928

CONTRACT NO. 1
SUPPLEMENTARY DWG. NO. 2.
Smithland
Revised 3/26/29

MODJESKI & MASTERS ENGINEERS

Made by: E.A.S.
Checked by: F.C.K.

Δ = 29°-12'
D = 2°-00'
T = 746.3'
L = 1460.0'

P.I. Sta 44+27.3

P.T. Sta 51+41.0

River

Cumberland

70' Right of Way

Boring No. 1C.

Boring No. 2C.

Boring No. 3C.

Boring No. 4C.

500'

Storage Space

200'

500'

301'-6"

300'-0"

Storage Space

230'

Contours 2 ft. intervals

Contours 5 ft. intervals

Contours 2 ft. intervals

TO LOUISVILLE U.S. ROUTE 60

El. 300

El. 297.0
- YELLOW MUD & SAND
- BLUE CLAY, SAND & DEBRIS
- GRAVEL, SAND & SOME BLUE CLAY
- COARSE GRAVEL WITH SOME SAND & CLAY
- SANDSTONE WITH SEAMS OF HARD CLAY & GRAVEL
- HARD CLAY & GRAVEL
- SOFT BLUE SHALE
- El. 234.91

Boring No. 1 C

El. 300.23
- YELLOW SAND
- MUCK-BLUE MUD & SAND
- LOOSE GRAY SAND WITH BLUE CLAY
- GRAY SAND
- BLUE CLAY
- COMPACT GRAY SAND WITH LEAVES & WOOD
- BLUE CLAY
- LOOSE GRAY SAND & GRAVEL
- COARSE GRAY SAND
- GRAVEL
- BLUE LIMESTONE BRITTLE AGGREGATE OF FLINT

Boring No. 2 C.

El. 328.0
- LOAM
- LOOSE FINE YELLOW SAND
- YELLOW CLAY
- LOOSE FINE YELLOW SAND
- YELLOW CLAY
- LOOSE SHARP GRAY SAND
- BLUE CLAY
- LOOSE SHARP GRAY SAND
- BLUE CLAY & SAND
- BLUE CLAY
- SATURATED SHARP GRAY SAND
- FINE GRAVEL & BLUE CLAY
- GRAY SAND & BLUE CLAY

Boring No. 3 C.

El. 336.54
- YELLOW SANDY LOAM
- SANDY YELLOW CLAY
- BLUE CLAY & FINE SAND
- GRAY SAND LOOSE & FINE
- COMPACT SHARP GRAY SAND
- FINE GRAVEL & SAND
- COMPACT GRAY SAND WITH, OCCASIONAL STREAKS OF FINE GRAVEL & BLUE CLAY

El. 236.54

Boring No. 4 C.

VICINITY MAP

Sta. 57+09

Sta. 62+09

Sta. 65+10.5

Sta. 68+10.5

Sta 57+63.19 · Sta 57+97.71 · Sta 53+98.81 · Sta 55+02.81 · Sta 56+06.81 · Sta 57+09.0 · Sta 62+10.0 · Sta 63+12.87 · Sta 64+15.72 · Sta 65+18.70 · Sta 66+21.67 · Sta 67+24.53 · Sta 68+27.45 · Sta 69+30.37 · Sta 70+32.39 · Sta 70+78.32

PIER "A" PIER "B"

Extreme High Water El. 342.2 - 1913

Ohio River Pool No. 52 Elev. 299.8

Ground Line

S A · S P4 · S P3 · S P2 · S P1 · N P1 · N P2 · N P3 · N P4 · N P5 · N P6 · N P7 · N P8 · N A

Edge of Water 57+11.0 El. 295.0 Nov. 12, 1928

Edge of Water 62+91.0 El. 300.2 Nov. 12, 1928

Sta. 58+58.0 El. 277.5.0 · Sta. 59+41.5 El. 274.00 · Sta. 60+20.0 El. 268.5.0 · Sta. 61+09.0 El. 260.0 · Sta. 61+96.0 El. 290.0

Plane above which flood water has not remained at any time longer than 5 consecutive days, El. 341.7

Approximate upper limit of ordinary boating water El. 330.0

Elevations shown are Cumberland River Datum U.S.B.M. No. 192-1889, Construction Datum El. 341.898, Smithland, Ky.
B.M. elevation referred to Ohio River Datum, or M.S.L. El. 344.148.
To convert from Cumberland River Elevations to Ohio River Elevations or M.S.L. add 2.25 feet.

Elev. 350.82 Ohio River datum at Smithland Courthouse 1937 maps 61
2.25
348.57 Highwater Cumberland River datum — 1937
342.20
6.37 ft.

Sht. #10
Dr. # 7646

COMMONWEALTH OF KENTUCKY
STATE HIGHWAY DEPARTMENT

CUMBERLAND RIVER SURVEY CONTOUR MAP

SCALE
100 0 100 200

NOVEMBER 1928

MODJESKI & MASTERS
ENGINEERS

CONTRACT NO. 1.
SUPPLEMENTARY DWG. NO. 1.
Smithland

Revised 3/26/29

Made by G.M.
Chk. by F.M.

TO SMITHLAND, KY.

TO LOUISVILLE, KY.

N

PROFILE 50' WEST OF BRIDGE ℄ TAKEN MAY 1931

El. 350.

El. 300.

El. 250.

Pool Stage El. 299.87

River bed Elevations as of May 1931

NOTE:
The Control Bench is a R.R. spike in concrete located on Bridge ℄ between Approach Piers NP7 and NP8. Cumberland River Datum of U.S. Engineers used.

Stations 50' West of Bridge ℄

Stations on Bridge ℄

Stations 50' East of Bridge ℄

℄ Bridge Survey

SP4 SP3 SP2 SP1 PIER A PIER B NP1 NP2 NP3 NP4 NP5 NP6 NP7 NP8 NA

RIVER

CUMBERLAND

PLAN

NOTE:
Control Stakes on the 45' offset lines are 6' lengths of 1½" ϕ pipe with a wood plug with a tack in it, or a 6' length of 1" reinforcing rod with a cross on it driven flush in the ground. These points have been encased in concrete to a depth of 2 feet.
The points on the Piers are lead plugs, set in the concrete with a tack in the point.

Pool Stage El. 299.87

Elevation 250.007

River bed Elevations as of June 1931

PROFILE ON BRIDGE ℄ TAKEN JUNE 1931

Pool Stage El. 299.87

River bed Elevations as of May 1931

Elevation 250.007

El. 350.

El. 300.

PROFILE 50' EAST OF BRIDGE ℄ TAKEN MAY 1931

El. 250.

Rock SP4 El. 321.54 Rock SP3 El. 321.97 El. 303.47 SP2 El. 322.98 El. 273.48 SP1 El. 261.59 Cemented Gravel PIER A

Pool Stage El. 299.87

El. 215.56 Cemented Gravel PIER B

El. 261.93 Sand & Clay NP1

El. 270.4 Sand & Clay NP2

El. 321.94 NP3 El. 272.44

El. 323.41 NP4 El. 273.91

El. 328.46 NP5 El. 290.96

El. 330.51 El. 300. NP6 El. 291.01

El. 321.48 NP7 El. 291.98

El. 332.01 El. 307.51 NP8 El. 309.96

El. 334.46 NA

El. 250.

LEGEND
Profile on ℄ of Bridge (1928 Survey)
Profile on ℄ of Bridge (1931 Survey)
Profile 50' East of Bridge ℄ (1931 Survey)
Profile 50' West of Bridge ℄ (1931 Survey)

SCHEDULE OF PILES AS DRIVEN

	NO. OF PILES	LENGTH	ELEV. BOTTOM
NP 3	18	50'	272.7
NP 4	17	50'	274.0
NP 5	21	40'	289.0
NP 6	12	40'	291.1
NP 7	12	40'	292.1
NP 8	10	25'	307.6
NA	15	25'	310.1
SP 1	18	50'	273.4
SP 2	18	25'	303.4

BENCH-MARK REFERENCE DATA

All elevations are referenced to PBM-192 which is on the left bank of the Cumberland River at Smithland, Ky., B.M. is a nick in the center of a copper bolt leaded into C.B. Davis store at corner of Commet and Water Streets and on Commet St. side near end of building. Bolt is one foot from Southeast corner and 4.8 feet above ground. Elevation 341.898 (1929) datum. On this basis, the low water of Ohio River pool 52 is Elevation 299.8 the high water is Elevation 342.2 and steel clearance at center of 500' Span is Elevation 387.2.

Revised July 27, 1931

Sht. # 17
Dr. # 7646

COMMONWEALTH OF KENTUCKY
STATE HIGHWAY DEPARTMENT

CUMBERLAND RIVER BRIDGE
AT SMITHLAND, KY.

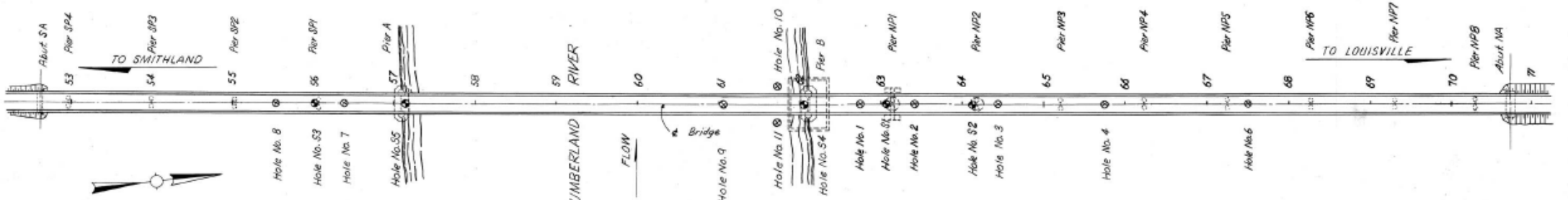
PLAN AND PROFILES SHOWING RIVER BOTTOM AND PIER LOCATION DATA AS OF MAY 1931

SCALE IN FEET
50 25 0 50 100 150

JUNE 1931

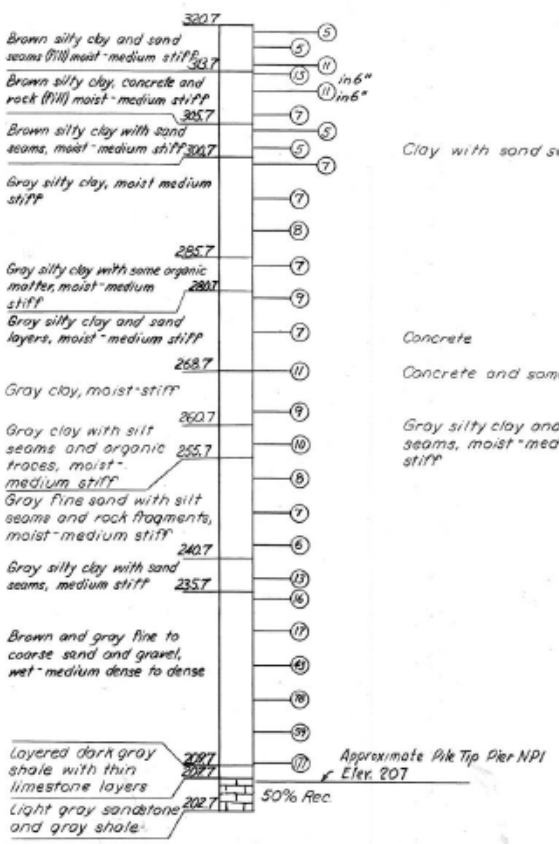
MODJESKI AND MASTERS
ENGINEERS

SK-S1

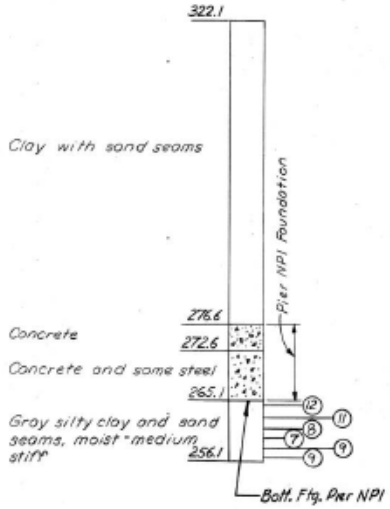


PLAN

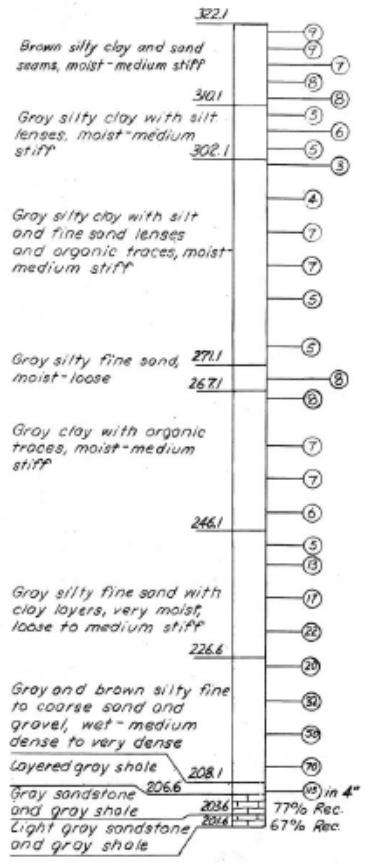
Hole No. 1
Sta. 62+74
on ℄



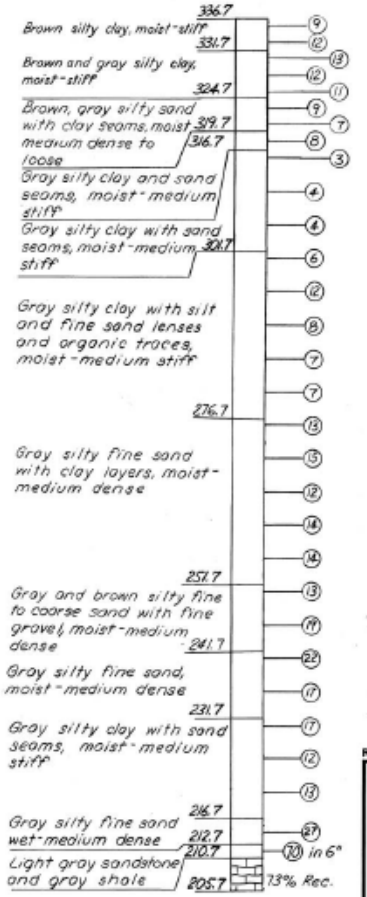
Hole No. 51
Sta. 63+06
on ℄



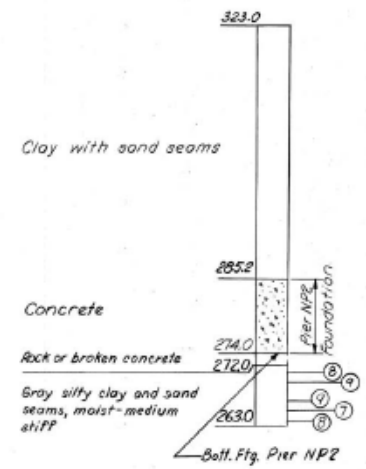
Hole No. 2
Sta. 63+41
on ℄



Hole No. 6
Sta. 67+51
on ℄



Hole No. 52
Sta. 64+09
on ℄



See Sheet B5 for notes

LOG OF SOUNDINGS

SHEET 5

REPAIRS TO BRIDGE CARRYING US.60 OVER CUMBERLAND RIVER

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT
COUNTY OF
LIVINGSTON
SMITHLAND-MARION
ROAD

STATION — PROJECT NO. SP 70-70

BRIDGE NUMBER — DRAWING NO. — INDEX 18180