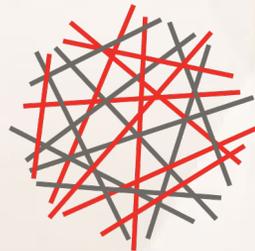


Culvert Replacement in Karst Topography

NOVEMBER 20, 2025 CEPDS



HWC

ENGINEERING

Introduction of Presenters



Eric Plaiss, PE

Project Manager
HWC Engineering



Alex Schwinghamer, PE

Principal Hydraulics Engineer
INDOT, Hydraulics Division



Outline of Presentation

- **Identification of Project**
- **Karst Elements of Southern Indiana**
- **History of SR 135 Corridor**
- **Existing SR 135 Roadway Elements and Drainage Infrastructure**
- **Preliminary Design Progression**
- **Project Hydraulics**
 - Scoping
 - Abbreviated Engineer's Report
 - Final Hydraulic Memoranda
 - Pre-Discharge Filtration Ditches
- **Lessons Learned**
- **Questions**

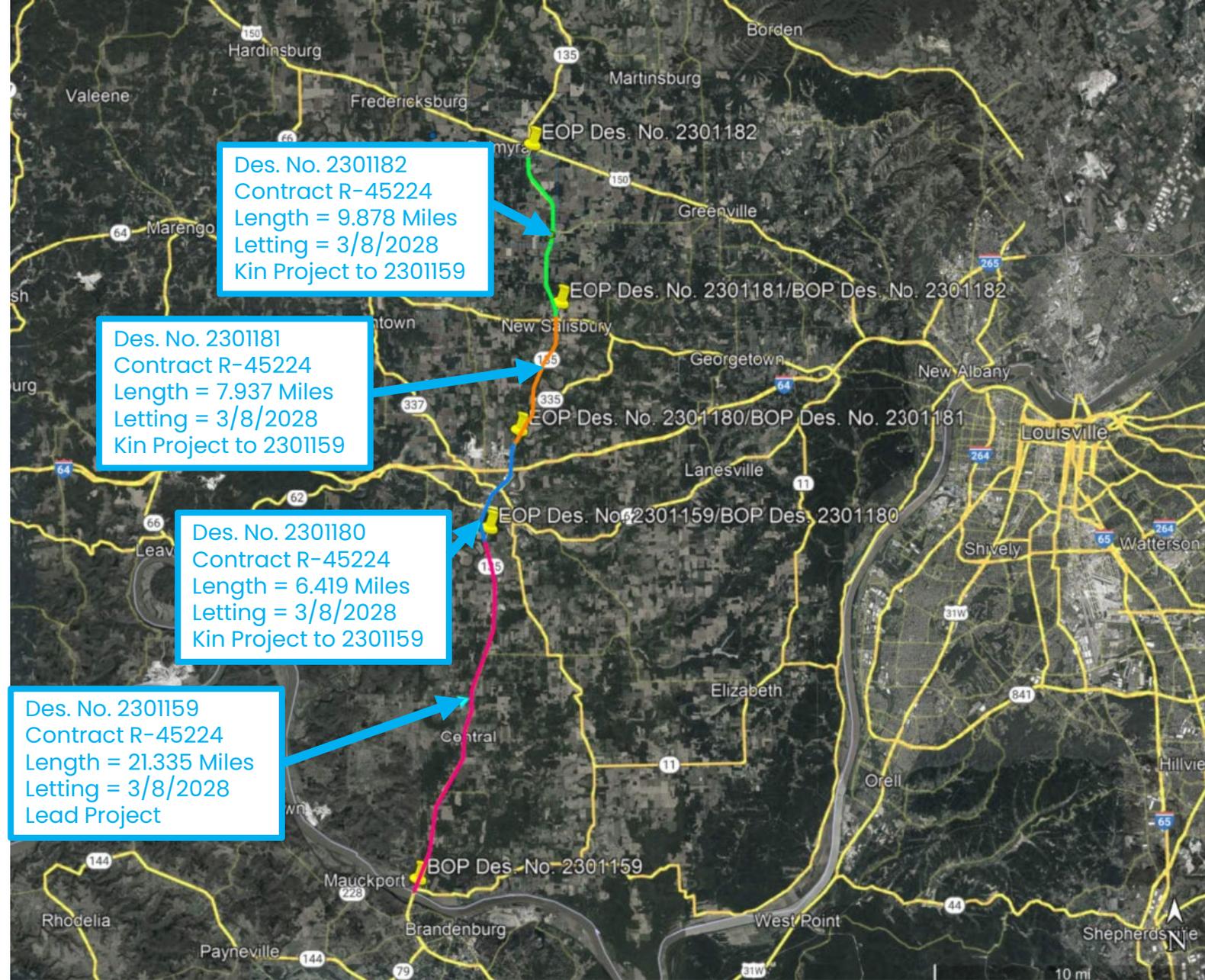


Identification of Project

- Des. No. 2301159 (Contract R-45224)
- Small structures & drains construction on SR 135
 - 0.35 mile south of SR 11 to 1.32 mile South of SR 62
- Lead project with three kin projects
 - Des. No. 2301180
 - Des. No. 2301181
 - Des. No. 2301182
- Letting date: 3/8/2028
 - Revised from SPMS date of 7/14/2027
- The Des. No. 2301159 project will be covered in this presentation



Project Location



Karst Elements of Southern Indiana

What is Karst topography?

- Terrain typically underlain with limestone and dolomite bedrock
- Presence of caves, sinkholes, sinking streams, and subterranean drainage

What is a sinkhole?

- A karst feature that is characterized by a basin or funnel-shaped surface depression
- Formed above a void within underlying limestone bedrock

Karst topography is present within the southern one-third of the state, located south of the Wisconsin Glacial Limit

- South of the Wisconsin Glacial Limit
- Within Mitchell Plateau and the Crawford Upland physiographic divisions



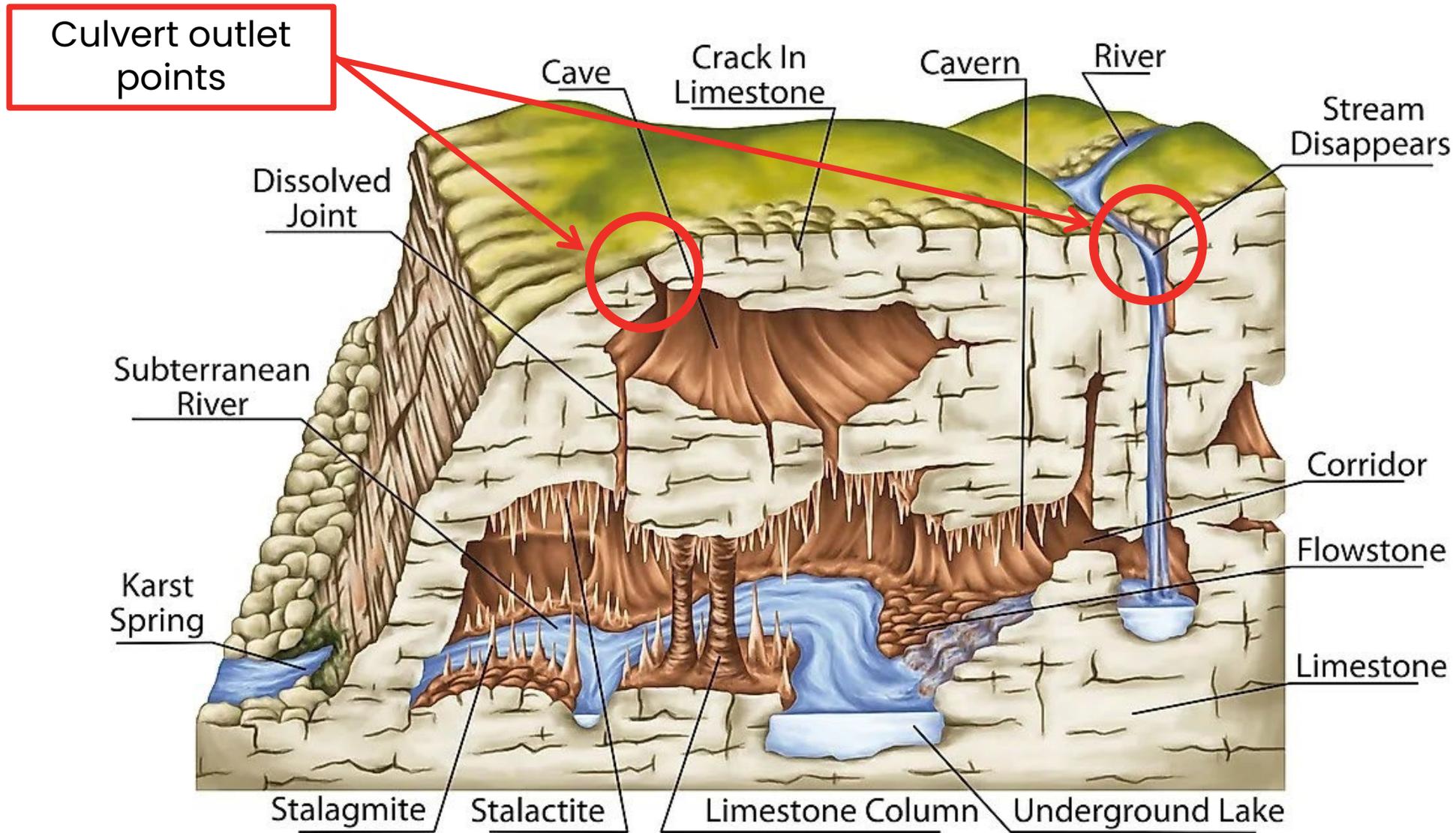


Figure source: <https://www.worldatlas.com/articles/what-is-karst.html>



Southern Indiana Physiographic Divisions

Mitchell Plateau

- Low and broad plateau
 - Developed atop Mississippian period carbonate bedrock

Crawford Upland

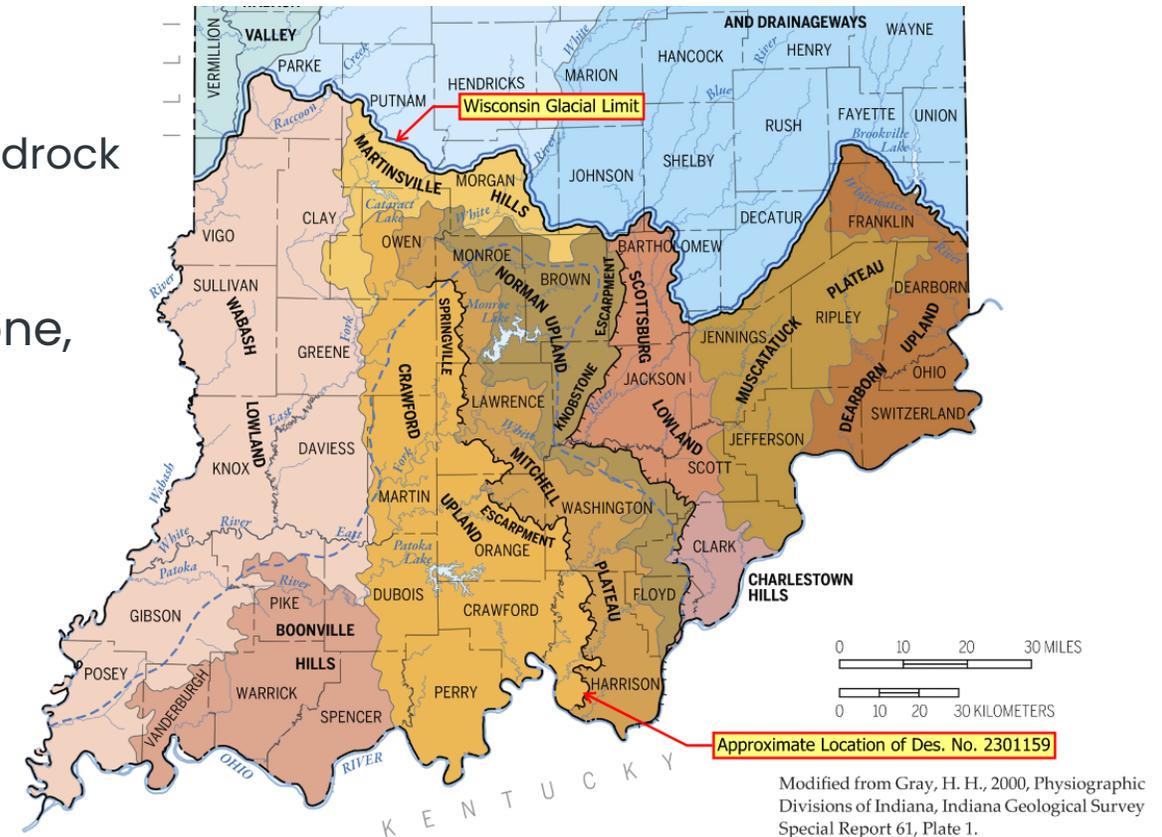
- Contains ridges and valleys
- Developed on Mississippian period shale, sandstone, and carbonate bedrock

Both Divisions

- Did not fully experience direct glacial ice effects of the Wisconsin and Illinoian glaciation.
- Glacial meltwater affected the topography by erosion

Indiana as a Whole

- Northern two-thirds: bedrock overlain by up to 400' of glacial drift
- Southern one-third: covered by much thinner soil deposits



Map Source: Indiana Geological and Water Survey, Indiana University, Bloomington



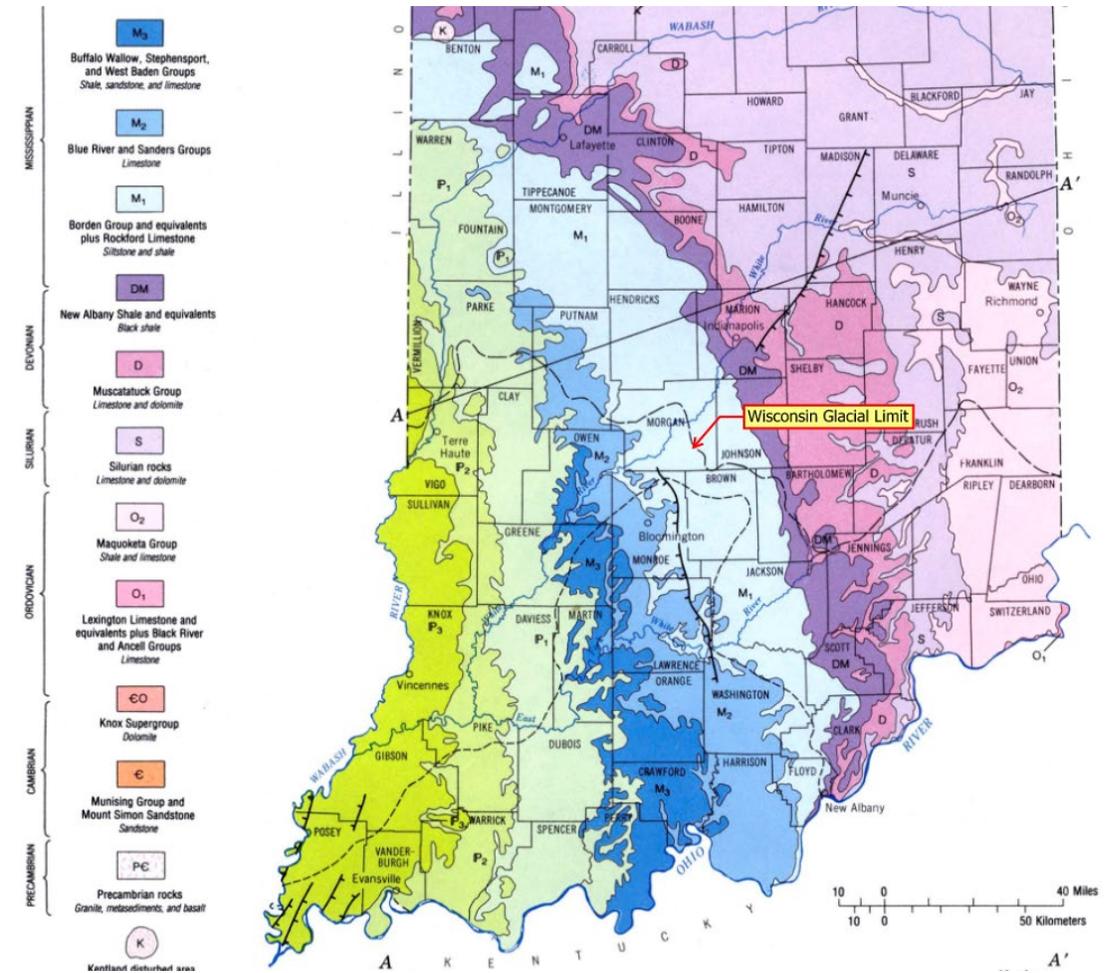
Southern Indiana Bedrock Geology

Harrison County Bedrock Geology

- Consists of both the Mitchell Plateau and the Crawford Upland physiographic regions
- Comprised of limestone

Limestone: Sedimentary Rock Lithified from Carbonate Sediments such as Sand and Mud

- Main chemical composition is calcium carbonate (CaCO_3)



Map Source: Indiana Geological and Water Survey, Indiana University, Bloomington

Formation of Sinkholes

Dissolution of Soluble Bedrock

- Acidic rainwater percolates through the ground
 - Absorbs carbon dioxide
 - Forms a weak carbonic acid
 - Creates cracks and fissures that enlarge over time

Most Common Types of Sinkholes in Indiana

- Solution sinkhole
 - Overlying unsupported soils collapsing into the bedrock void caused by the dissolving of the limestone bedrock
 - Water table variability within overlying soils create instability due to decreased soil strength and collapse
- Collapse sinkhole:
 - The rock roof of an underlying cave fails and allows the overburden to enter the cave

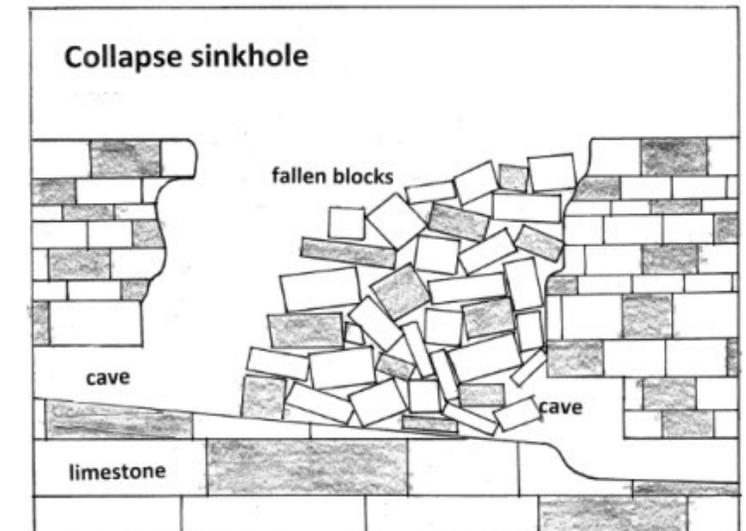
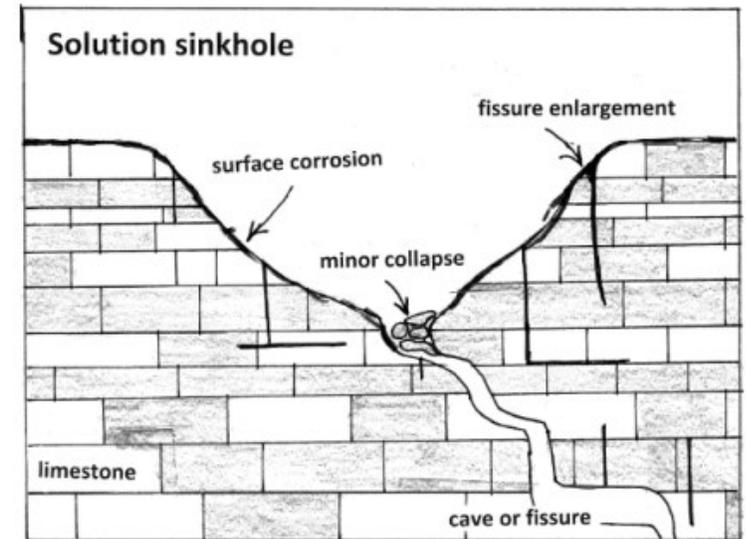
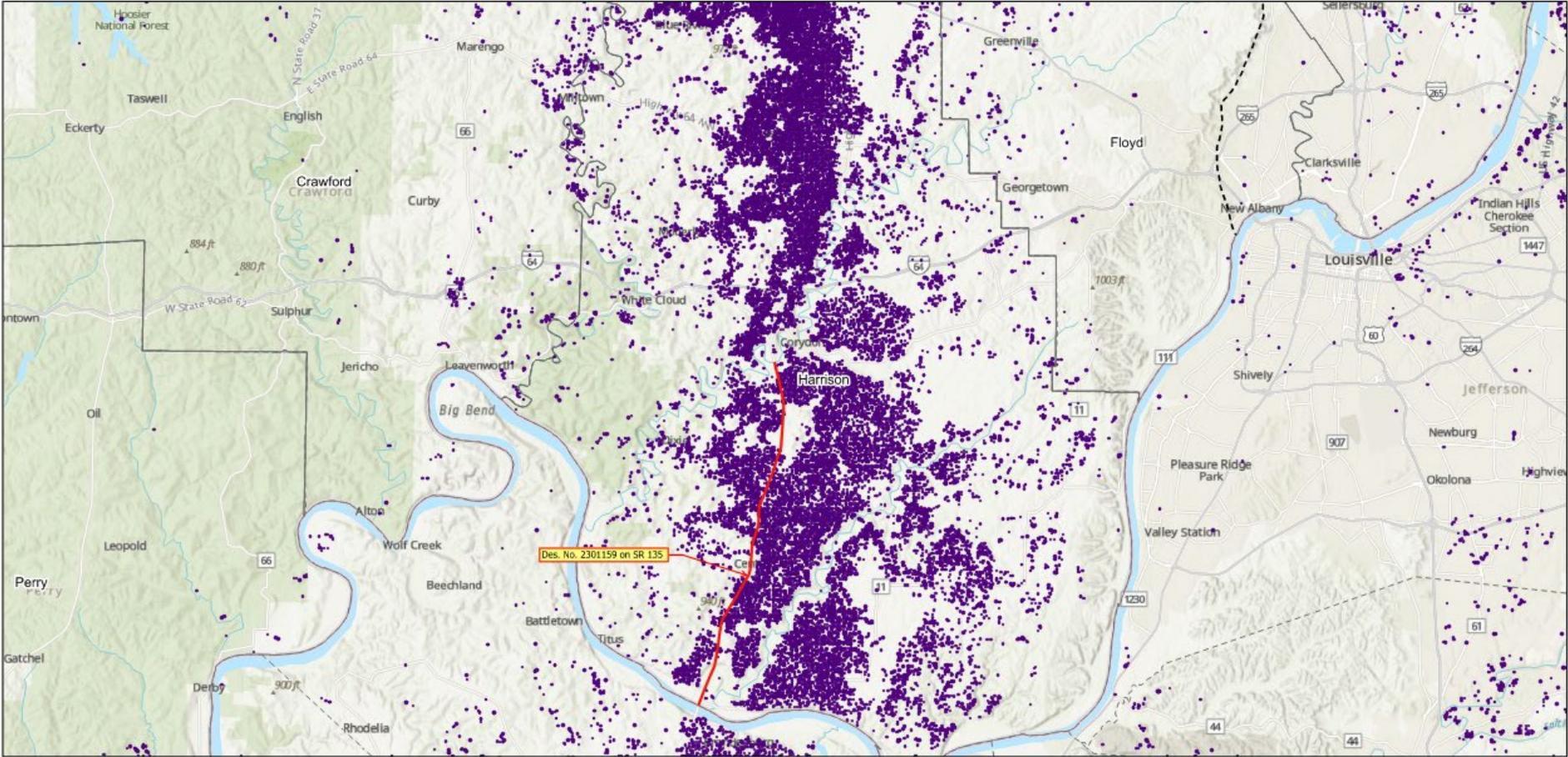


Image Source: INDOT Protection of Karst Features During Project Development and Construction

Inventoried Sinkholes in Harrison County (2011)

Sinkhole Density within Harrison County



November 2, 2025
 □ County Boundaries of Indiana Current
 - - - - Glacial PreWisconsin Limit
 • Karst Sinkhole Inventory IN KY 2011
 World_Hillshade

1:288,895
 0 2.75 5.5 11 mi
 0 4.25 8.5 17 km

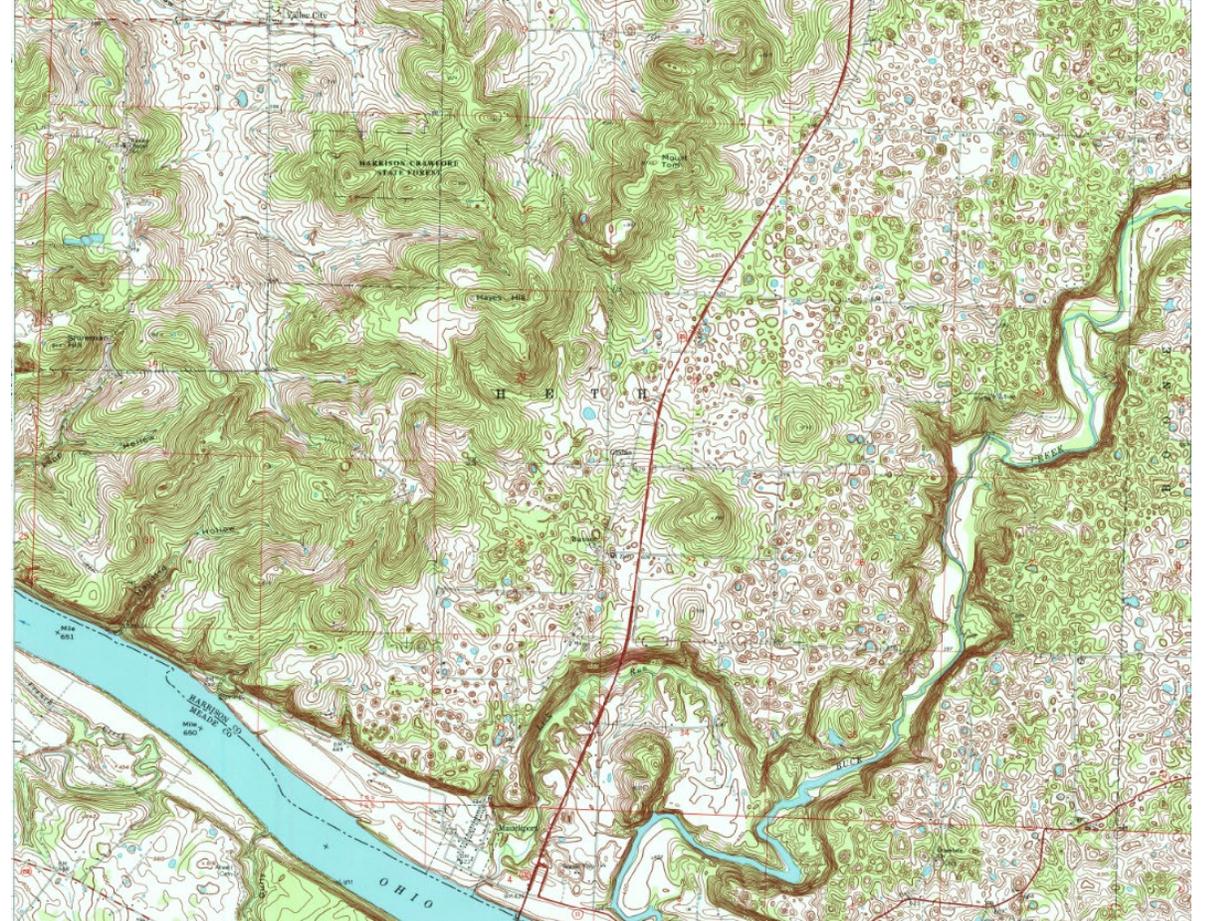
Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Sources: Esri, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user

Map Source: IndianaMap

Indiana Viewer

Hydrology of Project Specific Karst Topography

- SR 135 is located just east of the elevated ridges of the Crawford Upland division and within the flatter areas of the Mitchell Plateau
- Very few well defined channels within the project limits from Lick Run at the south to Indian Creek to the north
 - The few defined channels that are present flow into natural depressions and swallows
- The land adjacent to SR 135 in this area contains sinkholes, karst valleys, and caverns
- Most of the Mitchell Plateau's drainage is located underground



Map Source: USGS



Examples of Existing Sinkholes Adjacent to SR 135



Existing sinkhole located along the east side of SR 135 that receives CLV-67003 discharge



CLV-67003 sinkhole; note funnel shape of opening

Examples of Existing Sinkholes Adjacent to SR 135

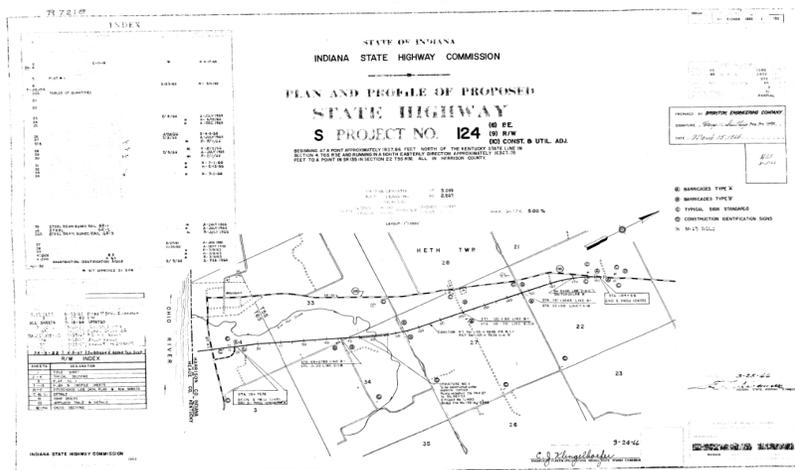


Large sinkhole basin located along the west embankment of SR 135 near CLV-67015

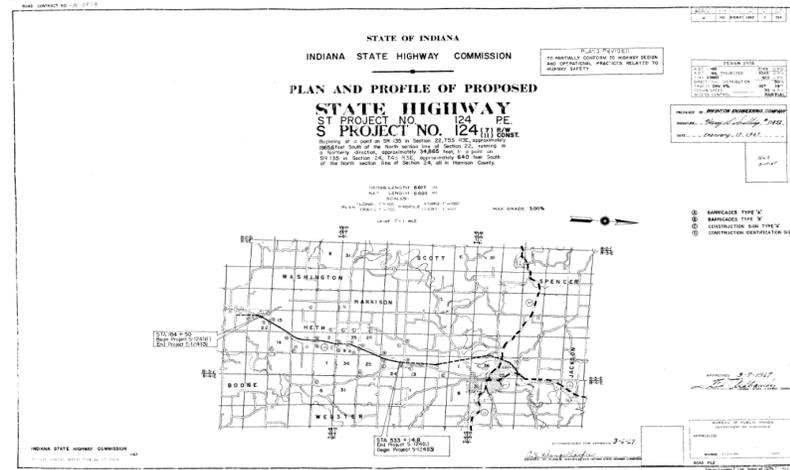


SR 135 Corridor Elements - Background

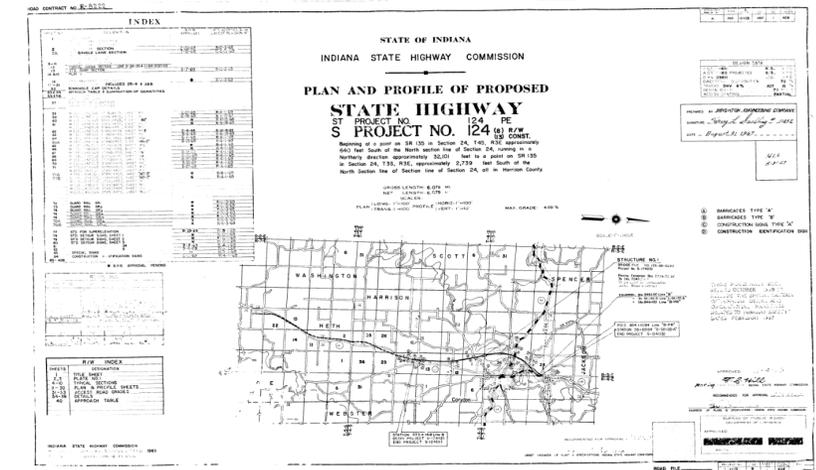
- The segment of SR 135 within Des. No. 2301159 was constructed in the late 1960s through early 1970s across three Indiana State Highway Commission projects
 - Realignment and relocation of the existing SR 135.
- Functional Classification: Minor Arterial
- Not included on the National Highway System
- Included on the National Truck Network
- Posted 55 MPH speed limit
- 2025 AADT = 5,141 VPD NB & 5,124 VPD SB
- 2049 AADT = 6,329 VPD NB & 6,308 VPD SB
 - Trucks = 6.21% of AADT
- The SR 135 corridor provides access to I-64 to the north
 - Local farming operations as well as industrial and commercial businesses in Kentucky utilize SR 135



S-124(10) – Southern one-third of SR 135



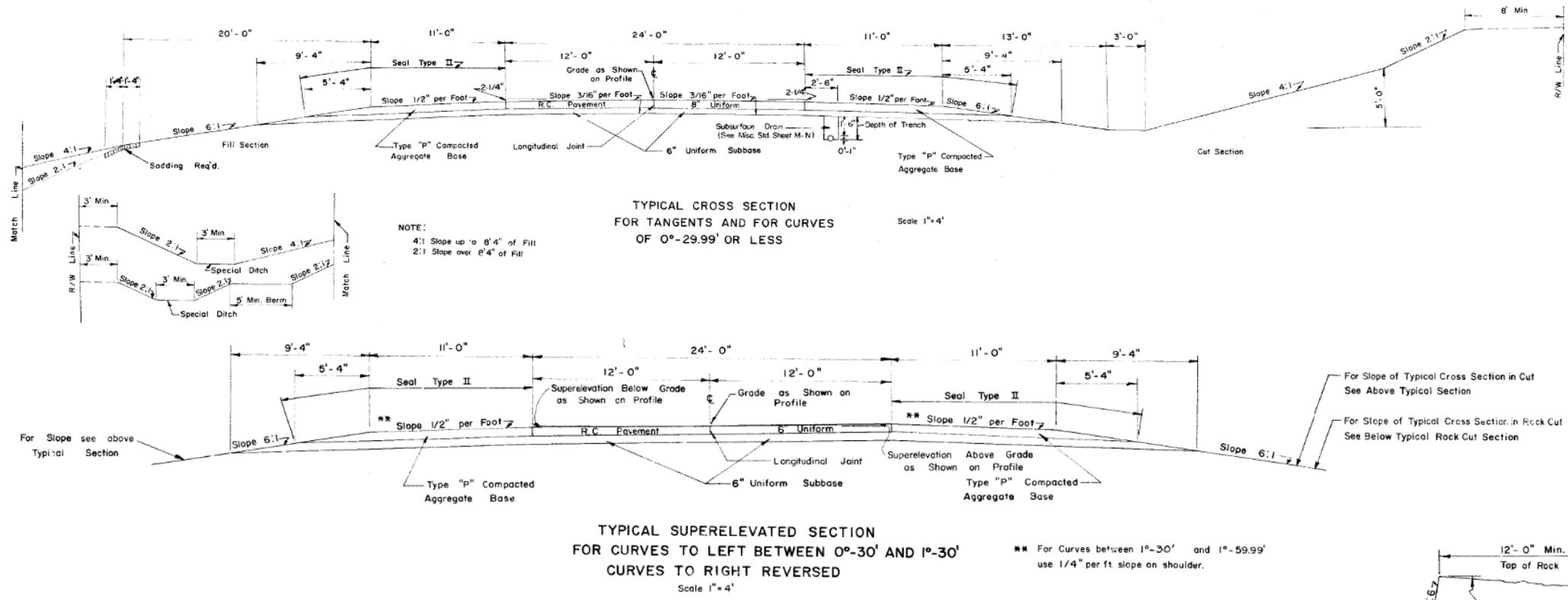
S-124(11) – Middle one-third of SR 135



S-124(13) – Northern one-third of SR 135

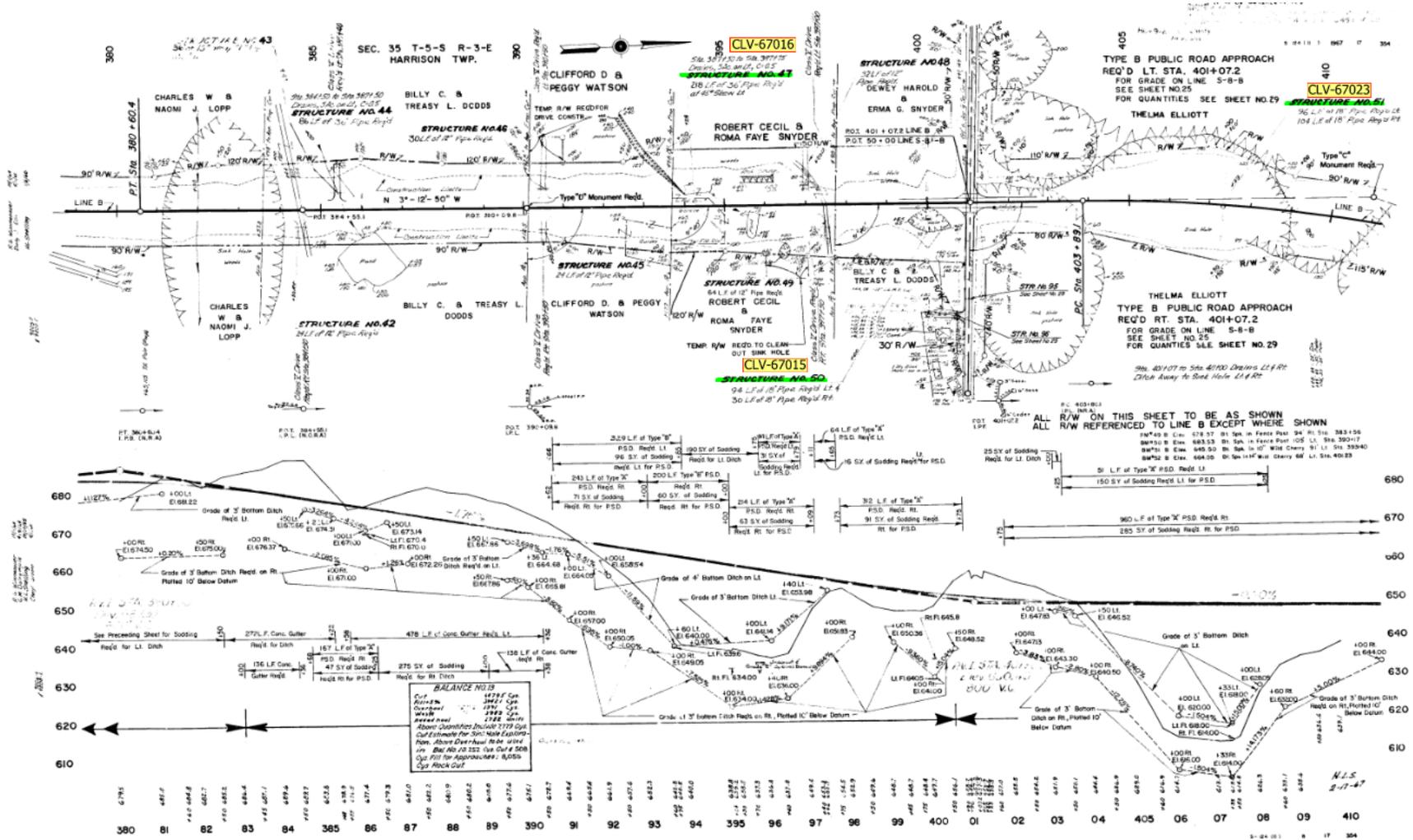
SR 135 Corridor Elements – Typical Section

- SR 135 consists of two 12'-wide HMA travel lanes adjacent to 10'-wide HMA shoulders
- Archive plans show SR 135 as being constructed with an 8" thick reinforced concrete pavement section, but it has been overlaid with HMA
- A 3'-wide (minimum) paved side ditch is present at all embankment fill locations

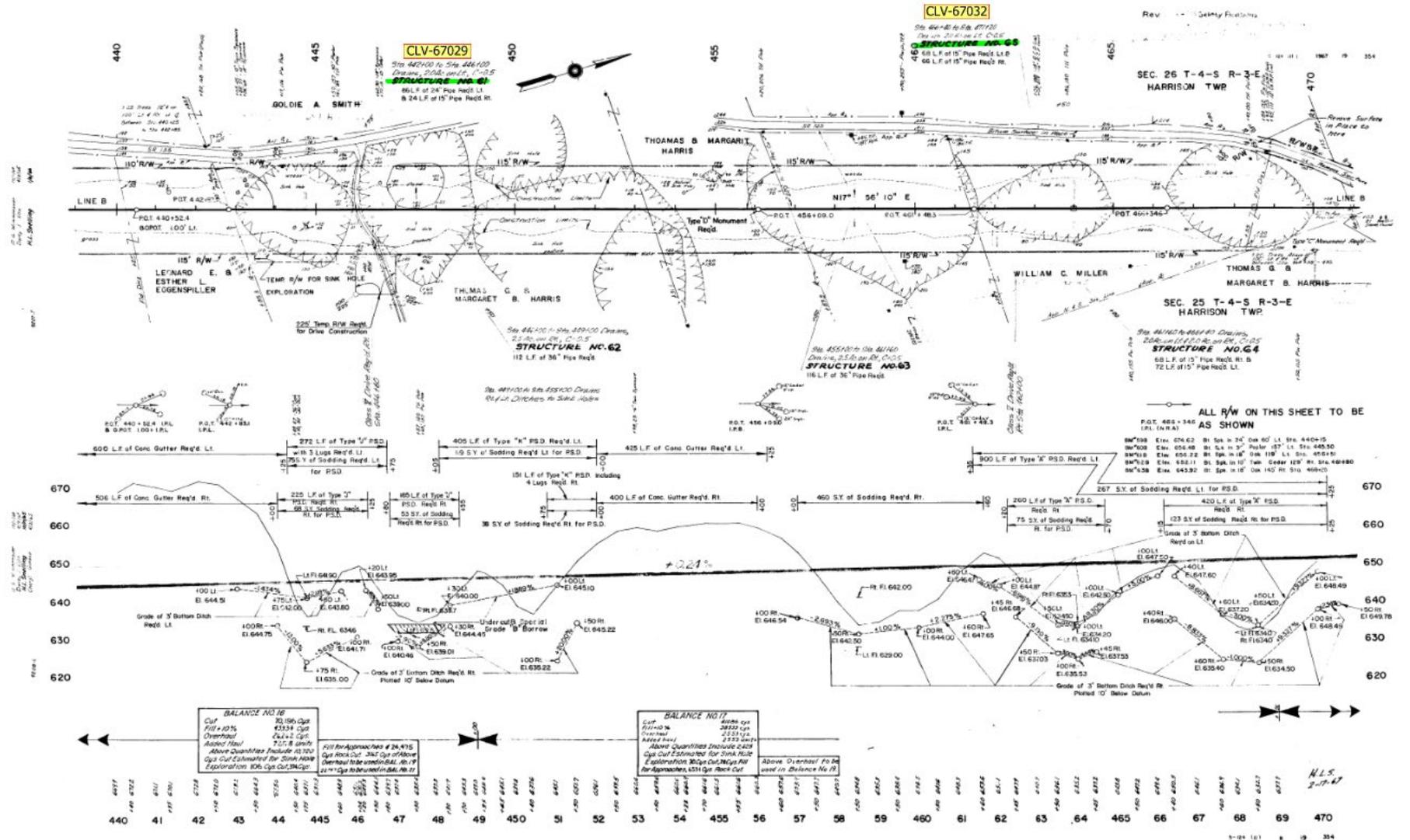


SR 135 Corridor Elements – Alignment

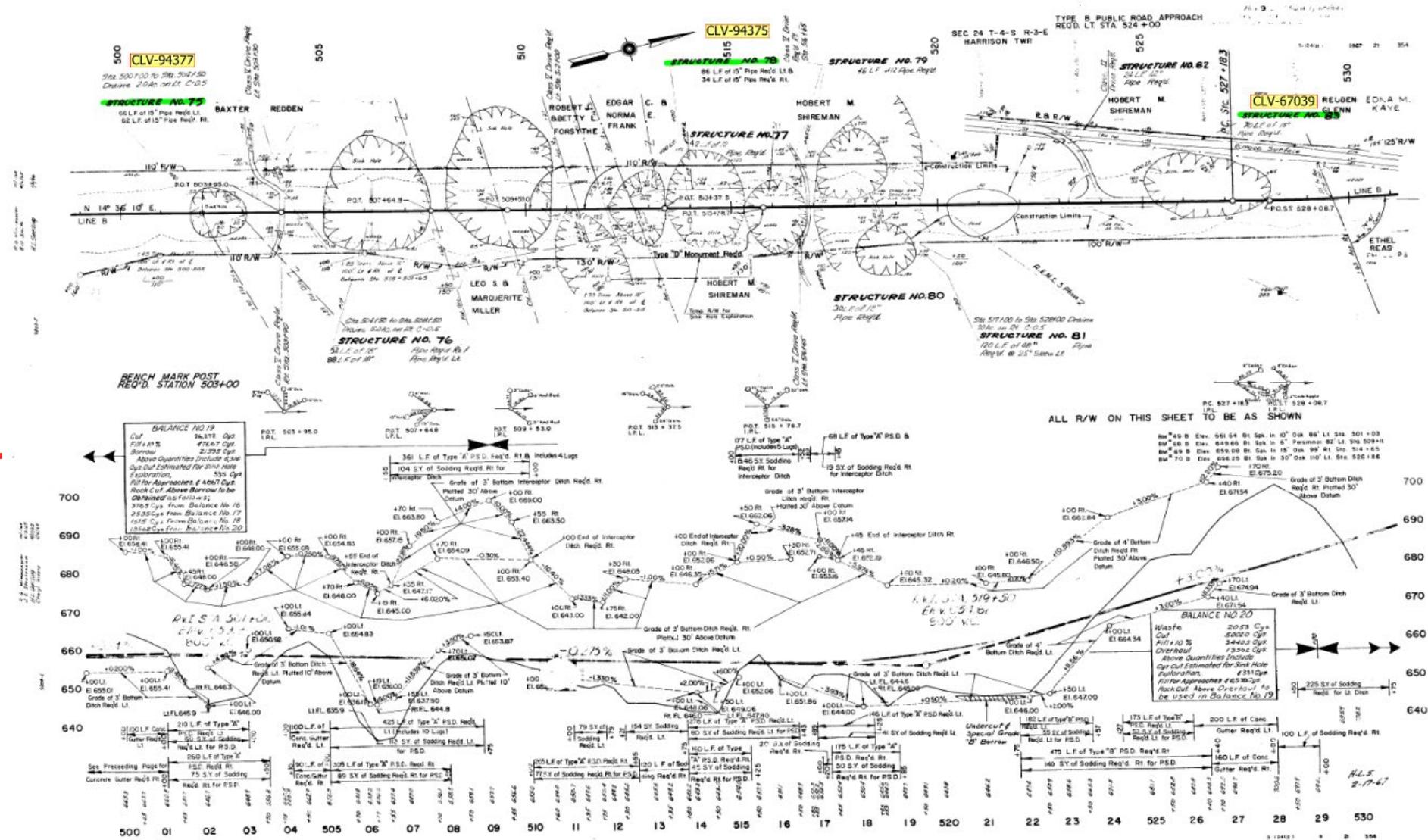
- The realignment of SR 135 produced a roadway that was straighter and had larger, smoother radii curves than those of the existing SR 135
- However, the realignment of SR 135 placed the corridor of the roadway within numerous sinkholes and karst features



SR 135 Corridor Elements - Alignment (Cont.)

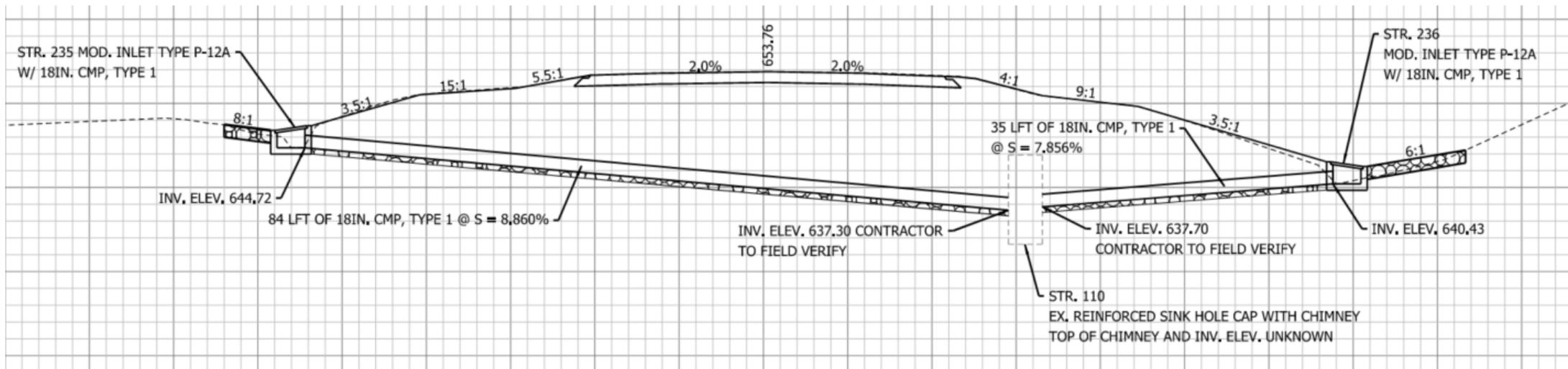


SR 135 Corridor Elements - Alignment (Cont.)



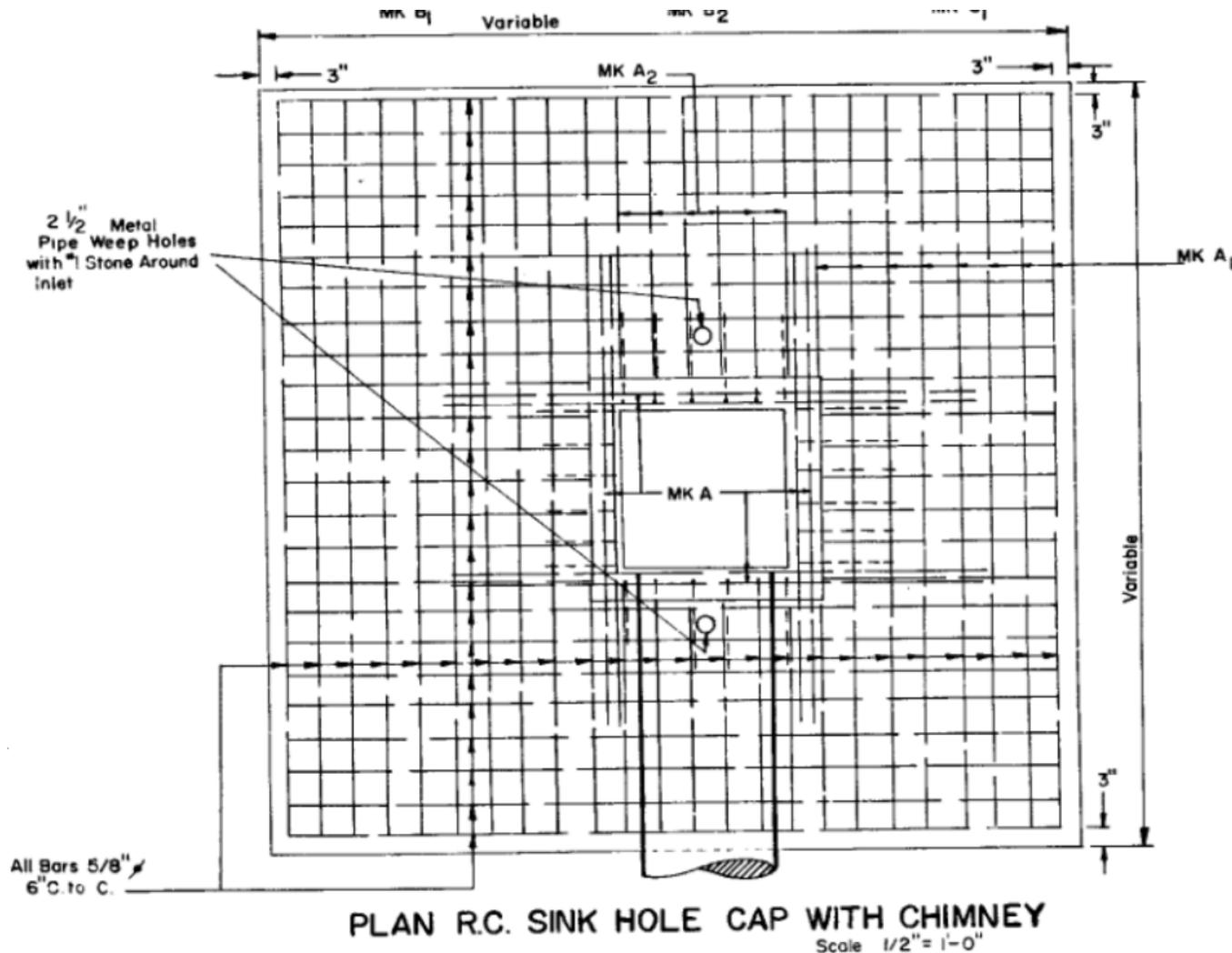
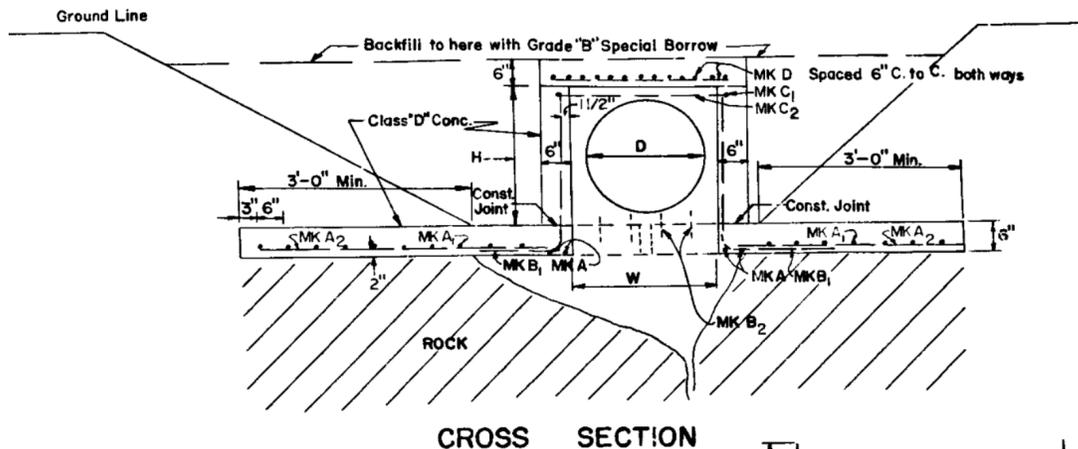
Existing Karst Drainage Structures

- The natural drainage mechanism for the land areas adjacent to the realigned SR 135 rely upon surface flows to be directed into local depressions, swallows, and sinkholes
 - No channelized streams are present to carry surface flows out of the area via point discharges
- Manmade karst drainage structures were constructed as an element of the SR 135 realignment project
 - Structures were constructed atop existing excavated sinkholes so that stormwater is discharged directly into the karst feature opening
- This segment of SR 135 contains three types of existing karst structures:
 - Chimney
 - Special pipe catch basin
 - Special manhole type C-4
- Each chimney collects stormwater from each side of the road via separate pipes
- Existing pipe diameters range from 15" to 24"



Chimney

- No external access besides the pipe itself
- Structures located beneath the pavement or within the embankment foreslope
- All chimney structures within Des. No. 2301159 intercept flow from both the east and west sides of SR 135 via separate pipes



Special Considerations of Existing Karst Structures

- Actual location of karst features may deviate from plans
 - Chimneys are not visible from the road and may vary along the road's traverse width
- Pipe layouts may vary from plans
 - Plans show one pipe connection, but the field has two connected pipes (an east and west pipe draining each side of the embankment)
- In-situ dimensions of the chimney structures appear to vary from the plan dimensions per pipe videos
- Upwards of 7,800 CYS of exploratory excavation was performed for the installation of each karst structure per existing plans
- INDOT only assigns one asset ID per structure assembly

SINK HOLE CAP QUANTITIES

SINK HOLE AT STATION	STRUCTURE NUMBER	CONCRETE CU YDS.	STEEL LBS.	GRADE B SPECIAL BORROW C.Y.	ESTIMATED EXCAVATION FOR EXPLORATION C.Y.	CAP SIZE	CATCH BASIN SIZE
LT 198 + 00	16	7.97	1,915		6,439	12x12	
RT 249 + 00	25	4.29	992		2,738	10x10	
RT 284 + 00		1.85	397	50	30	10x10	
LT 298 + 25		1.85	397	100	2,580	10x10	
RT 310 + 00		1.85	397	100	1,418	10x10	
RT 318 + 00	34	1.89	364		1,258	10x10	18"
LT 331 + 77		1.85	397	75		10x10	
LT 340 + 70	36-A	2.98	703		1,583	10x16	24"
CLV-67015 RT 400 + 00	50	5.02	1,349		7,779	14x14	
CLV-67023 LT 407 + 33	51	2.81	449		1,629	10x10	
RT 412 + 60	53	1.88	364		3,604	10x10	15"
RT 415 + 55		1.85	397	100	830	10x10	
LT 433 + 00	57	3.73	771		1,011	10x10	
RT 434 + 50		1.85	397	100	3,588	10x10	
RT 436 + 40	59	1.89	364		3,388	10x10	18"
CLV-67029 RT 444 + 75	61	3.89	887		2,733	10x10	
LT 454 + 22		1.85	397	100	356	10x10	
CLV-67032 LT 464 + 00	64	3.39	783		1,224	10x10	
RT 468 + 50	65	3.34	785		843	10x10	
LT 470 + 50		1.95	397	100	2,156	10x10	
RT 471 + 75	66-A	2.22	493		5,367	10x12	15"
CLV-67036 LT 487 + 00	71	3.38	890		733	10x10	
LT 495 + 00	72	3.75	945		2,489	10x10	
CLV-94377 RT 502 + 00	75	3.19	748		1,927	10x10	
LT 506 + 19	76	3.39	862		1,900	10x10	
CLV-94375 RT 514 + 00	78	1.85	397	100	1,900	10x10	
516 + 50		1.85	397	100	3,289	10x10	
LT 526 + 40		2.22	476	75		10x12	
"S-10-B							
RT 48 + 90	100	3.08	745		837	10x10	
Total		86.30	19,614	1,000	66,552		



Field Examples of Existing SR 135 Karst Structures



R.C. sinkhole cap with special pipe Cctch basin Located along the east toe of embankment slope near CLV-67016



Field Examples of Existing SR 135 Karst Structures



R.C. sinkhole cap with special pipe catch basin located along the west side of embankment slope near CLV-67610



Field Examples of Existing SR 135 Karst Structures



Chimney Structure – East Inlet of CLV-67023: A number of structures have been encroached upon by trees



Chimney Structure – West Inlet of CLV-67023: This structure is under approximately 36' of fill



Chimney Structure – East Inlet of CLV-67029: Note the existing metal mesh and heavy sedimentation of adjacent ditches

Field Examples of Existing SR 135 Karst Structures



Special MH Type C-4 – CLV-67047: Type 4 casting located adjacent to west shoulder



Special MH Type C-4 – CLV-67047: Interior of MH, approx. 30' deep. Plans specify 8' structure depth with no additional pipe at invert



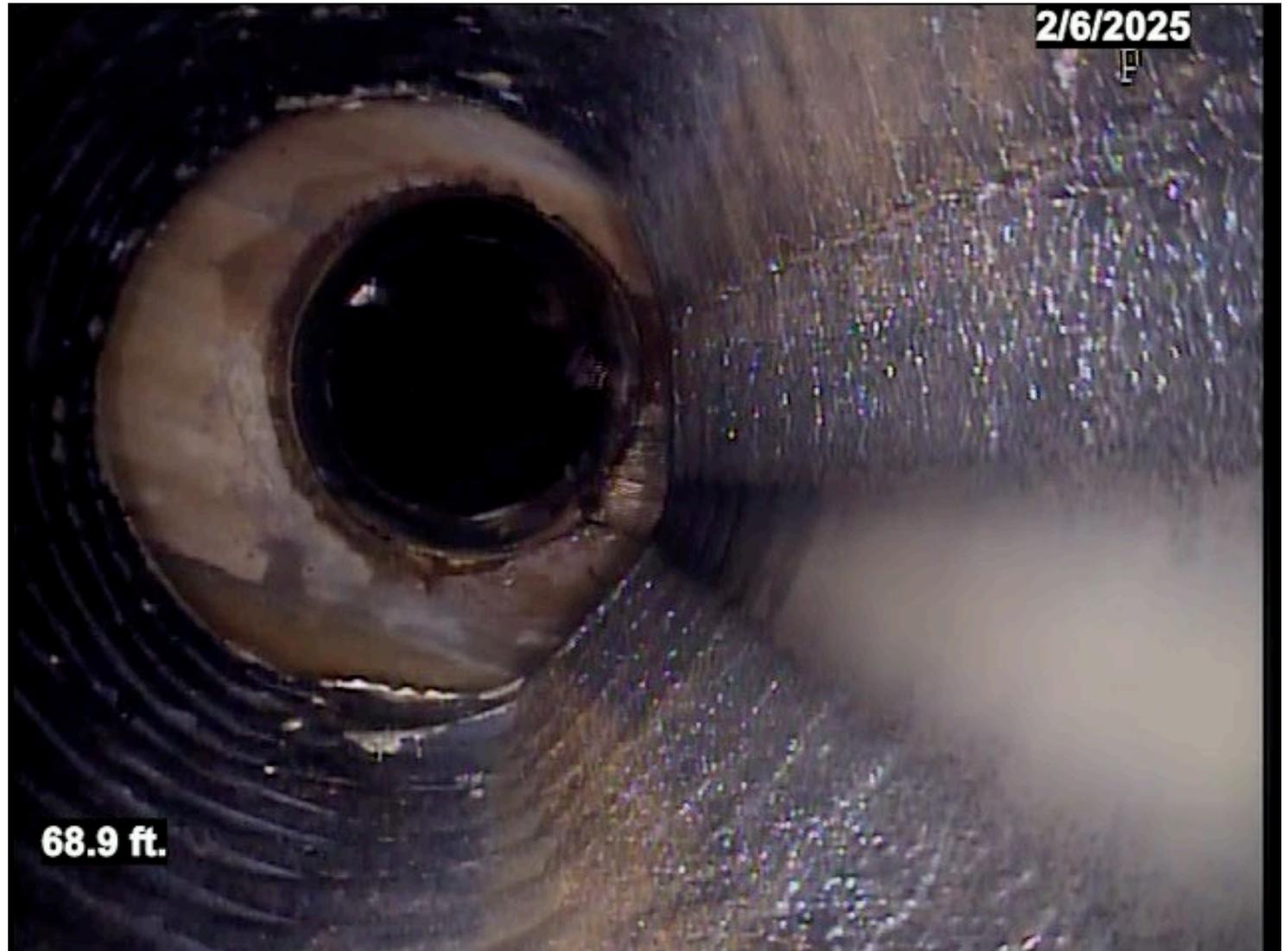
Special MH Type C-4 – CLV-67047: Inlets of connecting pipes still retain the as designed rebar grating and steel mesh fabric

CCTV Inspections of Existing Karst Structures

- CCTV pipe inspections were performed for each karst structure
 - Information found:
 - Location and visual condition of each karst structure and its connecting pipes
- Some structures were unable to be videoed completely due to blockages present within the existing pipes
- Running distances of the pipe buggy were used to verify the transverse location of the karst structure against the location shown on the plans



Pipe Video of Existing Karst Structures



CLV-67036



Indiana Department of Transportation
INDOT

Confidence in the built environment
hwcengineering.com



HWC
ENGINEERING

Pipe Video of Existing Karst Structures



CLV-67023



Indiana Department of Transportation
INDOT

Confidence in the built environment
hwcengineering.com



HWC
ENGINEERING

Pipe Video of Existing Karst Structures



CLV-67047



Abbreviated Engineer's Report & Preferred Alts.

- AER development began after field reconnaissance
- Guided by scoping meetings that were held prior to the issuance of the NTP of the project:
 - No lining of any karst feature pipe per INDOT Environmental
 - No trenchless installation methods
 - Try to keep existing chimneys due to budgetary constraints
 - Preliminary hydraulics performed for each structure to check hydraulic adequacy
 - Development along the corridor may have increased the flow compared to original installation date
 - Increased flow may harm the karst feature itself changing its structural stability and resilience
 - Some fashion of non-proprietary, pre-discharge filtration would be required for the inlet pipes of all karst structures

Abbreviated Engineer's Report

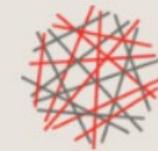


SR 135 Small Structures & Drains Construction
Harrison County, Indiana

Des. No. 2301159
Contract R-45224

Prepared for:
Indiana Department of Transportation
SEYMOUR DISTRICT

May 2025



HWC
ENGINEERING

303 Scribner Drive, Suite 201, New Albany, IN 47150 | 812-913-6419

Confidence in the built environment
hwcengineering.com



HWC
ENGINEERING



Indiana Department of Transportation
INDOT

Abbreviated Engineer's Report & Preferred Alts.

Preferred alternates were developed for each group of culverts based on field observations, hydraulic needs, constructability, and MOT concerns.

- **Five Public Approach Culverts (Non-Karst)**

- To be replaced via the open cut method
 - Proposed diameters range from 12" to 24"
 - Road closures for construction

- **Eight Mainline Culverts (Karst Structures)**

- To be replaced via the open cut method
 - One structure required its pipes to be upsized
 - Proposed pipe diameters range from 15" to 24"
- Traffic shifts, single lane closures, and temporary signals

- **Two Mainline Culverts with Deep Cover (Non-Karst)**

- 36" diameter
- Abandoned and replaced by jack and bore method
 - Method chosen due to the high cover atop the culverts and the suitability of the surrounding terrain to accommodate the bore pit and receiving pit

- Existing pipe to be filled with cellular concrete fill
- Traffic maintained through shoulder closures

- **Three Mainline Culverts with Shallow Cover (Non-Karst)**

- 36" diameter
- To be replaced via the open cut method
- Traffic maintained through shifts, single-lane closures, and temporary signals



Special Design Considerations for Karst Structures

- Videos show concrete of the existing karst structures cracking and spalling around the pipe openings
 - Proposed: concrete patching and epoxy injection crack repair
- Structural repairs designed for portions of structures that have failed
 - Rebar dimensions and layouts provided in archived plans since they can't be cut open
- Upsizing pipes will require subsequent pipe openings to be enlarged
- Soil tight pipe connection necessary at pipe opening
- Sedimentation accounted for in ditch design
- Deep cover atop structures will require the use of temporary shoring
 - Slide rail anticipated
- Contractor access considered due to the steepness of the foreslopes
- MOT critical to traveling public
 - Phasing accounted for location of the karst chimneys and required excavation



Hydraulics Considerations During Scoping

- Early meetings with INDOT hydraulics shaped requirements
- *Replacement In-Kind Policy* per IDM 203-2.08 used where applicable
- Pipes under 48" would typically not warrant review from hydraulics
 - INDOT hydraulics reserves the right to review all structures
 - Unique situation called for review from INDOT hydraulics
- INDOT required preliminary hydraulics be performed
- Particulate filtration required at the upstream end of each inlet pipe
 - No proprietary BMP to be used for filtration
 - Asset number may be needed for each filtration measure
- No existing concrete paved side ditches (PSD) to be perpetuated within the construction limits
- No CIPP liners on karst structures
 - Epoxy resins are a pollution hazard to the receiving karst feature



Preliminary Hydraulics for Abb. Engineer's Report

Abbreviated Engineer's Report (AER): two month timeline

Hydraulics information was critical for AER approval

- Topographic survey taken during AER.
 - Surveyed invert elevations not available for AER
 - Existing plans used for inverts instead
- LiDAR used for watershed delineation

AER hydraulic elements

- Hydrologic analysis (watershed, "C" value)
- Q100 discharge for backwater
- Q50 discharge for velocity
- Proposed pipe diameter and material for capacity
- No outlet riprap protection needed for chimney structures



Preliminary Hydraulics - Hydrology

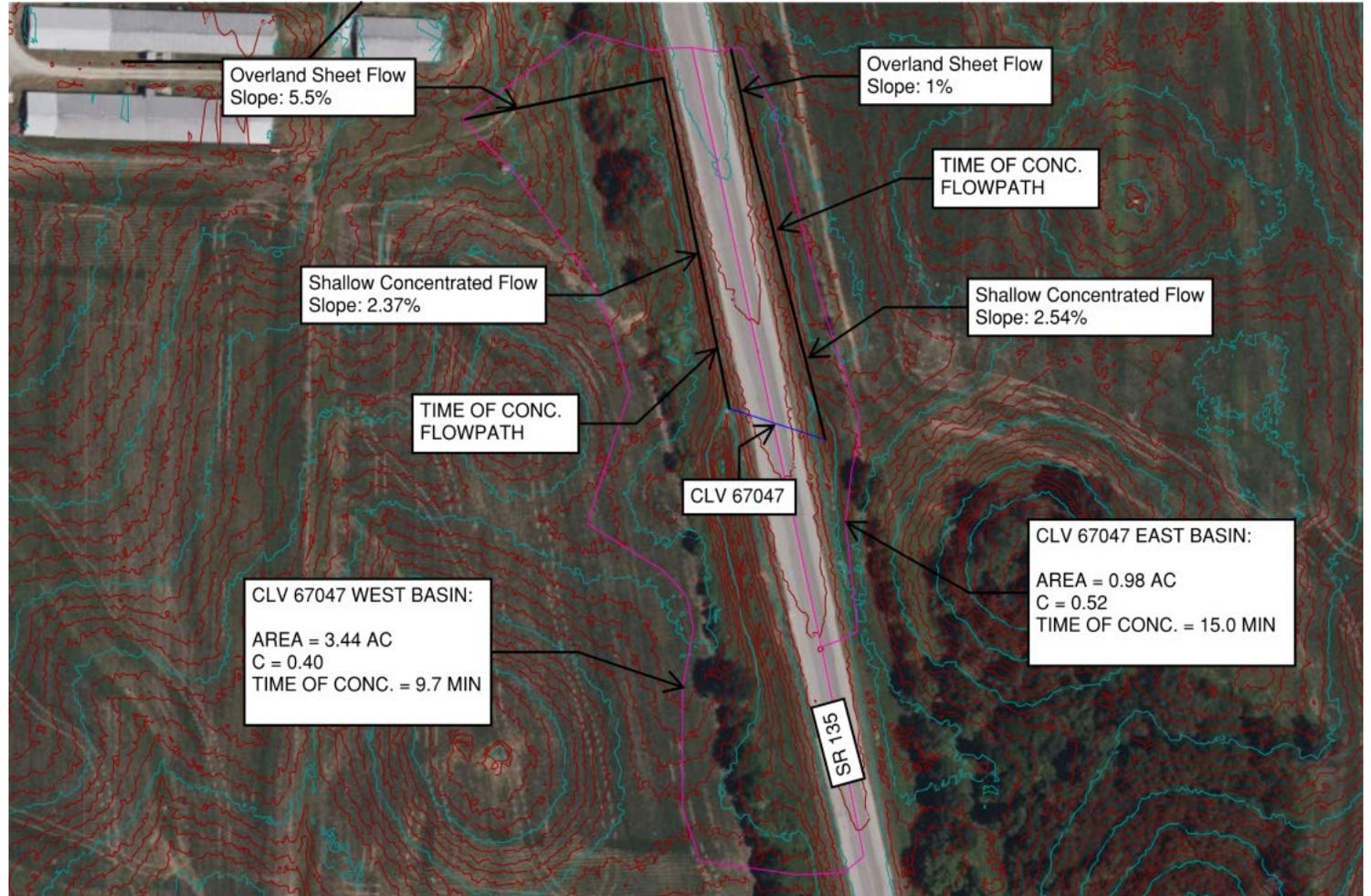
Rational method $Q=CIA$

- Composite land use "C" value
- NOAA rainfall intensity "I" based on time of concentration
- LiDAR and survey data for watershed area "A"

AADT determines event to be examined - >3,000

- Q100 discharge for backwater and service ability
- Q50 discharge for velocity

Both sides evaluated independently

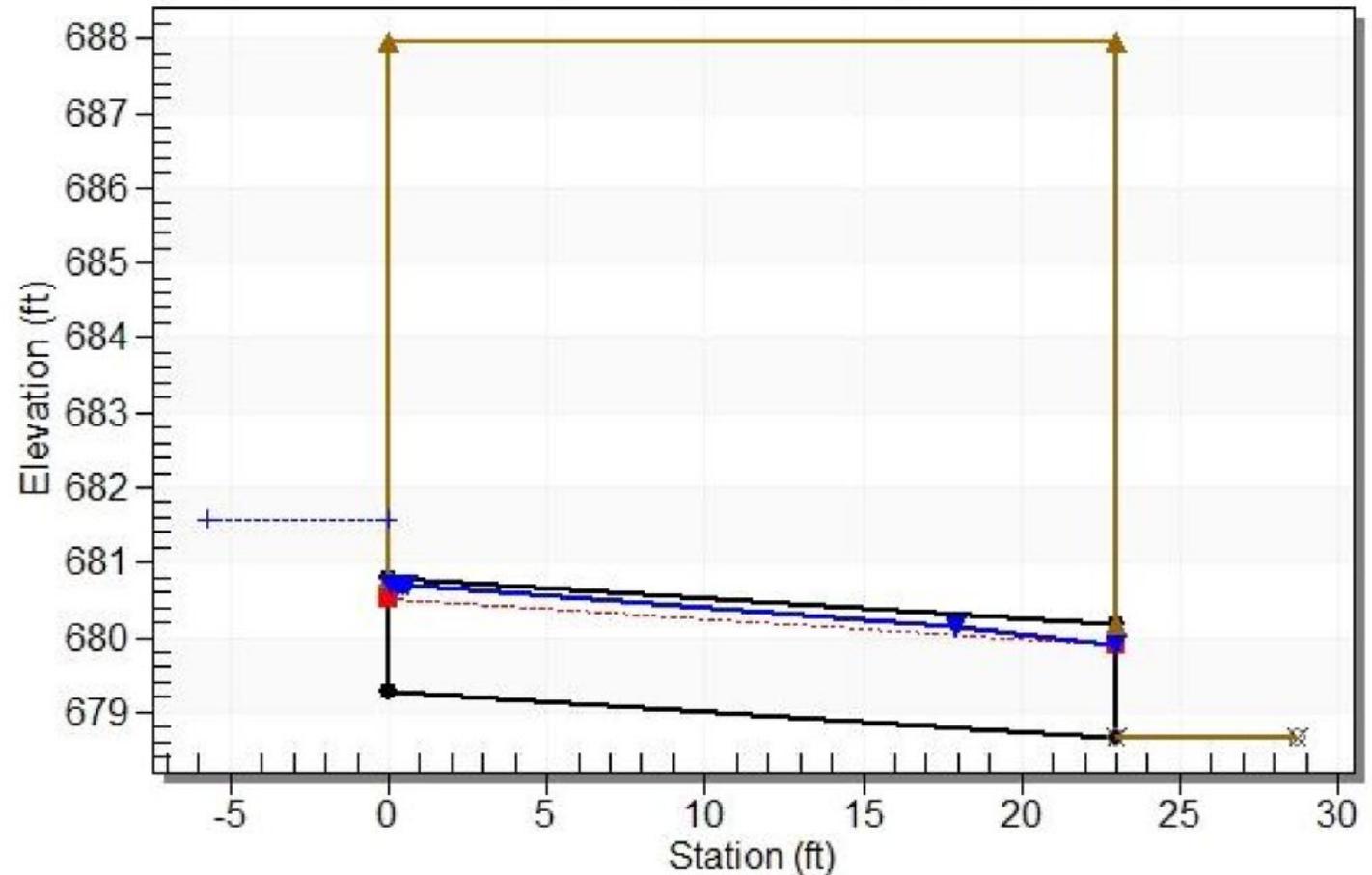


Preliminary Hydraulics

HY8 version 7.2 to check on RIK policy

- Existing Structure analysis to find existing backwater
 - Backwater = headwater depth - tailwater depth
- Proposed structure analysis to find proposed backwater and service-ability
 - Analyzed smooth interior and corrugated metal
 - (different Manning's n-value)
 - If proposed backwater > existing or >3', analysis of backwater and ROW location

Crossing - CLV67047 W, Design Discharge - 10.2 cfs
Culvert - EX 18" CMP, Culvert Discharge - 10.2 cfs



Preliminary Hydraulics – Special Considerations

- Tailwater = outlet invert to create a free fall condition
- Conversion of old plan outlet elevations from NGVD29 Datum to NAVD88 Datum to correspond with LiDAR/survey
- Backwater calculations use outlet depth rather than the typical tailwater depth (depth in the pipe vs depth in a downstream channel)

Station	Structure	Material	Length	Angle	Inlet Elev (NGVD29)	Outlet Elev (NGVD29)	Outlet Elev (NAVD88)	Notes
66+00	18" A PIPE	96			679.0	679.0	678.67	CONNECT TO M.H. - CONSTRUCT INLET DITCH 1'-18" BENDS REQ'D.
67+50	24" A PIPE (S-17-B)	82			684.1	684.1	683.78	CONSTRUCT INLET AND OUTLET DITCHES
69+50	18" D PIPE	84	45°	3.5'	677.5	677.0	676.67	
70+75	18" D PIPE	84	45°	3.7'	677.5	677.0	676.67	
681+45	15" D PIPE	40			664.3	663.5	663.17	
700+00	6" F.B.C. PERFORATED C.S.	70						
700+00	20" F.B.C.C.S./P.I.	154					11.67	3 SPECIAL ANCHORS REQ'D.
700+00	36" F.B.C.C.S./P.I.	150					11.67	3 SPECIAL ANCHORS REQ'D.

CLV 67047 Inverts
 West: 679.0 NGVD29
 East: 679.0 NGVD29

(NGVD29 – 0.33 = NAVD88)

CLV 67047 Inverts
 West: 678.67 NAVD88
 East: 678.67 NAVD88



Hydraulic Memoranda for Karst Structures

Final hydraulics used topographic survey and the AER – memos and calculations provided to INDOT and approved without comment

- Each inlet to a chimney analyzed separately
- Corrugated and smooth circular pipes – in general backwater stayed on ROW or was equal to existing

N-12 and P-12 inlets: provide filtration for trash, debris, and floatables

- Generally similar hydraulic function to existing flared end sections

West Structure: Existing 18" CMP

Site Parameters		
Drainage Area	3.44	acres
Q ₁₀₀ (AEP 1%) Discharge	10.19	cfs
Q ₅₀ (AEP 2%) Discharge for velocity	9.46	cfs
Q ₁₀₀ (AEP 1%) Tailwater Depth	1.23	ft.
US Edge of Travel Lane	687.96	ft.
Design Roadway Serviceability Elevation	686.96	ft.

Culvert Properties						
Parameter	Existing		Proposal 1		Proposal 2	
Structure Size & Type	18" Circular CMP		18" Circular CMP		18" Circular Smooth	
Q ₁₀₀ Headwater Elevation	681.56	ft.	681.56	ft.	681.58	ft.
Meets Roadway Serviceability @ Q ₁₀₀ (AEP 1%)	Yes		Yes		Yes	
Backwater	1.05	ft.	1.05	ft.	1.39	ft.
Minimal Low Structure Elevation (US)	680.78	ft.	680.78	ft.	680.78	ft.
Assumed Flowline Elevation (US)	679.28	ft.	679.28	ft.	679.28	ft.
Sump Depth	0	in.	0	in.	0	in.



Ditch Hydraulics for Karst Structures

- Ditch design ongoing with coordination with INDOT
- Original concrete paved side ditches still in-place today
 - Some heavily undermined and broken apart
 - Inlets adjacent to PSDs covered with up to 18" of dense sedimentation
 - Most adjacent to cultivated fields
- Design considerations for karst structure ditches include:
 - Ditches located adjacent to the toe of embankment or hill slope
 - Retention of stormwater must be analyzed so that sitting water does not compromise slopes.
 - Must be easily maintained
 - Should not depend on specialized concrete structures or filtration devices
 - Rely on aggregates, tall grasses, etc.
 - No native plants planted within 30' of the edge of shoulder for mowing purposes
 - Proposed ditch dredged to original paved side ditch elevation
 - Rubblize existing paved side ditches



Not All are Culverts

- 064-31-06286A
- Chimney structure set under a slab top
- Well defined channel upstream to a raised swale downstream
- Q100=900 cfs w/ 2.45 sq mi drainage area
- Overflow goes to another karst feature 1100' to the north
- No pipe is under natural downstream county road



Upstream swale



Downstream swale



Chimney under bridge

Lessons Learned so Far

- Thoroughly research all documentation available for a project
- Early Coordination:
 - INDOT Asset Owners
 - Subject matter experts
 - INDOT Maintenance Supervisors
 - Continue coordination through project development – not just prior to and after submittals
- **FIELD CHECK ALL STRUCTURES!!!**
 - Include younger staff in on-field work
- Physically mark locations of structures in the field prior to video inspection or survey



Thank you!

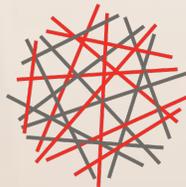
Questions & Discussion



Eric Len Plaiss, PE
eplaiss@hwcengineering.com



Alex Schwinghamer, PE
aschwinghamer@indot.in.gov



HWC
ENGINEERING