River Bank Foundation Design

MIPSYCON 2016

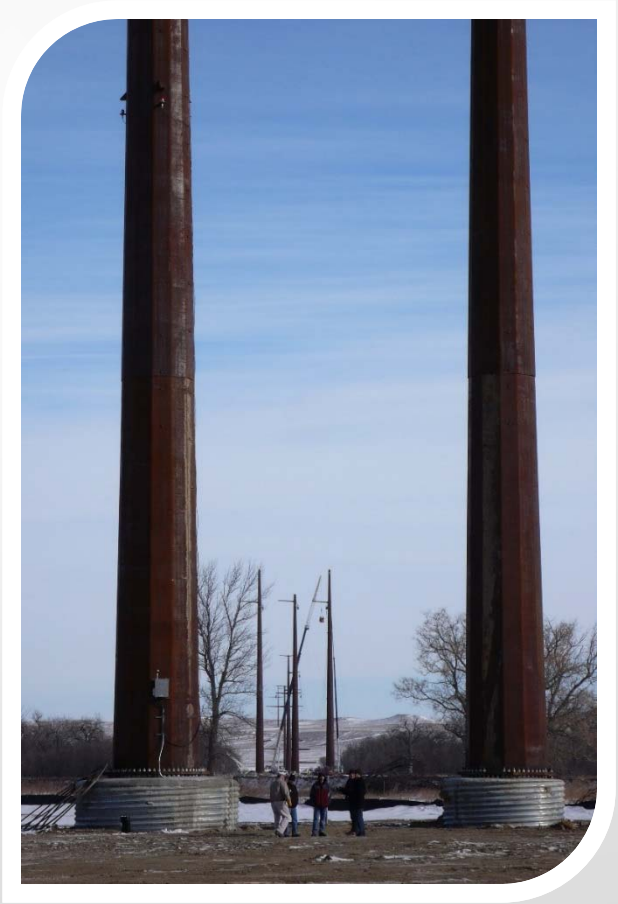
Luke Karels and Duane Phillips
Stanley Consultants, Inc.

Stanley Consultants INC.

Objective and Basis

- Presentation of design and construction considerations for river bank and river crossing foundations on transmission line projects.
- Topics Covered
  - Loading
  - Structure Types
  - Design Process and Alternatives
  - Constructability and Construction Methodology
- Project Examples:
  - 2,700-foot crossing of Missouri River
  - Multiple crossings of Minnesota River

Examples - Foundations



Basic Foundation Design

Loading Factors

Significantly higher load due to wire selection (strength) and tension.

Resulting ground line moments significantly higher.

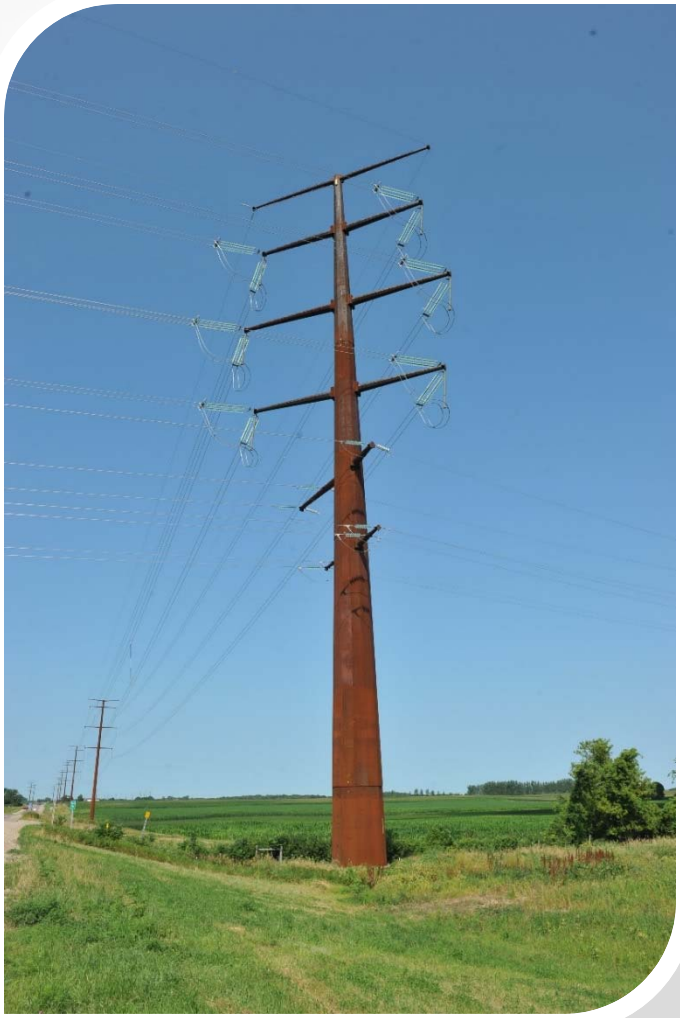
Total loading may result in alternative designs.

Loading Considerations

- Guyed vs. self-supporting
- Deadend vs. tangent
- Required additions
  - Markings, lighting, maintenance, underbuild
- Geotechnical (soils/rock)
- Environmental concerns
  - Water flow, flooding, debris, wildlife

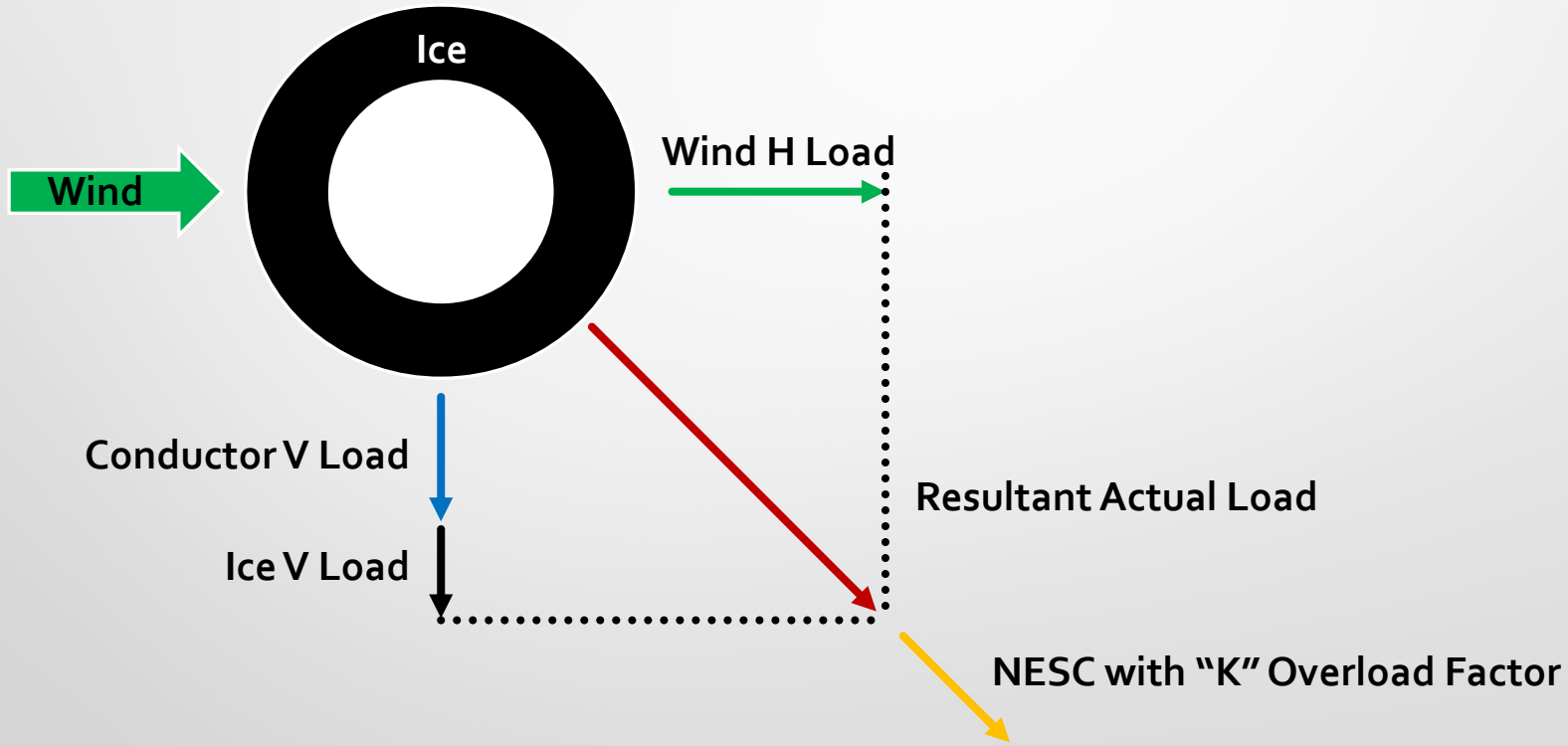
Pole Loads - General

- Conductor point loads
- Pole self-weight
- Wind loads
  - Wind on pole
  - Wind on wire
- Ice loads
- Hardware
- Maintenance/construction loads
  - Stringing loads



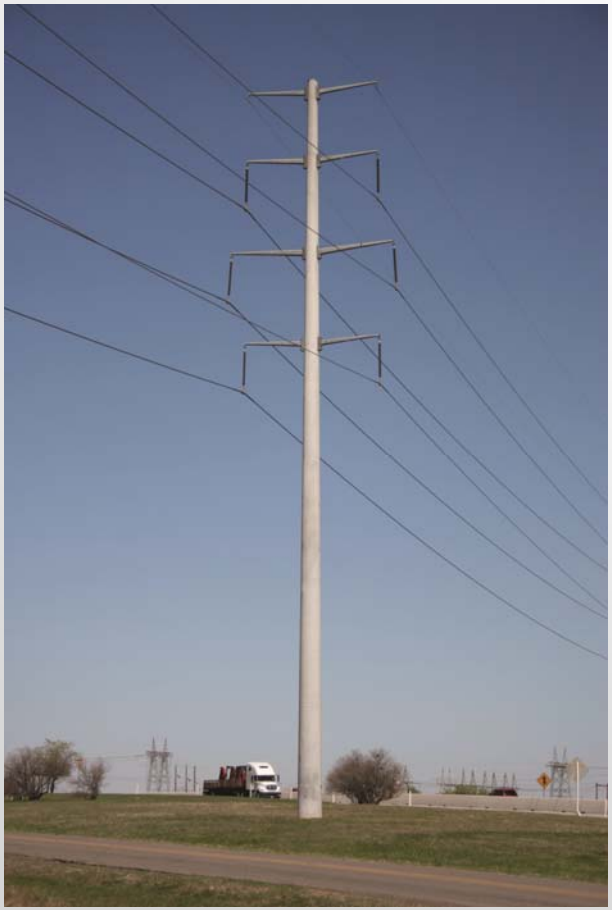
Conductor Resultant Load

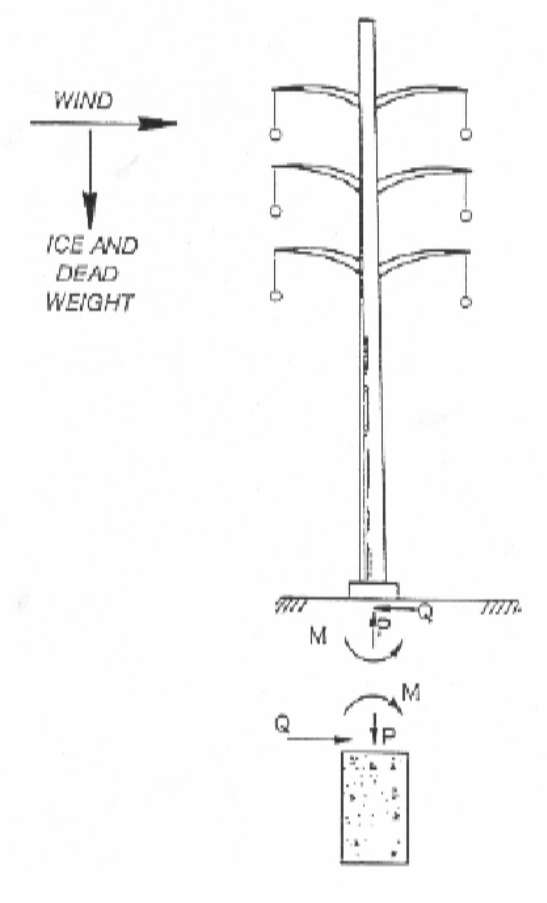
- Conductor weight, ice, and wind combined



Structure Types

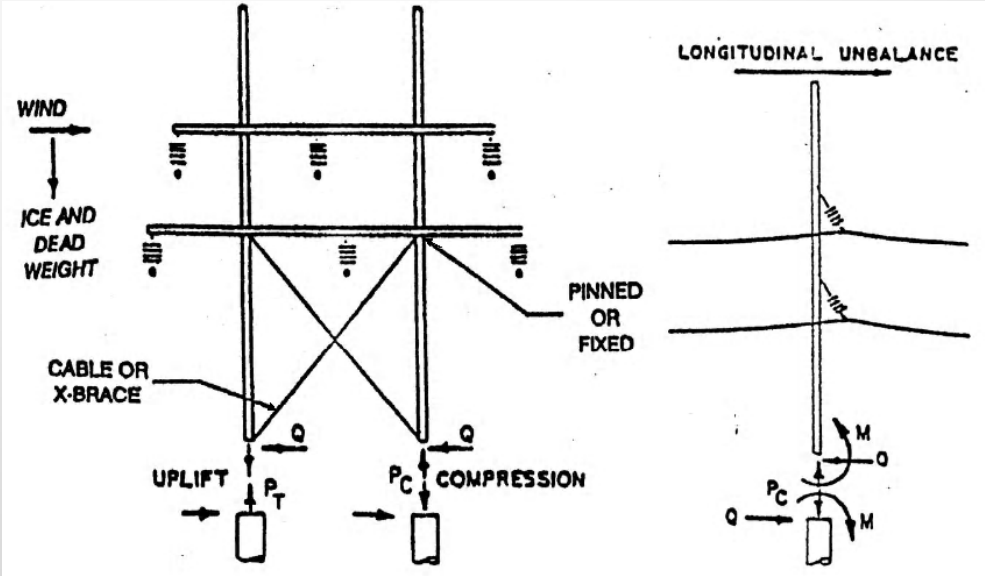
Monopoles





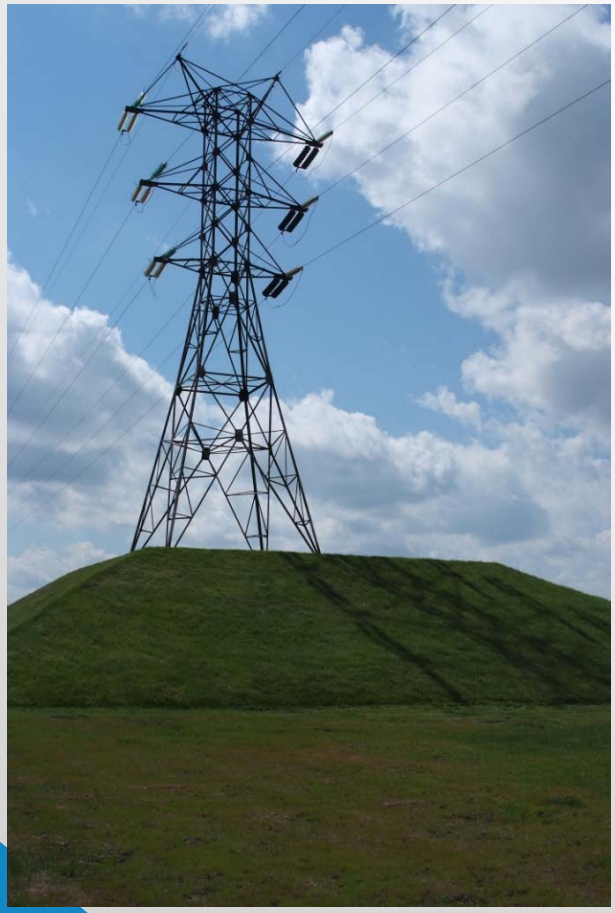
Structure Types

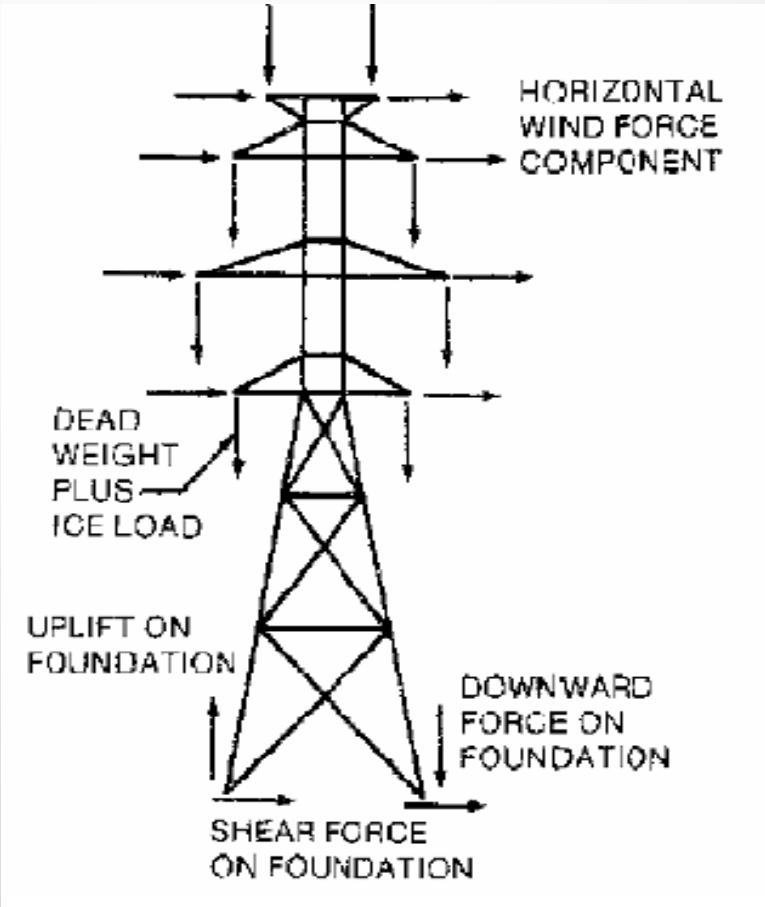
Multi-Pole Structures



Structure Types

Lattice Structures

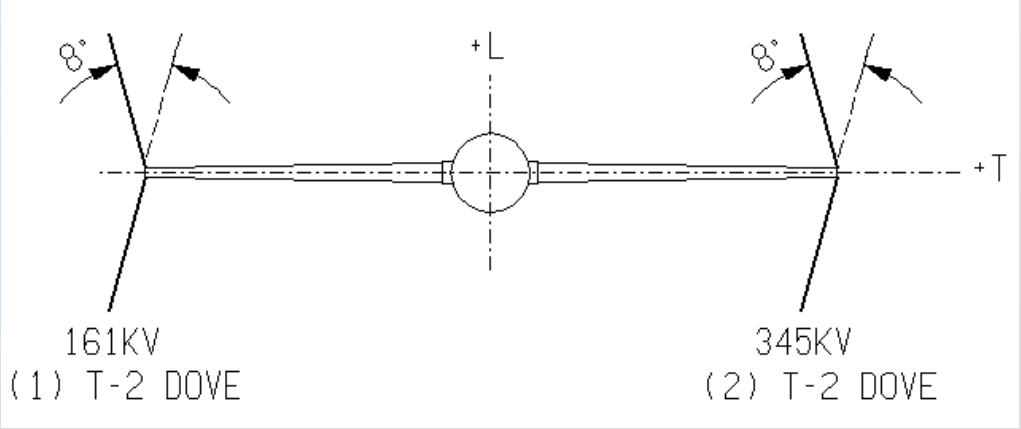




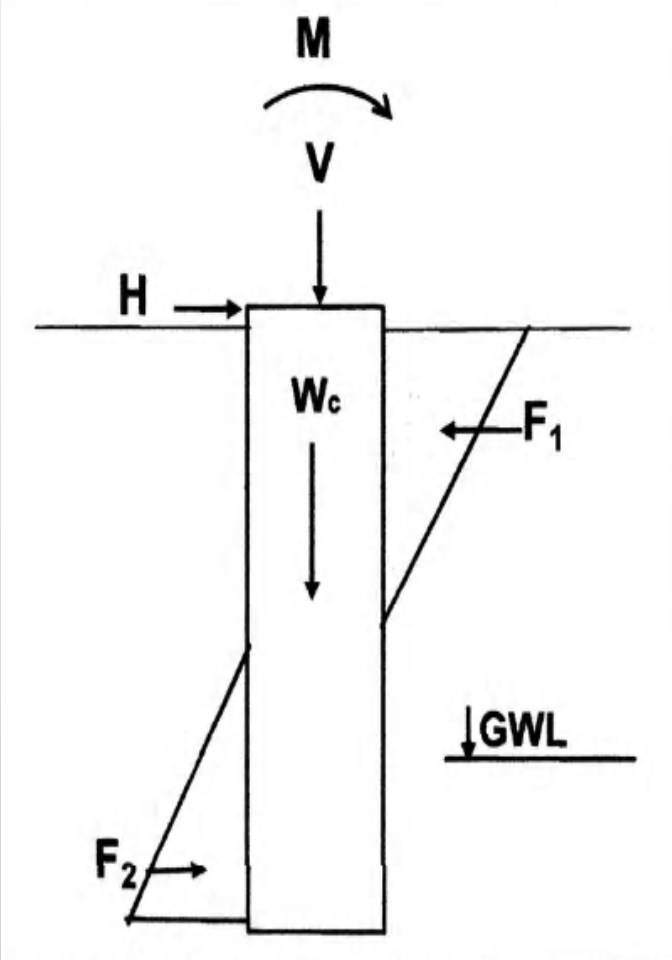
Structure Loads

Transverse and longitudinal load due to conductor tension

- Changes in line direction
- Span length variation
- Unbalanced ice
- Broken wires
- Dynamic loads



Foundation Design Process

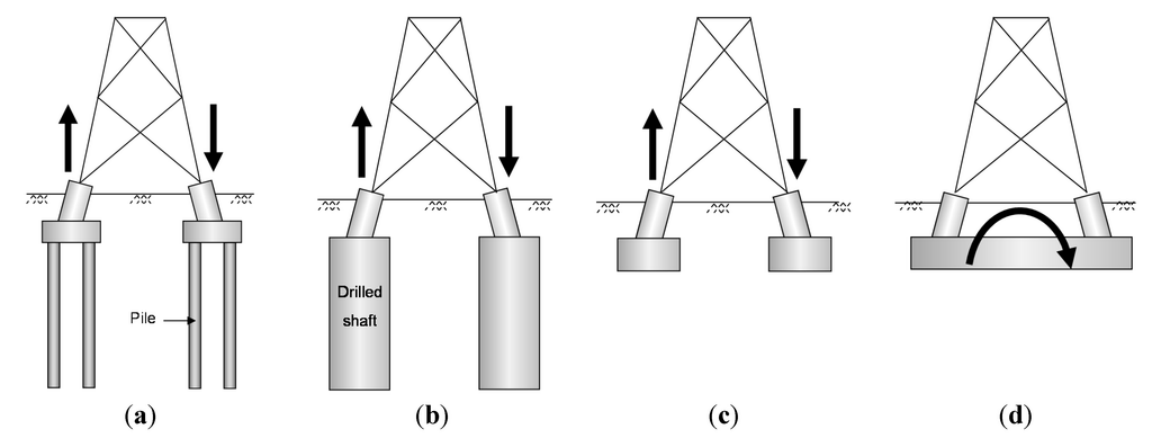


- **Single Pole w/o Guys (self-supporting)**
  - Large overturning moment (M)
  - Relatively small horizontal load (H)
  - Vertical load (V) driven by structure/foundation weight and wire
  - Typically use drilled piers, driven steel caissons

Foundation Design Process

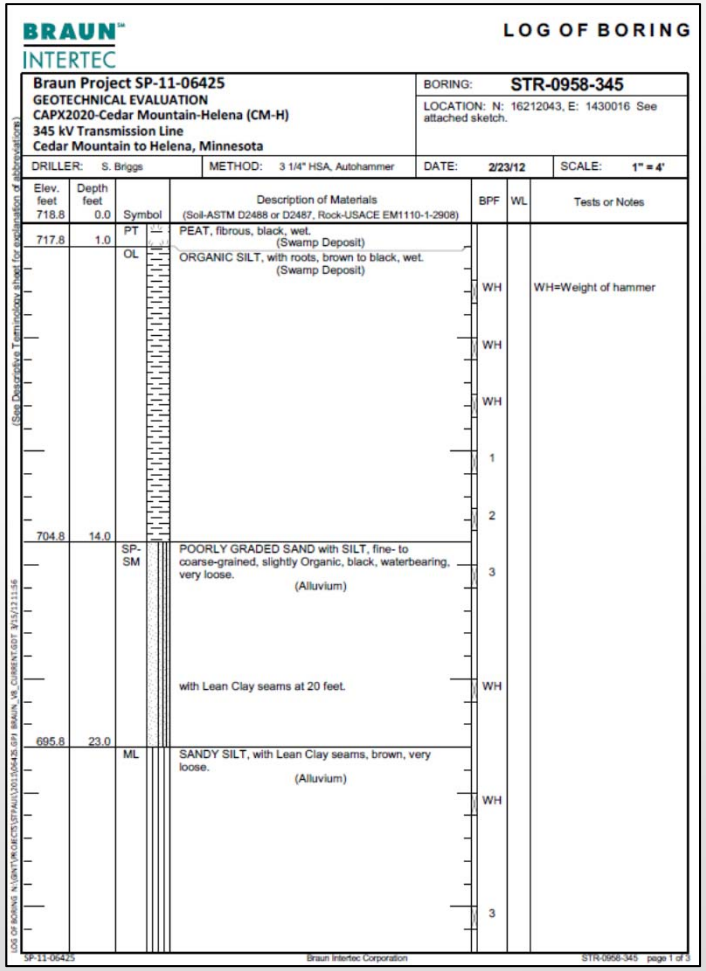
Lattice tower w/o guys

- Small base moment
- Relatively small shear load
- Large vertical load, downward or upward
- Typically use caissons, spread footings, or driven piles



Subsurface Conditions

- Borings taken at each pole location:
  - Identify cobbles, boulders or other obstructions
  - Drivability a concern
- Soil profile:
  - Low blow counts
  - Soft organic swamp deposits (organic clay, organic silt, peat)
  - Loose alluvial deposits (loose silty sand, silt)
  - Glacial till (stiff sandy lean clay, stiff clayey sand)



BRAUN INTERTEC

LOG OF BORING

Braun Project SP-11-06425
GEOTECHNICAL EVALUATION
CAPX2020-Cedar Mountain-Helena (CM-H)
345 kV Transmission Line
Cedar Mountain to Helena, Minnesota

BORING: STR-0958-345
LOCATION: N: 16212043, E: 1430016 See attached sketch.

DRILLER: S. Briggs | METHOD: 3 1/4" HSA, Autohammer | DATE: 2/23/12 | SCALE: 1" = 4'

(See Descriptive Terminology sheet for explanation of abbreviations)

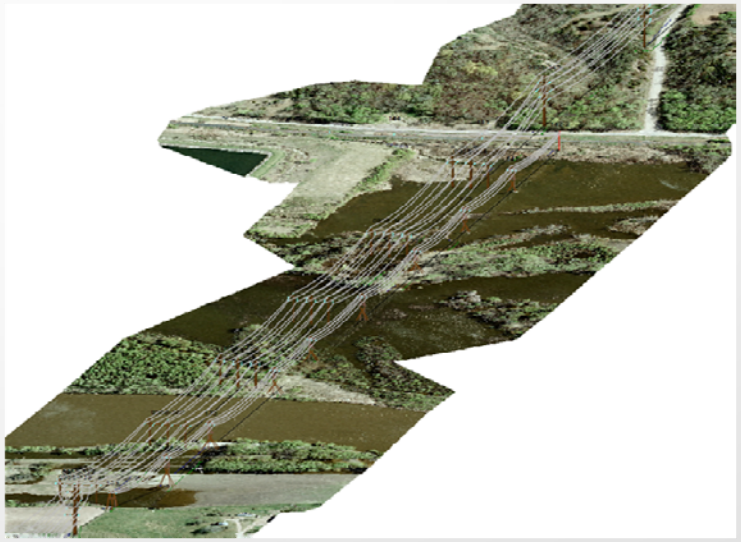
Elev. feet	Depth feet	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
718.8	0.0					
717.8	1.0	PT	PEAT, fibrous, black, wet. (Swamp Deposit)			
		OL	ORGANIC SILT, with roots, brown to black, wet. (Swamp Deposit)	WH		WH=Weight of hammer
				WH		
				WH		
				1		
				2		
704.8	14.0					
		SP-SM	POORLY GRADED SAND with SILT, fine- to coarse-grained, slightly Organic, black, waterbearing, very loose. (Alluvium)	3		
			with Lean Clay seams at 20 feet.	WH		
695.8	23.0					
		ML	SANDY SILT, with Lean Clay seams, brown, very loose. (Alluvium)	WH		
				3		

LOG OF BORING N:\GINT\PROJECTS\PAUL\201\06425.GPJ BRAUN_VB_CURRENT.GDT 9/13/12 11:56

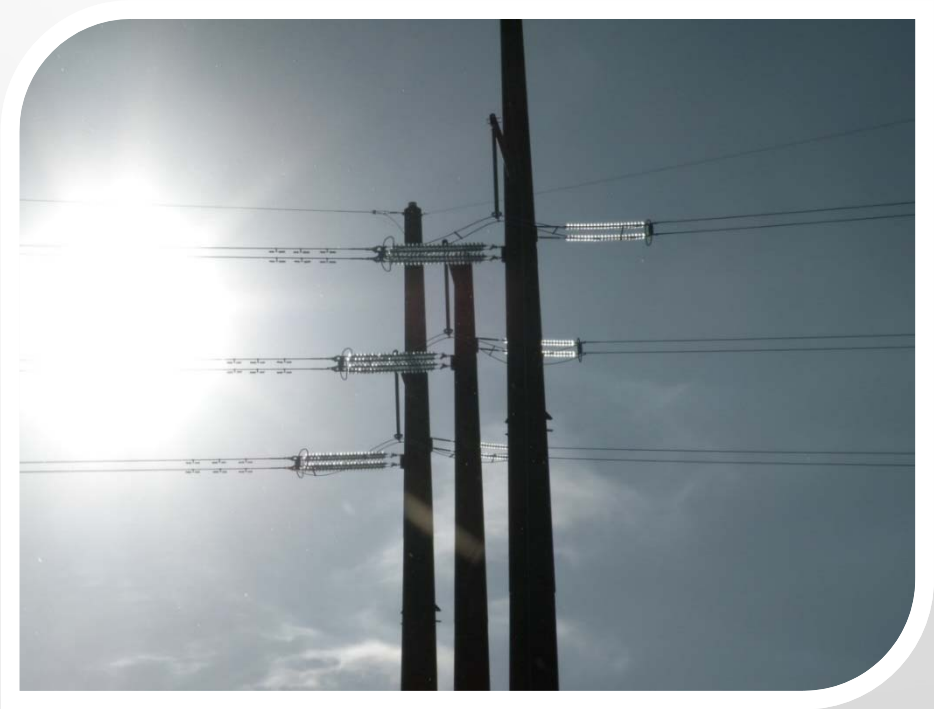
SP-11-06425 Braun Intertec Corporation STR-0958-345 page 1 of 3

River Crossing Challenges

- Potential challenges include:
  - Dynamic terrain changes
  - Unique structure loading
  - Poor soil conditions
  - Unfavorable construction access
  - Environmental restrictions
- Must use communication and collaboration to overcome challenges
  - Engineers, owners, and contractors must work together



Design Alternatives



Alternatives

Traditional Drilled Piers	Driven Piles with Pile Cap	Vibratory Caissons
• Deep, permanent casing, spoils, many concrete trucks (access)	• Concrete, pad excavation with high water table	• Eliminate need for large amounts of concrete • Minimal equipment needed • Requires soils conducive to vibratory installation

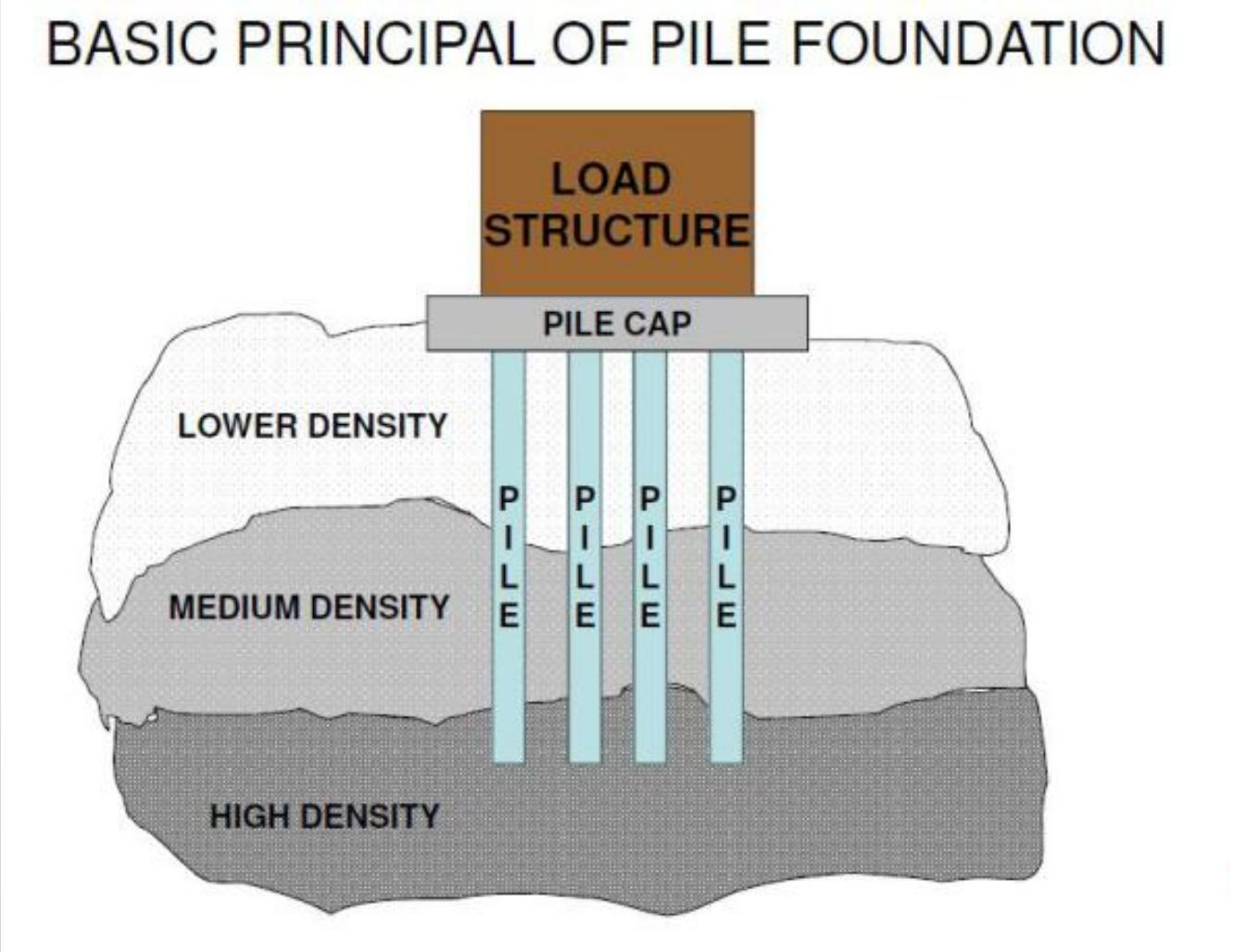
Considerations:

- Cost
- Material availability
- Procurement schedule
- Hauling requirements
- Required construction equipment
- Access requirements
- Maintenance requirements

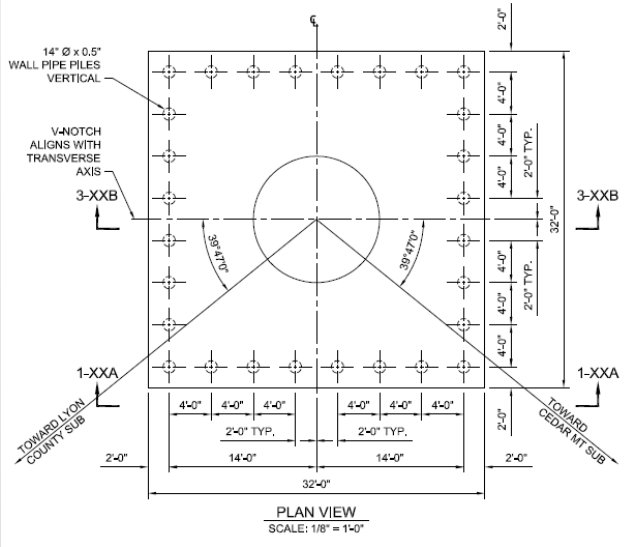
Drilled Pier with Casing

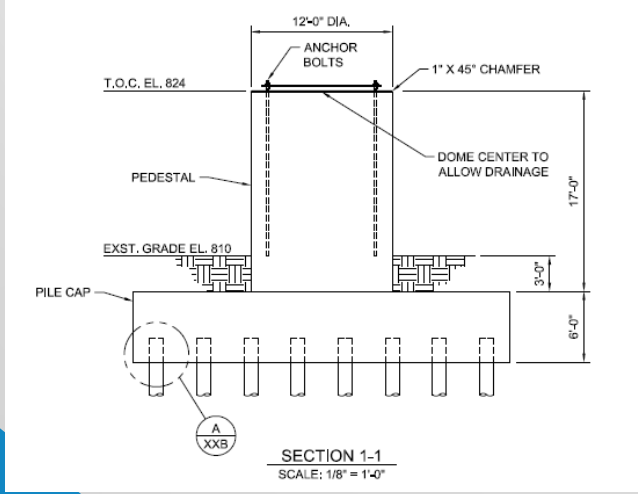
Drilled Pier with Casing

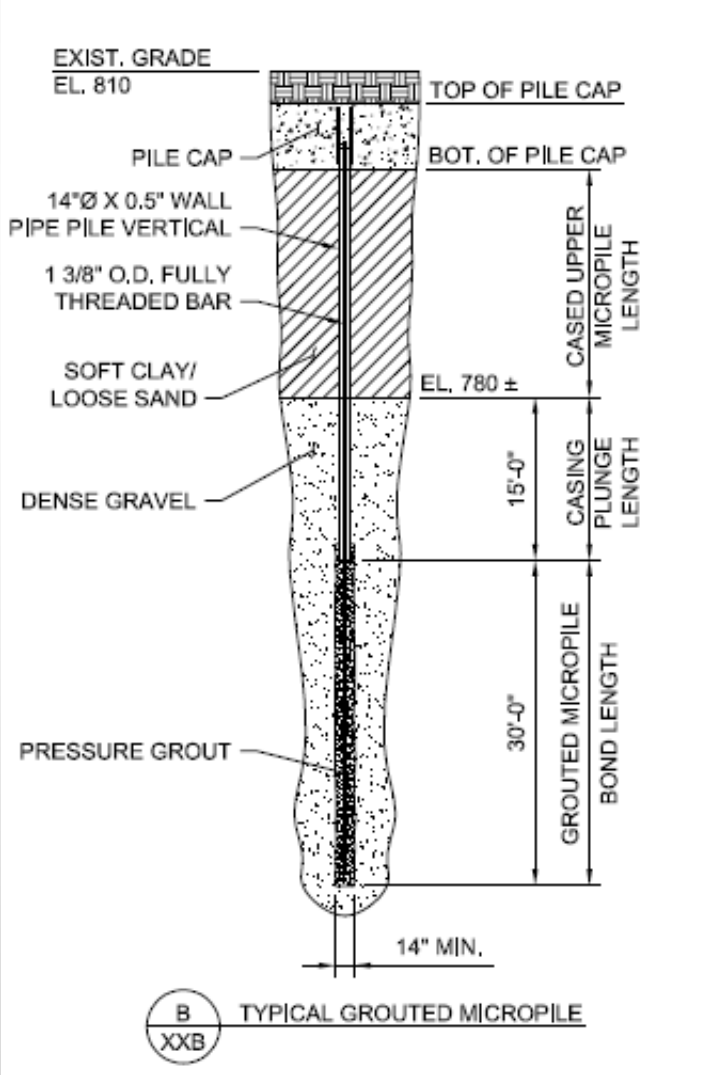
Driven Pile with Pile Cap



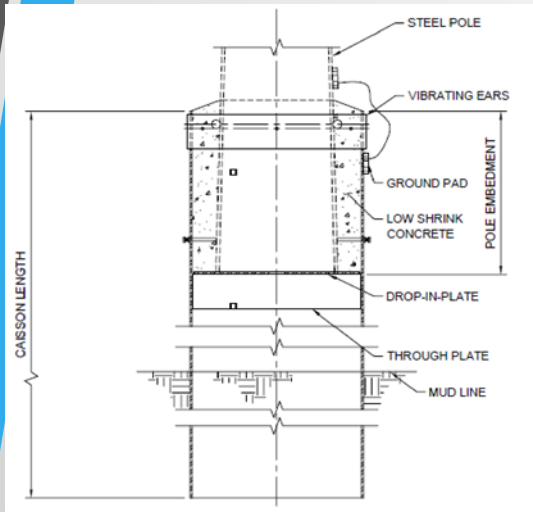
Micropiles


14" Ø x 0.5" WALL PIPE PILES VERTICAL
V-NOTCH ALIGNS WITH TRANSVERSE AXIS
3-XXB
1-XXA
TOWARD LYON COUNTY SUB
TOWARD CEDAR MT SUB
39°47'0"
2'-0" TYP.
4'-0"
14'-0"
32'-0"
2'-0"
PLAN VIEW
SCALE: 1/8" = 1'-0"


12'-0" DIA.
ANCHOR BOLTS
1" X 45° CHAMFER
T.O.C. EL. 824
DOME CENTER TO ALLOW DRAINAGE
PEDESTAL
17'-0"
EXST. GRADE EL. 810
3'-0"
PILE CAP
6'-0"
A
XXB
SECTION 1-1
SCALE: 1/8" = 1'-0"

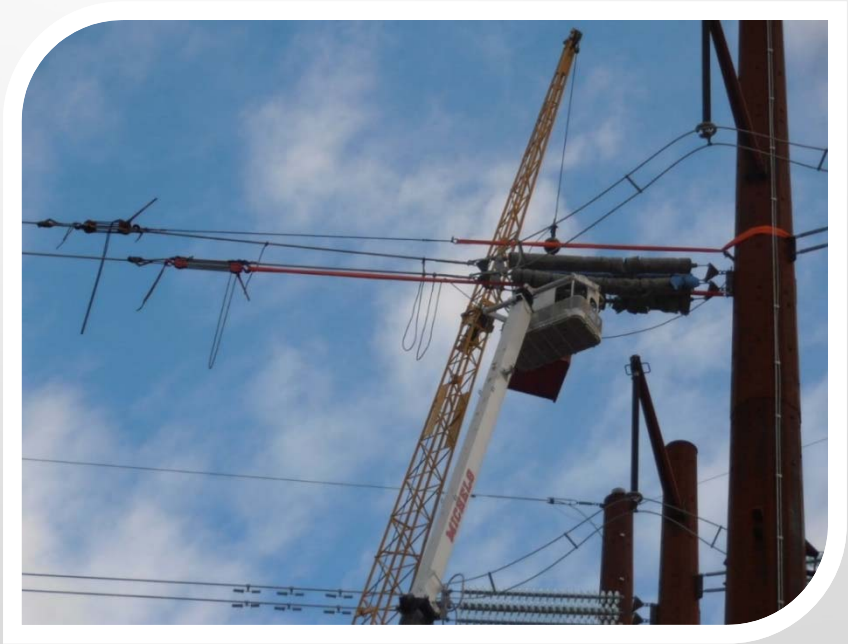

EXIST. GRADE
EL. 810
TOP OF PILE CAP
PILE CAP
BOT. OF PILE CAP
14"Ø X 0.5" WALL PIPE PILE VERTICAL
1 3/8" O.D. FULLY THREADED BAR
SOFT CLAY/ LOOSE SAND
EL. 780 ±
CASED UPPER MICROPILE LENGTH
DENSE GRAVEL
15'-0"
CASING PLUNGE LENGTH
PRESSURE GROUT
30'-0"
GROUTED MICROPILE BOND LENGTH
14" MIN.
B
XXB
TYPICAL GROUTED MICROPILE

Vibratory Caisson "Socket" Connection



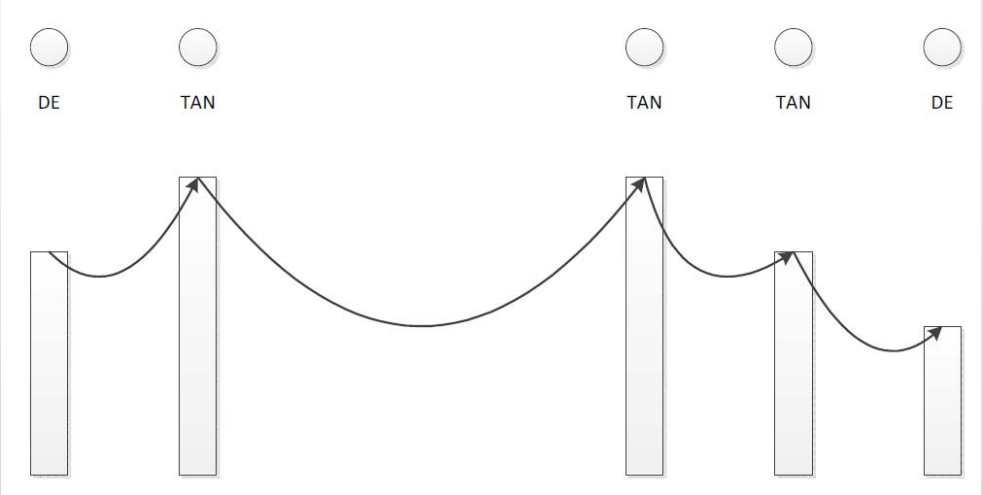
Vibratory Caisson

Design Considerations



Typical Long Span Concepts

- Tension vs. Height
  - ↑ Tension → ↑ Load and ↑ Galloping
  - ↓ Tension → ↑ Sag → ↑ Height
- Tangent vs. Deadend
  - Typically trade height for load and type



Operational Considerations

Terrain → access for construction and maintenance

Additional Support → lighting, supplemental power

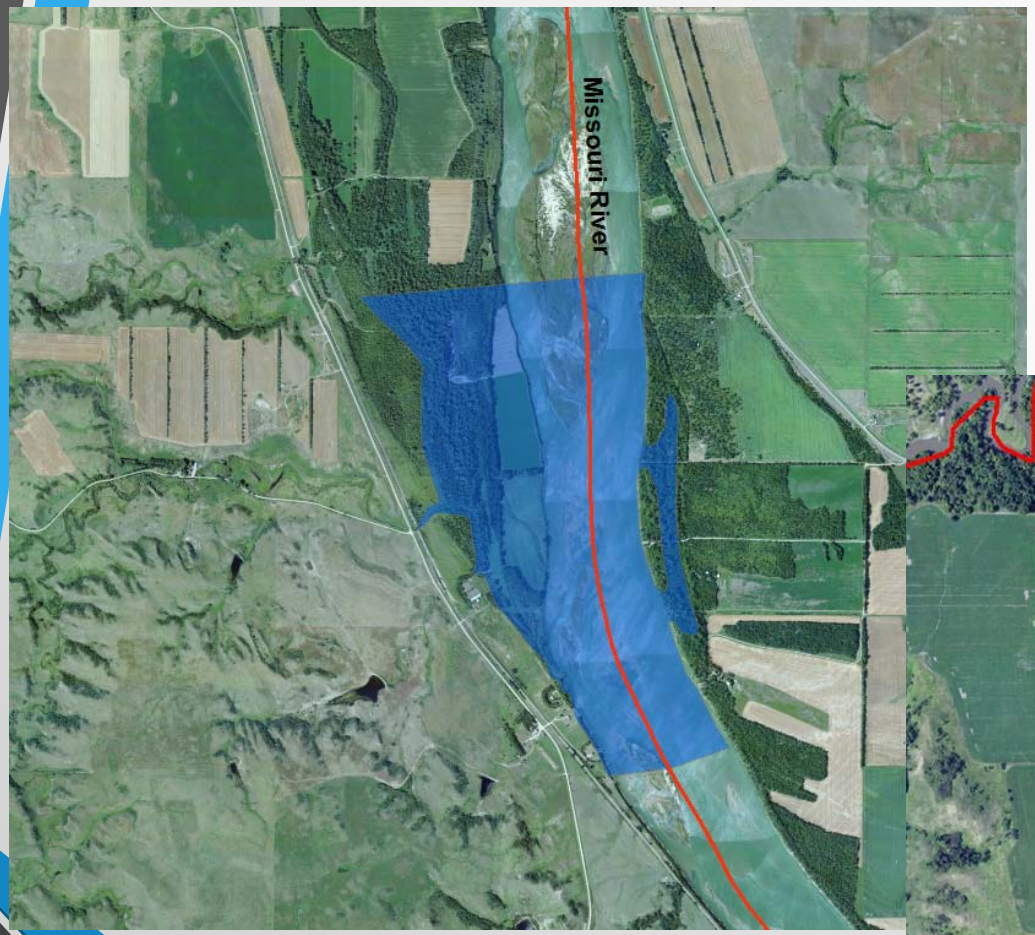
Ground → geotech, grounding, ground water, flood plains

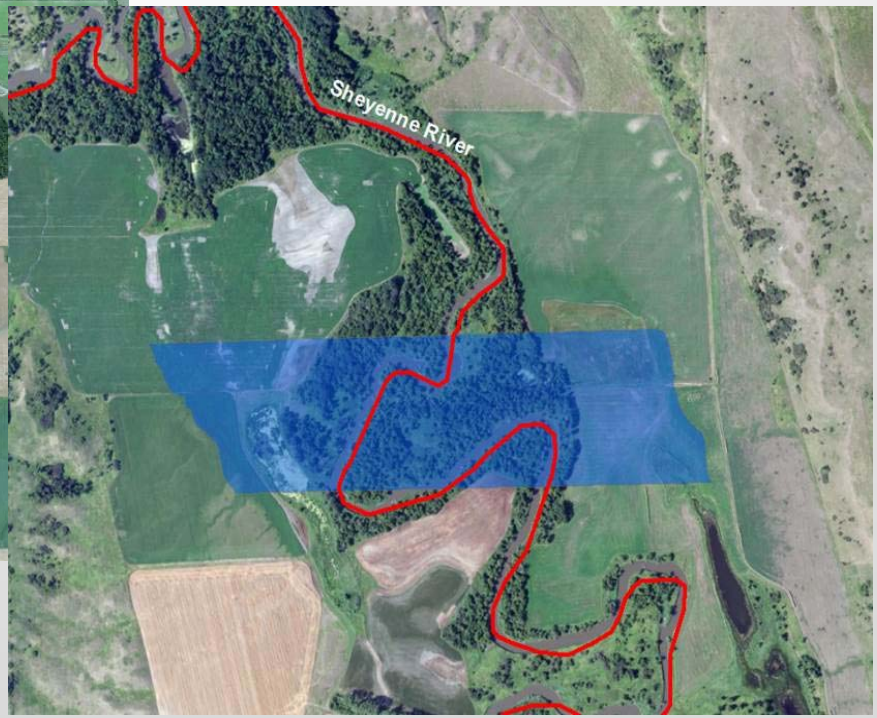
Flowing Water → flood plains, debris damage, erosion

Flood Plain Factors

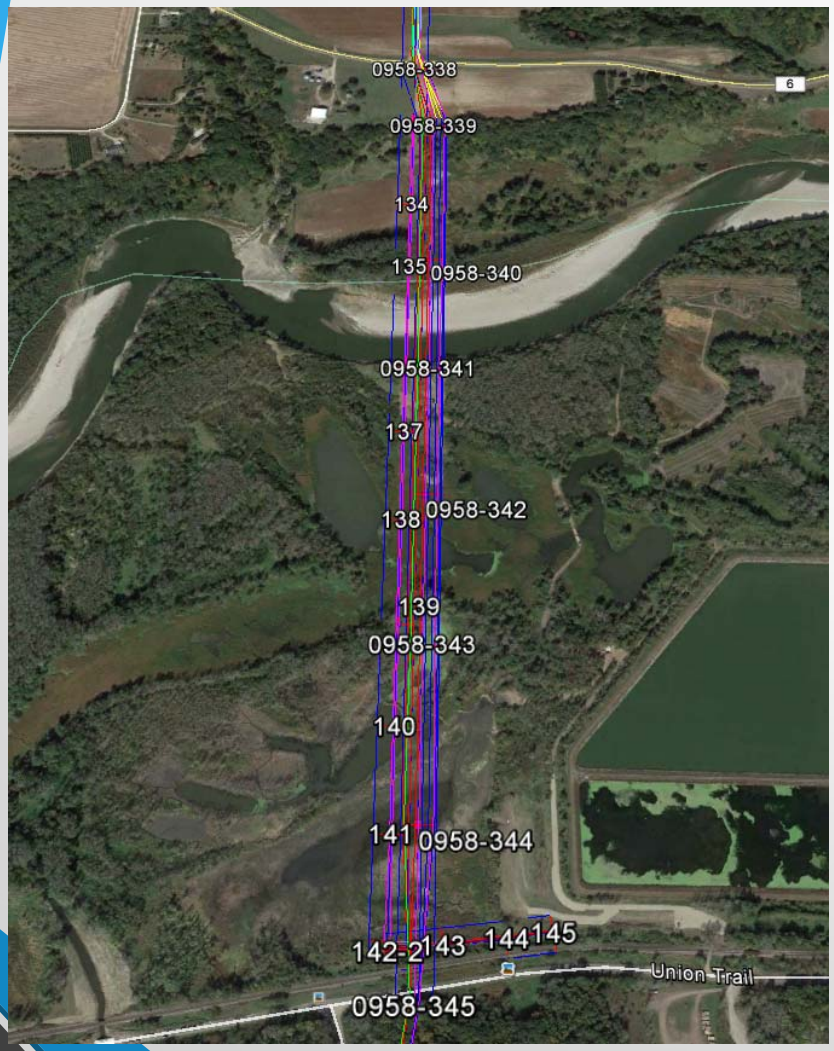
- Height of foundation vs. flood plain levels
- Loading from flowing water and ice
- Loading from floating debris
- Soil erosion from water flow
- Soil bearing and skin friction assumptions

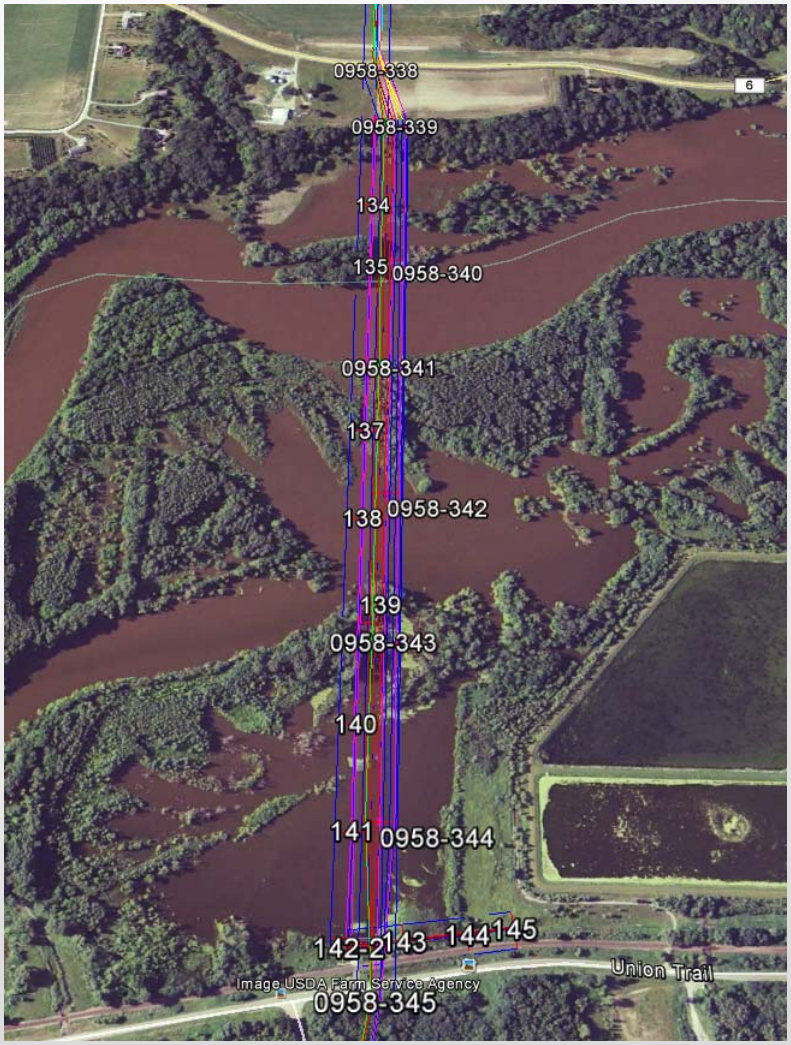
100-Year Flood Levels





Riverbank Erosion Example





Riverbank Erosion Example

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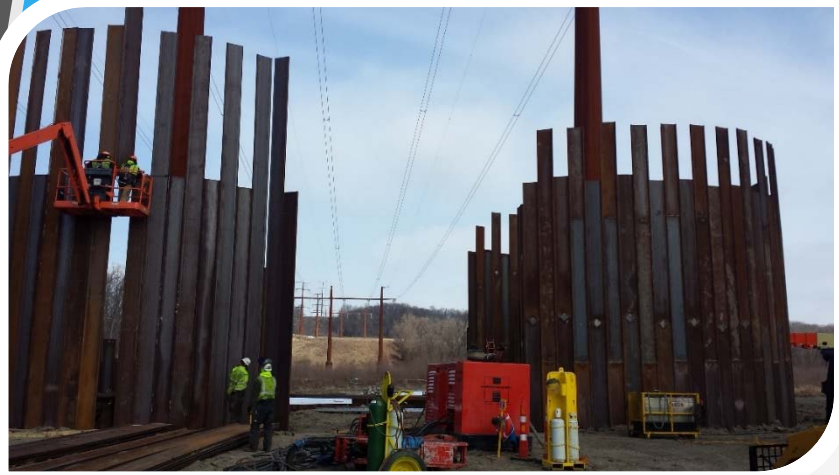

Constructability

Site Conditions

Space Availability → Can we build there?

Site Access → Can we get there?

Weather → When can we gain access and for how long?

Environmental → Are there any environmental limitations to accessibility?

Maintenance → When do we need to get there in the future? How will we get there (once contractor is long gone)?

Installation Factors

- Site access for materials and equipment
- Limitations to construction sequence for installation
- Locations to set-up construction equipment
- Environmental factors that would limit construction
- Scheduling and coordination concerns

Construction Methods

- Experience and expertise of contractors
- Detailed review of methods (and alternatives) and expectations
- Site access requirement reviews
- Review of equipment to be used during installation
- Observation with design support during installation

Keys to Success

Create sub-project to enhance focus

Define project constraints

Scope/budget/schedule

Conduct thorough data collection

Know what you are dealing with	Study various alternatives	Identify all possible obstacles

Collaborate with all parties

Thoughtful planning	Dynamic communication	Efficient execution

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QUESTIONS?

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