Sioux City Iowa Utilizes HDD to Install Twin 36” Casings for Sanitary Sewer Siphons

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Presentation Outline…

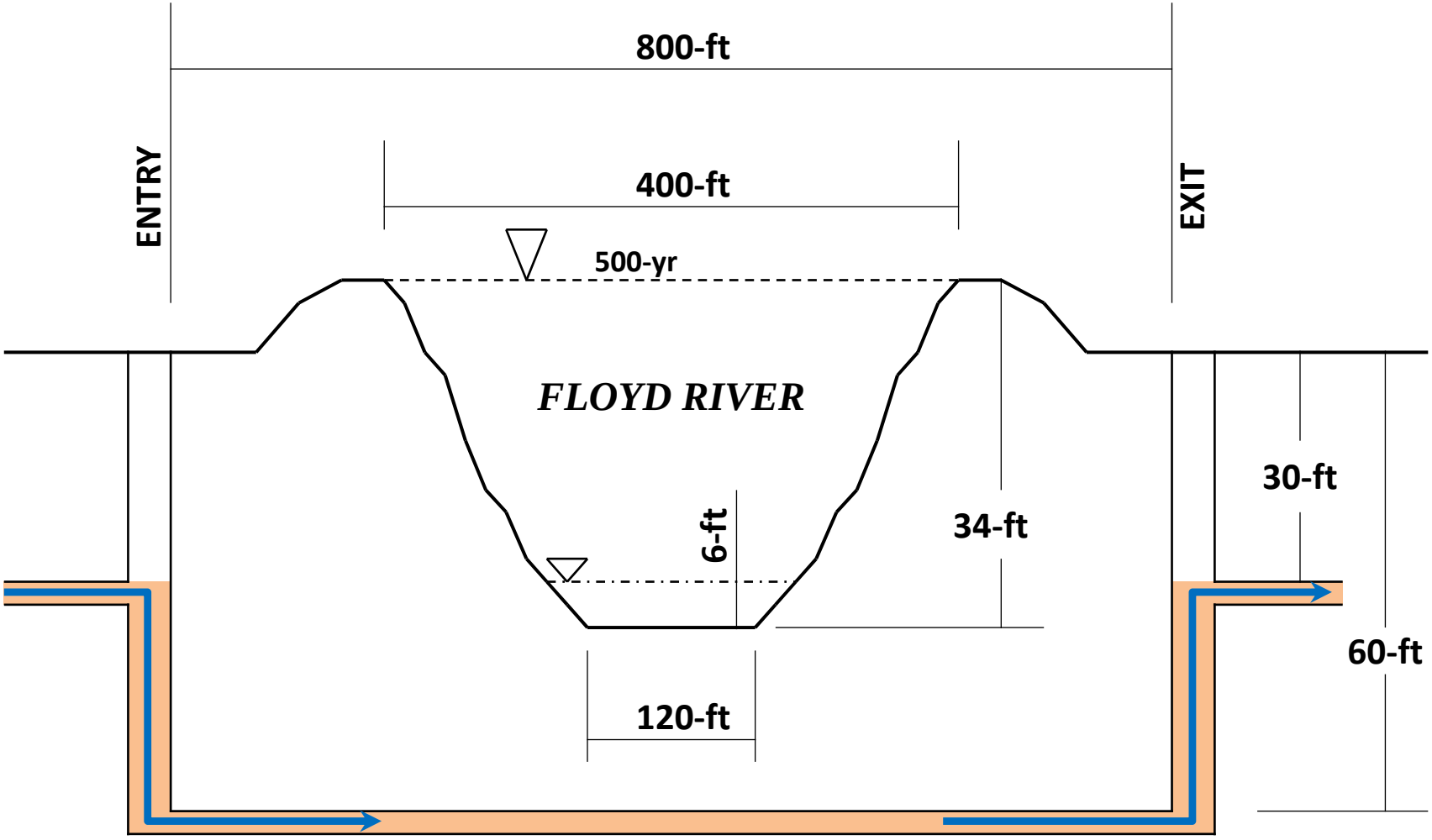
1. **Problem Definition**
2. **Design Process**
   a. **Trenchless Technique Selection**
   b. **Profile Geometry & Pipe Material Selection**
   c. **Plan Approvals & Permitting**
3. **Construction**
   a. **Overview**
   b. **Work Site Logistics**
   c. **Aerial Insertion**
   d. **Keys to Success**
4. **Lessons Learned**

Problem Definition…

Part of the "I-29 Segment 2 Utility Replacement Project"

- Owned by Sioux City, Iowa.
- New Siphon designed in 2013 & constructed in 2014.
- Replaces an existing Double Barrel Siphon located in IaDOT Right-Of-Way in the way of the highway expansion; specifically a bridge abutment.
- Located approximately 1,100-ft upstream of the original location.

Problem Definition…

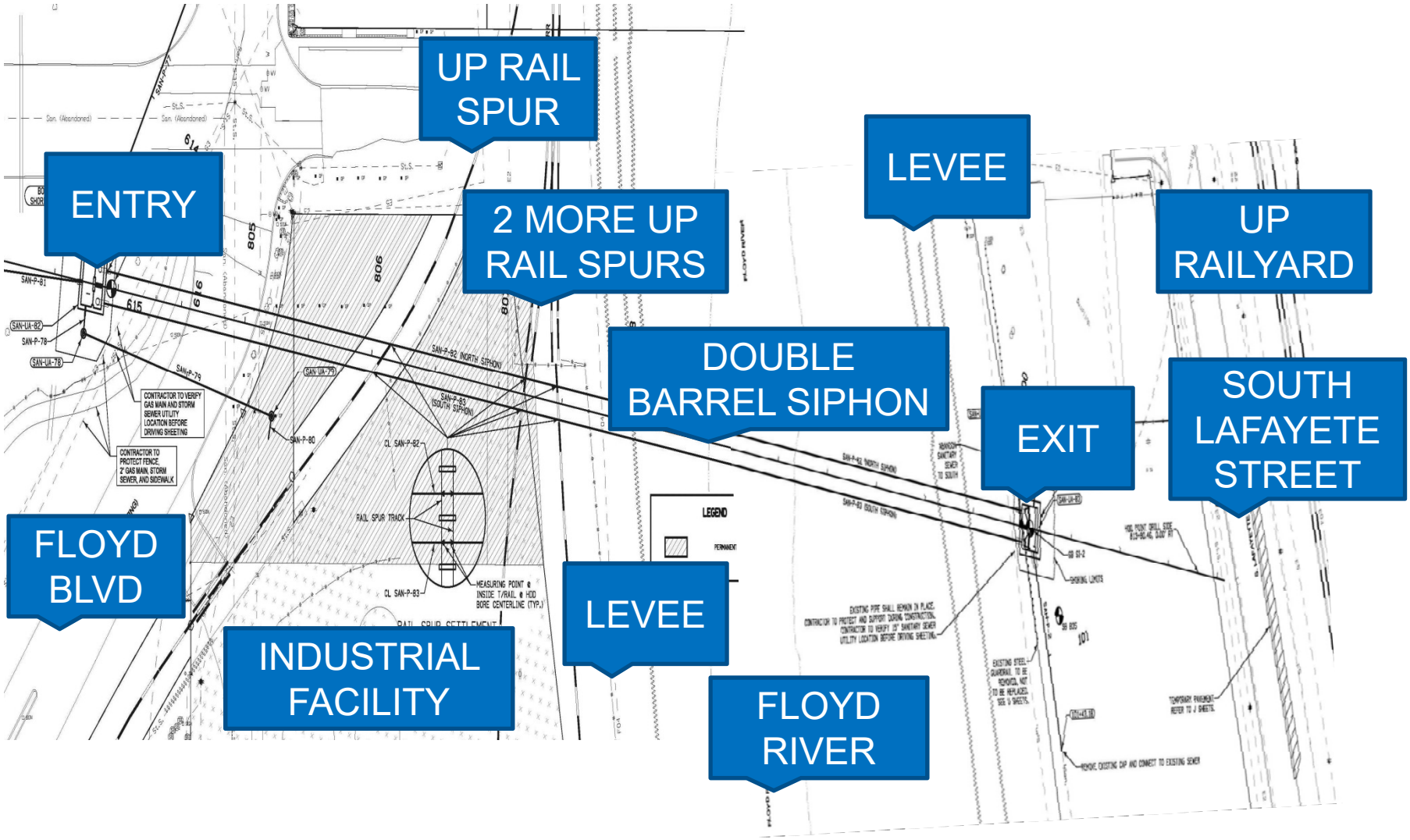


Problem Definition…

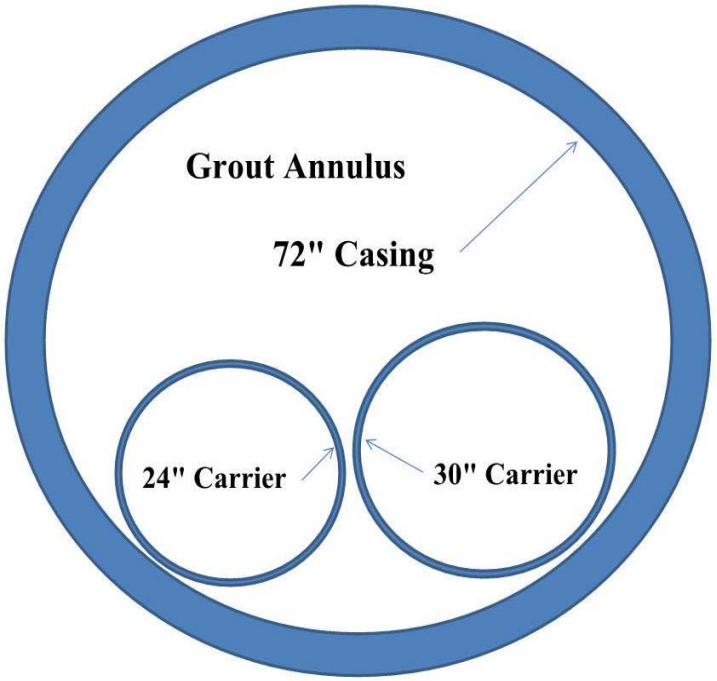
Subsurface Conditions:

- Missouri River alluvium.
- High groundwater table.
- Random layers of sand, clayey sand, and sandy clay overlain by fatty clay and man-made fill.
- Bedrock was not encountered.

Problem Definition…



Design… Trenchless Technique Selection



Microtunneling (MT) Alternate

- 24” & 30” PVC or HDPE carrier pipes bundled into a single 72” steel pipe casing.
- Grouted annulus.
- Budget level EOPC **$5.3 million**.
- **9** months to **one** year to construct.

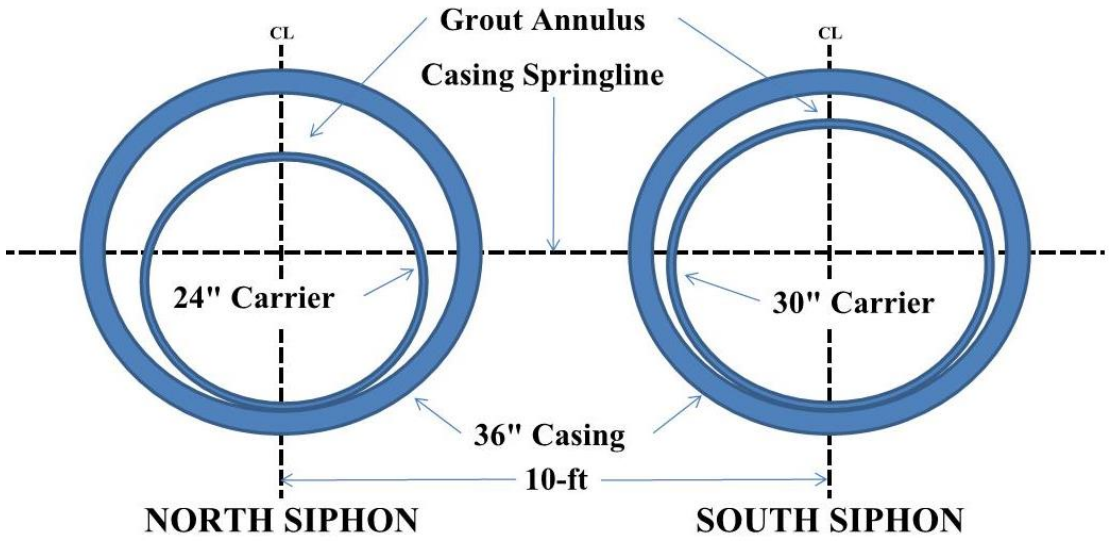
MT Constructability Issues

- Use the slurry method w/ closed face earth pressure balance tunnel boring machine (EPB-TBM).
- 60-ft deep bore pit shafts.
- Continuous dewatering.
- Pipe lubrication during jacking.
- At least one intermediate jacking station.

Design…

Trenchless Technique Selection

Preferred Alternate!



HDD Alternate

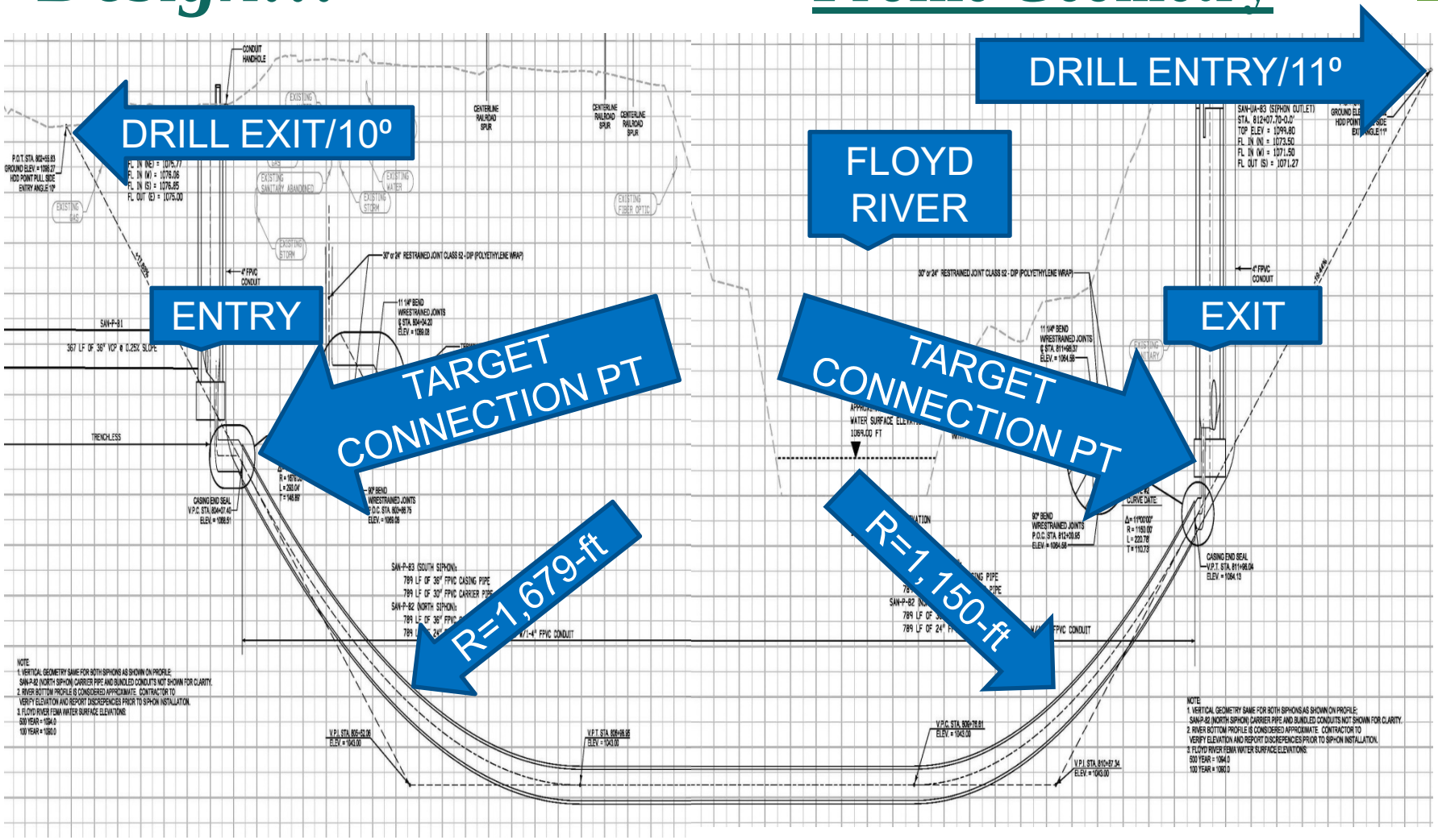
- Each carrier pipe is installed in its own casing pipe.
- Twin siphon casing pipes are installed in parallel horizontally and vertically.
- Grouted annulus.
- Budget level EOPC **$2 million**.
- **6** months to construct.

HDD Constructability Issues

- 36” casing pipe in 48” borehole.
- Requires a “maxi-rig” for the installation.
- Bend radius estimate eliminated steel and ductile iron pipe.
- PVC and HDPE were remaining choices.

Design…

Profile Geometry



APPROXIMATE BORE PATH LENGTH=1,500-ft

Design… Pipe Material Selection

It's all about pipe stiffness!

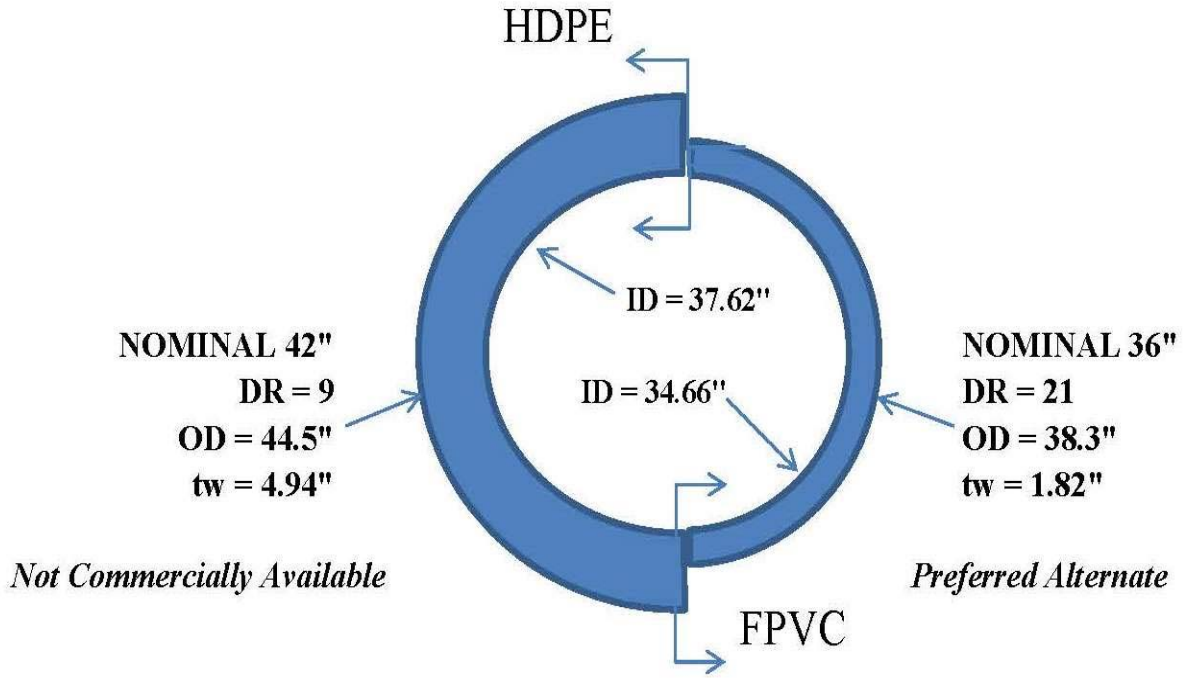
- A pullback force of **235,000-lbs** was estimated requiring a pipe stiffness of approximately **224 psi**.
- Pipe stiffness, PS = (2*E/(3*(DR-1)^3))/0.149
  - E = Modulus of Elasticity of the pipe material, psi.
  - DR = Dimension Ratio of the pipe section; OD/tw.
  - HDPE has a modulus of elasticity = 100,000 psi.
  - PVC has a modulus of elasticity = 400,000 psi.
- Evaluation of the pipe material choices for identical installation and external loads resulted in:
  - For HDPE, a 36" DR13.5, **BUT**, a 42" DR9 is necessary to meet required inside casing diameter tolerance.
  - For Fusible PVC, a 36" DR21 is necessary and meets the inside casing diameter tolerance.

Design…

Pipe Material Selection

AWWA Standards:

- C905 FPVC
- C906 HDPE



- Key is the need for a minimum casing ID = 34” in order to slipline a 30” carrier pipe with an OD of 32” (2” tolerance).

- A 36” HDPE DR13.5 has an ID = 32.29” (Out of tolerance by 1.71”).

Design… Plan Approvals & Permitting

Two key agencies from which approval was required:

- **Union Pacific Railroad (UPRR)** ~ had most stringent criteria:
  - AREMA (AREMA 2013) Manual for Railway Engineering Sections 5.3 & 5.6.

    - Pipe External Load Analysis.
    - Pipe Axial Stress Analysis.
    - Hydro-Fracture Risk.
    - Borehole Collapse Potential.
    - **Work Site Logistics.**
    - **Machine Performance Prediction.**
    - **Mud Circulation, Volume & Disposal.**
    - **Operation & Maintenance.**

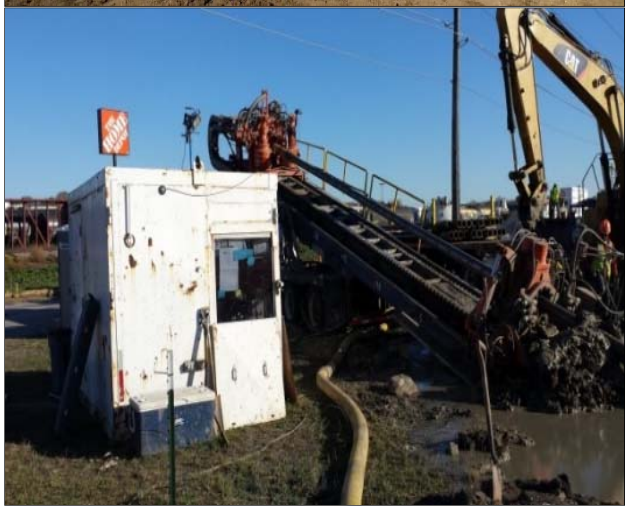
Design… Plan Approvals & Permitting

- **Iowa Department of Natural Resources (DNR):**
  Required the siphon pipelines be cased for the segments located beneath the river; and
  Required and obtained a variance for the use of trenchless technology.

- Submittal documentation structured using AREMA topic format.
  Includeded evaluation of worksite logistics, rig compatibility, hydro-fracing, borehole collapse, mud circulation/volume/disposal.

- With slight adaptation, the documentation prepared for the UPRR was submitted to the DNR for review and approval.

Construction…



General Contractor:

- Minger Construction of Chanhassen, Minnesota.

Directional Drill Subcontractor:

- Gabe's Construction of Sheboygan, Wisconsin.

Equipment:

- American Augers DD330 Maxi Rig w/ 330,000 lbs of thrust.
- Mud Technology MCT 1000 Recycling System w/ Tulsa TT 660 Mud Pump.
- Pilot hole drilled with a wireline location system.

Construction…

Drilling Process:

- 10-5/8” Pilot Hole.
- Reaming passes of 30”, 42”, and 52” - using a “fly cutter”.
- Final hole conditioning swab with ball reamer prior to pull-in.

Construction…

Overview

30” FPVC Carrier Pipe in 36” FPVC Casing:

- Full length of carrier & casing fused prior to pull-in.
- Carrier pipe was pre-loaded into casing.
- Water ballasted.
- 7 hour pull-in time w/ 130,000 lb max recorded pull force.
- Annular space grouting.

24” FPVC Carrier Pipe in 36” FPVC Casing:

- Full length of carrier & casing fused prior to pull-in.
- Carrier pipe was pre-loaded into casing.
- Water ballasted.
- 7.25 hour pull-in time w/ 140,000 lb max recorded pull force.
- Annular space grouting.

Construction…

Work Site Logistics

Construction…

Work Site Logistics

During Design

- Conceptualize drill operation.
- Prepare a worksite layout plan.
- Set expectations for equipment & facility space allocation.
- Identify location to fuse and string pipe.
- Get City & DOT buy-in.

Construction…

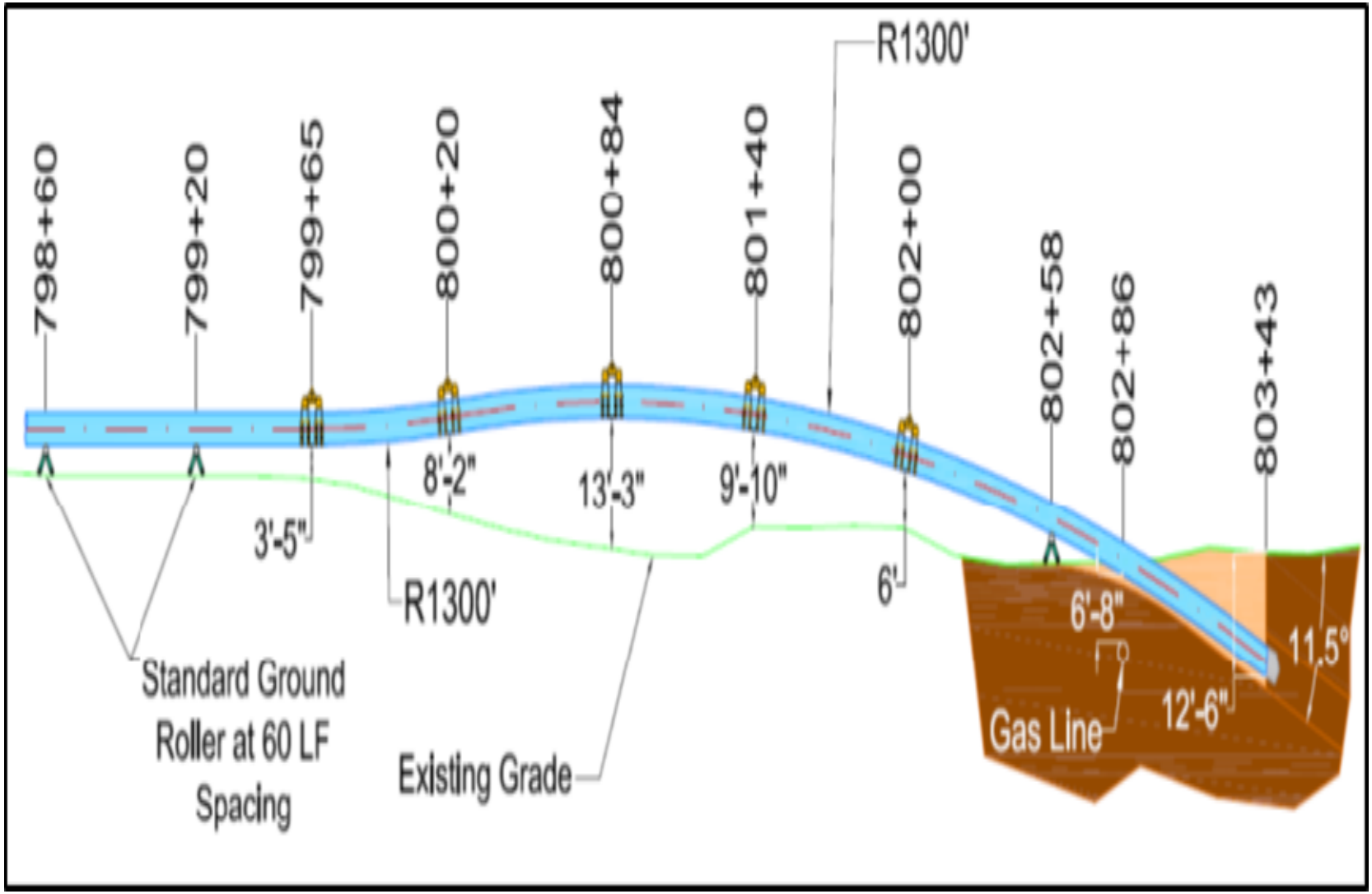
Work Site Logistics

During construction

- Does the design plan work?
- Modifications based on contractors work plan.
- Discovery of unknowns?
- Getting the right equipment & support facilities placed at the site.
- Continuous coordination with City & DOT.
- Execution of the plan.

Construction…

Aerial Insertion

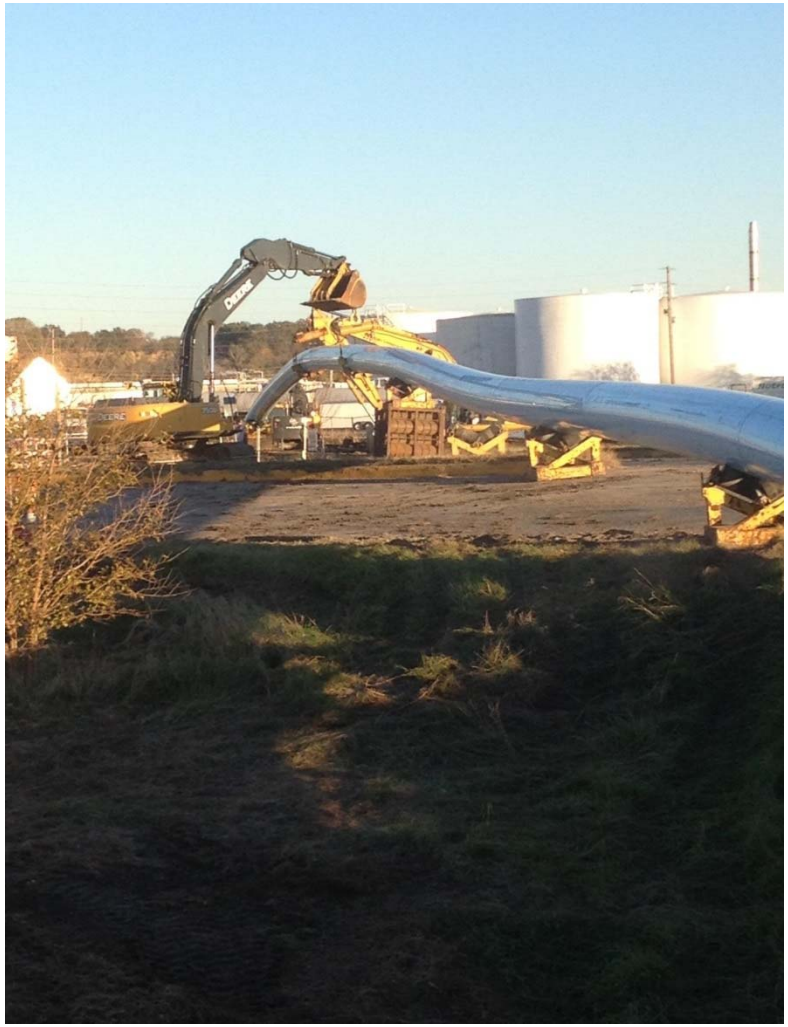


Construction…

Aerial Insertion

Construction…

Keys to Success



- Space was available for a maxi-rig operation.
- Ability to fuse and layout the full length of pipe.
- Carrier pipe pre-loading.
- Closing of I-29 on-ramp during pull-in.
- Aerial insertion.
- Water ballasting.
- Communication.

Lessons Learned…

Defensible Constructible Design

- *Use AREMA as a template!*

Pipe Material Selection

- *The right pipe for the right application…its all about pipe stiffness!*

Worksite Logistics

- *Designers need to do their homework!*

Design-Build

- *Designer-Contractor collaboration!*

Lessons Learned…

Profile Geometry

- *Direct correlation with pipe axial stress…beware of the capstan effect!*

Field Adjustments / Modifications

- *Construction means & methods flexibility!*

Communication

- *Communicate-communicate-communicate!*

QUESTIONS FROM THE AUDIENCE

Ask away…

Thank You !

HRGreen

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