21st Annual Sharing Technologies Seminar

NORTHERN CALIFORNIA PIPE USERS GROUP

Design and Construction of a Unique 7,000 LF, Single Insertion Slipline Rehabilitation Project

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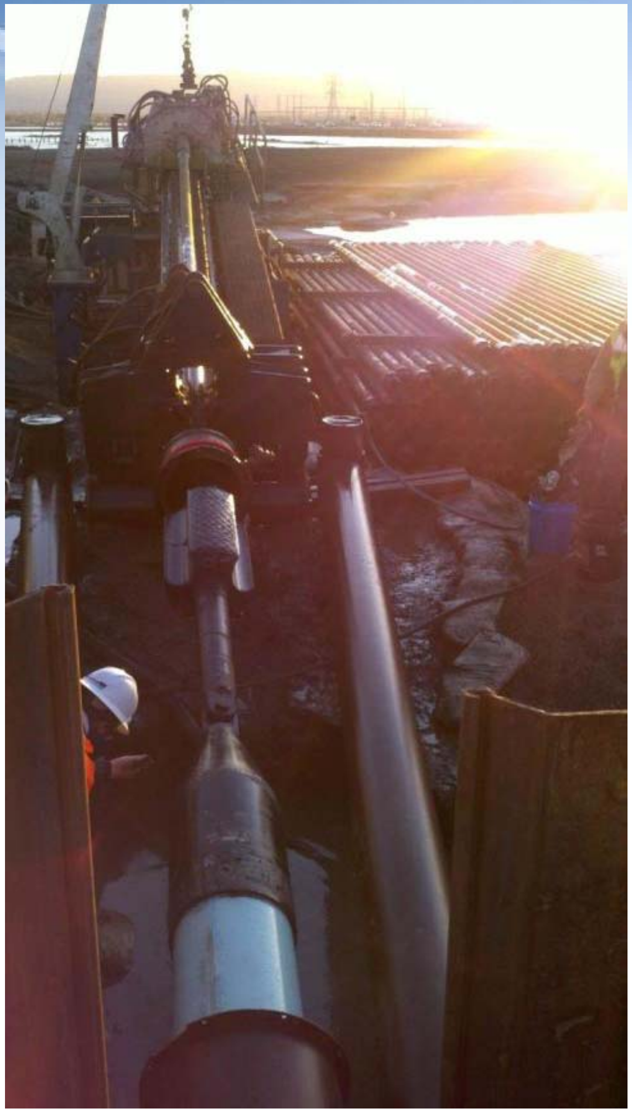
7,000 LF Slipline Installation in a single insertion…



- What I will BREIFLY cover:
  - Accomplishments first – surprise! It WAS successful!
  - Project set-up and details
- What I will cover in more depth:
  - Feasibility analysis
  - Construction methodology design and follow-through
  - Installation specifics
  - Data analysis from install
- What we will NOT cover:
  - Location of project
  - Client
  - Details on operation of pipeline
  - Conveyed fluid stream

Slipline was chosen as the only viable rehabilitation option…

- Industrial pipeline application
  - ~7,000 LF long under large body of water
  - Corrosion of pipeline identified as a major concern for the design life of the pipe
  - Environmentally sensitive area

- Project Team
  - Client’s Operations and Engineering groups
  - Galindo Construction (General Contractor)
  - J-C General Engineering, Inc. (Trenchless Subcontractor)

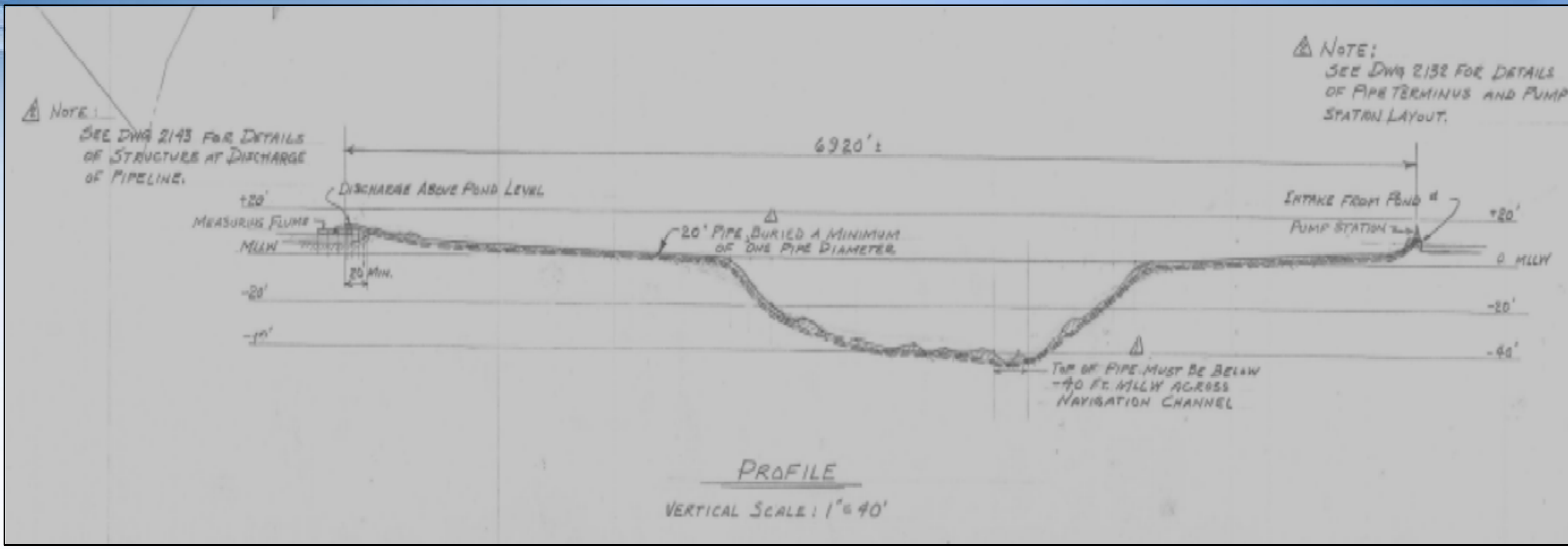
- Evaluation of pipeline alignment and current state vs. options for rehabilitation

- Decision made on methods and materials

…and a single insertion of 7,000 LF of FPVCP was completed successfully to accomplish project goals.

- Existing pipe was characterized (alignment), cleaned, and reamed with typical horizontal directional drilling (HDD) equipment.
- 80 foot long ‘proof piece’ of Fusible PVC™ pipe (FPVCP) to be sliplined was pulled through entire alignment.
- 7,000 LF of 14” DR 21 (DIPS) FPVCP was fused and staged in 5 days.
- FPVCP was self-ballasted upon insertion. Pipe installed in 2 days.
- FPVCP hydrostatically tested, accepted and placed into operation.

Options were limited for rehabilitating the pipeline…



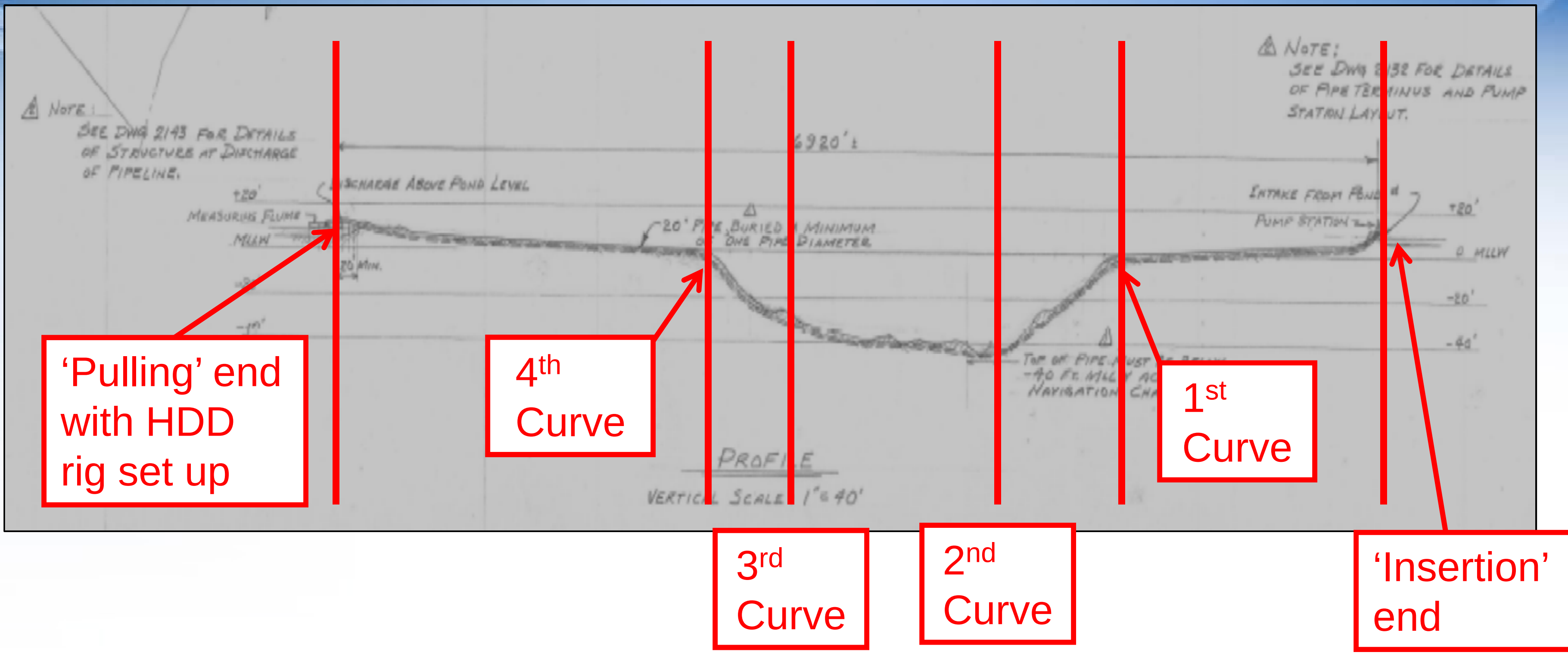
- Central ‘U-shaped’ section could not be drained, created curvilinear alignment to navigate.
- Length and condition of pipe precluded many options such as CIPP, liners of various types and make-up, and pipe bursting.
- HDD and ‘tow-in’ methods only real alternatives – meaning that lengthy permitting and approvals, along with publicity would be required.

Slipline was chosen as the only low-impact rehabilitation option that met the project goals

- Sliplining was a viable option:
  - Required flow area for the rehabilitated pipeline <u>less than</u> original line
  - Would be a ‘new, whole-pipe’ solution
  - No impact to the body of water environment

- Sliplining pipe material selection:
  - The length of the single installation
  - Curvilinear alignment and unknown aspects of alignment
  - Low-profile, high strength joint required
  - 14” (DIPS) Fusible PVC™ pipe (FPVCP) selected

The existing alignment needed to be verified to assure that the installation constraints of the sliplined pipe were met



- 14" DR 21 (DIPS) FPVCP:
  - Minimum allowable bend radius of ~320 feet
  - Safe allowable pull force of ~93,000 lbs
- Existing alignment could not over-bend the pipe
- Installation needed to heed the safe allowable pull force

'Wireline' survey is prepared to compare to the as-built drawings

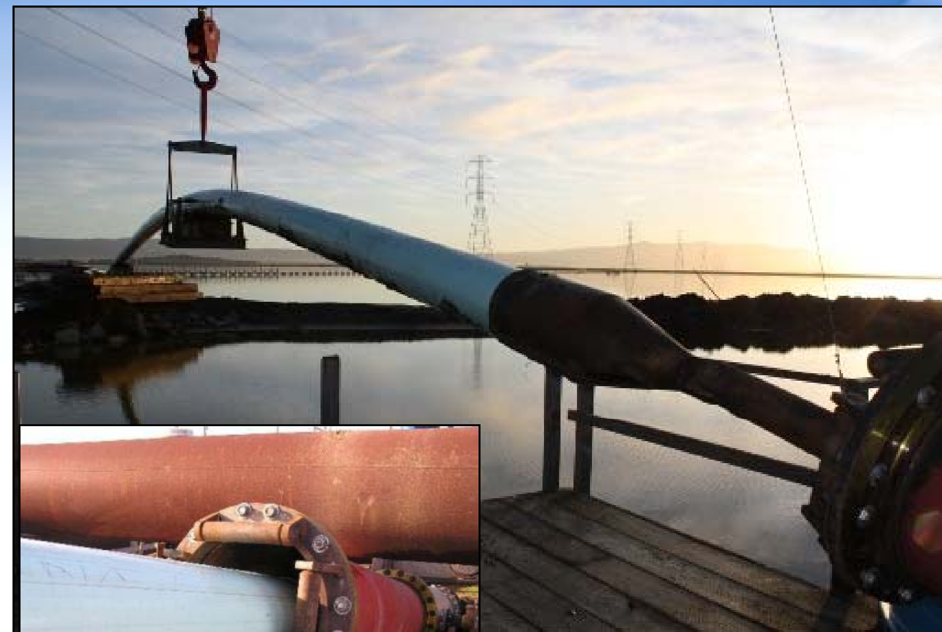
- 'Wireline' survey – typical of long-range HDD pilot bores used:
  - Tracked inclination of tooling
  - Distance of rods extended
- In areas of curvature, used the survey to verify existing bend radii of the host pipe
- Radii averaged 1,500 feet or greater
  - Typical of a fully welded steel pipeline
  - Indicated gradual curvature of the existing pipe
- Tightest radius recorded at 1st curve, ~600 feet

Proof pull performed to verify no major obstructions

- 80 foot long length of pipe pulled through the entire alignment
- Two 40 foot lengths of pipe and one fusion joint
- Only very minor surficial scratching noted

The insertion setup and support was also evaluated

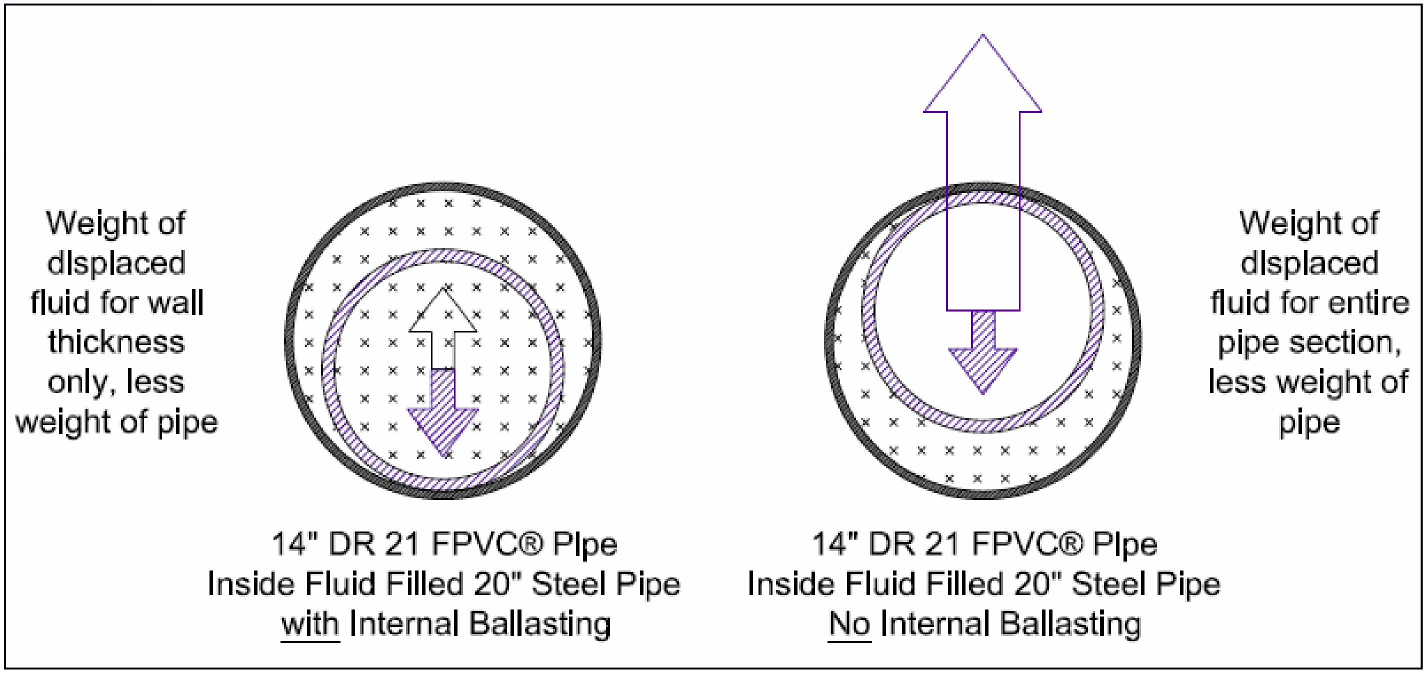
- Drag at grade
  - Large portion of pipe floated, decreasing drag
- Proper support for the arc into the host pipe attained:
  - Crane and cradle roller support
  - Roller flange on extension piece
  - Typical rollers on the pipe string side
- Extension piece added to the insertion side host piping



What type of pull forces would be expected for the FPVCP during the installation?

- Expected pull forces to come from several sources:
  - Ballasting efforts utilized or not utilized
  - Curvilinear alignment of host pipe
  - Drag of pipe at grade and through insertion set up

- Ballasting – to fill or not to fill, that is the question…



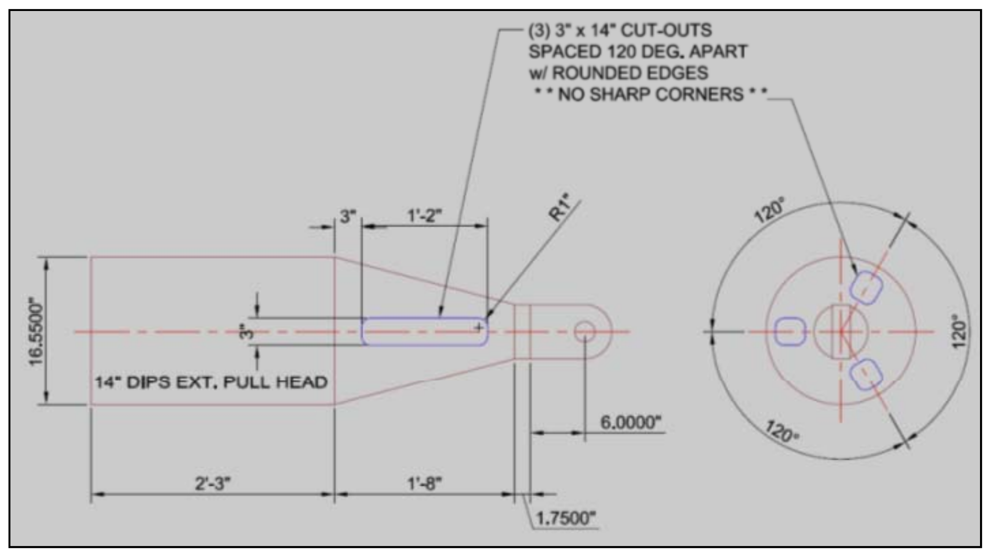
Evaluating buoyancy and pipe drag at grade as part of the construction design

	Self-Ballasted		Unballasted	
Drilling Fluid Density	Bouyancy Loading	Net Bouyancy Load	Bouyancy Loading	Net Bouyancy Load
[specific gravity]	[lbs/LF]	[lbs/LF]	[lbs/LF]	[lbs/LF]
(Water) 1.0	15.32	-6.51	79.67	57.84
1.1	16.86	-4.97	87.64	65.81
1.2	18.39	-3.44	95.60	73.77
1.3	19.92	-1.91	103.57	81.74
1.4	21.45	-0.38	111.54	89.71
1.5	22.98	1.15	119.50	97.67
Pipe Weight =	21.83	lbs/LF		

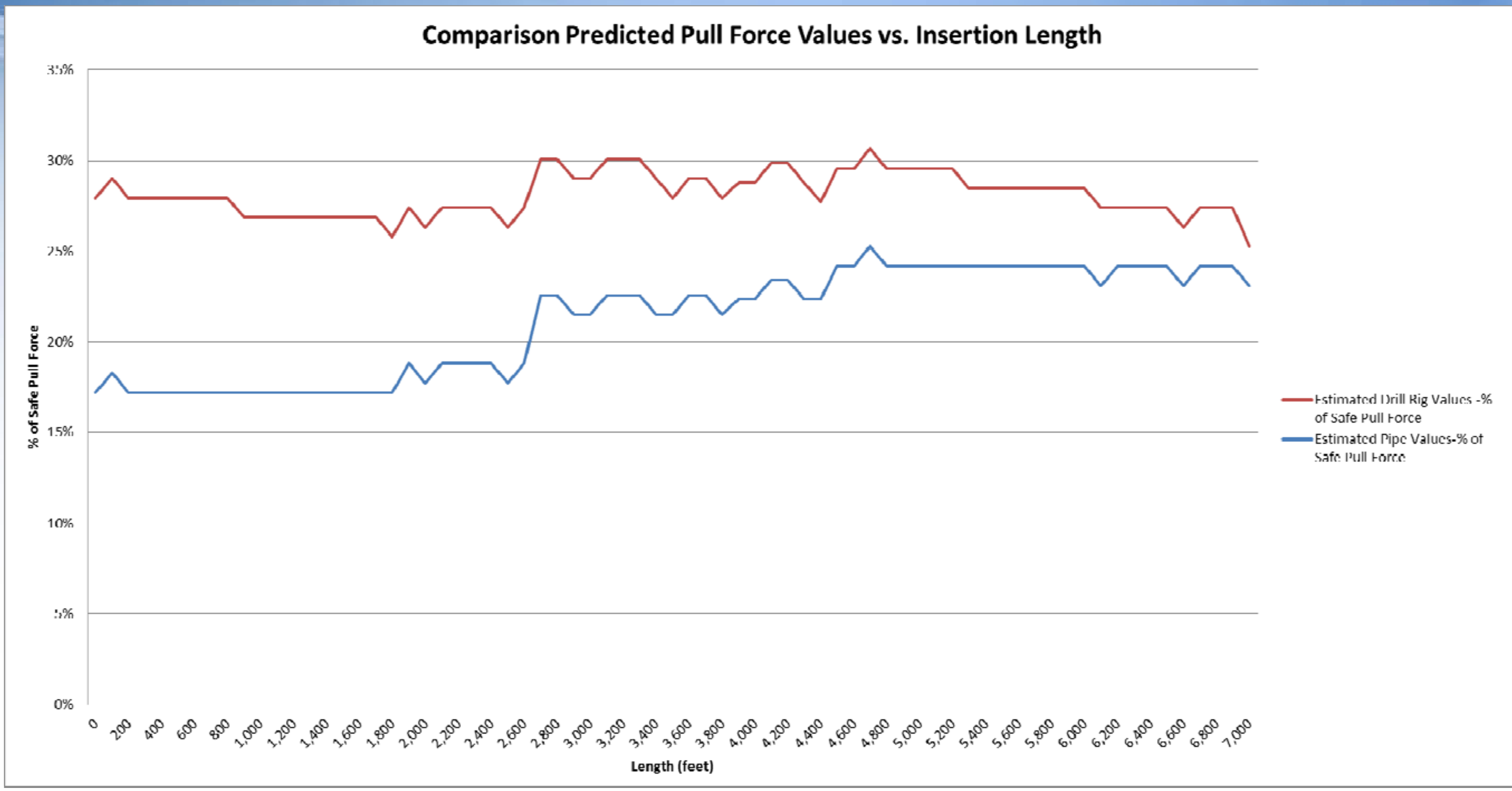
Notes: [-] negetive value means that the sliplined pipe will sink

[+] positive value means that the the sliplined pipe will rise to the top of the host pipe

- Self-ballasting method applied
- ‘open’ ended pull head utilized
- Slurry fills pipe as it is installed
- Slurry flushed from the pipe after installation by pigging, backfilling with clean water

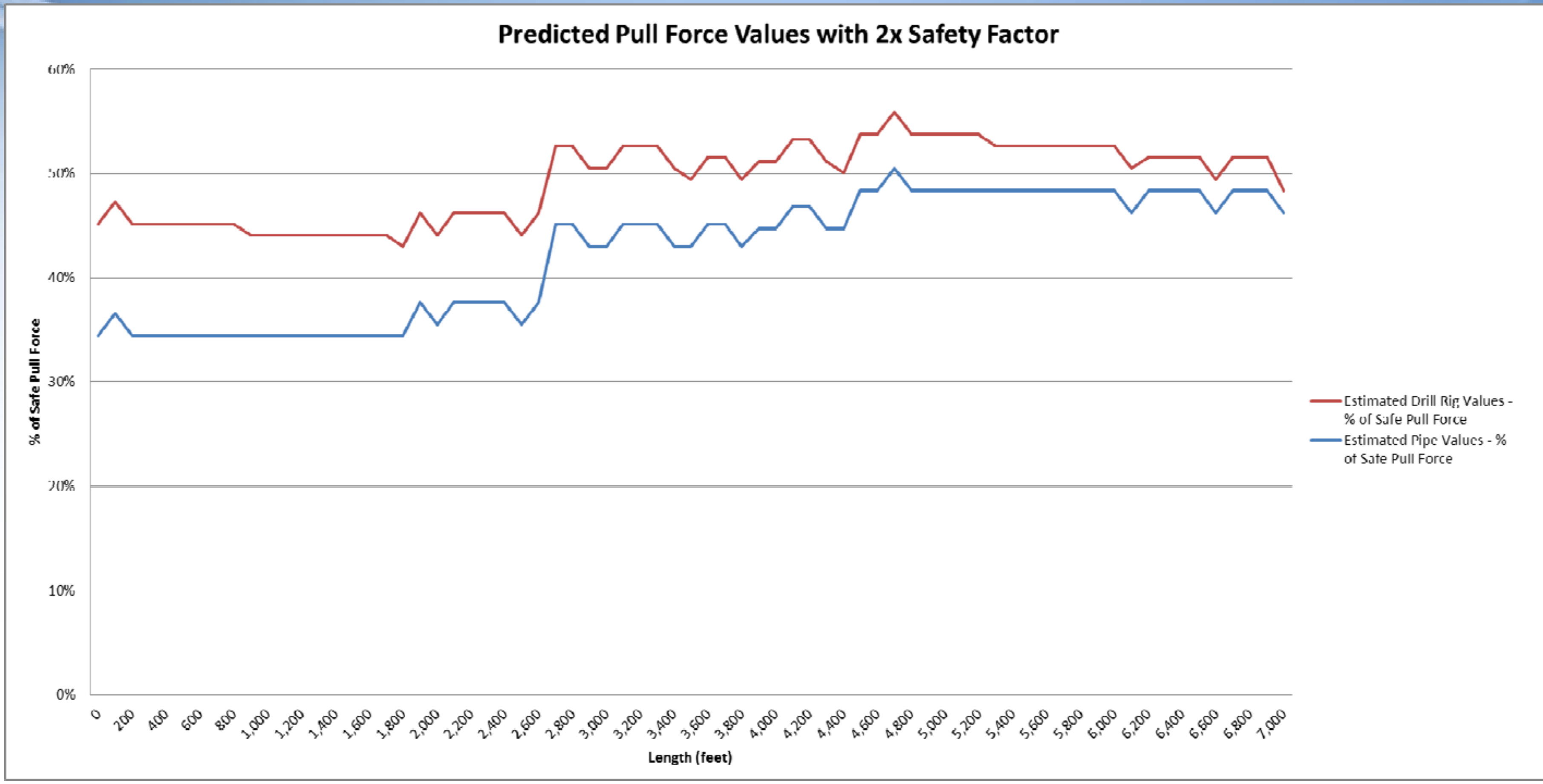


Dealing with the alignment issue – how much will it add to the pull forces?



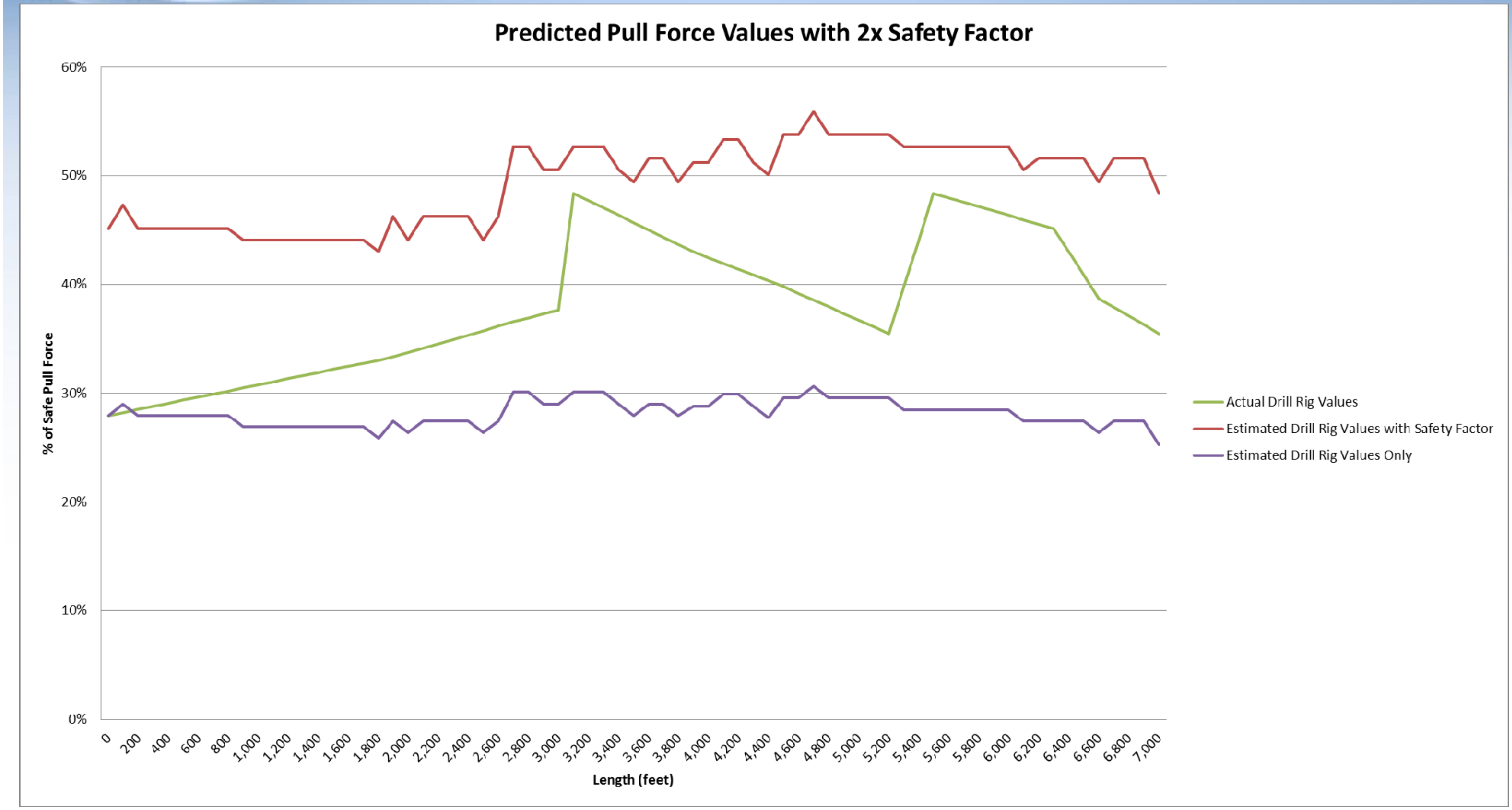
- Estimated forces based on buoyancy, capstan effect for major bends, and pipe drag loading
- Additional estimate on Drill rig values (includes pull force for tooling)

When evaluating the "go – no-go" for the project, total predicted loading on the pipe was estimated with a 2x Safety Factor

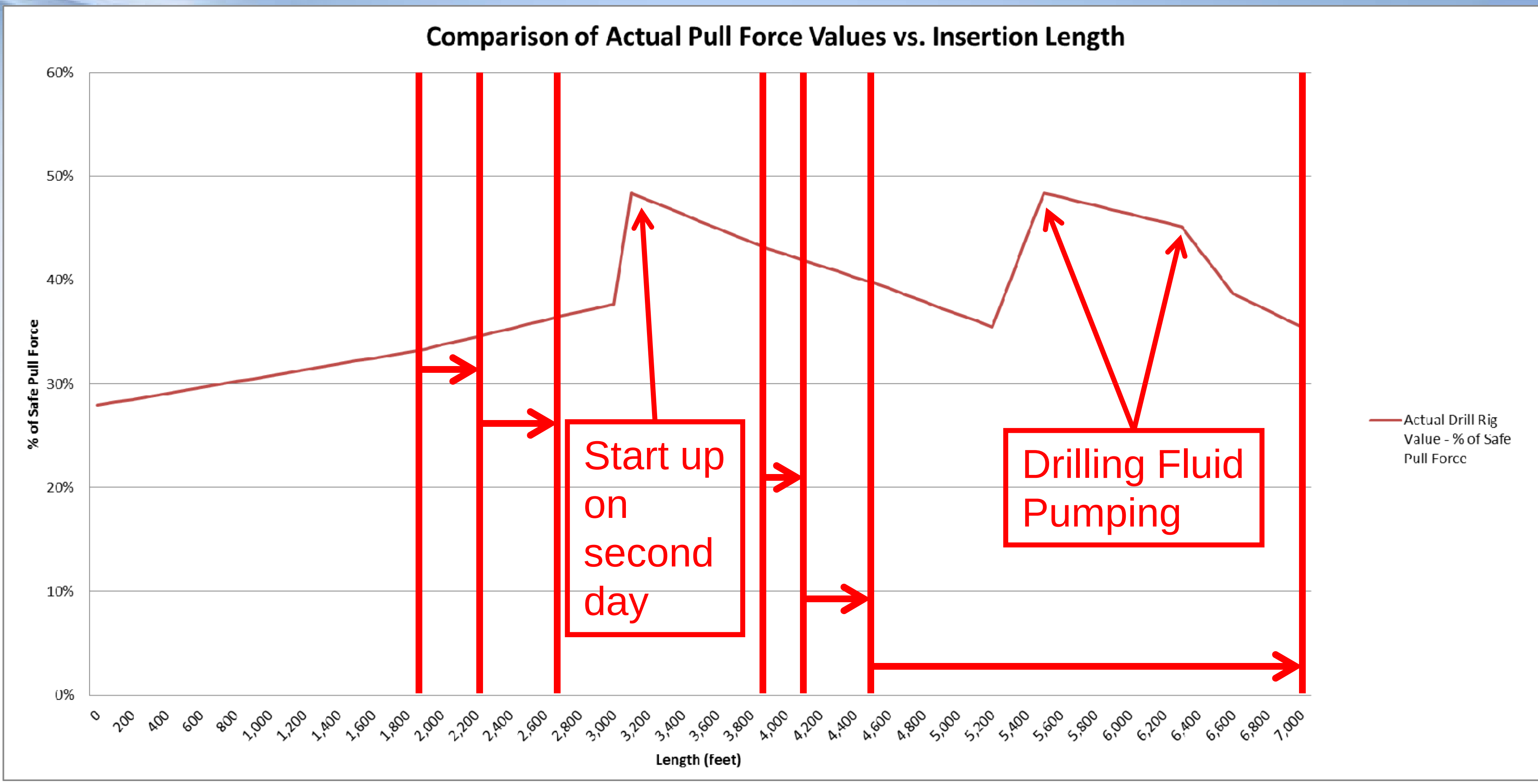


- Safety Factor applied to total 'in pipe' forces, on a sliding scale from the beginning to the end of the insertion
- Drill rig values also looked at as an adder on top of these estimates

Total predicted loading on the pipe compared to what was actually realized during installation – how did the prediction turn out?



Reviewing the installation pull forces required, broken down by installation specifics…



First Downward Bend

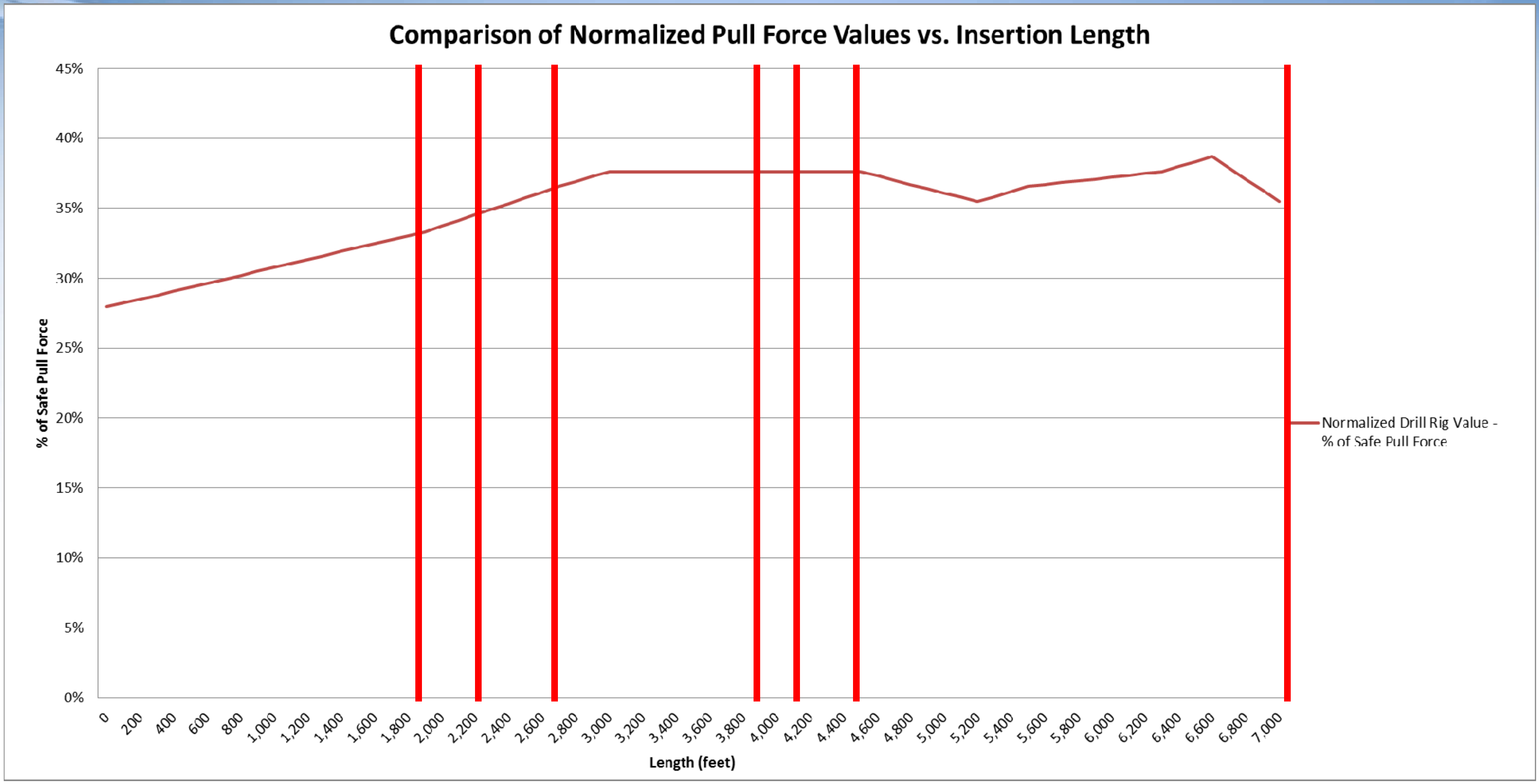
Second Bend Flattening

Third Upward Bend

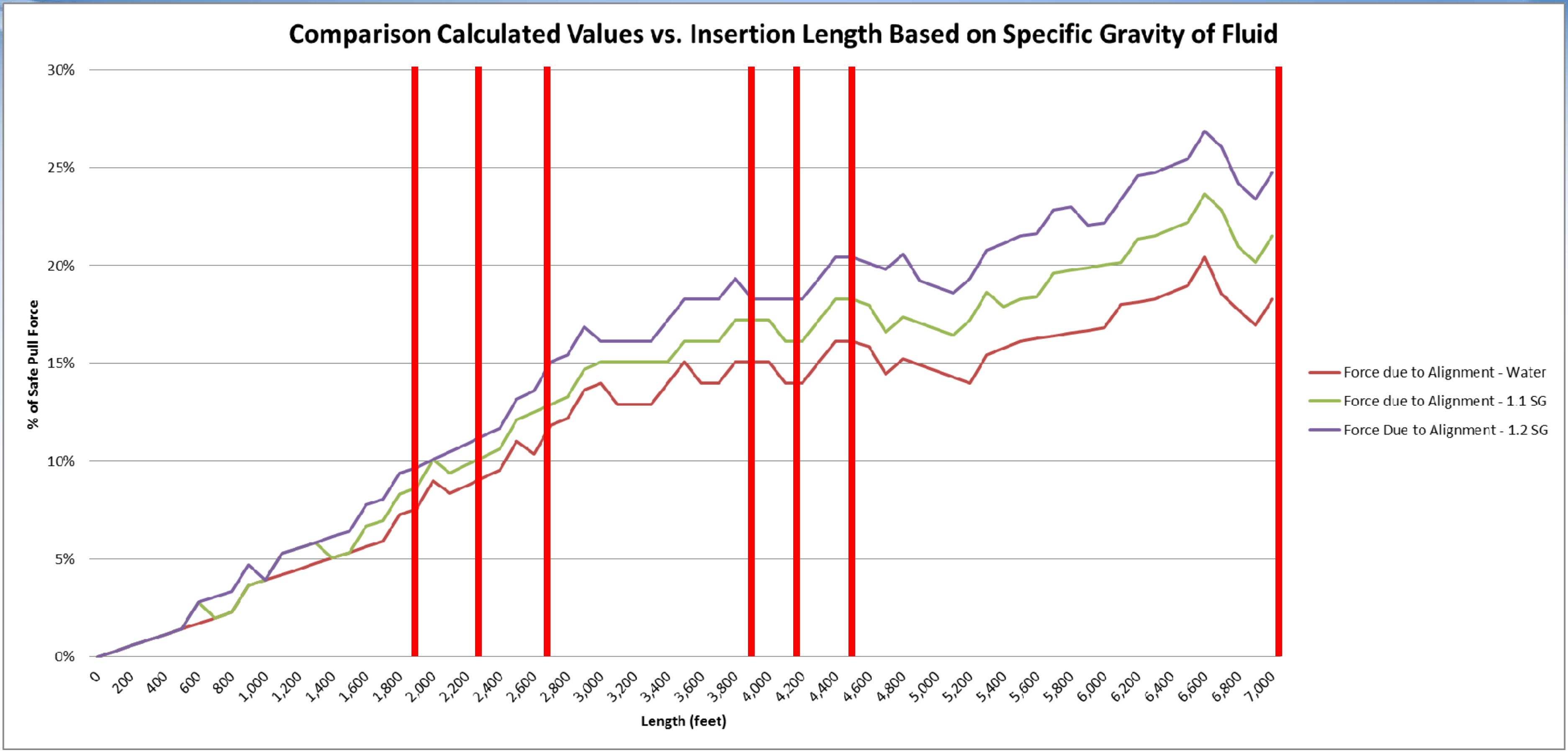
Fourth Leveling Bend

End of Installation

Pulling forces are normalized for buoyancy application and insertion logistics…



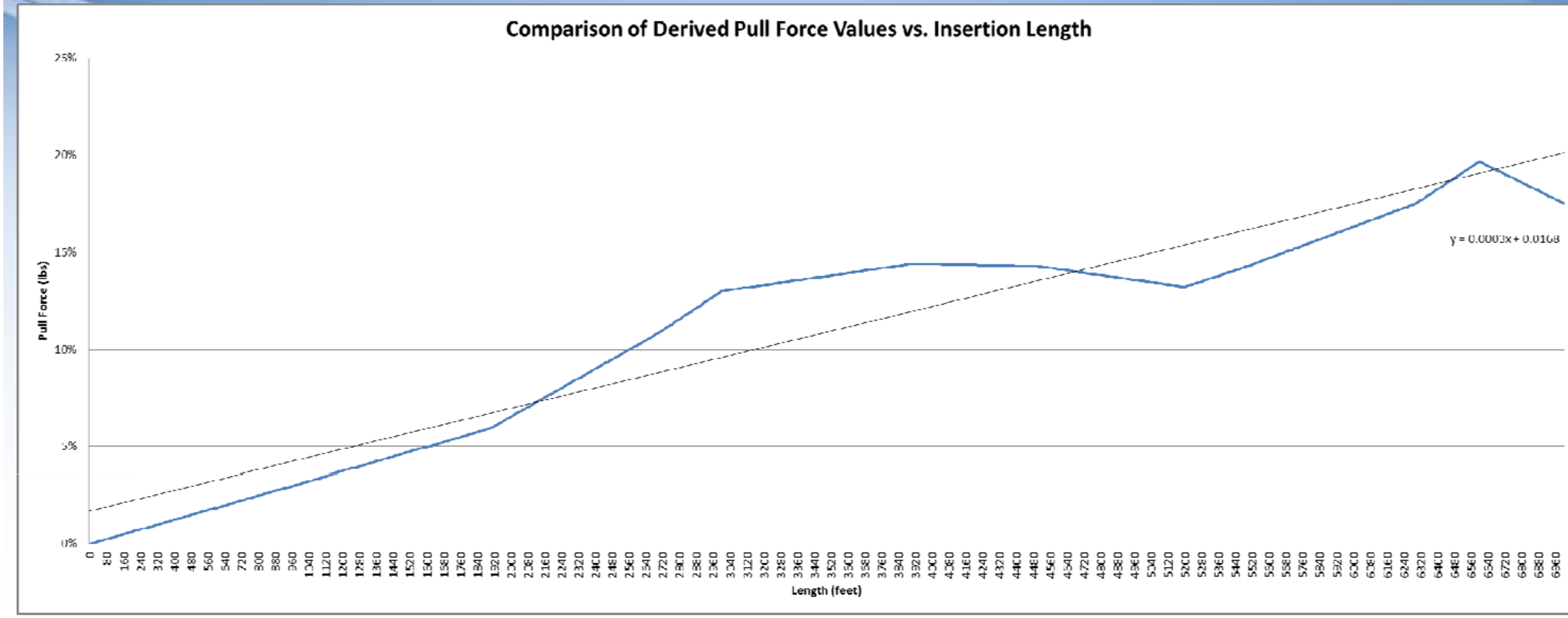
From the assumptions regarding components of the pull force, estimates can be made on pull force due to alignment



Assumptions:

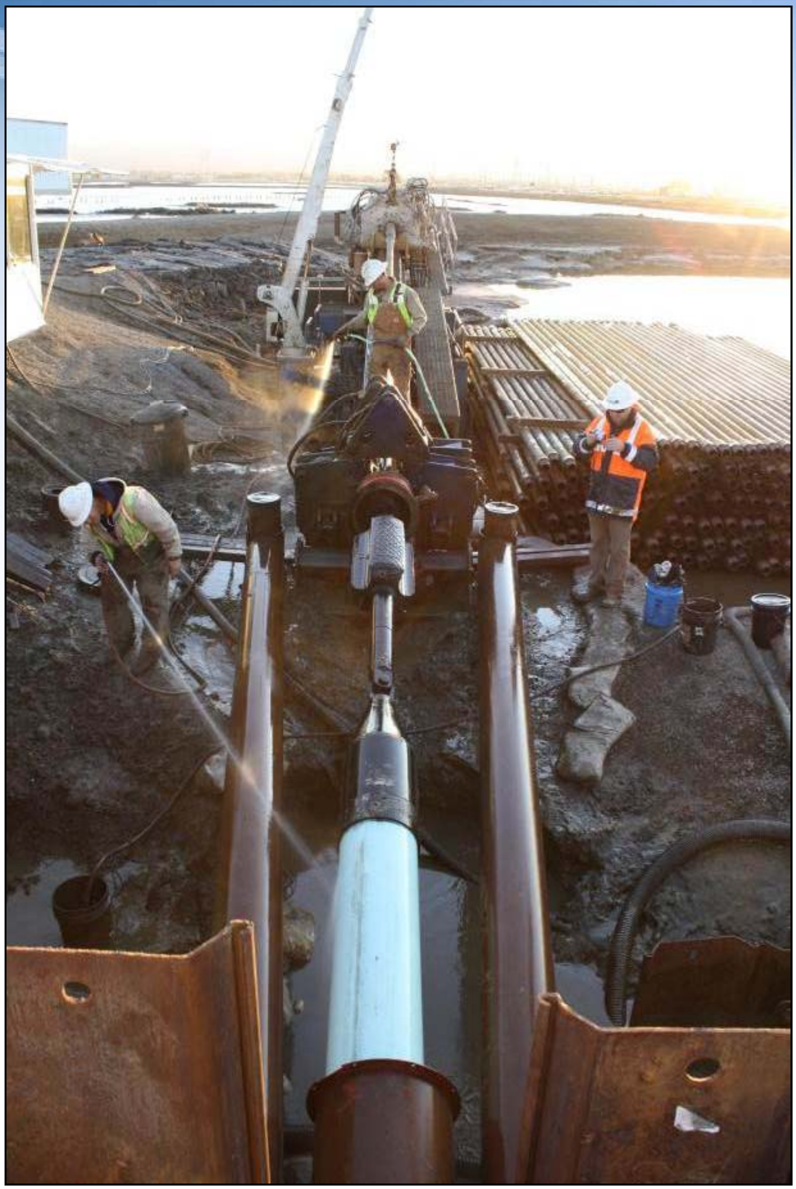
- 0.3 friction factor between FPVCP and host pipe
- Normalized pull force values used
- Estimated at-grade and insertion set up drag, and drill rig losses included

Removing all aspects of the pull force estimation yields an additional trend for pull force loading



- Roughly 0.003% per LF was required in addition to calculated loads.
- At the end of the pull, this accounted for about ~20%, or about 1/3 of total loading for the drill rig, and almost double the original estimates for the pipe only

Lessons taken from this specific and unique installation regarding sliplining



- Typical friction factors of ~0.3 seemed to correlate well
- Curvilinear alignments with undulations will add significant loading to the pull in
  - For this case it was double the original estimates for pipe loading
  - It was a third of required drill rig loading
- Important to assure appropriate volume balancing when relying on self-ballast or traditional ballast as a pull force reducing agent for slipline (or HDD)

Successfully completed project in terms of an effective solution on all levels

- Sliplining is a simple and effective rehabilitation method:
  - flow area and pressure design must be workable
  - Alignment plays a critical role in installation
  - Pipe staging, insertion and receiving pit alignments important
- Environmental issues were completely averted
- Very quick turn around time for completion of project

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