# Specification & Design Considerations for Sewer Bypass

**Tony de Bellis / Garrett Rehs**

June 2024

# Agenda

- INTRODUCTION
- OVERVIEW OF RAIN FOR RENT & PROJECTS
- SPEC WRITING CONSIDERATIONS
- BYPASS PROJECT PITFALLS
- DESIGN PREFERENCE IMPACTS ON COST
- TWO CASE STUDIES

# First – Thank you!

- We Know That Putting Together These Projects – In Writing And For The Record! Not Easy
- Consider Us A Resource.  Call Anytime.
  - *This Is Just Our Experience*
- This Is Focused On Raw Sewer Bypass But Does Apply To Water And 2nd Effluent

# Family-Owned for 90 Years

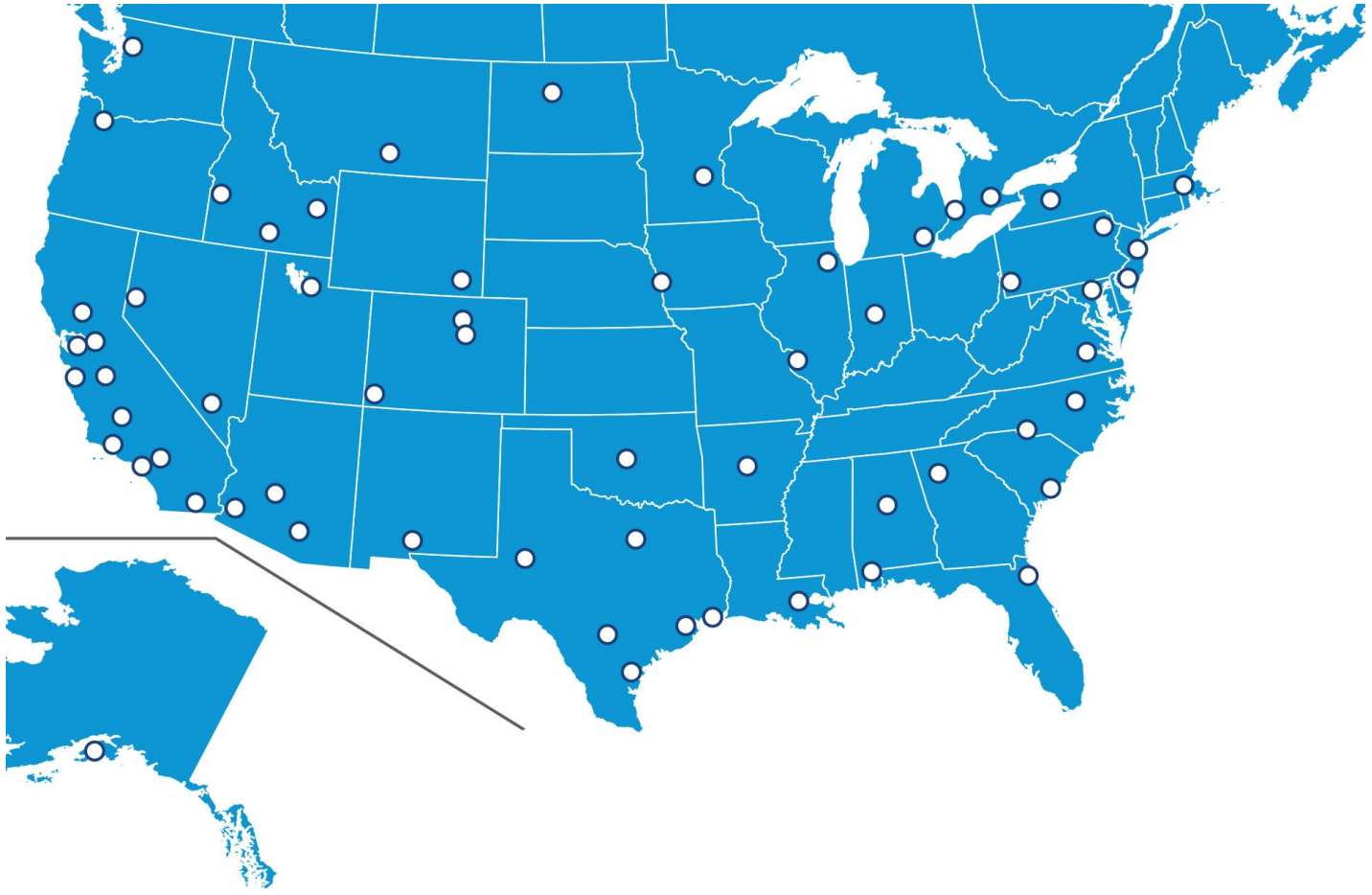
RAIN FOR RENT

Liquid Ingenuity®
Since 1934

# Company Owned Local Operations

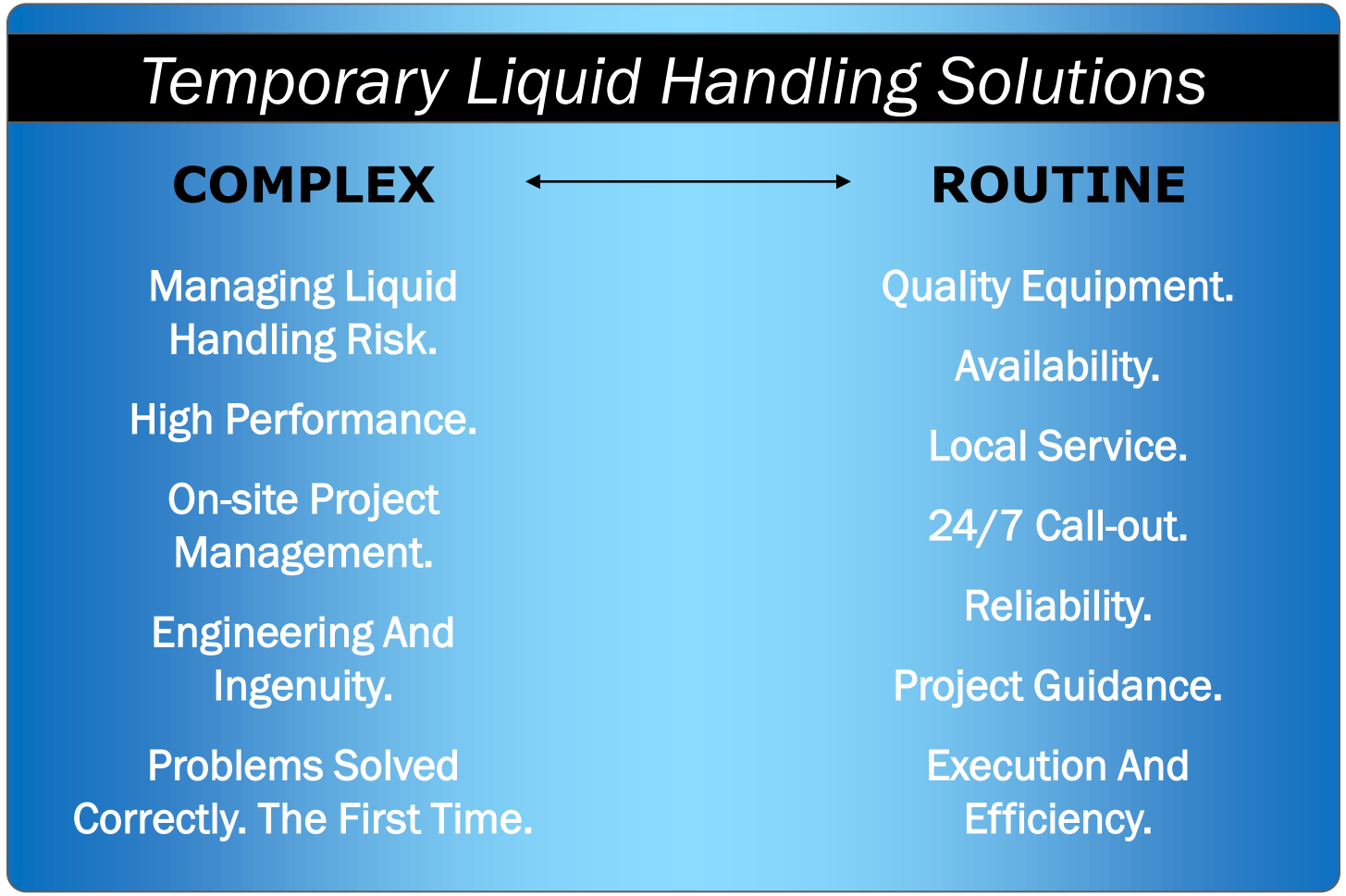
## We Are Family-owned Business Backed By

61 Branches • 90 Years Of Experience • Centralized Engineering Department



RAIN FOR RENT

# How We Help Our Customers

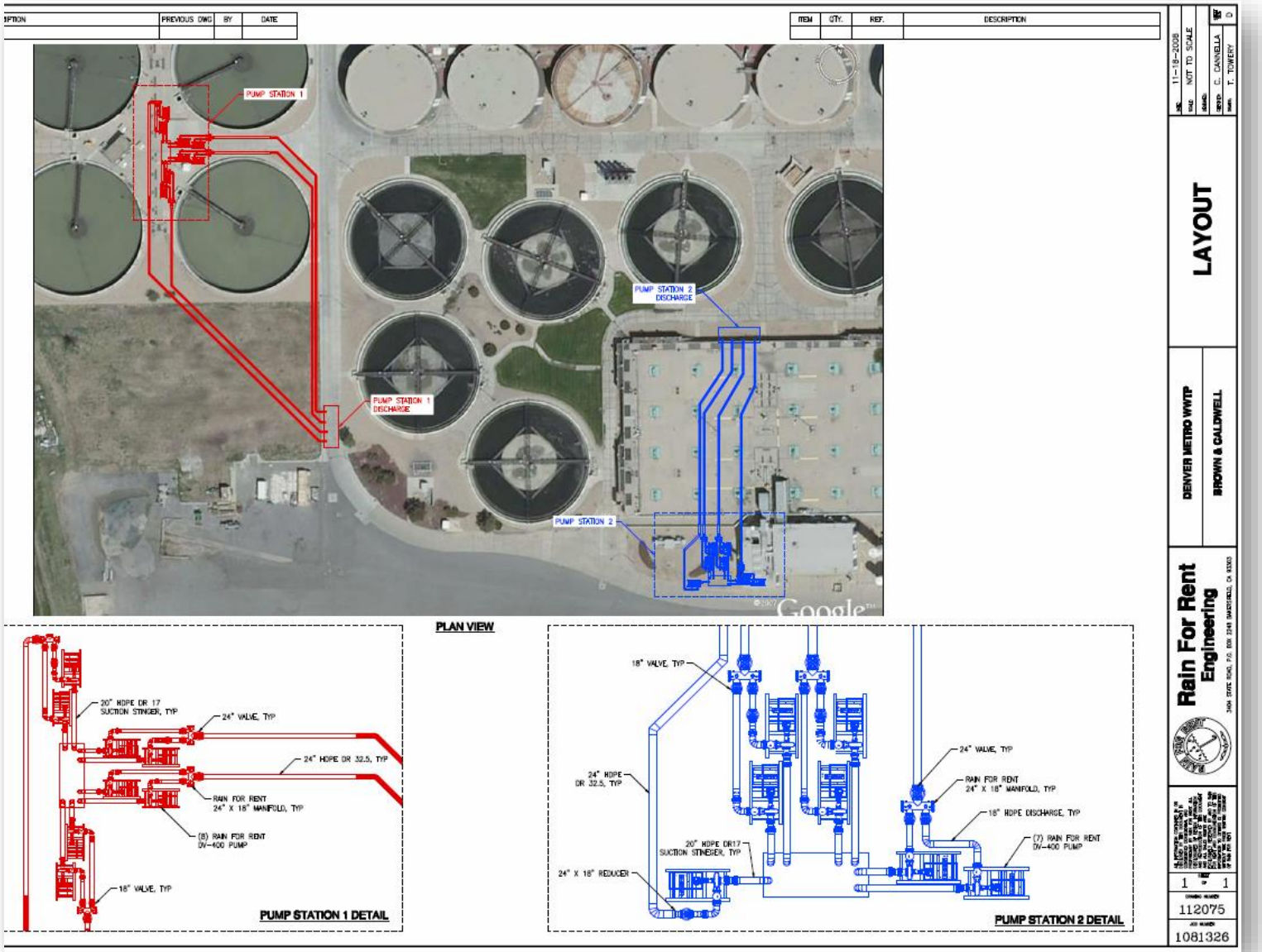



**Responsive | Safe | Proven Expertise**

# Our Goal


RAIN FOR RENT

# Design Services




RAIN FOR RENT

# Design Services

***Phoenix Bypass***
**145 MGD**


***Memphis Bypass***
**120 MGD**

RAIN FOR RENT

# Design Services

***Sydney Tar Ponds, Nova Scotia 9***


RAIN FOR RENT

# 576 MGD Flood Control

- Omaha, Nebraska
- Combined Sewer Overflow During Rain Events
- Unique Floating Pumps Capable Of ~100MGD Each
- Dv600c’s (5), Electric And Hydraulic Submersibles


RAIN FOR RENT

# Plant Sewer Bypass

RAIN FOR RENT

# Cooling Tower Bypass/Filter

# Cooling Tower Bypass


RAIN FOR RENT

# Potable Water Emergency Pumping


RAIN FOR RENT

# 125 CFS Canal Bypass – Knightsen, CA

RAIN FOR RENT

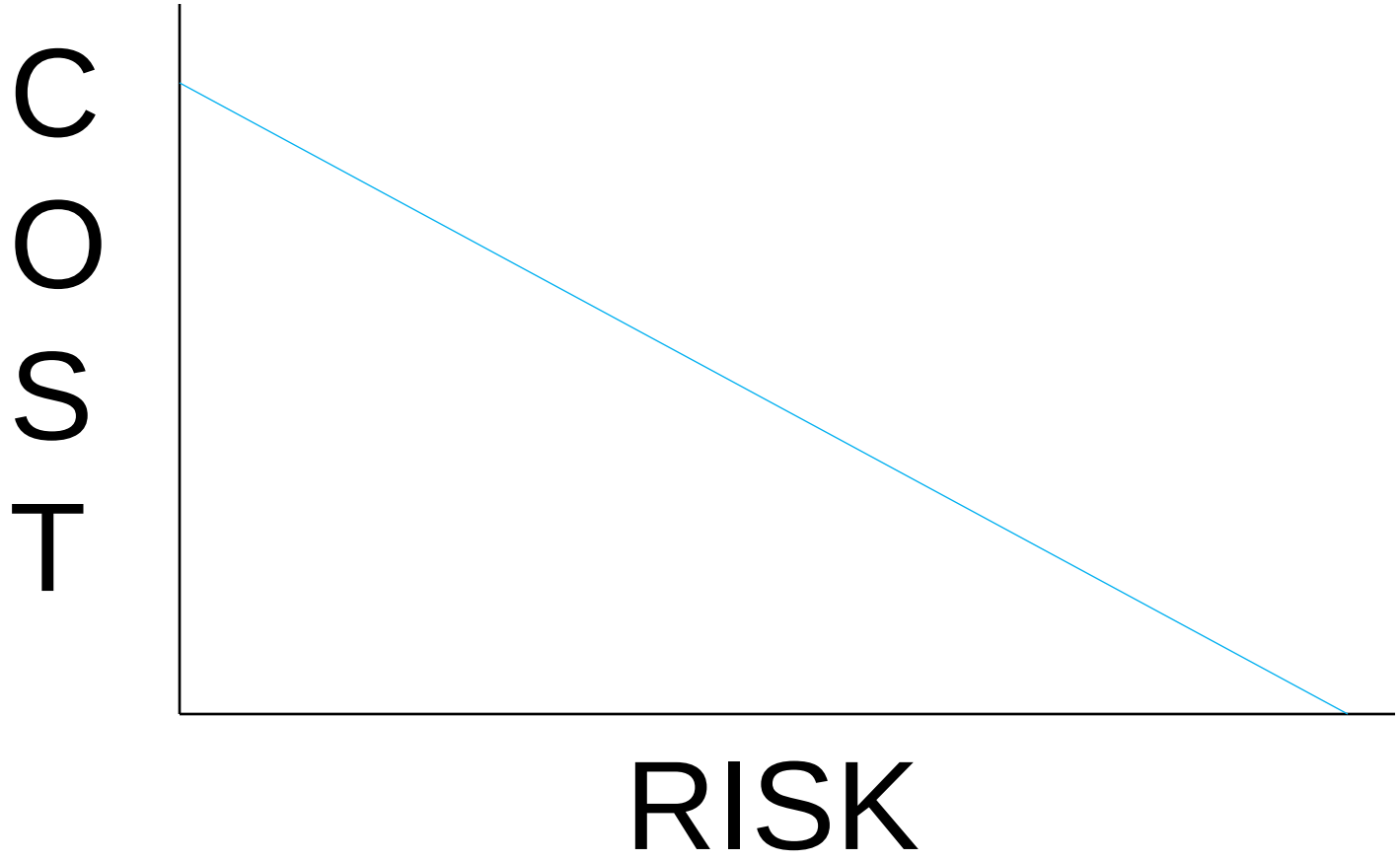
# What Is A Bypass, Really?

- A Temporary Lift Station That Must Be As Reliable As A Permanent Lift Station
- Both Can Be Quite Expensive
- Would You Risk Under Sizing Or Oversizing Your Permanent Lift Station?

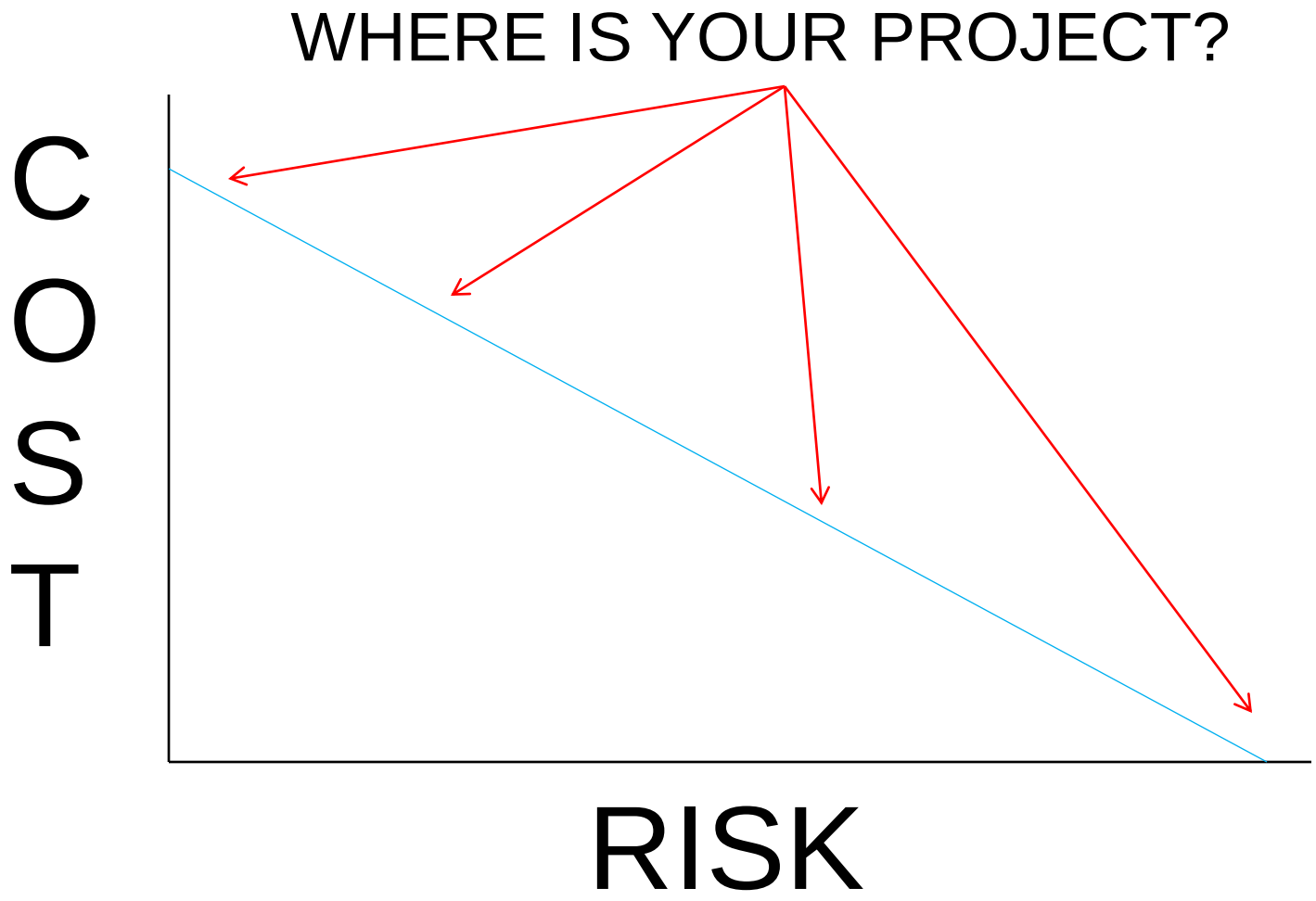
# Specification Writing

- Bypass Projects Have A Clear Risk Vs. Cost Relationship
- Not All Bypasses Have The Same Risk Parameters
- Goal Of The Spec:
  - Give The Contractor Enough Detail With Clear Requirements So That The System Installed Matches The Risk Comfort Levels & Estimated Budget.
  - Contractors also manage risk.  A good spec. will bring more competition to the bid.

# Cost vs. Risk



# Cost vs. Risk



# Mistakes We Have Seen (*recently*)

- Safety Factor Applied To Flow Not Redundancy – Actual Was 17 MGD Spec Said 25 MGD (Oversize x 1.5)
- Pump Redundancy Requirement Called Out For The Average Flow Not The Peak Flow (Undersize)
- Spec Flow 30% Of Actual Flow (Undersize)
- Suction Lift Required Violates Laws Of Physics
- Impractical daily bypass set-up and tear down requirement

# What We Need In The Spec

- Correct High Flow And Low Flow – Average Is Irrelevant
- Elevations (Suction Lift)(Surcharge Limits)
- Withdrawal Location
- Discharge Location
- Required Redundancy For High Flow
- Required Material (Hint – HDPE Is Lowest Risk)
- Pump & Pipeline Protection (K-rail?)

# What You Can Have In The Spec.

- Contractor Experience Requirements.
- Automation Or Instrument Requirements.
- Pipeline Velocity’s.
- Vertically Integrated Services And Equipment.
- Bypass Test/Commissioning Period (72 Hrs.)
- Bypass providers pre-qualification to bid.

# Accurate Flow Rates

- Modeling Accuracy Depends On Accuracy Of Inputs
  - Downstream Debris Changes Fullness
  - Ground Water Seepage
  - Unknown Laterals
  - Corrosion/Roughness Of Pipeline
  - Storm Run-off
  - Have Faith In Our Ancestor Engineers!  That 50 y/o 18” pipe is there for a reason.

  - Our Experience – Flows From Models Need To Be Fact Checked By Opening The Manhole Or Installing Temp Flow Meters.

# Accurate Flow Rates

- Inaccurate Inputs → Inaccurate Flows → Over/Under Designed Bypass System
- Which Is More Money And Delays & Opportunity Cost To The Owner
- If Possible, Verify Model Inputs & Output With:
  - Flow Meters (Temporary Or Existing)
  - Hazen Williams Equation – Slope / Fullness / Roughness

# Plans & As-Built's

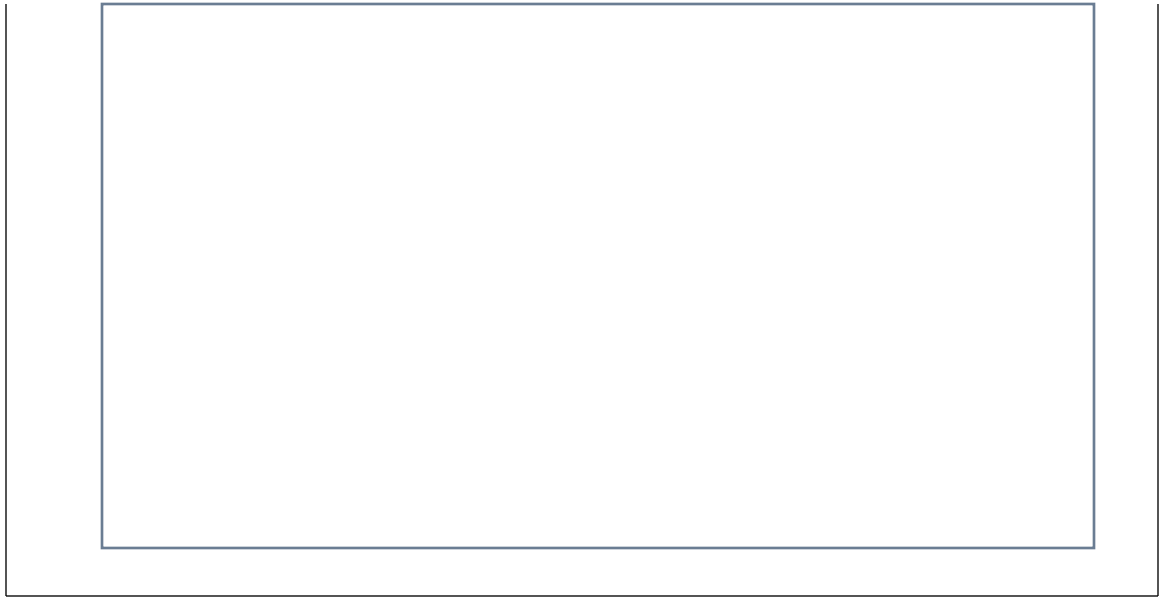
- Historical Drawings
  - May Not Show Upgrades, Modifications, Or Other Changes To The System

# Omaha, NE 576MGD Station

CULVERT X-SECTION AS
SHOWN ON PLANS
(30” CONCRETE WALLS)

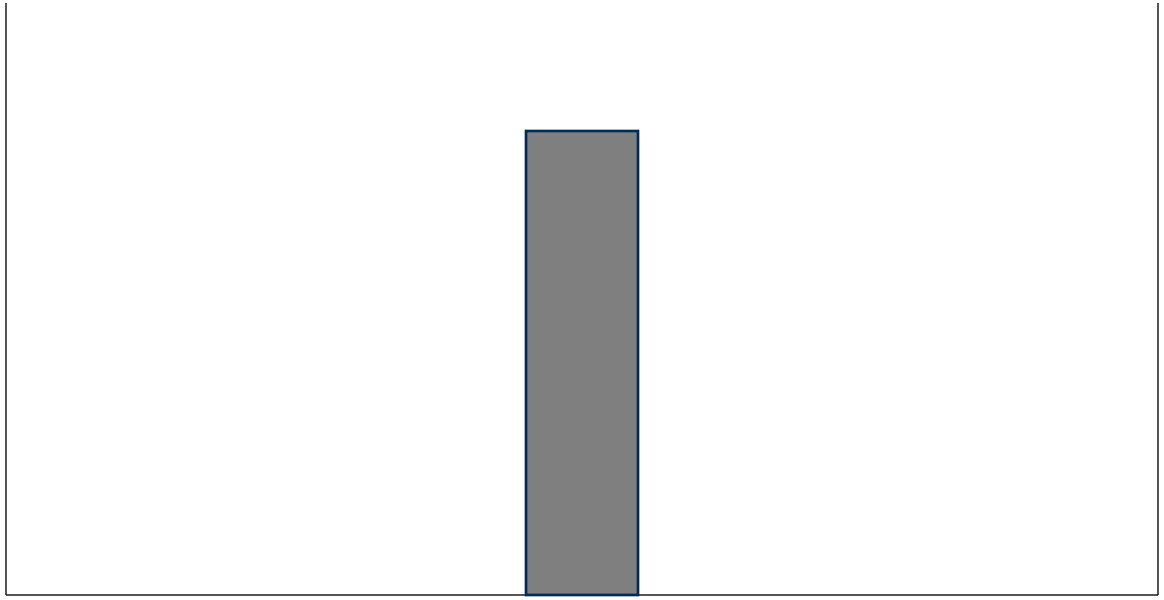
# Omaha, NE 576MGD Station

## The Plan…Concrete Cut Lid and Place Floating Pump Inside Culvert



# Omaha, NE 576MGD Station

## Actual Culvert X-section With Weir Wall



# Solution

RAIN FOR RENT

# Pump Station Design

- Centrifugal Vs. Submersible
- Redundancy & Pump Watch


RAIN FOR RENT

# Pump Choice

- Centrifugal Pumps
  - Theoretical Suction Lift Of 28ft
  - Realistic Suction Lifts Of Up To 15 To 20 Ft
    - NPSHR Is Huge Towards Far Right Of Curve
  - Solids Handling Up To 4”
  - Open Or Semi-open Impeller
  - Easy To Swap Out
  - Self Priming (Can Have Backup Priming)
  - Requires 3-5ft Of Suction Submergence/Surcharge
  - Smaller Footprint In The Manhole/Pipeline

Example - 18” suction stinger for 3500GPM

# Lift vs. Flow

- 12” Pump w/ 12” suction and 500’ feet 12” discharge 0 elevation change.  Site elevation is 5’

| Suction Lift (ft) | Flow Rate (GPM) | TDH (ft) |
|---|---|---|
| 6 | 5500 | 72 |
| 12 | 5000 | 68 |
| 14 | 4500 | 60 |
| 16.5 | 4000 | 54 |
| 18 | 3500 | 48 |
| 19.5 | 3000 | 42 |
| 21 | 2500 | 38 |
| 22 | 2000 | 34 |
| 23 | 1500 | 31 |
| 23.5 | 1000 | 29 |
| 24 | 500 | 27 |

# Centrifugal Pumps

RAIN FOR RENT

# Submersible Pumps

- Great For Deeper Vaults (21’+)
  - No Suction Lift – All Discharge
- Quite And Out Of The Way
- Difficult To Swap Out
- Require Generators Or Power Drop and VFD’s
- Power can be separated from pump – smaller footprint
- Should Be Explosion Proof
- 3500 GPM Trash Sub = 44” At The Base

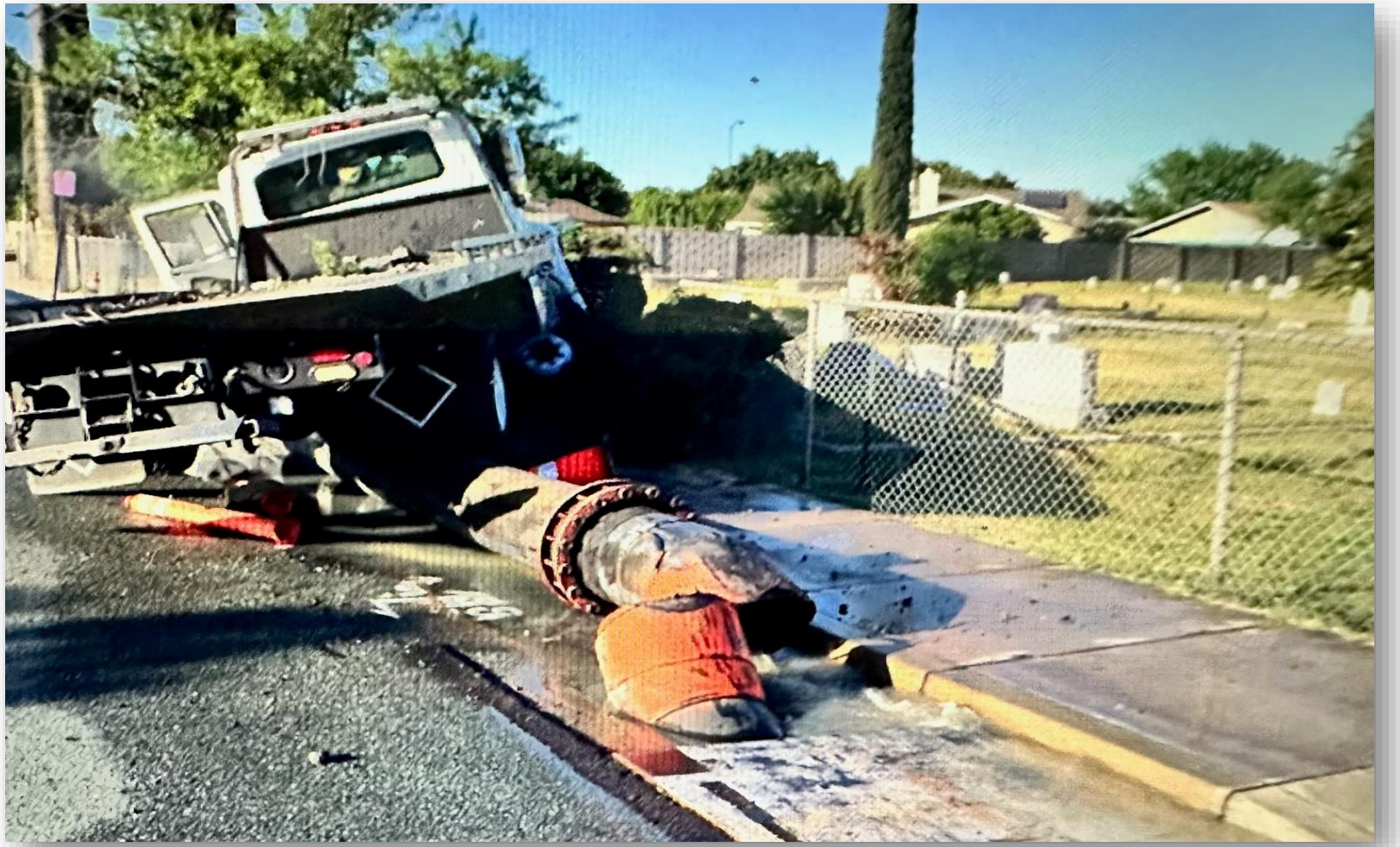
# Submersible Pump

RAIN FOR RENT

# Redundancy Defined

- Please - Clearly Define Redundancy At Peak Flow
  - For Pumps And Generators
    - 100%  1 Backup Pump Per 1 Duty Pump
    - 50%  1 Backup Pump Per 2 Duty Pumps
  - For Discharge Pipe
    - 1 Main Capable Of Peak Flow = 0%
    - 2 Main Capable Of Peak Flow = 100%
- Its All About Risk (in the Public Right Of Way?)

# Single Discharge Line - Example



# Single Discharge Line - Example

# Pump Watch (Operators)

- Need To Define If On Site Manning Is Required Or You Will Get A Ring Camera.
- 2-man Crew Minimum (1 Person Is A Witness)
- 95% Boredom 5% Stark Terror.  Owner Is  Paying For The 5%.
- Automation Is Great – In Reality People Are Hours Away (DOT hours of service for example)
- Raw Sewer Bypass Needs Manning – Water Probably Not

# De-Ragging

- Even Non-clog Impellers Need Cleaning

RAIN FOR RENT

# Final Pump Station Goal

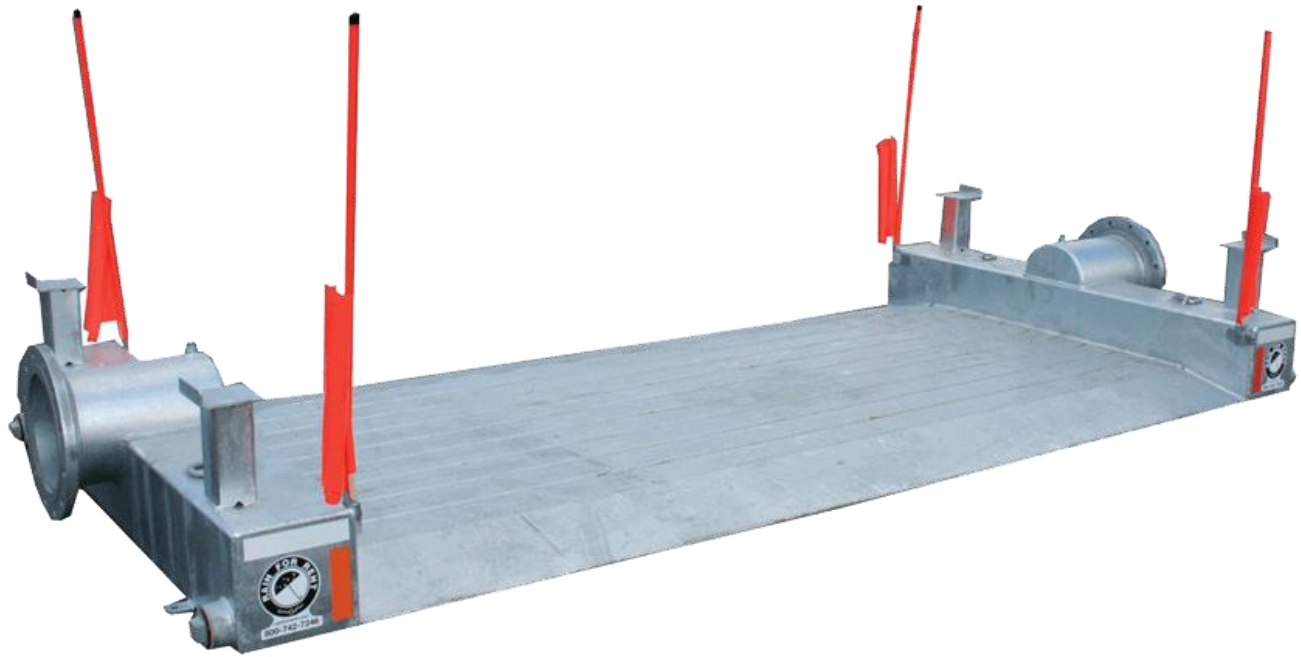
***Nova Scotia 9***

**354 MGD**

RAIN FOR RENT

# Surface Ramp For Discharge

- Road Crossings
- Materials
- Connections
- Velocities



RAIN FOR RENT

# Surface Ramp

# Discharge Road Crossings

- Trench And Plating Is Preferred Method
  - Should Trench And Plate For Pipelines Over 6’’ In Diameter

- Poor Alternative (Surface Ramps)
  - Slow Traffic / Traffic Hazard / Cars can high center.
  - Can Clog When Pumping Sewage / Good For Water.
  - Unstable On Roads
    - Crossings Are Flat
    - Roads Have A Crown For Drainage

# Discharge Material

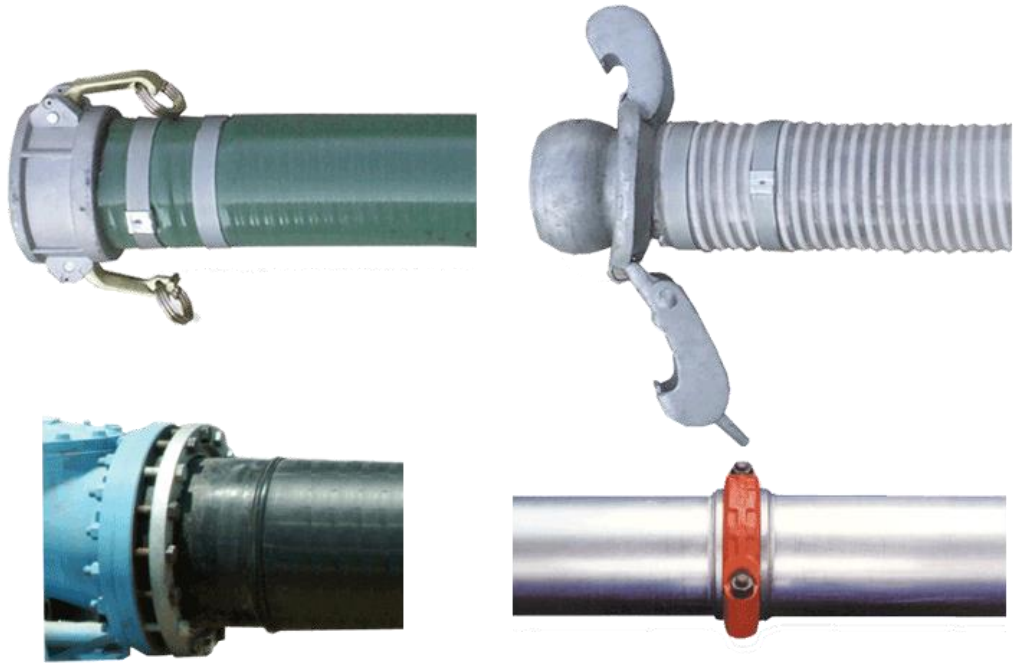
- Various Materials With Wide Spectrum Of Pros and Cons
  - Fused High Density Polyethylene (HDPE)
    - Leak Proof/Car Proof/Bullet Proof (Not Truck Proof)
    - Readily Available From 2’’ To 36’’
    - High Installation Costs
  - Layflat Hose/Rigid Hose
    - Quick Install
    - Pressures To At Least 75 Psi
    - 12’’ And Below
    - Hose Bauer and Camlock Connections Prone To Vandalism

# Discharge Material

- Various Materials With Wide Spectrum Of Pros and Cons
  - Aluminum Pipe
    - Quick Install W/Limited Labor
    - High Pressure Rating
    - Available 12” And Smaller
    - Horrible Suction Rating
    - Thin Walled / Brittle
    - High Scrap Value Is Tempting To Vandals
  - PVC
    - High Pressure Rating
    - Leak Proof
    - Becomes Brittle Over Time
    - Expensive (Labor & Material) For Large Diameters

# Connections

- Various Connection Types
  - Fusion Welded
  - Flanged
  - Industrial Groove (Victaulic)
  - Glued
  - Cam Lock
  - Bauer



# Discharge Velocities

- Typical Engineering Design Standards
  - Short Sections  Of Steel Or HPDE Pipe
    - Up To 20 Ft/Sec
  - Typical Sewer Bypass Mainlines
    - Up To 12 Ft/Sec
  - Discharge Into Critical Or Fragile Structures
    - Up To 5 Ft/Sec
  - Dangers:
    - Water Hammer (pump control setup is important here)
    - Damage To Structures

# Specification Writing

- Submittal Requirements
  - Pe Stamped Calculations & Drawings
    - Proof Of Concept
    - Eliminates The "I Know It Will Work Because It Worked Last Time" Mentality
    - Eliminate Submittal Calcs From An iPhone App

# Submittal Calculations

**Lift and TDH calculations for the pumps listed below**
(4) DV-200c @ 2605 GPM / Pump Primary
(2) DV-200c @ 2605 GPM / Pump Backup

| PIPE | Suction | Discharge-1 | Discharge-2 |
|---|---|---|---|
| Type | Hose | Aluminum | HDPE |
| Dia (in) | 12 | 12 | 18 |
| Rating | Suction | Ind Grove | 32.5 |
| I.D. (in) | 12 | 11.812 | 16.826 |
| Length (ft) | 30 | 100 | 1150 |
| Flow (gpm) | 2605 | 2605 | 5209 |
| Velocity (ft/s) | 7.391 | 7.628 | 7.517 |

**Total Suction Lift**

| | |
|---|---|
| 14.60 | Ft. lift, water==>ground level |
| 0.35 | Ft. Pipe Hf for 12" x 30' Suction Hose |
| 0.66 | Ft. Entrance Loss (k = 0.78) |
| 0.33 | Ft. (1) 12" 90° Elbow (k = 0.39) |
| 1.13 | Ft. 12" x 8" Priming Reducer (k = 0.64) |
| 3.29 | Ft. Trailer/ Skid Height |
| 20.36 | Ft. |

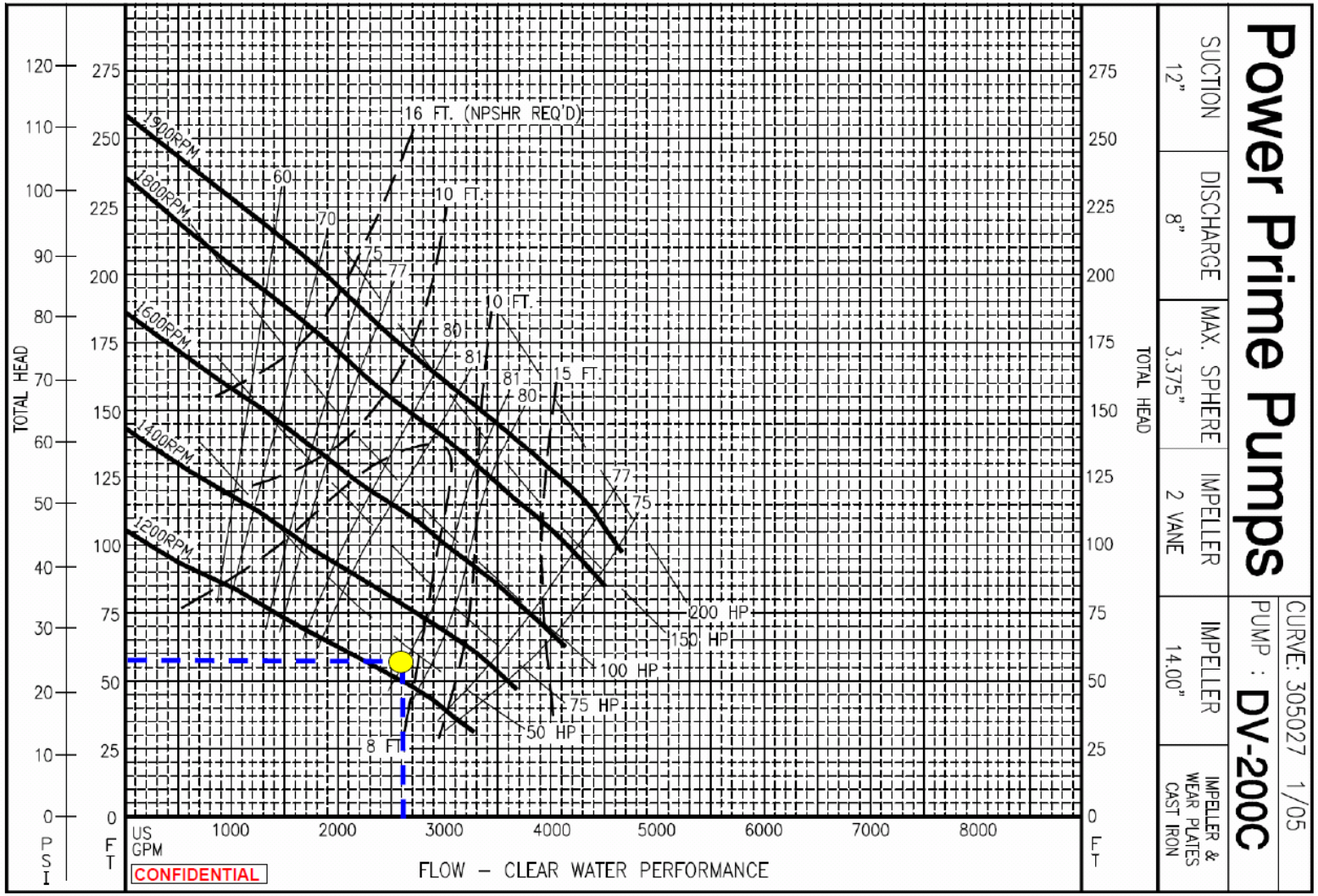
**Total Dynamic Head (TDH)**

| | |
|---|---|
| 1.62 | Ft. Pipe Hf loss 12" x 100' Ind Groove Al Pipe |
| 6.01 | Ft. 8" Check Valve (k = 1.4) |
| 1.13 | Ft. 8" x 12" Enlargement (k = 0.64) |
| 2.61 | Ft. (8) 12" Ind Groove 90° Elbow (k = 0.36) |
| 0.08 | Ft. (1) 12" Gate Valve (k = 0.10) |
| 2.12 | Ft. (1) 12" x 18" Manifold (k = 2.5) |
| 0.07 | Ft. (1) 18" Gate Valve (k = 0.10) |
| 9.22 | Ft. Pipe Hf loss 18" x 1150' HDPE SDR 32.5 |
| 1.03 | Ft. (3) 18" HDPE SDR 17 90° Elbow (k = 0.39) |
| 15.00 | Ft. Elevation Increase |
| 20.36 | Ft. Suction Lift |
| **59** | **Ft. Required Pump Pressure** |
| **26** | **PSI** |

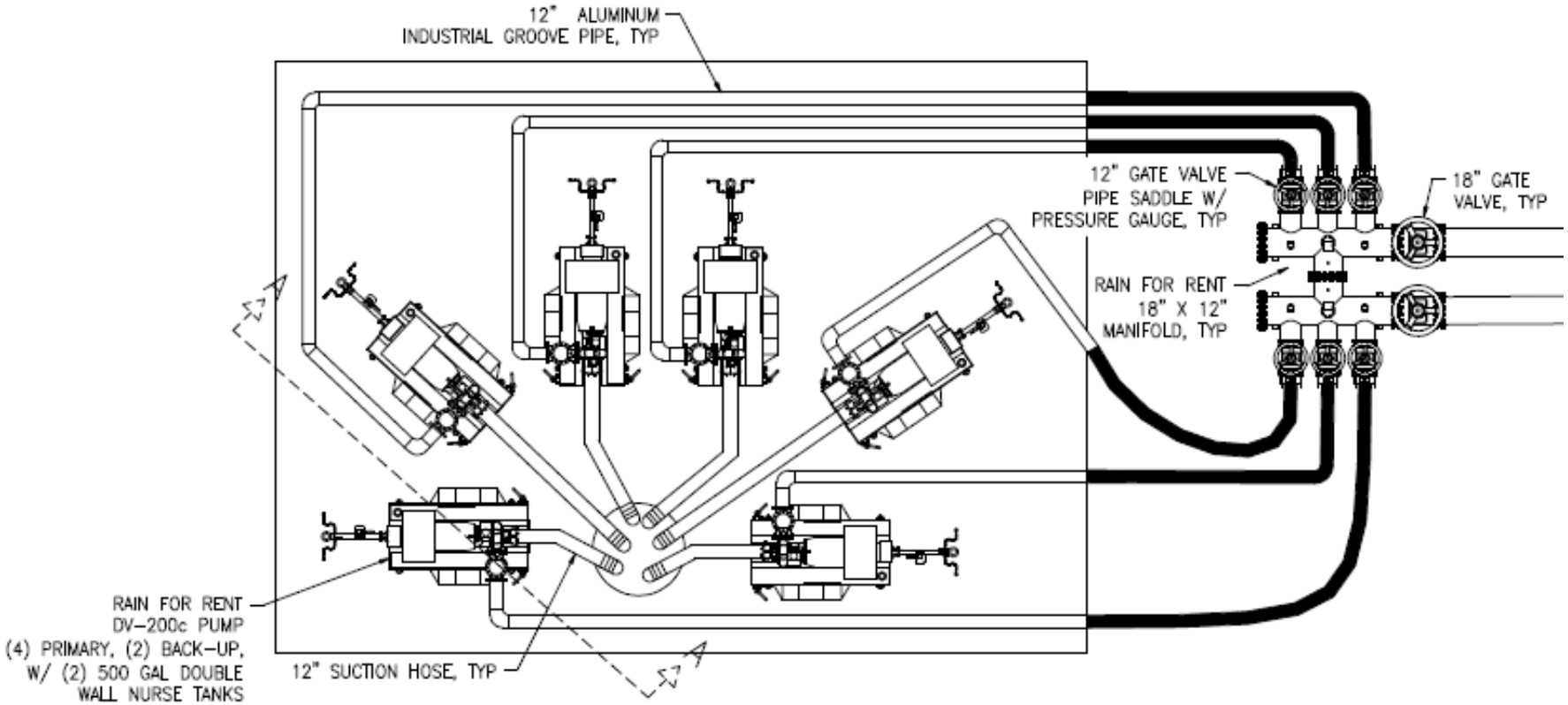
**NPSH**

| | |
|---|---|
| Altitude (Ft): | 100 |
| Atm Pressure (Ft): | 33.88 |
| Vapor Loss @ 80°F (Ft): | 1.20 |
| NPSHA | 12.32 |
| NPSHR | 8.00 |
| NPSHA > NPSHR | **OK** |

# Pump Curve


Power Prime Pumps
PUMP : DV-200C
CURVE: 305027 1/05
SUCTION 12"
DISCHARGE 8"
MAX. SPHERE 3.375"
IMPELLER 2 VANE
IMPELLER 14.00"
IMPELLER & WEAR PLATES CAST IRON
TOTAL HEAD
PSI
FT
US GPM
FLOW – CLEAR WATER PERFORMANCE
CONFIDENTIAL
16 FT. (NPSHR REQ'D)
10 FT.
15 FT.
8 FT
1900RPM
1800RPM
1600RPM
1400RPM
1200RPM
200 HP
150 HP
100 HP
75 HP
50 HP

# Submittal Drawing




**PUMP STATION DETAIL**

**NOT TO SCALE**

RAIN FOR RENT

# Pitfalls To Watch For

- Cone Removal
- Surcharging
- Clean Water Source
- Surging Flows Into Plant

# Manhole Cone Removal

- Typical Manhole Covers Are 22”-24”
  - Enough Room For (3) 8” Suction Hoses
- Should Remove Cone For Bypasses Above 5MGD
- May need to excavate and open the pipe.
- Extra Costs Excavating And Rehab
- Result –Possible Change Order Or
  - System Is Undersized
  - Suction Lines Are Undersized
  - Common Suctions Are Used
  - Pump System Is Not Optimal

# Cone Removed

RAIN FOR RENT

# Surcharging

- "The More The Better…as Long As It Is Not Too Much!"
  - All Pumps Require Submergence To Operate Properly – Rule Of Thumb 3 To 5 X The Dia. Of Suction Hose
  - Vortex – loose prime – wait to re-prime.  Minutes seem like hours
  - Suction stingers need separation
  - Surcharging Reduces Suction Lift Which Increases Submergence Which Increases Performance.
  - The joke is – surcharge is a self-correcting problem.
  - Caution:
    - Upstream Conditions
    - Suction Manhole/Wet Well Conditions (size)

# Too Much Surcharge

RAIN FOR RENT

# On-site Water (Hydrant)

- Hydro-test Prior To System Startup
- Flush Prior To System Removal
- Clean Water Is Required For Both Operations
  - If Not Onsite And Available, Contractor Will Need To Truck In Water
  - Result Is Possible Change Order Or System Is Not Hyro-tested And Flushed Properly

# Surging Plant Flow

- Bypass Flows Should Mimic Natural Diurnal Incoming Flows
- Bypass Systems With On/Off Mechanical Floats Can Cause Surges Into The Plant
- Result:
  - Damage To Existing Infrastructure
  - Inaccurate Plant Flow Measurement
  - Damage To Digester Or Ras Bacteria
- Solution
  - Precision Level Holding Automation @
  - Telemetry

# Design Impacts On Cost

- Overestimate Of Flows
- Aluminum Vs HDPE Vs Hose
- Level Control Automation
- Pump Watch

# Overestimate Of Flows

- Pumps Tend To Be Linear To Flow Rates
  - 40MGD Pump Is 2.5x The Cost Of 20MGD Pump

- Install Labor & Pipeline Costs Are Not Linear
  - 40MGD Labor Is 4 X The Cost Of 20MGD
  - Larger Systems Require:
    - Forklifts
    - Cranes
    - Generators
    - Higher Material Costs
    - Longer Install Times
    - Cone Removal

# Aluminum Vs HDPE

- 400ft 12’’ Aluminum
  - Install Costs = $2k
- 400ft 12’’ Fused HPDE
  - Install Costs = $5k
- Reasons:
  - Forklift, Fusion Machine, Fuel, Heating & Cooling Times

# Pump / Level Control (2 pumps)

- Mechanical On/Off Floats
  - Hold Level To Within 5ft
  - Cost Of Install = $500
  - Monthly Rental Cost = $300
  - Surges and Short Cycle Pump Issues

- Speed Control Automation
  - Hold Level To Within 2”
  - Cost Of Install = $5k
  - Monthly Rental Cost = $5k
  - Smooth

# Pump Watch

- Recommended On Sewer Projects
- Ensures Onsite Personnel Are Instantly Available To Manage The Problems
- Expensive
- Typical Daily Cost For 2-man Crew
  - $5 to $7k Per 24 Hour Day
  - (2) 2-person Crews On 12-hr Shifts
  - Why?  PW Weekend O/T And D/T

# Conclusion

- A Clear Spec And Scope Will Allow The Bypass Contractor To Provide The Customer With A System That Adheres To Their Risk Vs Cost Comfort Level
  - Owner Spends The Right Amount Of Money
  - Avoid Change Orders, Change Directives, Fines, Fees, Spills, Reputation Damage
  - Level Playing Field For Contractors
  - We Can All Sleep Better

# Case Study 1 – Bay Area

| | Specification Called called out | | Actual Site Conditions |
|---|---|---|---|
| | | | |
| **PDWF** | 9 MGD | | 26 MGD<br>40 MGD spike |
| | | | |
| **Control** | Float Switch's | | Automate multiple pumps w/ SCADA output |
| | | | |
| **Lift** | 12' | | 16' |
| | | | |
| **Upstream** | Gravity flow | | Large lift station |
| | | | |
| | **Bid price** | | **Final Cost** |
| **Price** | $850K | | $4.2 M |
| | | | |
| **Project Delay** | N/A | | 1 year |

# Case Study 1

RAIN FOR RENT

# Case Study 2 – Bay Area

| | Specification Called called out | | Actual Site Conditions |
|---|---|---|---|
| **PDWF** | 22 MGD | | 22 MGD |
| | | | |
| **Control** | Local automate | | Local automate |
| | | | |
| **Lift** | **Elevations not provided**<br>Bid Q "Can we surcharge?"<br>Bid A "whatever is needed" | | **Desired**<br>6' surcharge for 13' lift<br>plant ops limited project<br>2' surcharge for 17' lift |
| | | | |
| **upstream** | Gravity Flow | | Gravity Flow |
| | | | |
| **Price** | N/A | | plus $150K<br>(extra pumps) |
| | | | |
| **Project Delay** | None | | None |

# Case Study 3 – Bay Area

| | Specification Called out | | Actual Site Conditions |
|---|---|---|---|
| | | | |
| **PDWF** | 25.5 MGD | | 25 MGD |
| | | | |
| | | | |
| **Control** | Automate multiple pumps w/ SCADA output | | Automate multiple pumps w/ SCADA output |
| | Temp bar screen | | Temp bar screen |
| | | | |
| **Lift** | 4' | | 4' |
| | | | |
| **Unstream** | Gravilty flow | | distant lift sta. |
| | | | |
| | **Bid price** | | **Final Cost** |
| **Price** | $2.2 M | | $2.2 M |
| | | | |
| **Project Delay** | none - great spec. | | none - great spec. |


# THANK YOU!
# ANY QUESTIONS?

**Tony de Bellis**
925-679-2803