IRP Workshop

April 2, 2014

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2014 IRP

- February 25th
  - IRP Schedule
  - Review of IRP Order
  - December 5th Weather Event
  - Wexpro II

2014 IRP Schedule

- April 2nd
  - Master Planning of System
  - Gas Control Coordination
  - Monticello Event

2014 IRP Schedule

- April 30th - 10am- Noon
  - Heating Season Review
  - Review RFP
  - Annual Demand & Peak Day Forecasting (Impact of Energy Efficiency)
  - Clean Air
  - Report on Lakeside II
- June 25th
  - Present IRP to Utah PSC

System Planning and Analysis

- Natural Gas Delivery Systems
- Predicting Flow
- Gas Network Model
  - Verification
- Pipe Sizing
- Model Utilization
- Master Planning Model

Natural Gas Delivery System

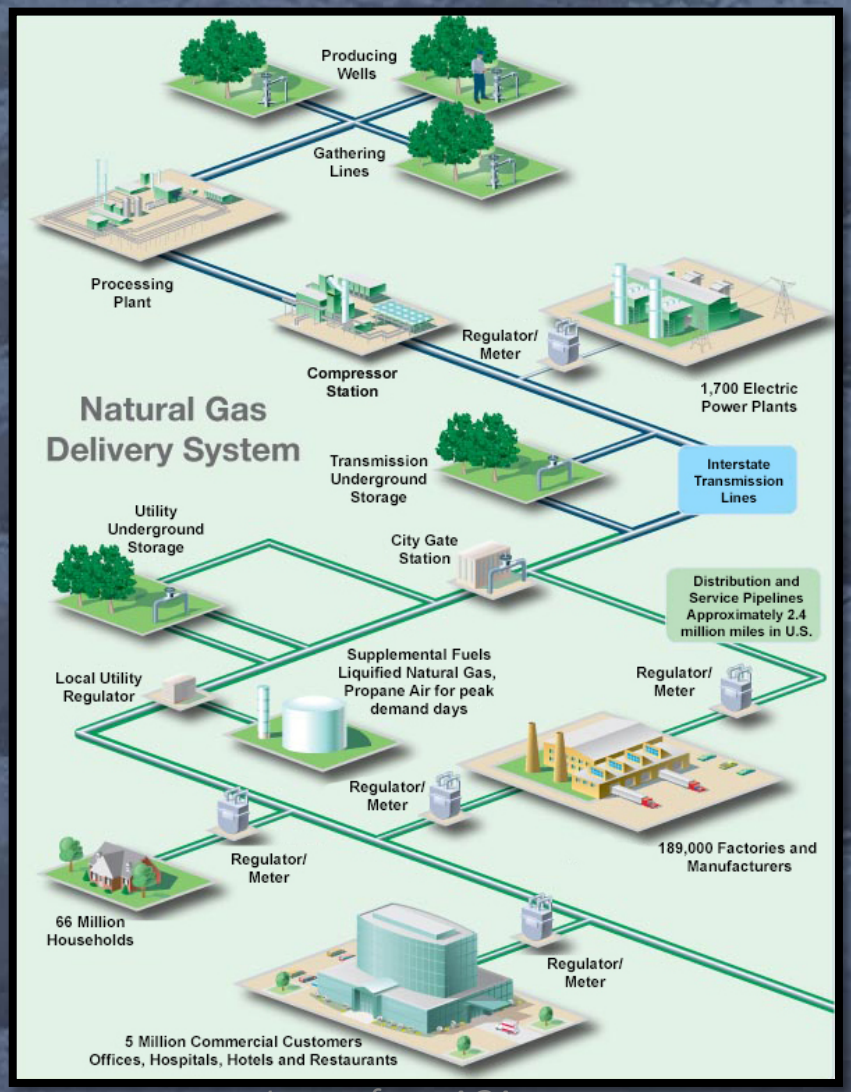

Image from AGA.org

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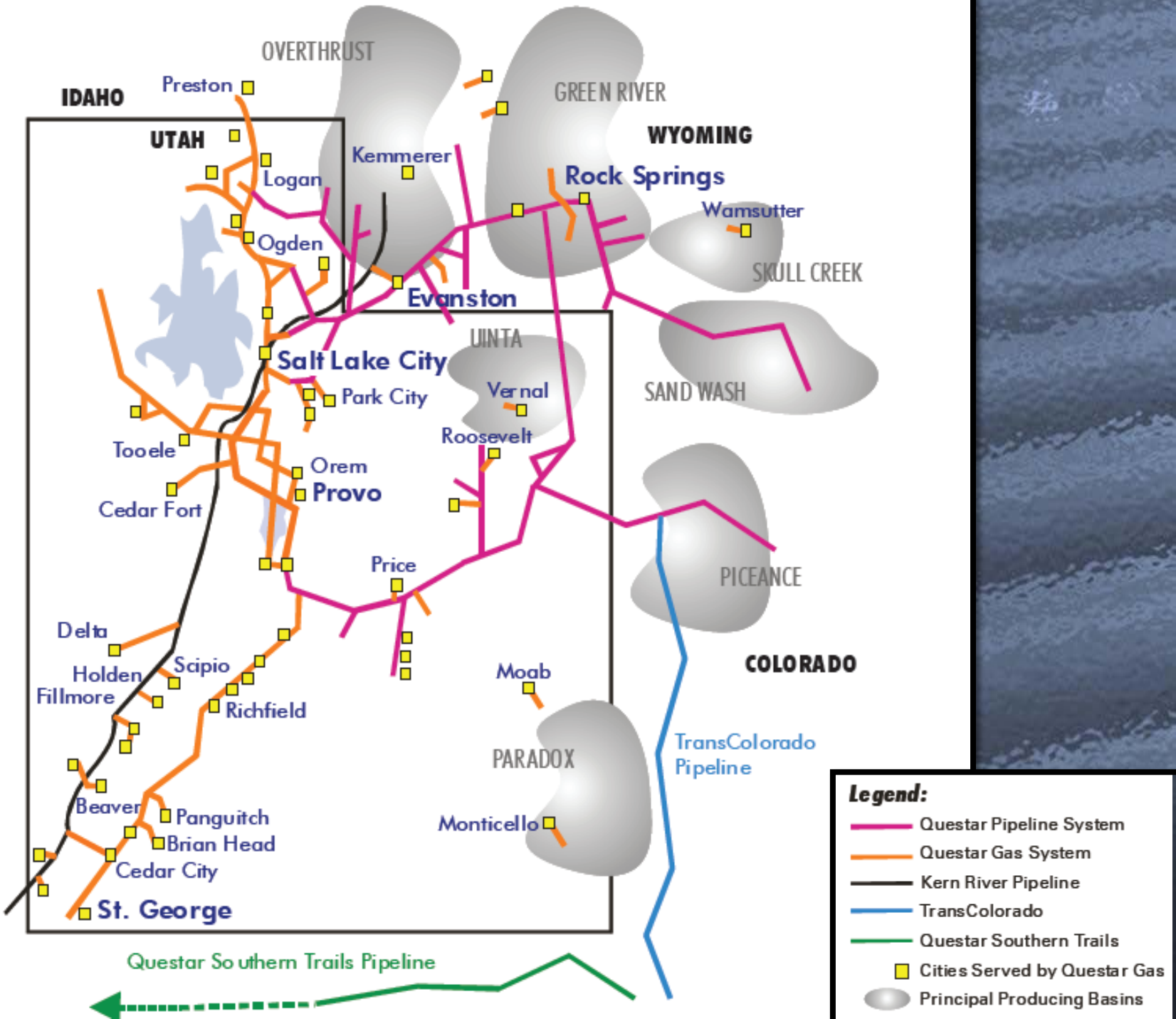
System Planning and Analysis


OVERTHRUST
IDAHO
Preston
UTAH
Logan
Ogden
Kemmerer
GREEN RIVER
WYOMING
Rock Springs
Wamsutter
SKULL CREEK
Evanston
UINTA
Salt Lake City
Park City
Vernal
SAND WASH
Roosevelt
Tooele
Orem
Provo
Cedar Fort
Price
PICEANCE
Delta
Holden
Fillmore
Scipio
Richfield
Moab
COLORADO
TransColorado
Pipeline
PARADOX
Beaver
Panguitch
Brian Head
Cedar City
Monticello
St. George
Questar Southern Trails Pipeline
Legend:
Questar Pipeline System
Questar Gas System
Kern River Pipeline
TransColorado
Questar Southern Trails
Cities Served by Questar Gas
Principal Producing Basins

Customer Meter

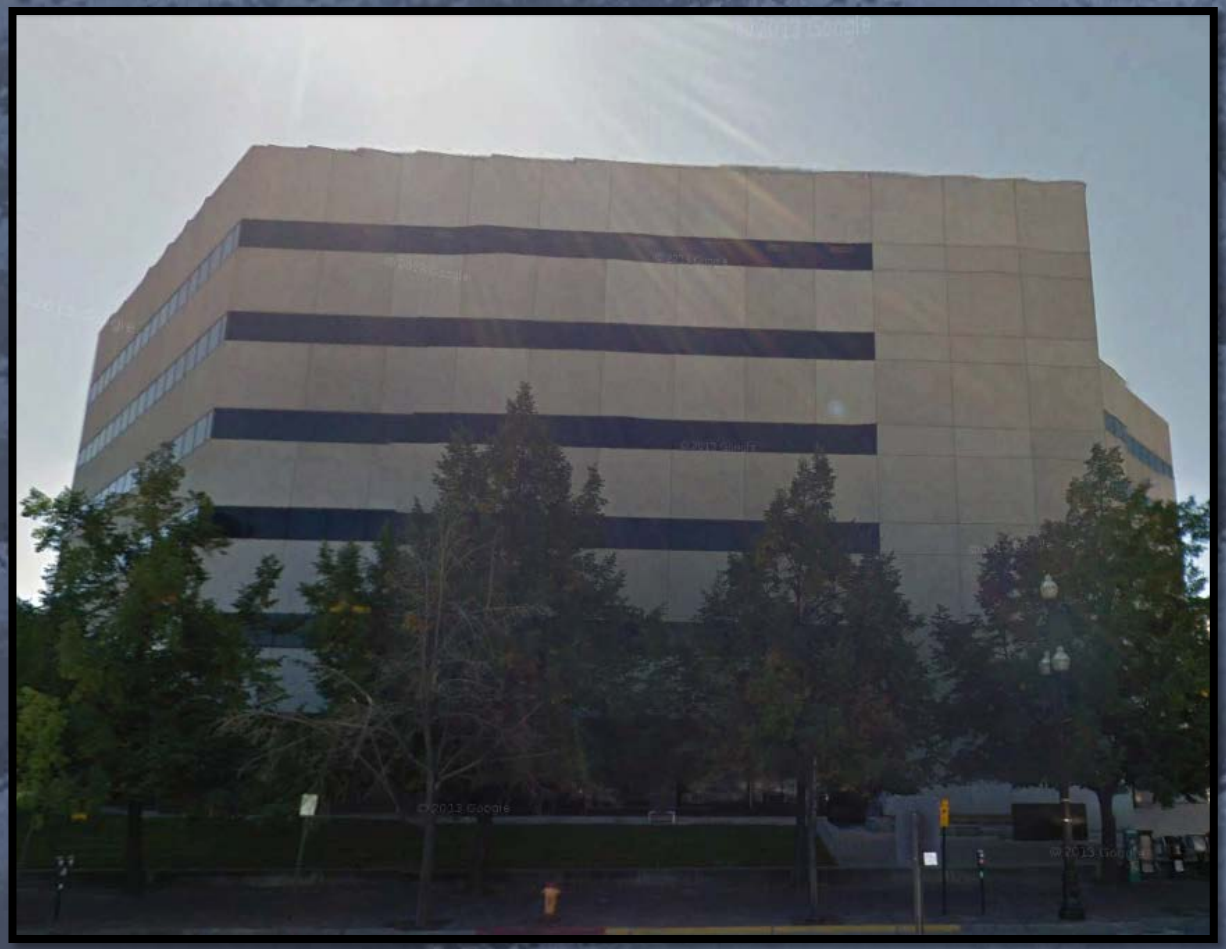


Image from Google Earth

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System Planning and Analysis

Service Line

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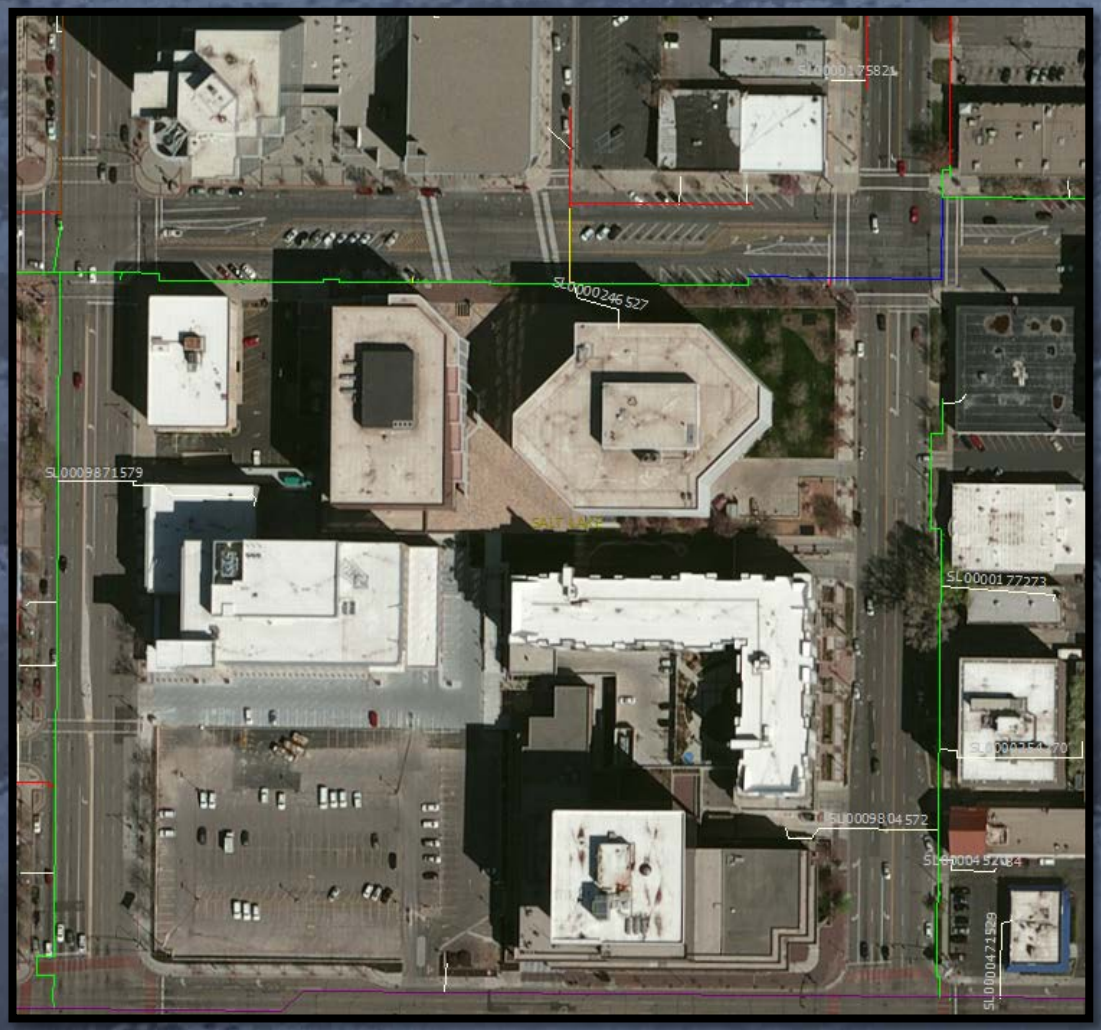
System Planning and Analysis

Intermediate High Pressure Mains



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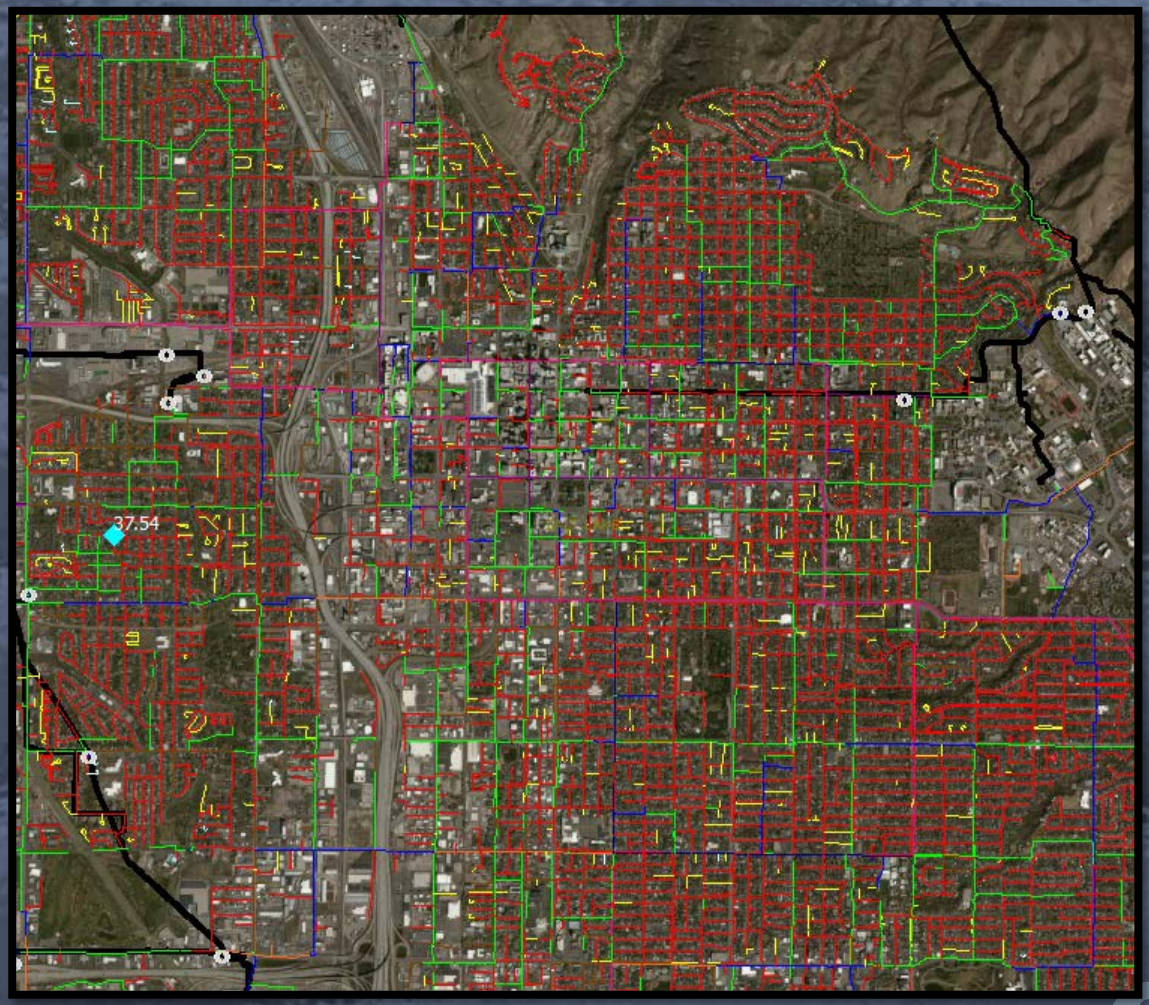
System Planning and Analysis

Regulator Stations



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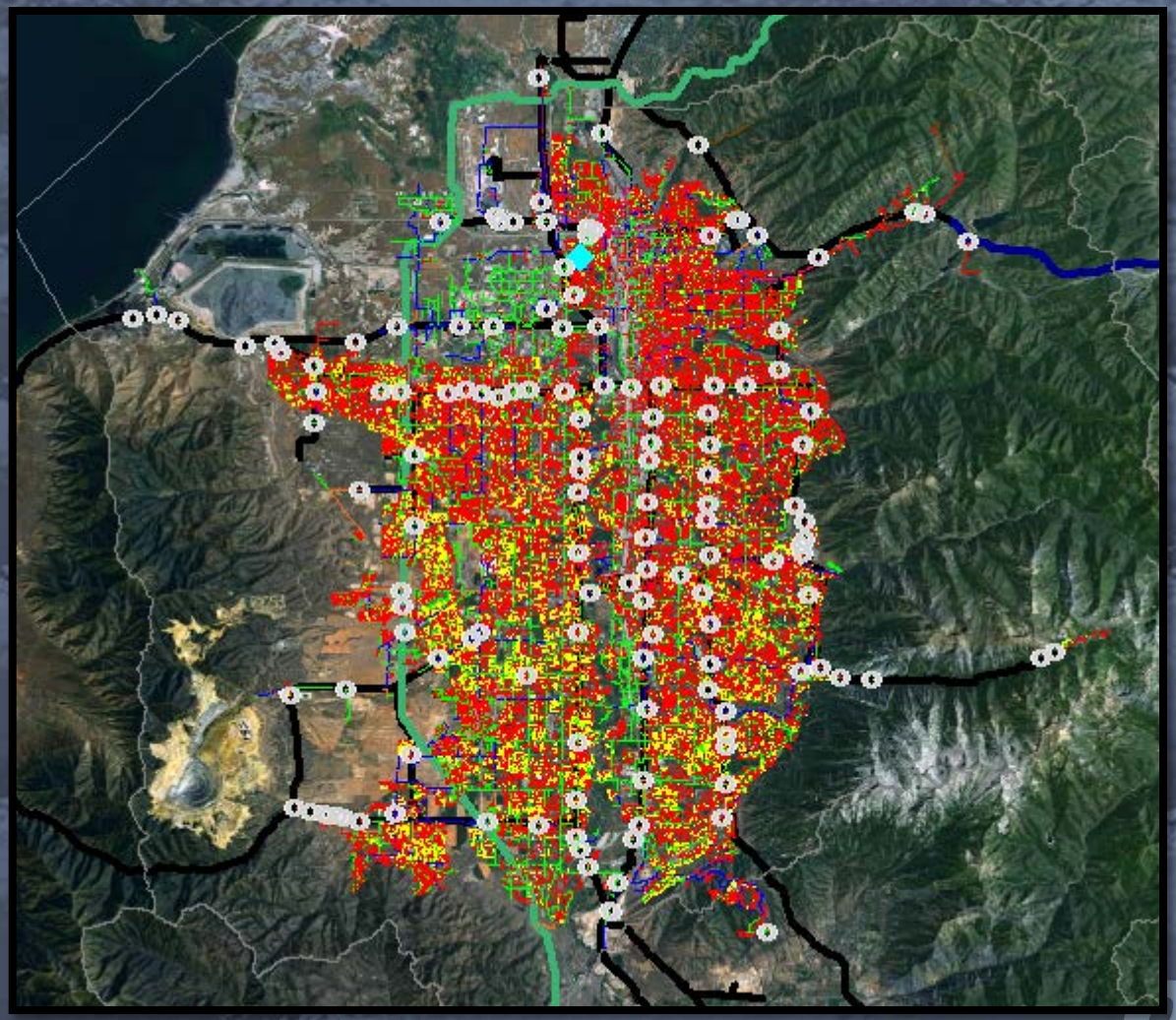
System Planning and Analysis

High Pressure Pipes



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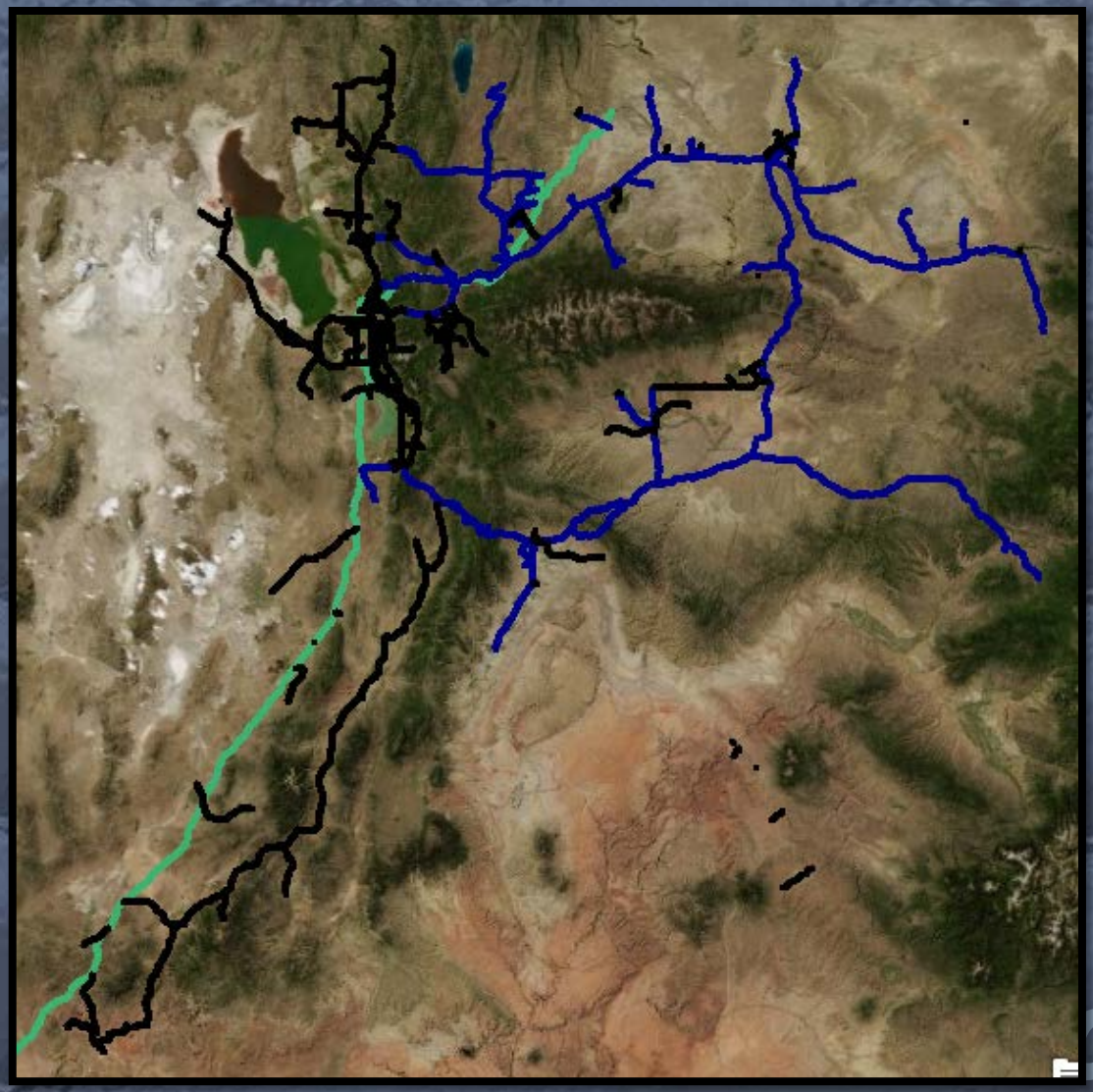
Transmission Lines



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Wells and Production

Image from Wikipedia

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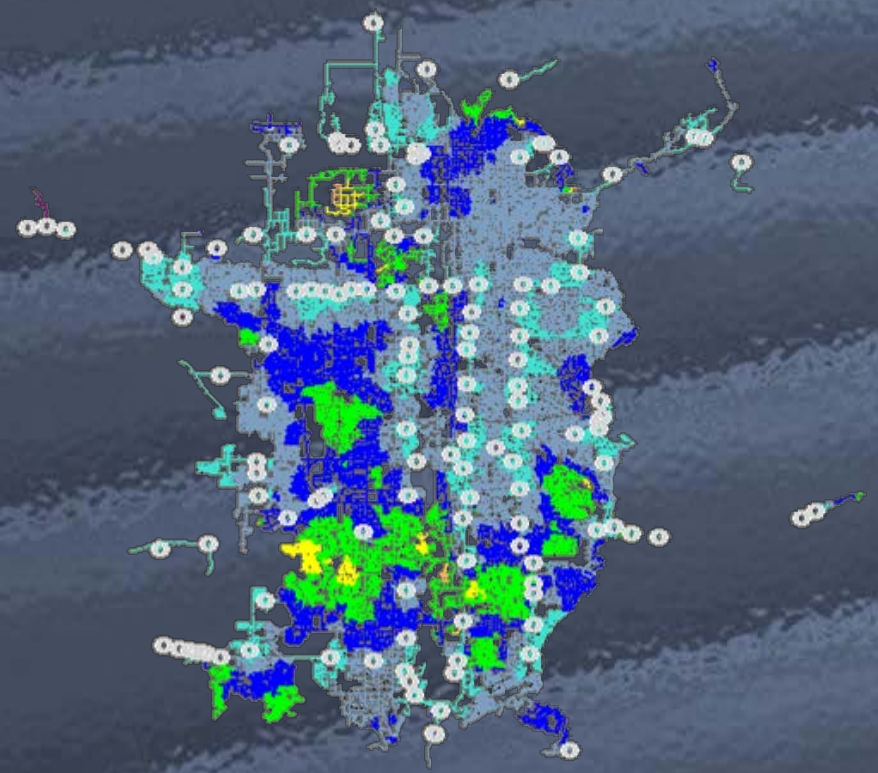
Fundamental Flow Equation

$$Q = (n+1)\ 77.54\ \frac{T_b}{P_b} D^{2.5} e \left(\frac{P_1^2 - P_2^2 - \left(\frac{0.0375 G (h_2 - h_1) P_a^2}{Z T_a} \right)}{G T_a L Z f} \right)^{0.5}$$

D	=	Pipe internal diameter	in
e	=	Pipeline efficiency	dimensionless
f	=	Pipeline friction factor	dimensionless
G	=	Gas specific gravity relative to air	dimensionless
h1	=	Upstream node elevation	ft
h2	=	Downstream node elevation	ft
L	=	Pipe length	mi
n	=	Number of additional pipes in parallel	dimensionless
P1	=	Upstream node pressure	psia
P2	=	Downstream node pressure	psia
Pa	=	Average pipeline pressure	psia
Pb	=	Base pressure of the standard gas state	psia
Q	=	Flow rate	SCFD (Klb/hr for steam)
Ta	=	Average gas flowing temperature for a pipe	°R
Tb	=	Base temperature of the standard gas state	°R
Z	=	Gas compressibility factor	dimensionless

Pipe Properties

- Salt Lake Model
  - ~128,000 Pipes

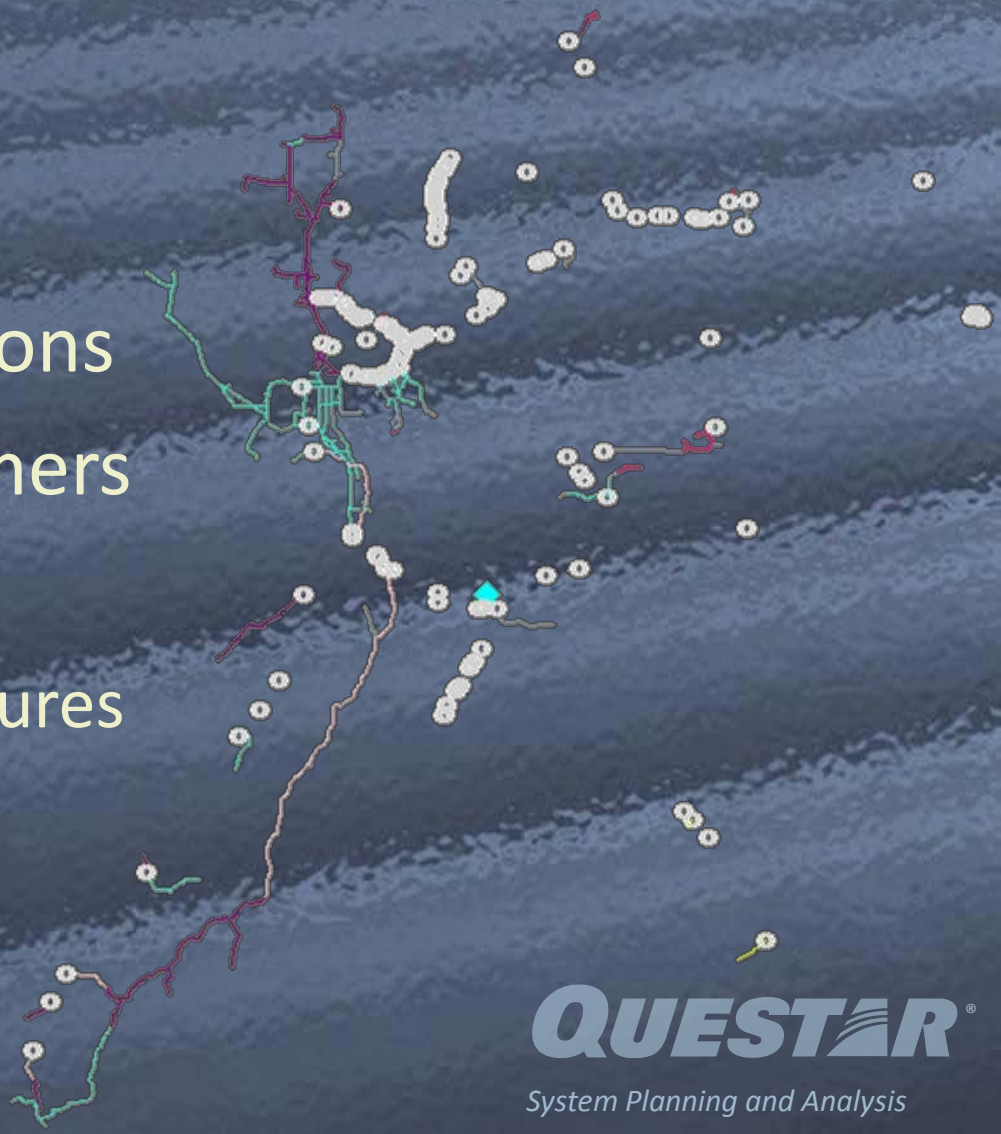


Attribute	Value	Unit
Active State	Active	
Ambient Temperature	60	deg.F
Average Pressure	33.2	psig
Control Node Name		
Diameter	3.71	in
Efficiency	0.9	
Flow	19.492	mscfh
Flow Absolute	19.492	mscfh
Friction Factor	0.0179	
From-Node Name	No80610	
From-Node Pressure	33.26	psig
Heat Transfer Coefficient	0.22	btu/hr-ft^2-deg.F
Length	183.91	ft
Linepack	0	mmscf
Load	4.982	mscfh
Material	P-AL	
Multiple Identical Pipes	0	
Name	201831	
Result Downstream Temperature	60	deg.F
Result Downstream Velocity	23.08	ft/s
Result From-Node Temperature	60	deg.F
Result Heat Loss Per Length	0	kbtu/hr-ft
Result Higher Heating Value	1000	btu/scf
Result Lower Heating Value	905.5	btu/scf
Result Pressure Change	0.11	psig
Result Pressure Change Per Unit Length	3.13	psi/mi
Result Pressure Drop Squared Per Unit Length	284.7	psi^2/mi
Result Pressure Ratio	1.002	
Result Specific Gravity	0.6	
Result Subsystem ID	3	
Result To-Node Temperature	60	deg.F
Result Upstream Velocity	23.02	ft/s
Reynolds Number	127189	
Roughness	0.00048	in
Service State	Enabled	
Specific Gravity	0.6	
Status	Known	
Steam Energy Loss	0	btu/hr
Super Heat	0	deg.F
Supercompressibility	0.993	
Symbol Name	Default Pipe	
Temperature	60	deg.F
Thermal Flow	0.5	kdth/d
To-Node Name	No80611	
To-Node Pressure	33.15	psig

High Pressure Model

Approximate Values

- 4,300 pipes
- 1,200 Regulator Stations
- 100 Industrial Customers
- 200 Supply Points
  - 30 Unique Inlet Pressures
  - 12 MAOP Zones



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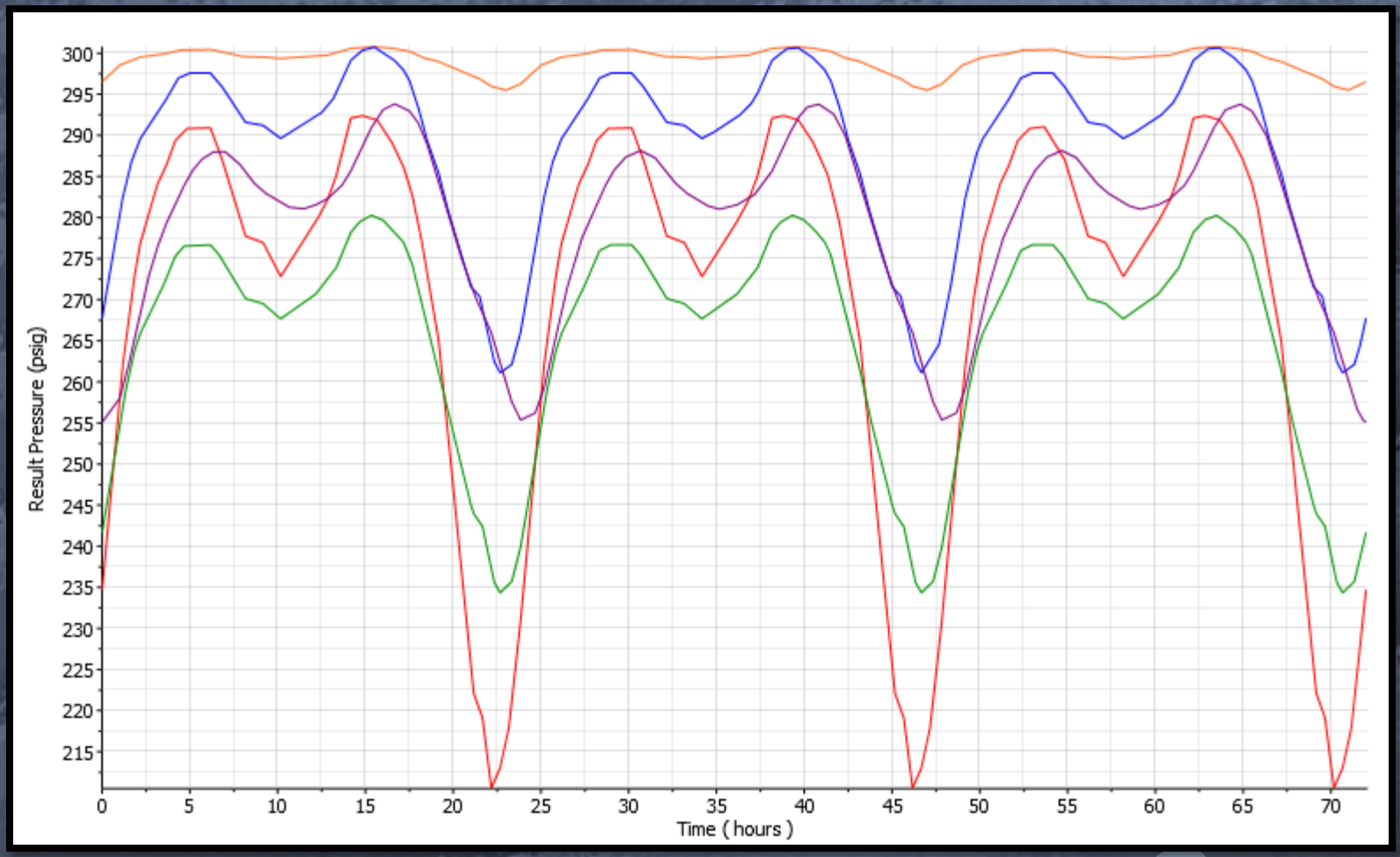
System Planning and Analysis

Unsteady-State



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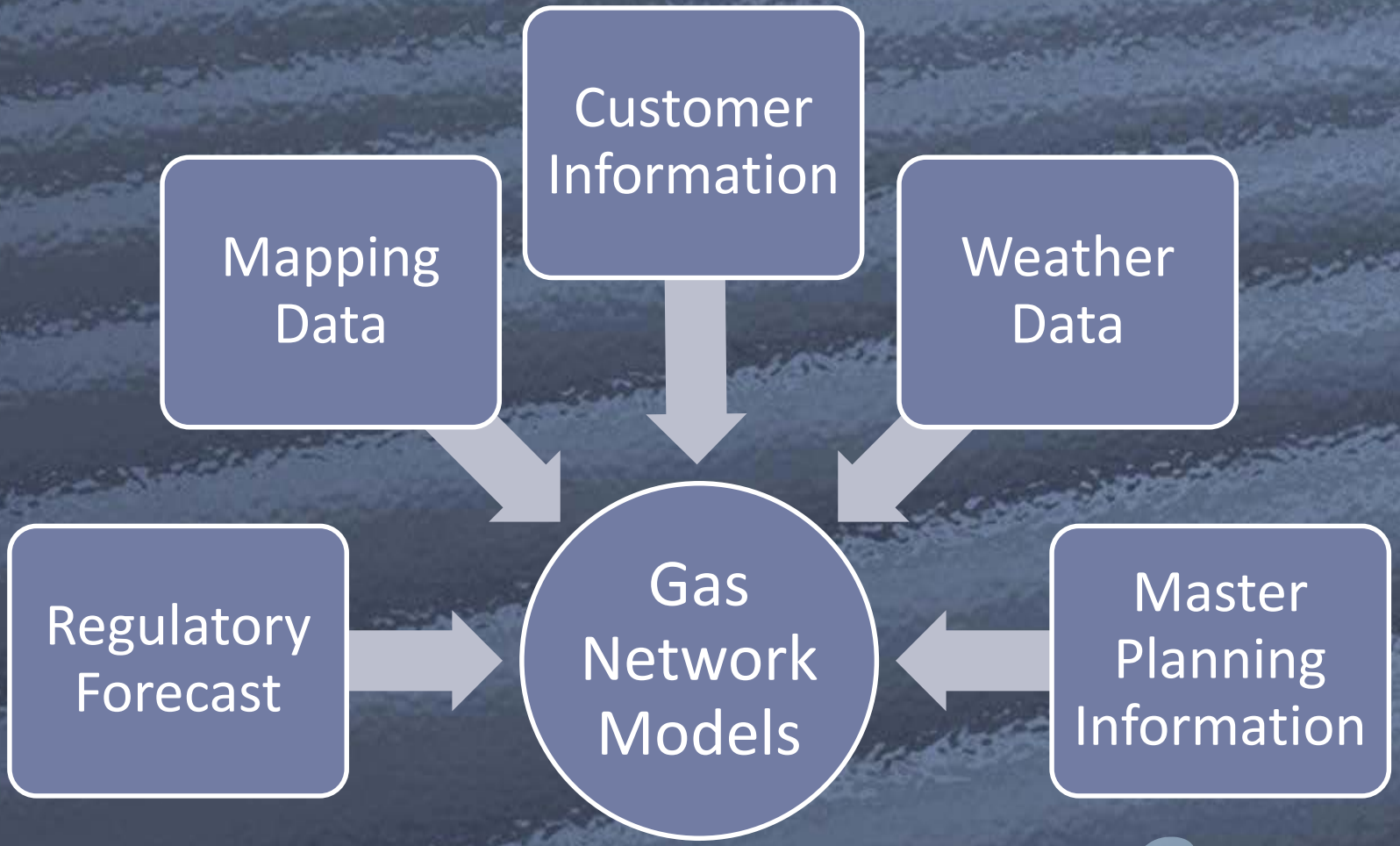
Gas Network Model Data



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System Planning and Analysis

Model Verification

- Goal
  - Verify that models accurately (+/-7%) predict system pressures given a set of conditions
- Variables
  - Heating Degree Days (Temperature)
    - Customer usage
  - Station pressures and volumes
    - Taken from analog charts and SCADA

How Much Capacity Does an 8-inch Pipe Have?

- It depends…
  - What is the inlet pressure to the pipe?
  - What is the required pressure at the end of the pipe?
  - Does the amount of expected flow impact other areas of the system?

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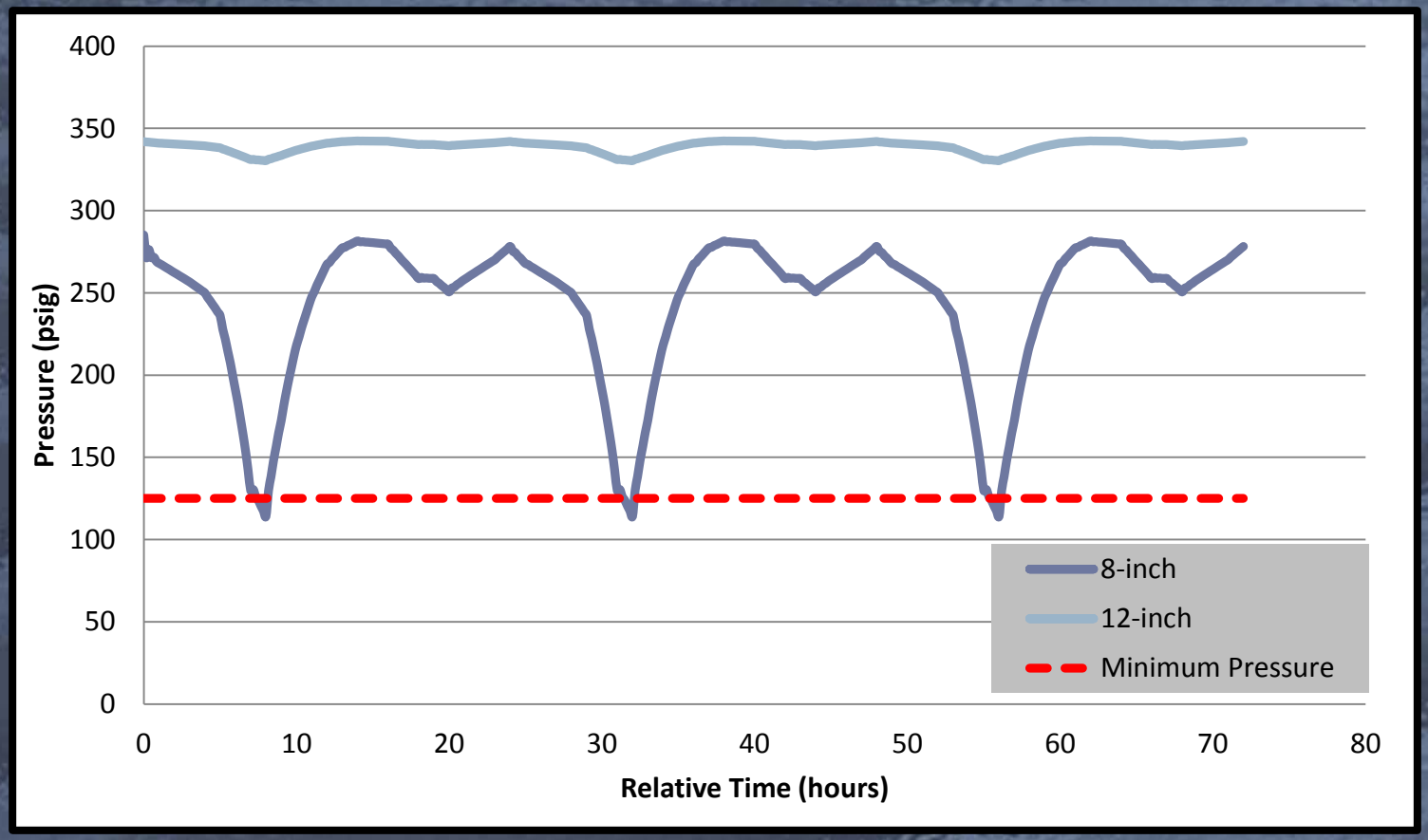
System Planning and Analysis

Ideal Sizing Analysis



Known Maximum Flow

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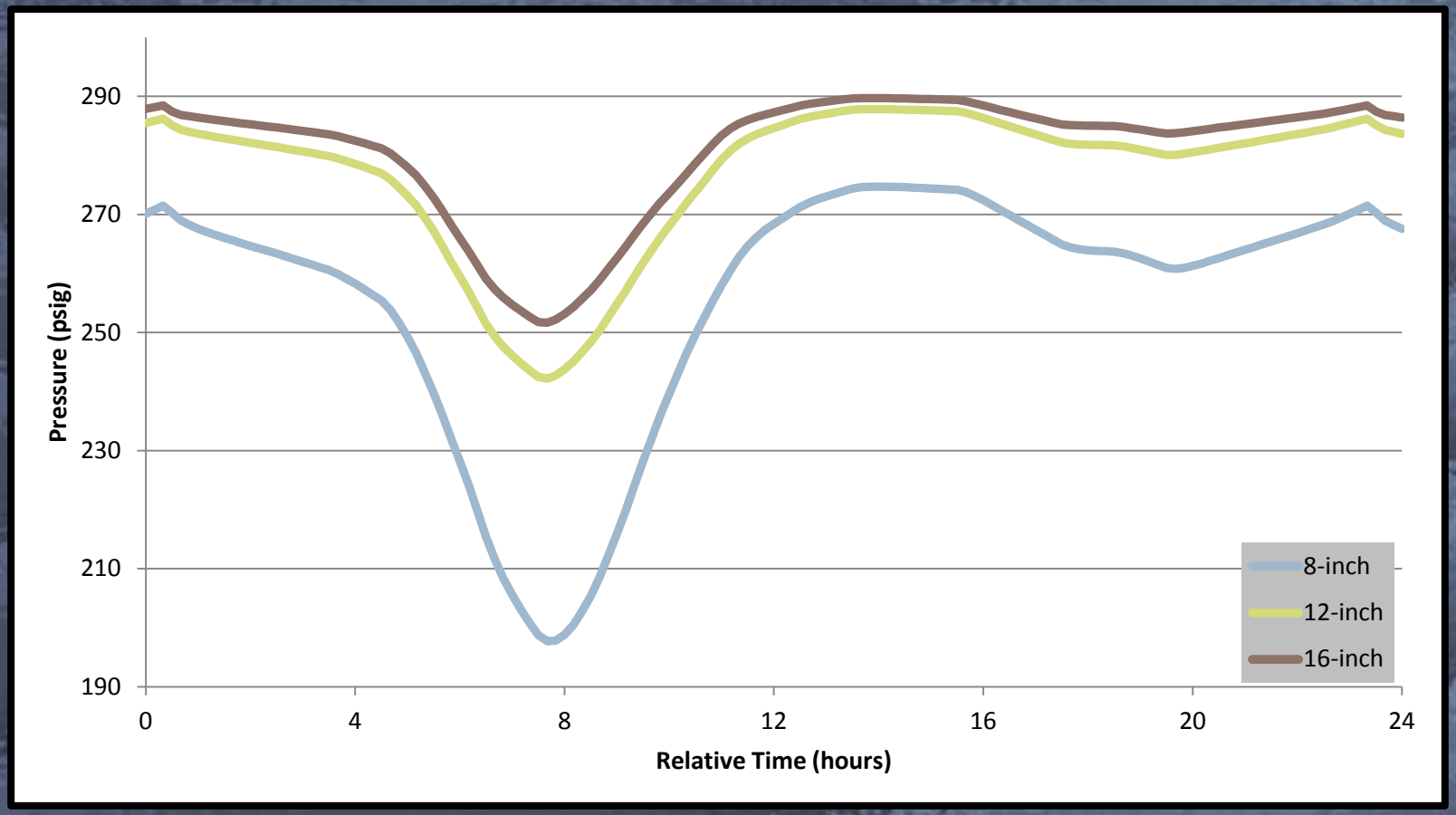
Sizing Analysis Example



Current Flow / Projected Flow

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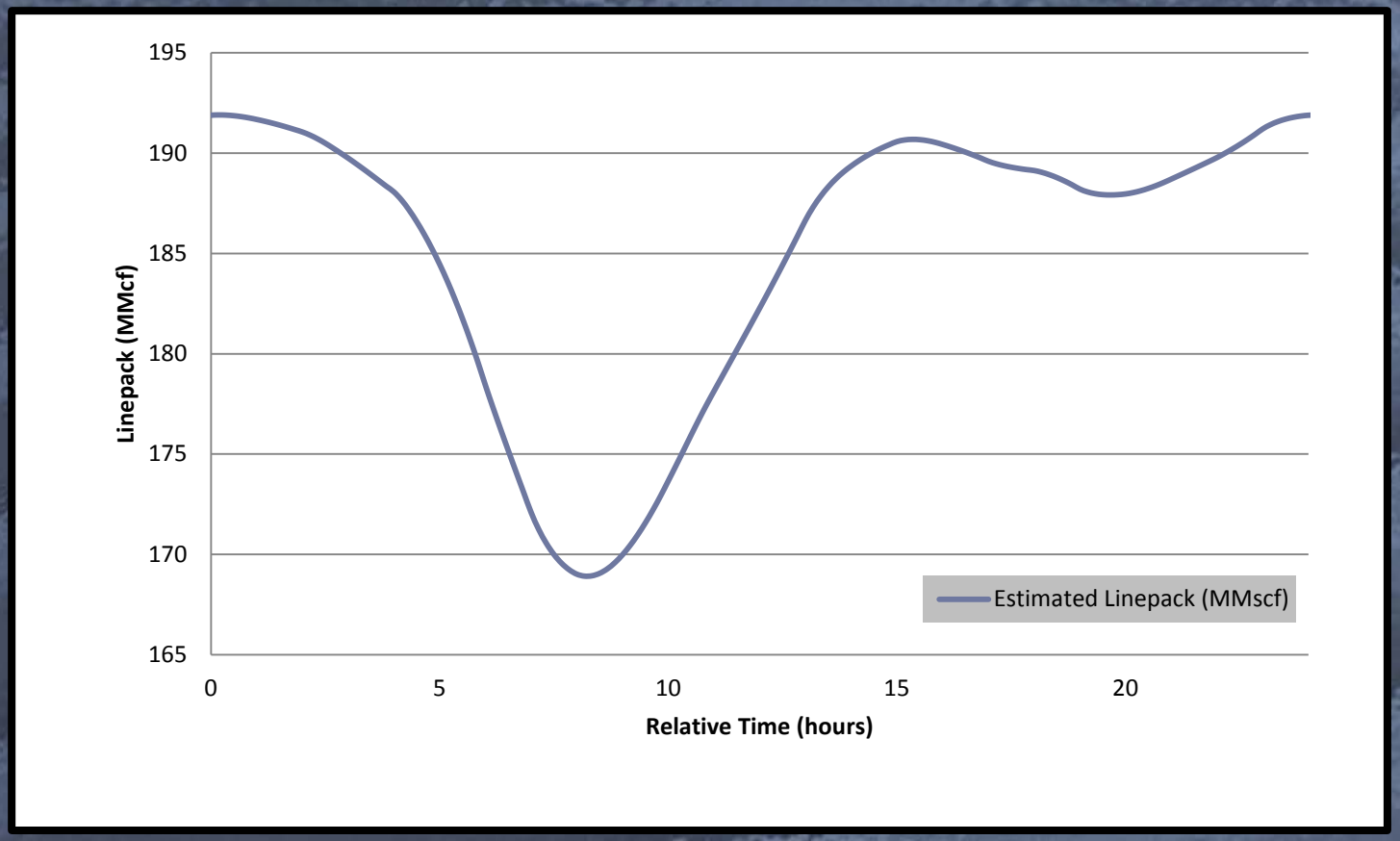
System Planning and Analysis

System Line Pack



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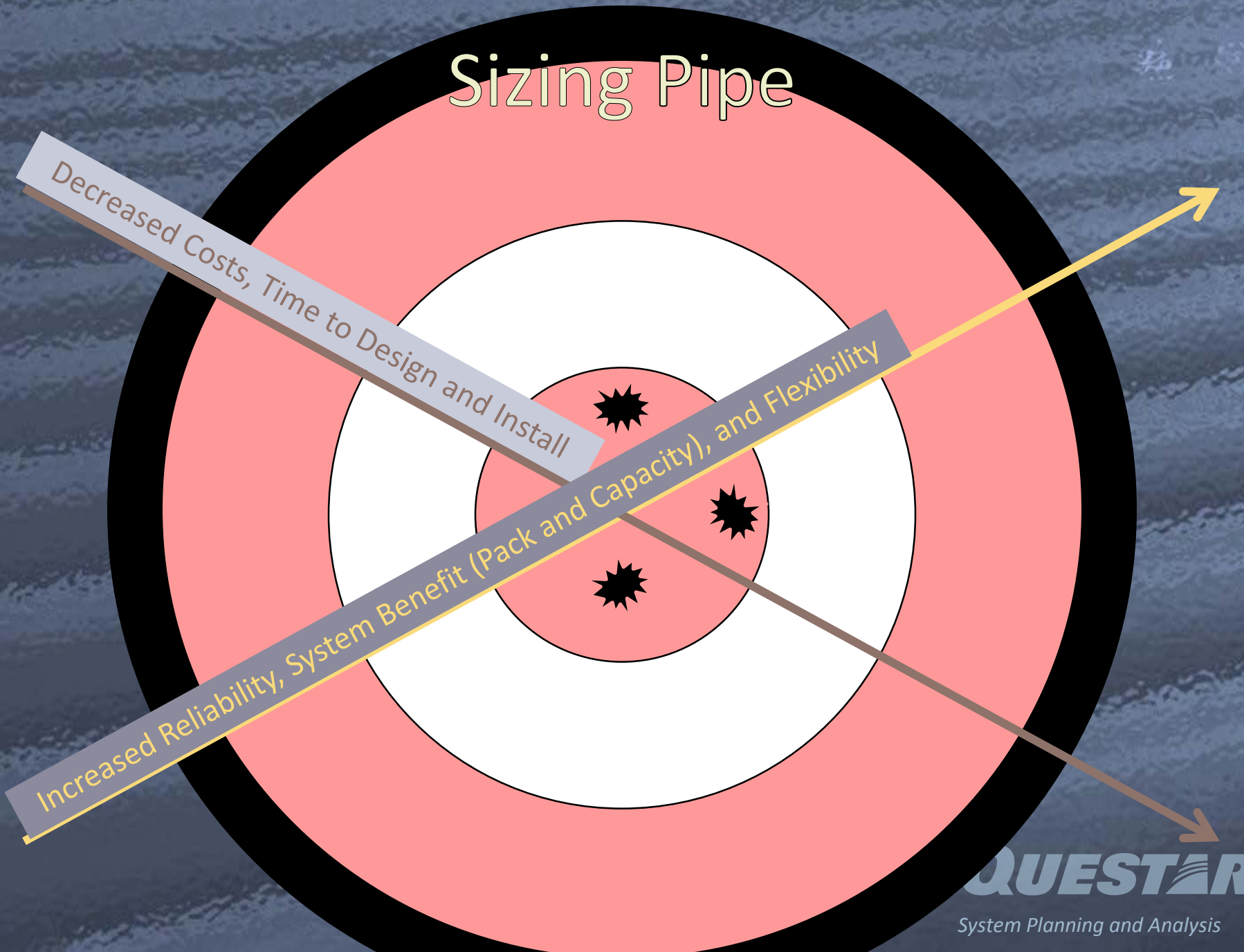
Sizing Pipe



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System Planning and Analysis

Model Utilization

- Customer Analyses
  - New Customer Feasibility
  - Rate Change Analysis
  - Interruption Analysis
- System Analyses
  - State of the System
  - Feeder Line Replacement Sizing
  - Joint Operations
  - Gas Supply Requirements
  - Construction Timeline
  - Equipment Capacity
  - Isolation
  - Growth Identification
  - Contingency Planning
  - Long Term Planning

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System Planning and Analysis

Master Planning Model

- Location Specific Growth
  - 5 Years
  - 25 Years
- Known High Pressure and Intermediate High Pressure Improvements
- Known Increased use for Industrial Customers
- Utilized for Sizing and Locating Future System Improvements

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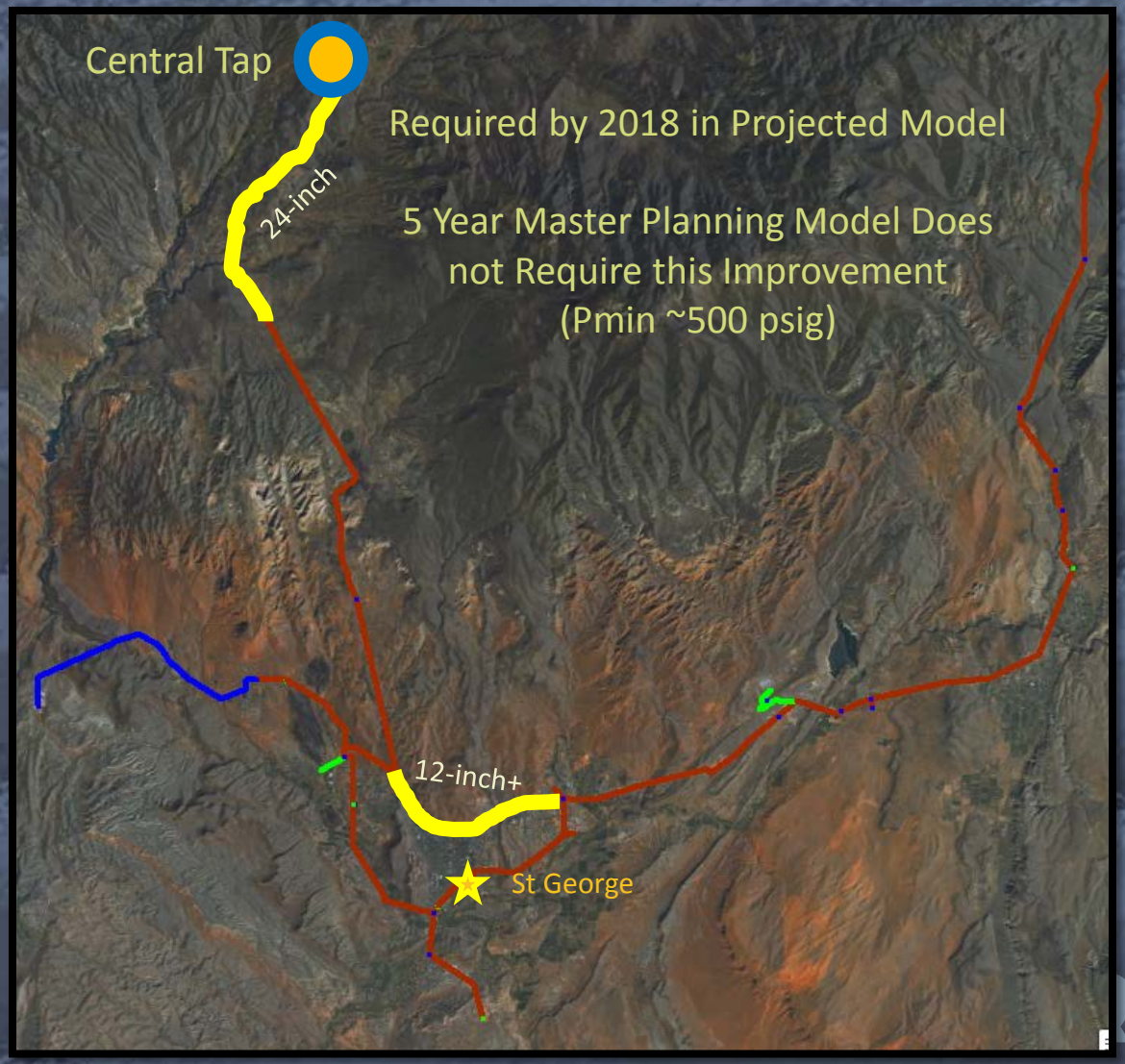
System Planning and Analysis

Master Planning Model



Questions

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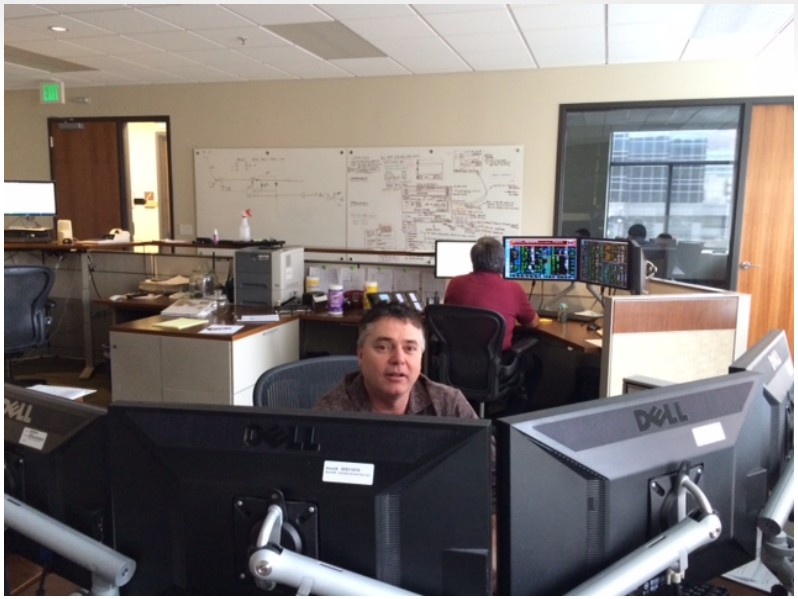
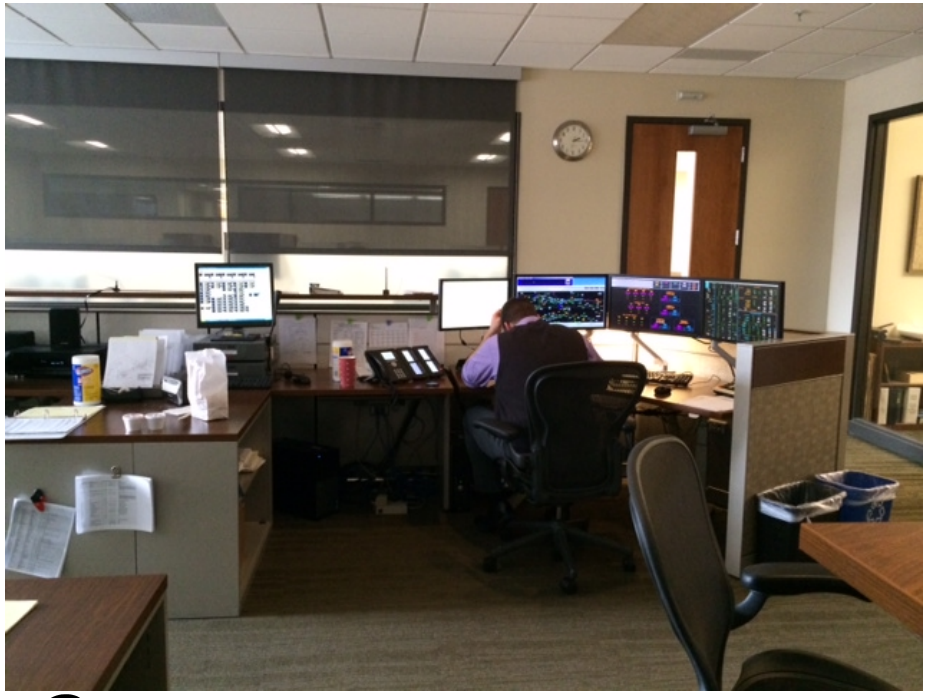
System Planning and Analysis

Introduction

Greg Paige
Jon Wheeler
Ron Jorgensen



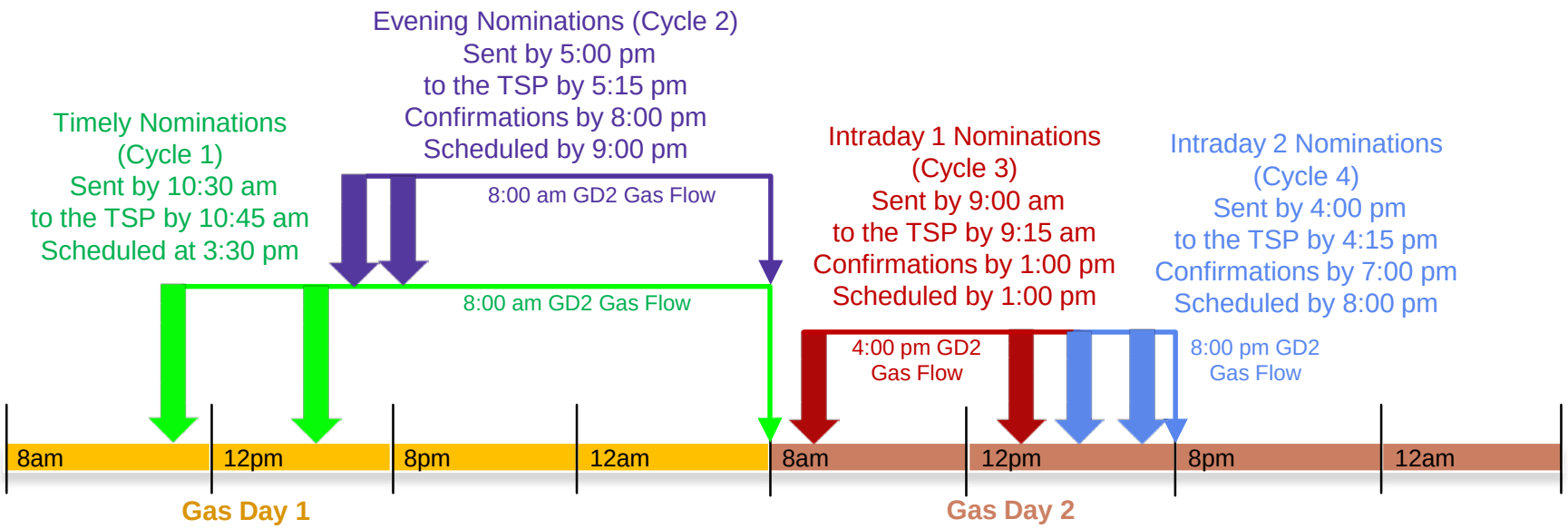


Gas Control Basics

- Shared Gas Control
  - Located in Questar Center (333 S. State)
  - Back-up locations and servers
  - Approx. 1/3 of Controllers time spent on QGC
- Supervisory Control and Data Acquisition (SCADA)
  - Several thousand QGC data points on SCADA
  - 20 control points (remote from Gas Control)
- Purpose and Need
  - Oversee real-time operations

Basic Gas Control Functionality

- **Meet scheduled nominations and demands daily (NAESB standards)**

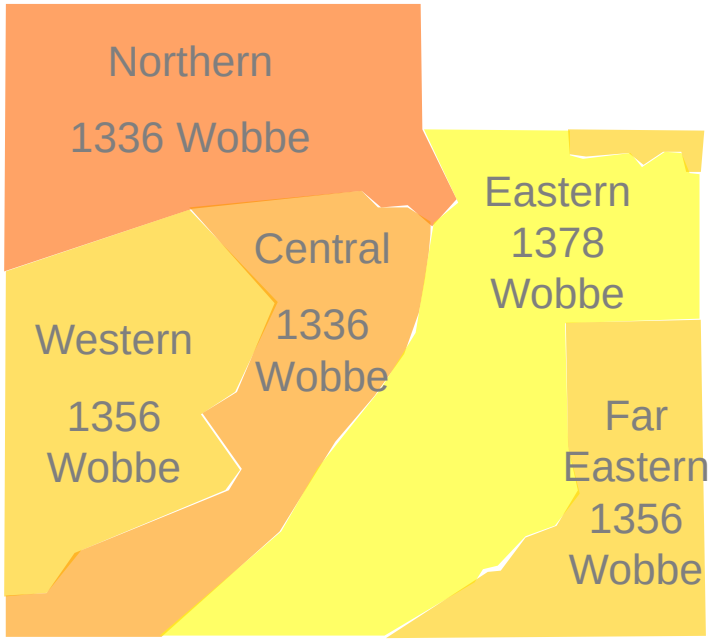


What we do as Gas Control

- Preparations for each day
  - Ensure adequate pressures for morning ‘pull’ – figuring in transit times (gas moves roughly 5 mph)
  - Start/stop compression (integrated system operations)
  - Adjust Storage supply and use of No-notice (as needed) Based on QGC specified cut and boost
- Daily meeting on Questar Gas gas supply plan
  - Review load forecasting
  - Discuss nomination strategy during high load events
  - Assist with service interruptions including replacement of lost production (e.g. field or production plant “freeze-offs”)

What we do as Gas Control

- Ensure proper gas quality at city gates

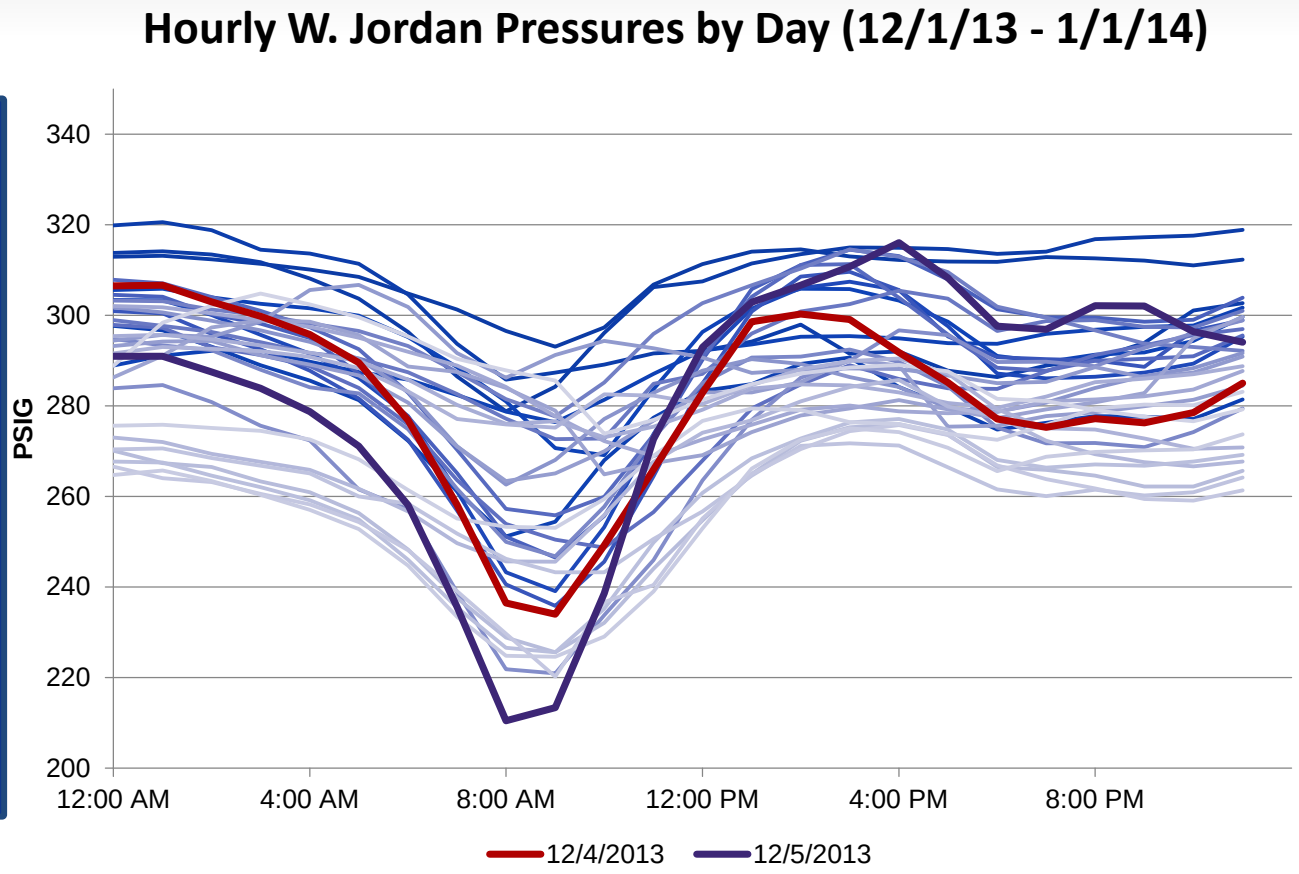


- Coordinate scheduled line work
  - Includes participation in Western area pipeline maintenance meetings (avoid schedule conflicts)

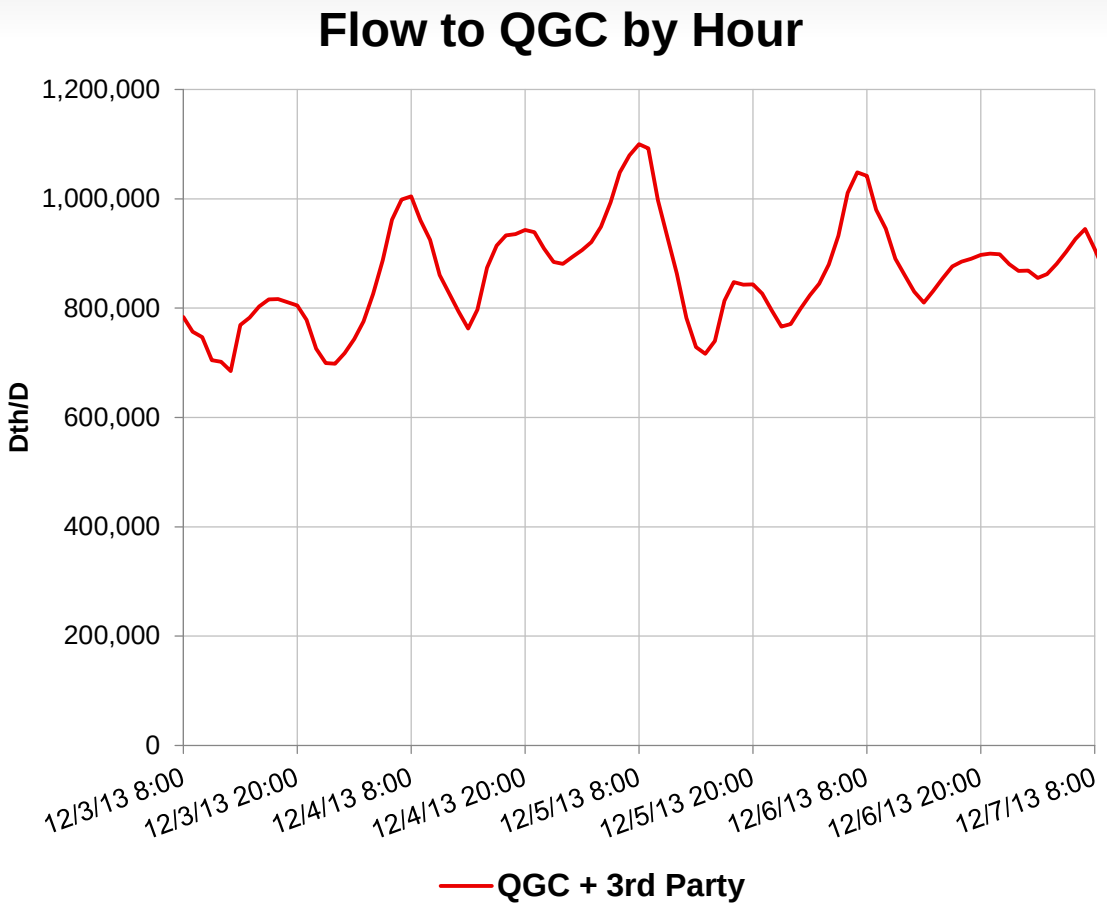
Manage System Pressures

"Tools in the Toolbox"

- ✓ Experienced controllers
  - Ten controllers with an average of 10+ years of experience
- ✓ Control room mgmt. plan
  - PHMSA 49 CFR § 192.631
- ✓ Integrated system coordination
- ✓ Multiple interconnects and QPC delivery points
- ✓ Line Pack management
- ✓ Storage
- ✓ No notice service



Efficiencies and Benefits



- ✓ Shared Gas Control staff
- ✓ Avoid duplicated SCADA and back up systems & sites
- ✓ Reliability:
  - Real time response to changing system needs
- ✓ Load forecasting
- ✓ Manage No-notice service / use of storage

Important Reliability Considerations

- ✓ 24/7 system control and monitoring by qualified & experienced controllers
- ✓ Prompt response to SCADA alarms & emergencies
- ✓ Timely adjustments to system operations (e.g. balance loads, maintain pressures, ensure gas quality)

Wrap-up

- Invitation to tour Gas Control (date TBD)
- Questions ?

Monticello Outage
October 31, 2013

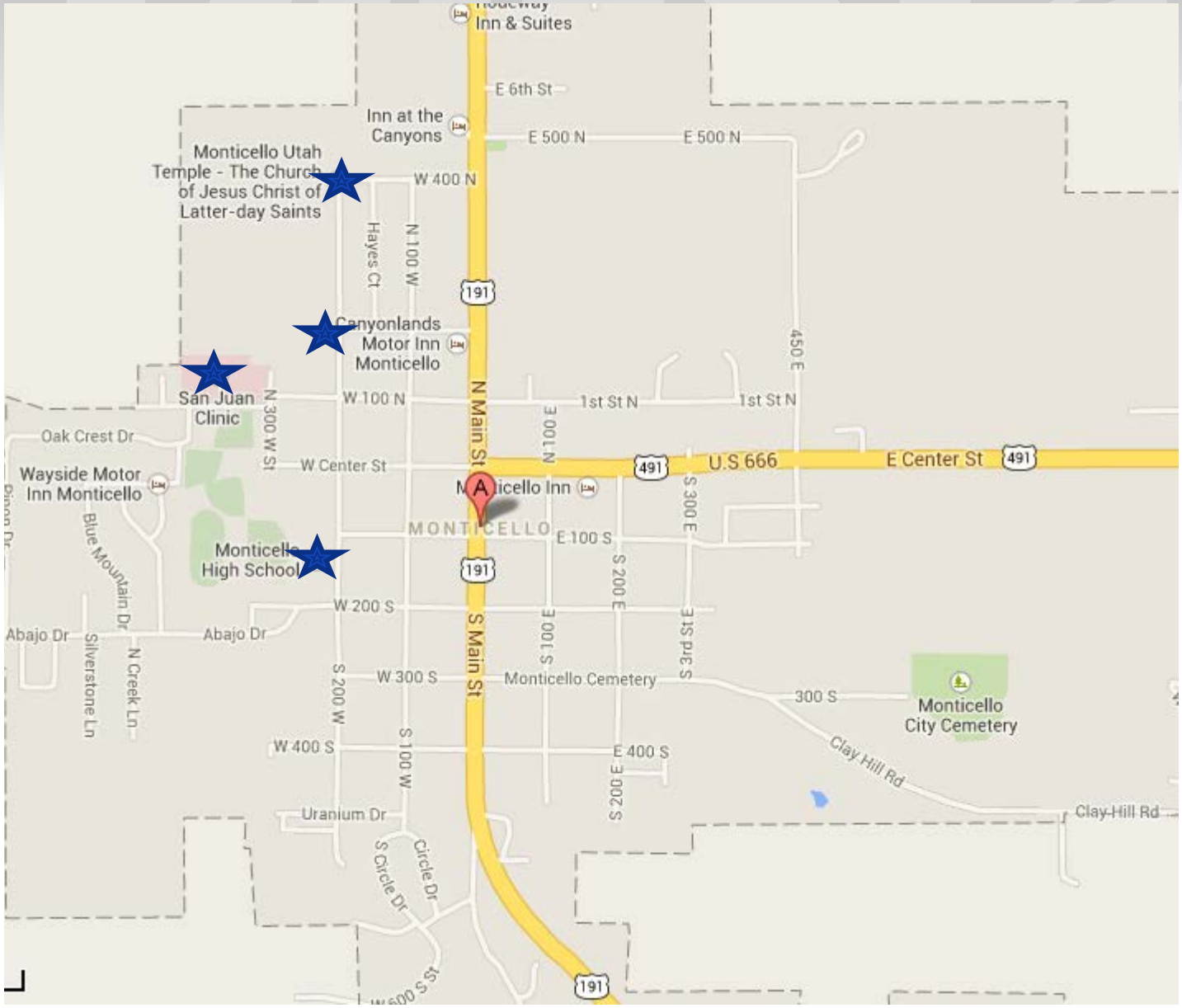
- 8:30am – Began Receiving No-Heat Calls
- 9:30am - Verified only 1.5 lbs pressure in distribution system
- 9:45am - Shut outlet valve of QGC Regulator Station
- 10:00am - Dispatched 35 Employees from Salt Lake, Bluffdale, Springville, Vernal, Price, Richfield, Ephraim and Moab

Monticello Outage
October 31, 2013

- 10:30am - Verified Integrity of QGC Tap Line from Northwest Pipeline
- 10:30am - Eastern Regional Manager leaves for Monticello to the Field Command Center

Monticello Outage
October 31, 2013

- 10:30am - Dispatched CNG Trailers for:
  - Elementary School
  - High School
  - Health Service Clinic
  - LDS Chapel (emergency shelter)


Inn & Suites
E 6th St
Inn at the Canyons
E 500 N
E 500 N
Monticello Utah Temple - The Church of Jesus Christ of Latter-day Saints
W 400 N
Hayes Ct
N 100 W
191
Canyonlands Motor Inn Monticello
450 E
San Juan Clinic
N 300 W St
W 100 N
N Main St
1st St N
1st St N
E 100 N
Oak Crest Dr
Wayside Motor Inn Monticello
W Center St
491
U.S 666
E Center St
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S 300 E
MONTICELLO
E 100 S
Monticello High School
191
S 200 E
W 200 S
Blue Mountain Dr
Abajo Dr
Abajo Dr
Silverstone Ln
N Creek Ln
S 100 E
S 3rd St E
S 200 W
W 300 S
Monticello Cemetery
300 S
Monticello City Cemetery
S Main St
W 400 S
S 100 W
E 400 S
Clay Hill Rd
Clay Hill Rd
S 200 E
Uranium Dr
S Circle Dr
Circle Dr
191

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Monticello Outage
October 31, 2013

- 11:00am-9:00pm – Shut off service to homes
- Noon – Verified pressure loss from Northwest Pipeline
- 9:00pm-10:00pm - Purged system-verified all services were shut off.
- 10:00pm-Midnight – Coordinated with Monticello Officials to restore service to critical buildings and seniors first.

Monticello Outage

- November 1, 2013, 7:30am – Continued restoring service to Entire Community. (750 Services)
- November 2, 2013, Midnight – All services restored except 7
- November 3, 2013, Sunday Morning – Coordinated with Sheriff, Locksmith or Friends to relight the remaining 7 customers.

Preventive

- Met with Northwest Pipeline to ensure no reoccurrence
- Installed telemetering on tap line
- Northwest Pipeline reimbursed Questar Gas Company for all expenses incurred