Aliso Canyon Modeling Scenarios

Independent Review of Hydraulic Modeling

Anatoly Zlotnik and Mary Ewers

7-28-2020

Los Alamos
NATIONAL LABORATORY
EST. 1943

NNSA
National Nuclear Security Administration
Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

LA-UR-20-25221

Agenda

7-28-2020

- LANL Review Activities
- Analysis Methodology
- Modeling Scenarios Overview
- Study of Failed Scenarios
- Break for Questions
- Examination of Inputs
- Future Methodology

Los Alamos
NATIONAL LABORATORY
EST. 1943

LANL Review Activities

LANL Credentials & Prior Activities

- **Dr. Mary Ewers**: Information & Modeling (A-1) group, LANL.
  Ph.D. (‘04) in economics, University of New Mexico.
  Oil & gas systems analyst, develops North American gas pipeline model.
- **Dr. Anatoly Zlotnik**: Applied Math & Plasma Physics (T-5) group, LANL.
  Ph.D. (’14) in systems engineering, Washington University in St. Louis.
  R&D scientist, develops new energy network analysis methods.

- Initial technical review of SoCalGas modeling for Aliso Canyon risk assessment by Anatoly Zlotnik (LANL) and Rod Walker (Walker & Associates) done during July-August 2016 (CA Docket 16-IEPR-02)
- Ongoing technical review and analysis support of Aliso Canyon issues for CPUC is led by Mary Ewers (LANL) during 2017-2020

Analysis Methodology

SoCalGas Hydraulic Modeling

- Capacity planning group at SCG conducts simulations of pipeline flow to assess ability of system to supply customers
  - High demand (1 day in 10 years) events (e.g. heat wave, cold snap)
  - Scheduled maintenance
  - Unscheduled outages
- Model of SCG system developed in Synergi Gas software
- Transient simulation done using the Synergi Gas Unsteady State Module (USM) to evaluate the impacts of time-varying loads on subsystem linepacks & pressures
- Industry standard practices, uses state-of-the-art commercial software

CPUC Hydraulic Modeling

- To provide direct oversight of SCG hydraulic modeling, in 2018 the CPUC initiated effort to develop in-house capability for pipeline hydraulic analysis using Synergi Gas
- Load profiles used for hydraulic transient analysis are guided by production cost model that predicts electricity loads (resp. gas-fired generator gas profiles) for summer & winter days 2020, 2025, & 2030
- Scenarios are evaluated by SCG engineers for successful solves and verified by CPUC analysts
  - System pressures between allowable maximum and minimum
  - Regulated flows below maximum rated capacities
  - Compressor usage below power limits
  - Subsystem linepacks returned to initial values at simulation end (24 hours)

LANL Hydraulic Modeling

- Since 2014, LANL has had an active fundamental applied research program in new methods for modeling, simulation, estimation, and optimal control of midstream gas pipeline systems.
  - ARPA-e Project GECO on gas-electric system coordination
  - DOE Office of Electricity Advanced Grid Modeling Research program
  - Dozens of peer-reviewed academic publications and open source software
  - Interfacing with energy industry through IEEE Power & Energy Society and the Pipeline Simulation Interest Group
- LANL supported CPUC with independent technical review since 2016
  - Initial review of SoCal Gas hydraulic modeling in Synergi
  - Ongoing review of CPUC developed scenarios 2017-2019
- Current 2020 review includes direct verification of SoCal Gas and CPUC modeling results in Synergi Gas software

Modeling Scenarios Overview

DEMAND (MMCFD)

	S01 WINTER 2020	S02 SUMMER 2020	S03 WINTER 2025	S04 SUMMER 2025	S05 WINTER 2030	S06 SUMMER 2030
Core	3,285	808	3,170.7	808	3034	808
Non-EG noncore	654	718.6	689.2	700.8	664.6	687
EG	1,048 CGR	1,030.2 CPUC	900 CPUC	1,109.6 CPUC	1,122.6 CPUC	1180 CPUC
TOTAL	**4,987**	**2,556.8**	**4,759.9**	**2,618.4**	**4,821.2**	**2675**

PIPELINE SUPPLY (MMCFD)

	S01 WINTER 2020	S02 SUMMER 2020	S03 WINTER 2025	S04 SUMMER 2025	S05 WINTER 2030	S06 SUMMER 2030
DEMAND	**4,987**	**2,556.8**	**4,759.9**	**2,618.4**	**4,821.2**	**2675**
North Needles	340	300	430	0	430	0
Topock	446.25	200	400	0	400	0
Kramer Junction	276.25	550	420	700	420	700
Wheeler Ridge	765	765	765	600	765	600
Kern River Sta.	0	0	0	0	0	0
Ehrenberg	833	750	728.5	920	980	920
Otay Mesa	195.5	50	300	0	50	0
CA producers	70	70	70	0	70	0
TOTAL	**2,926**	**2,685**	**3,113.5**	**2,220**	**3,115**	**2220**

Scenarios S01, S02, S03, S05 model SoCalGas “Best Case” in which Line 235 and Line 4000 operate at reduced pressures and gas receipts at Otay are available. In S04 and S06 these lines are not used.

MAXIMUM WITHDRAWAL RATE (MMCFD)

	S01 WINTER 2020	S02 SUMMER 2020	S03 WINTER 2025	S04 SUMMER 2025	S05 WINTER 2030	S06 SUMMER 2030
DEMAND	**4,987**	**2,556.8**	**4,759.9**	**2,618.4**	**4,821.2**	**2675**
PIPELINE SUPPLY	**2,926**	**2,685**	**3,113.5**	**2,220**	**3,115**	**2220**
Aliso Canyon	0	0	0	0	1265	0
Honor Rancho	800	802	802	672	802	0
La Goleta	230	228	228	197	228	228
Playa del Rey	300	299	299	247	299	299
TOTAL	**1,330**	**1,329**	**1,329**	**1,116**	**2,594**	**527**

S05 includes Aliso
determines minimum amount needed from Aliso

S06 excludes Honor Rancho and Aliso

MAXIMUM INJECTION RATE (MMCFD)

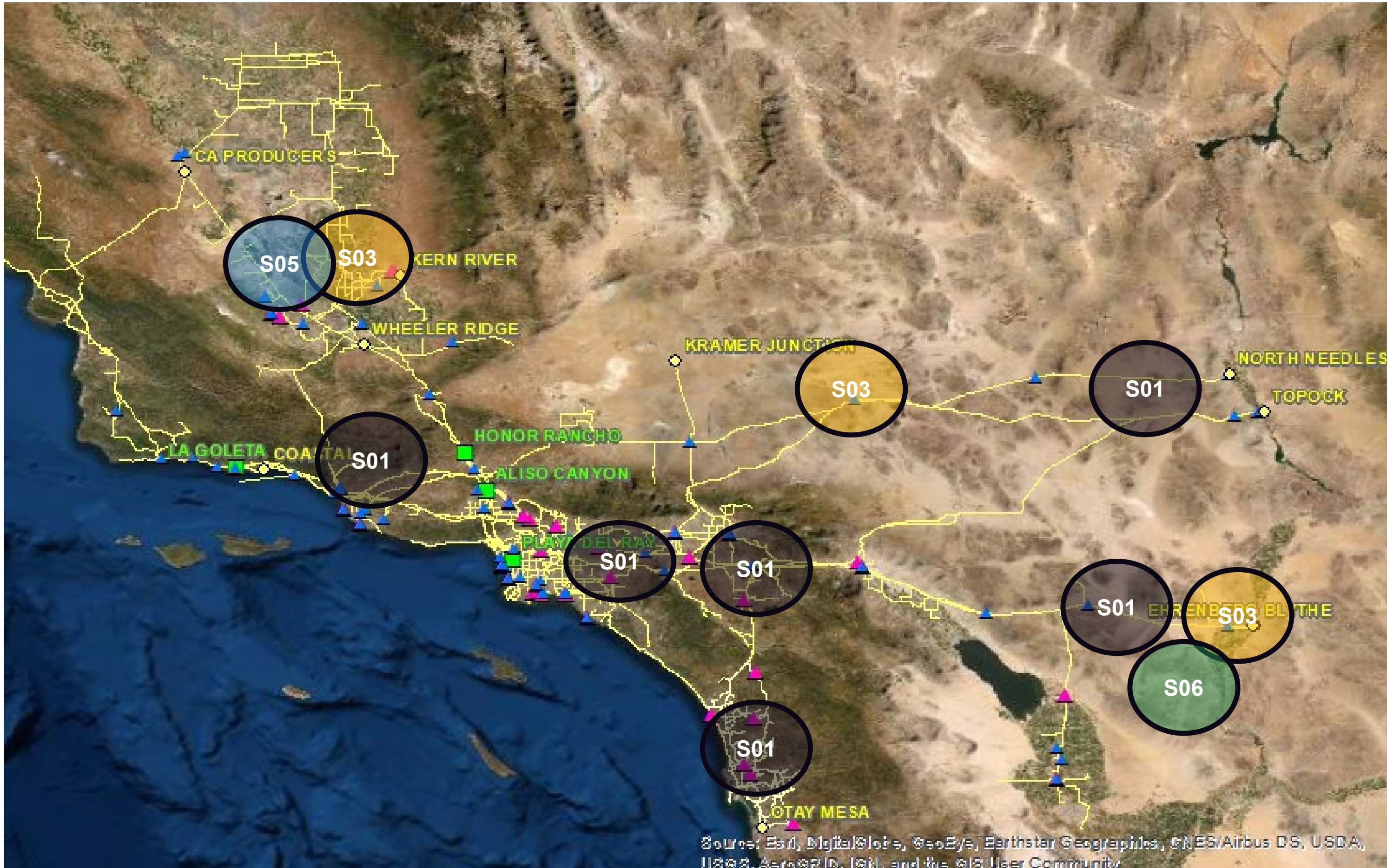
	S01 WINTER 2020	S02 SUMMER 2020	S03 WINTER 2025	S04 SUMMER 2025	S05 WINTER 2030	S06 SUMMER 2030
DEMAND	**4,987**	**2,556.8**	**4,759.9**	**2,618.4**	**4,821.2**	**2675**
PIPELINE SUPPLY	**2,926**	**2,685**	**3,113.5**	**2,220**	**3,115**	**2220**
MAX WD RATE	**1,330**	**1,329**	**1,329**	**1,116**	**2,594**	**527**
Aliso Canyon	0	0	0	0	0	0
Honor Rancho	184	184	184	251	184	0
La Goleta	109	109	109	116	109	109
Playa del Rey	75	75	75	75	75	75
TOTAL	**368**	**368**	**368**	**442**	**368**	**184**

SIMULATION RESULTS

	S01 WINTER 2020	S02 SUMMER 2020	S03 WINTER 2025	S04 SUMMER 2025	S05 WINTER 2030	S06 SUMMER 2030
DEMAND	4,987	2,556.8	4,759.9	2,618.4	4,821.2	2675
PIPELINE SUPPLY	2,926	2,685	3,113.5	2,220	3,115	2220
MAX WD RATE	1,330	1,329	1,329	1,116	2,594	527
MAX INJ RATE	368	368	368	442	368	184
Pressures above MinOP?	NO	YES	NO	YES	NO	YES
Pressures below MOP?	YES	YES	YES	YES	YES	YES
Linepack recovered?	NO	YES	NO	YES	YES	NO
Facilities operated within capacity?	YES	YES	YES	YES	YES	YES

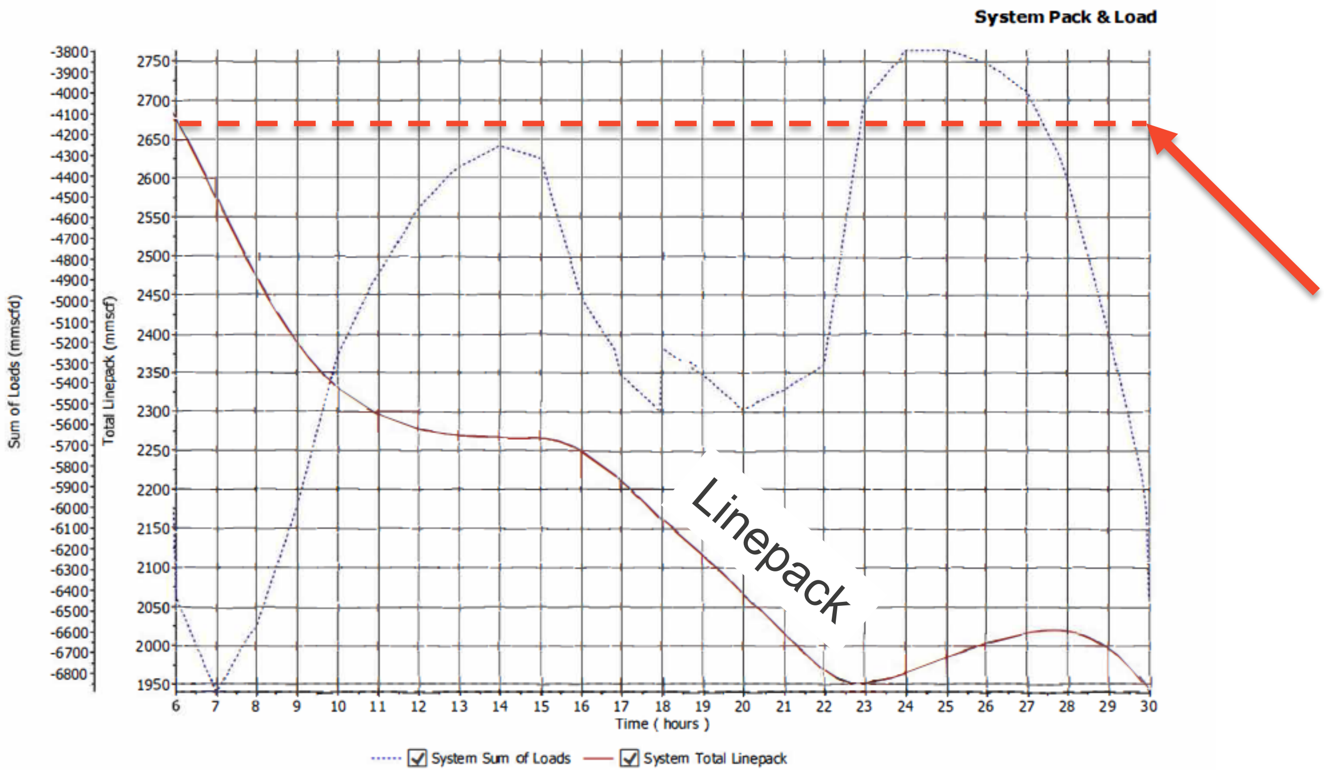
These are the criteria for success or failure of the simulation.

Where did pressures & linepack fail in Sims S01 S03 S05 S06?



Study of Failed Scenarios

S01 WINTER 2020 LINEPACK

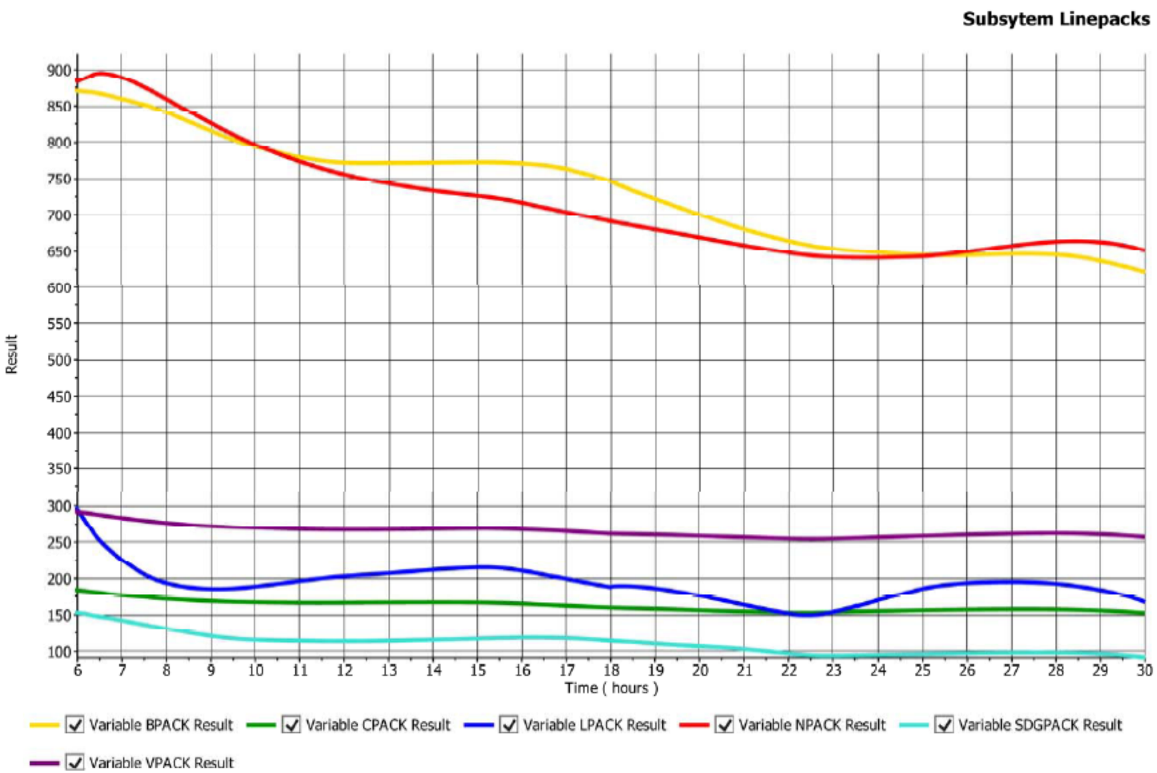


S01 Linepack Loss is ~750 mmcfd

Linepack must recover to this level for a successful simulation

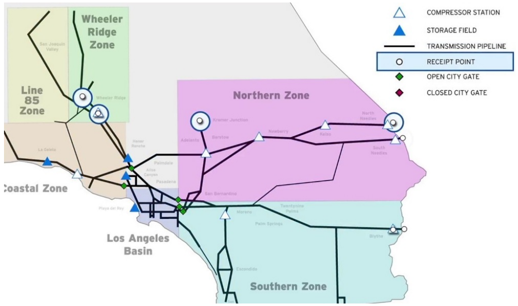
Lowest pressures:
South Basin
Orange County
Citygates
San Diego

S01 WINTER 2020 SUBSYSTEM LINEPACK



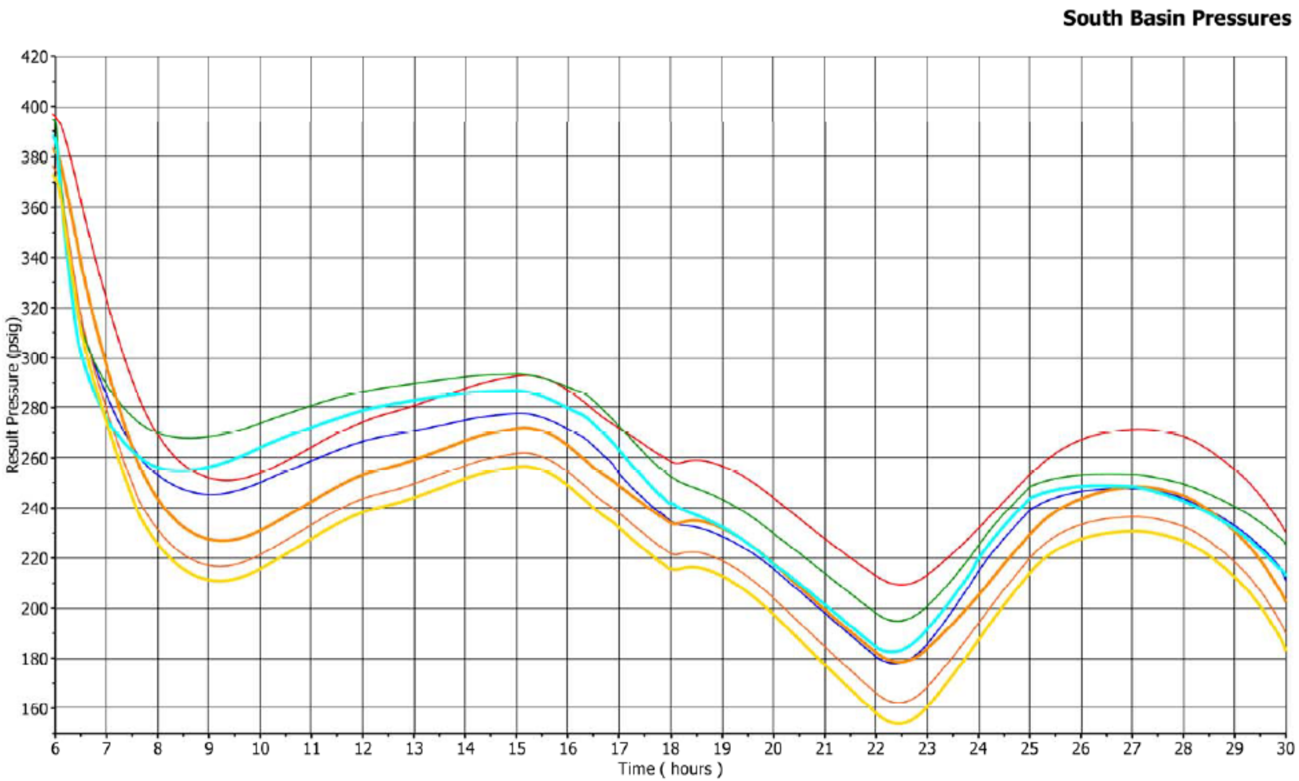
S01 Linepack Loss is ~750 mmcfd

Lowest pressures:
South Basin
Orange County
Citygates
San Diego



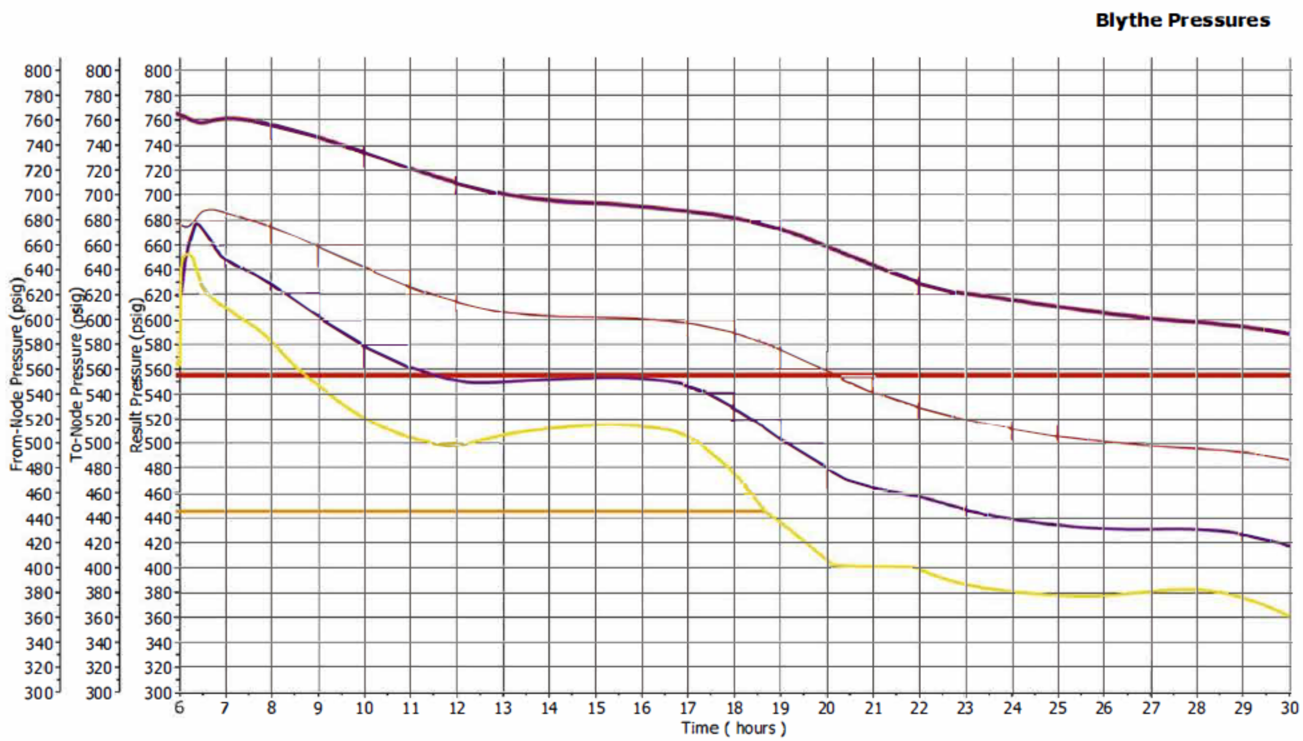
Blythe (Southern Zone)
Coastal zone
Loop (LA Basin)
Northern zone
San Diego
Valley (San Joaquin Valley)

S01 WINTER 2020 PRESSURES – SOUTH BASIN



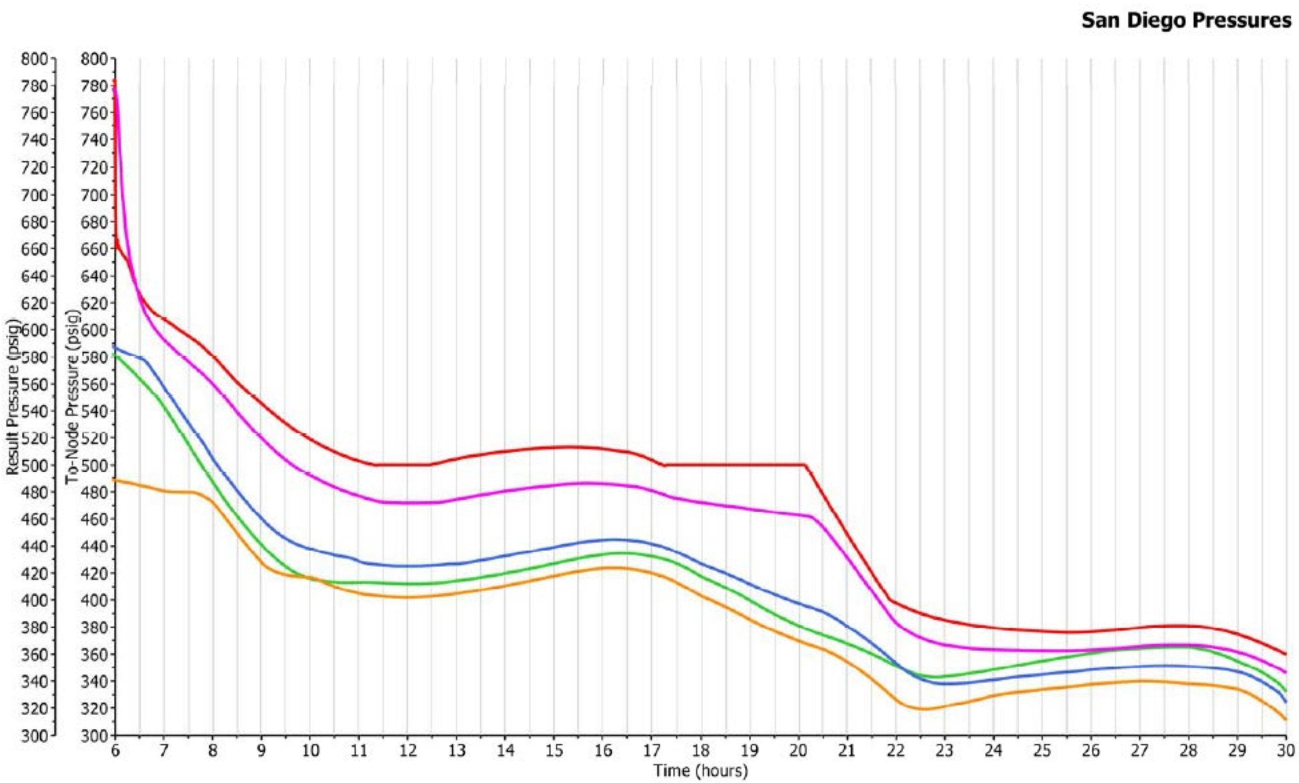
S01 pressure failures occur inside and outside the Loop. All subsystems are impacted.

S01 WINTER 2020 PRESSURES - BLYTHE



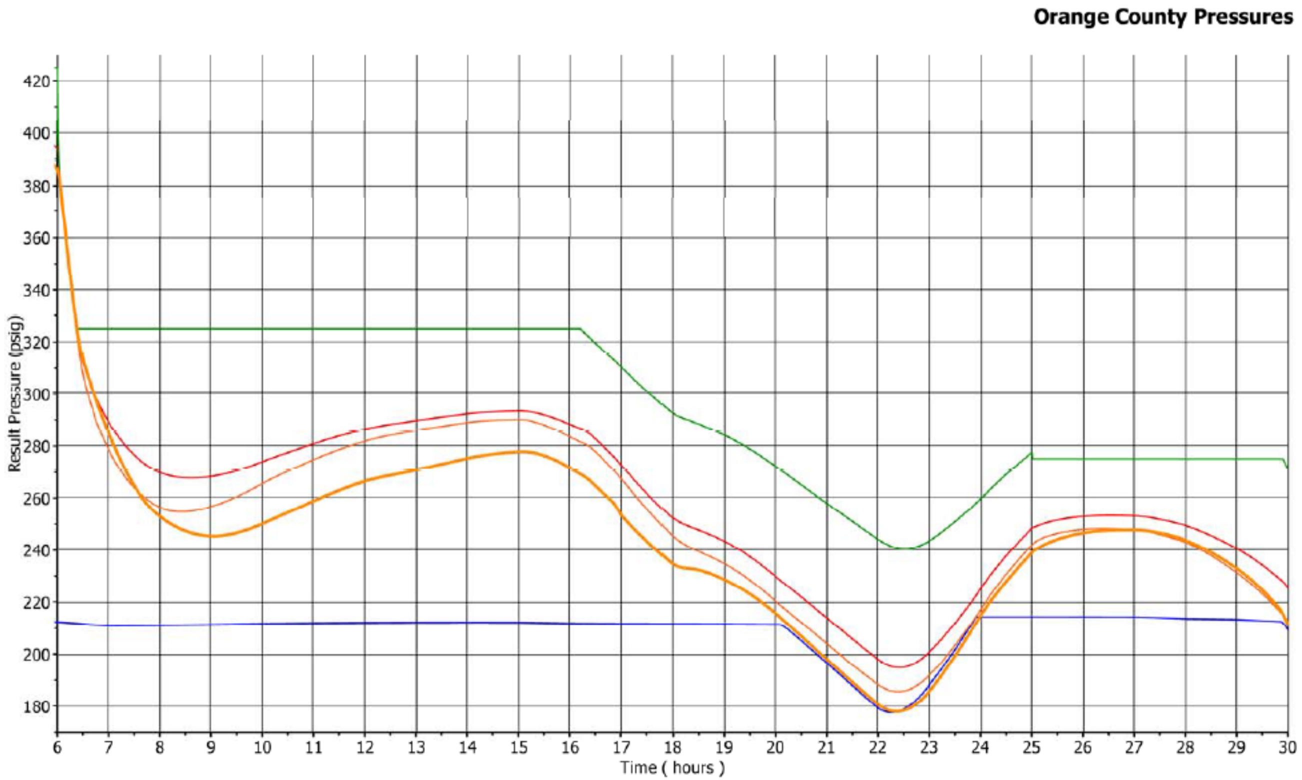
S01 pressure failures occur inside and outside the Loop. All subsystems are impacted.

S01 WINTER 2020 PRESSURES – SAN DIEGO



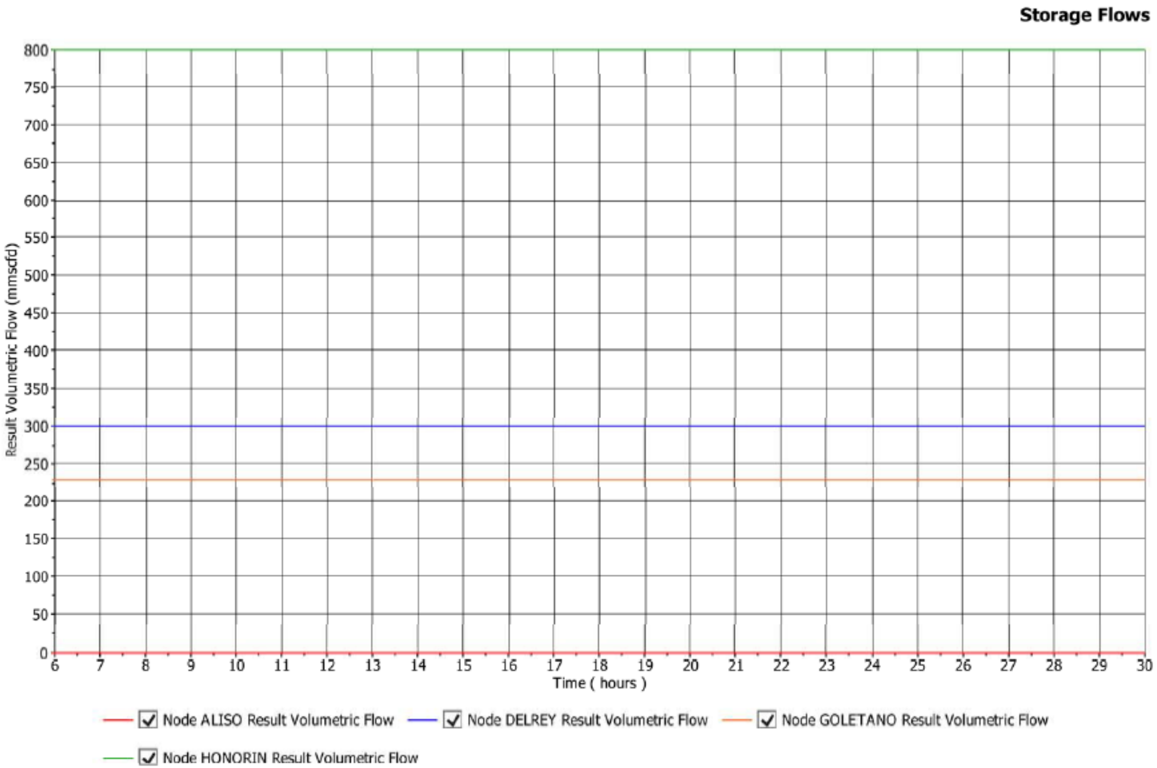
S01 pressure failures occur inside and outside the Loop. All subsystems are impacted.

S01 WINTER 2020 PRESSURES – ORANGE COUNTY



S01 pressure failures occur inside and outside the Loop. All subsystems are impacted.

S01 WINTER 2020 STORAGE WITHDRAWALS



Storage withdrawals for Non-Aliso fields were modeled at near max capacity, for the full 24 hours, for S01

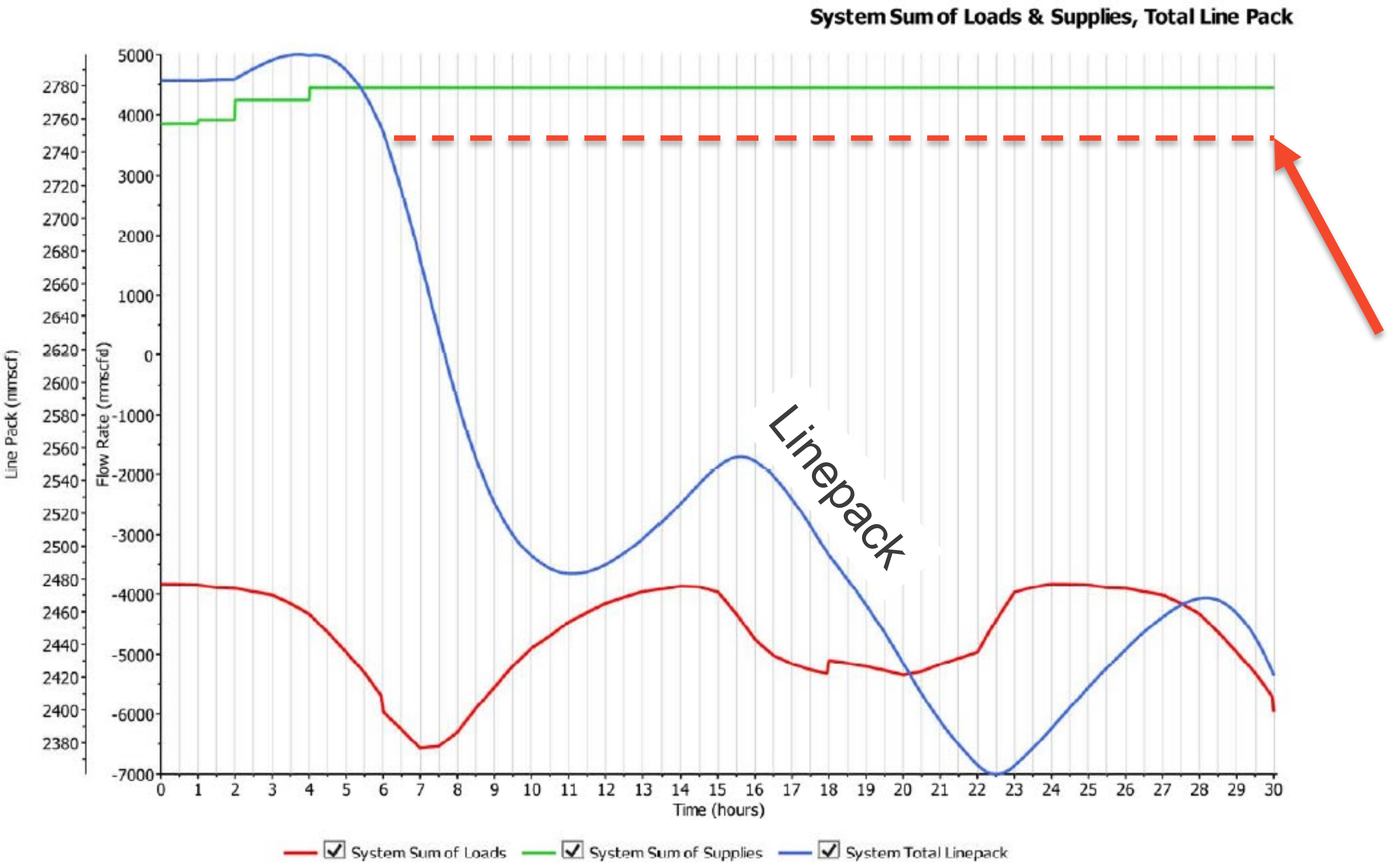
S01 OPERATIONAL ACTIONS

T=6 Start of simulation

T=18 Evening Peak

S01: City Gate pressures were increased at t=18 to try and keep the Los Angeles Basin pressures above MINOP but ultimately failed and were closed to preserve the Southern System pressures

S03 WINTER 2025 LINEPACK

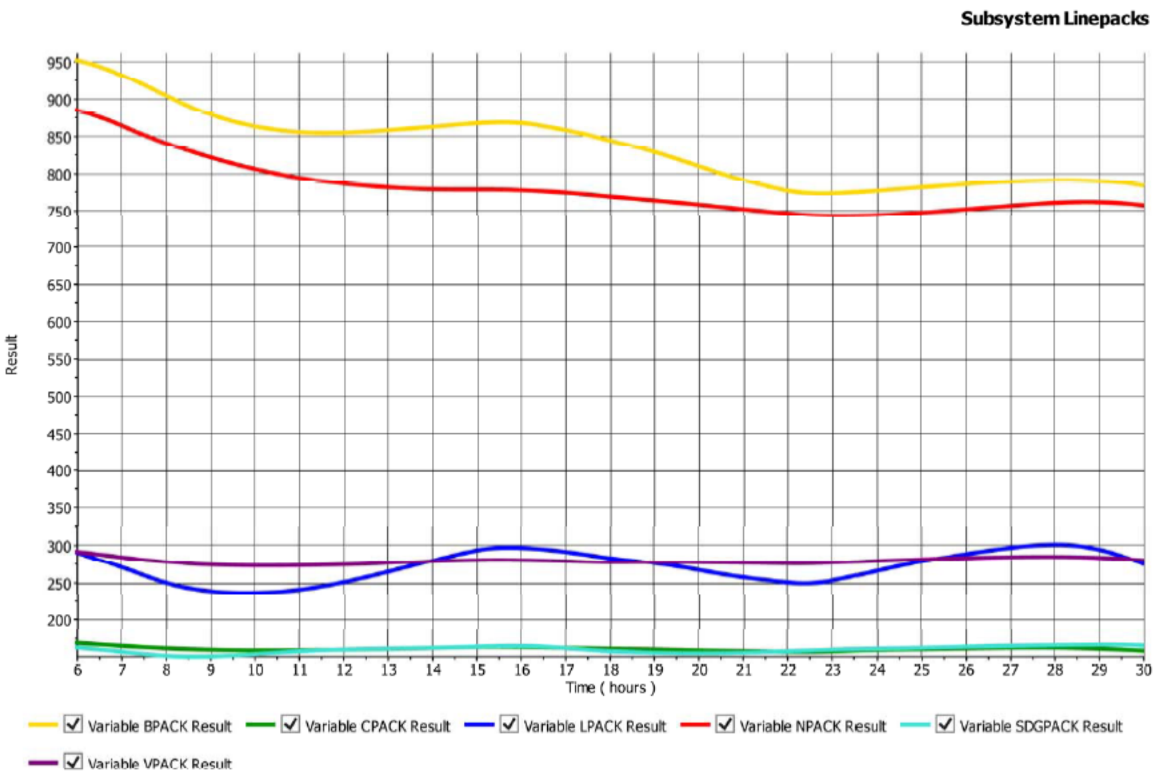


S03 Linepack Loss is ~360 mmcfd

Linepack must recover to this level for a successful simulation

Lowest Pressures:
San Joaquin Valley
Blythe
Line 4000

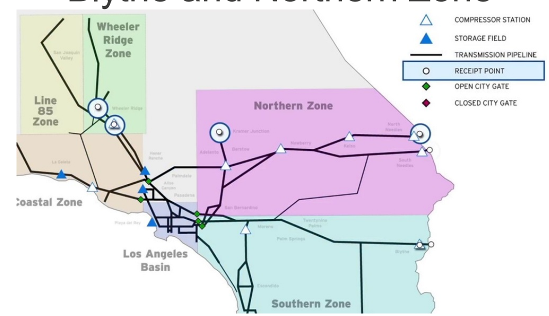
S03 WINTER 2025 LINEPACK



S03 Linepack Loss is ~360 mmcfd

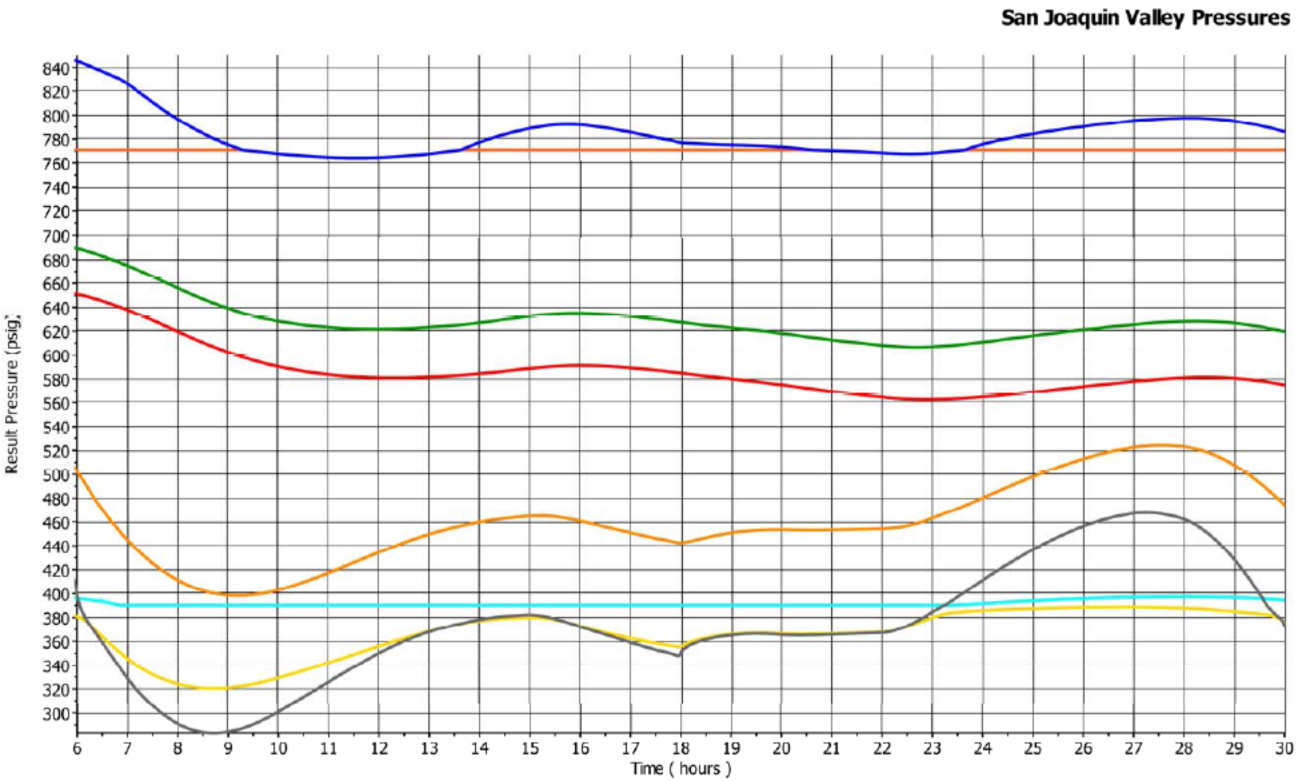
Lowest Pressures:
San Joaquin Valley

Linepack Failures:
Blythe and Northern Zone



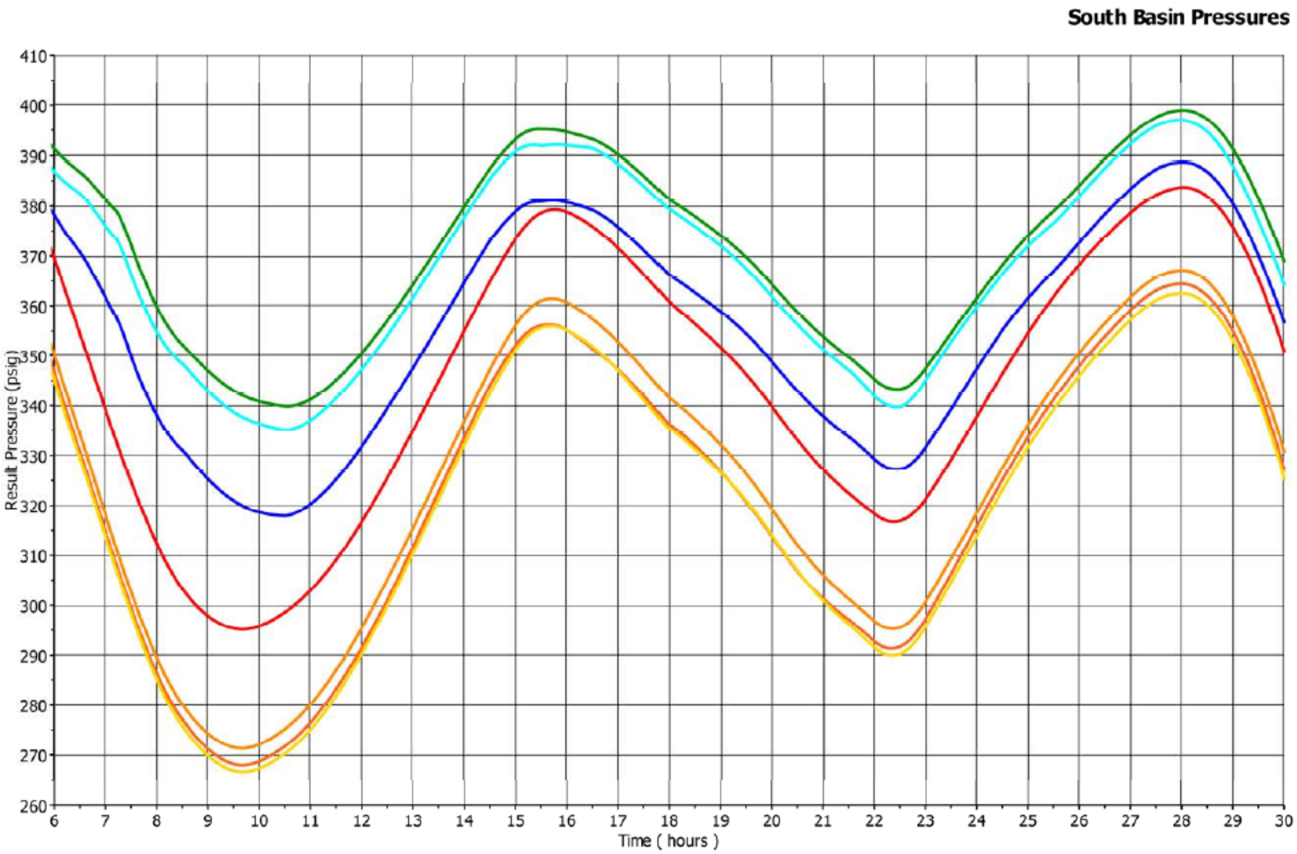
- Blythe (Southern Zone)
- Coastal zone
- Loop (LA Basin)
- Northern zone
- San Diego
- Valley (San Joaquin Valley)

S03 WINTER 2025 PRESSURES



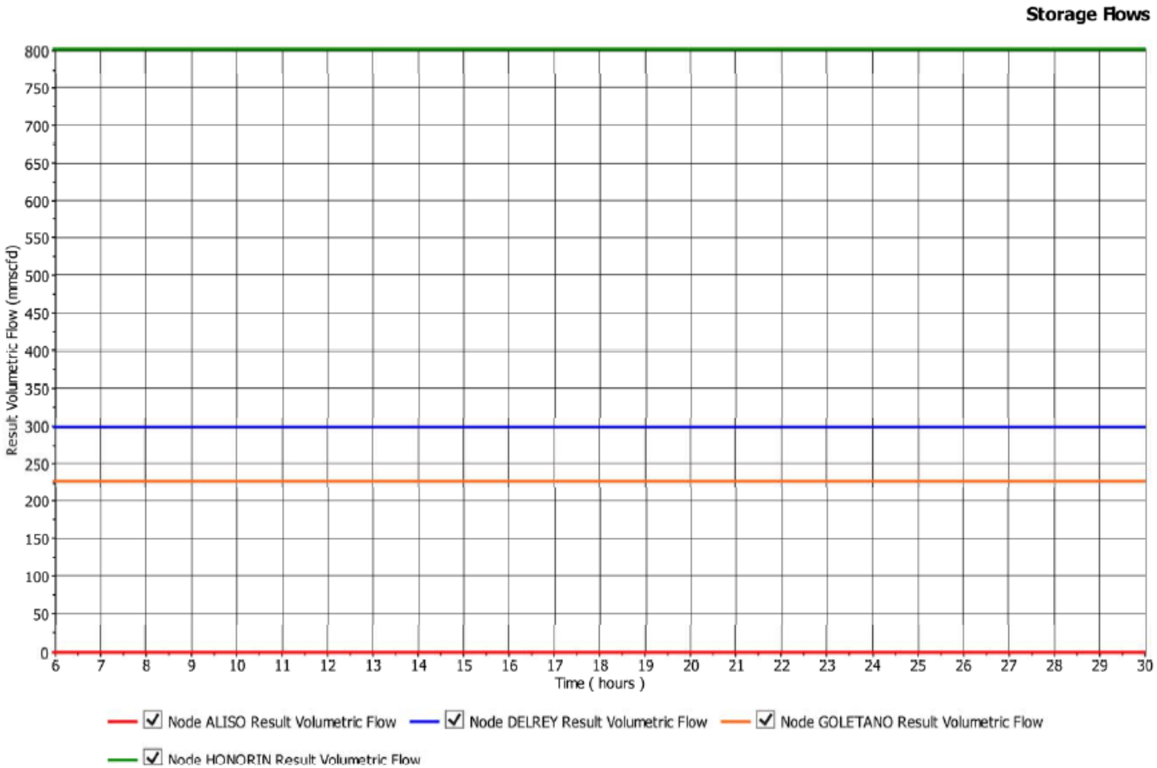
S03 pressure failures mainly occur at the boundaries of the system: San Joaquin Valley. Linepack failures occur in Northern Zone and Blythe.

S03 WINTER 2025 PRESSURES



S03 pressure failures mainly occur at the boundaries of the system: San Joaquin Valley. Linepack failures occur in Northern Zone and Blythe.

S03 WINTER 2025 STORAGE WITHDRAWALS



Storage withdrawals for Non-Aliso fields were modeled at near max capacity, for the full 24 hours, for S03

Aliso Canyon
Playa Del Rey
Goleta
Honor Rancho

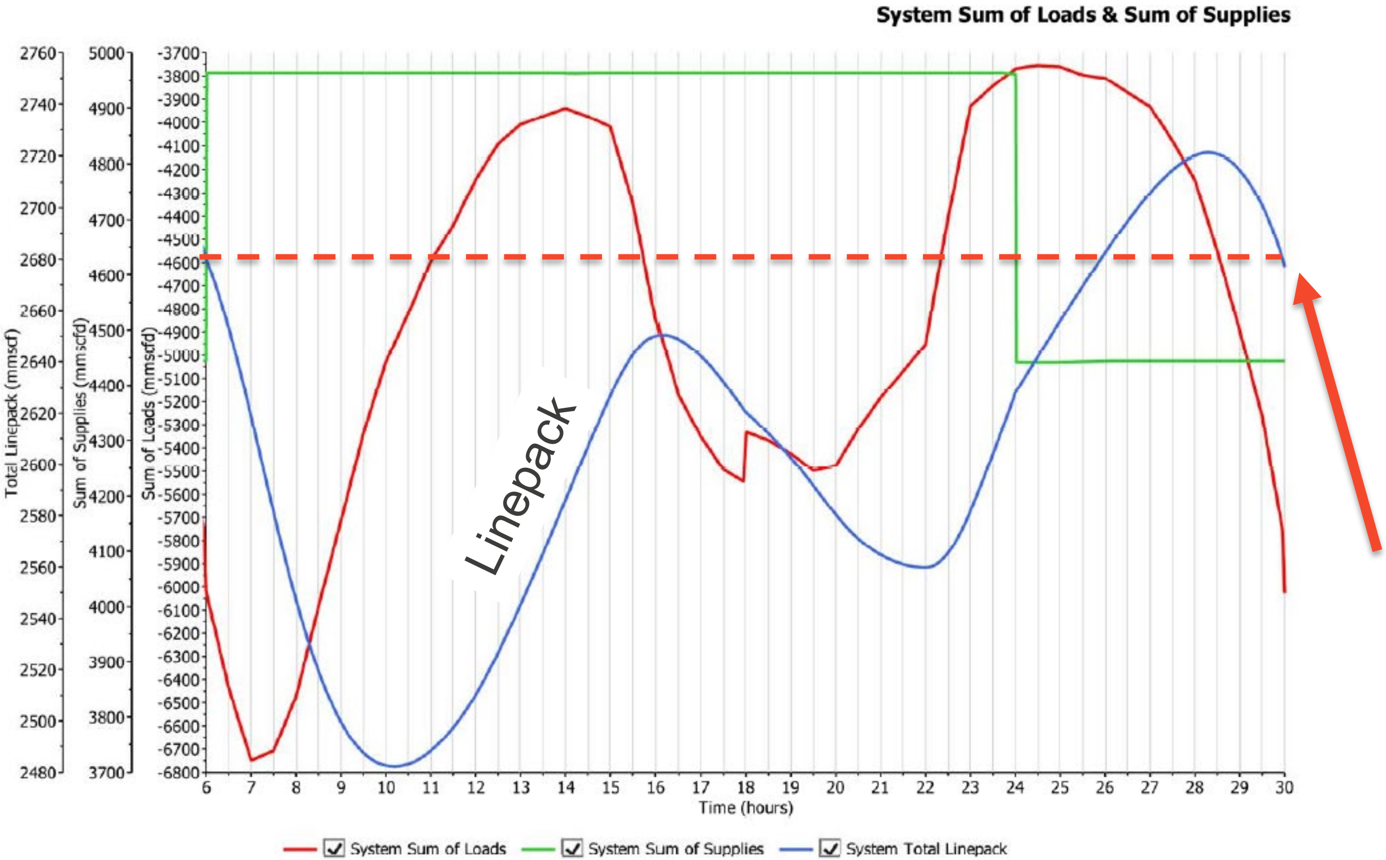
S03 OPERATIONAL ACTIONS

T=6 Start of simulation

T=18 Evening Peak

S03: Withdrawals and pressures were maxed out at the start of the day. Pressures in the basin stayed above MINOP so that no operational actions were needed, however, pressures failed at the boundaries of the system.

S05 WINTER 2030 LINEPACK (ALISO W/D ALLOWED)



S05 allowed the use of Aliso to determine a minimum amount required.

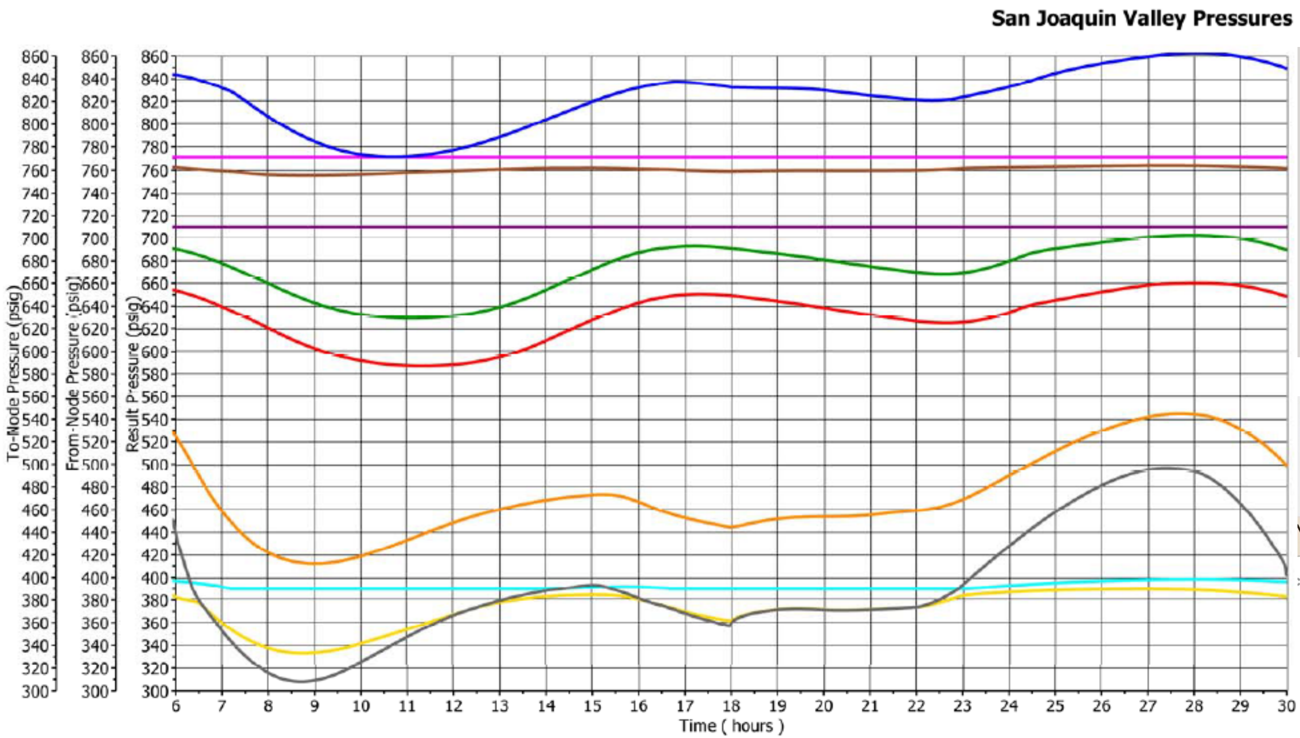
S05 does not have any Linepack Loss

Linepack recovered

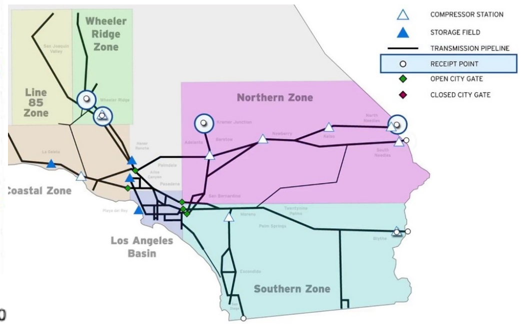
Lowest pressures: San Joaquin Valley**

The S05 pressure failures in SJV are being investigated by SCG

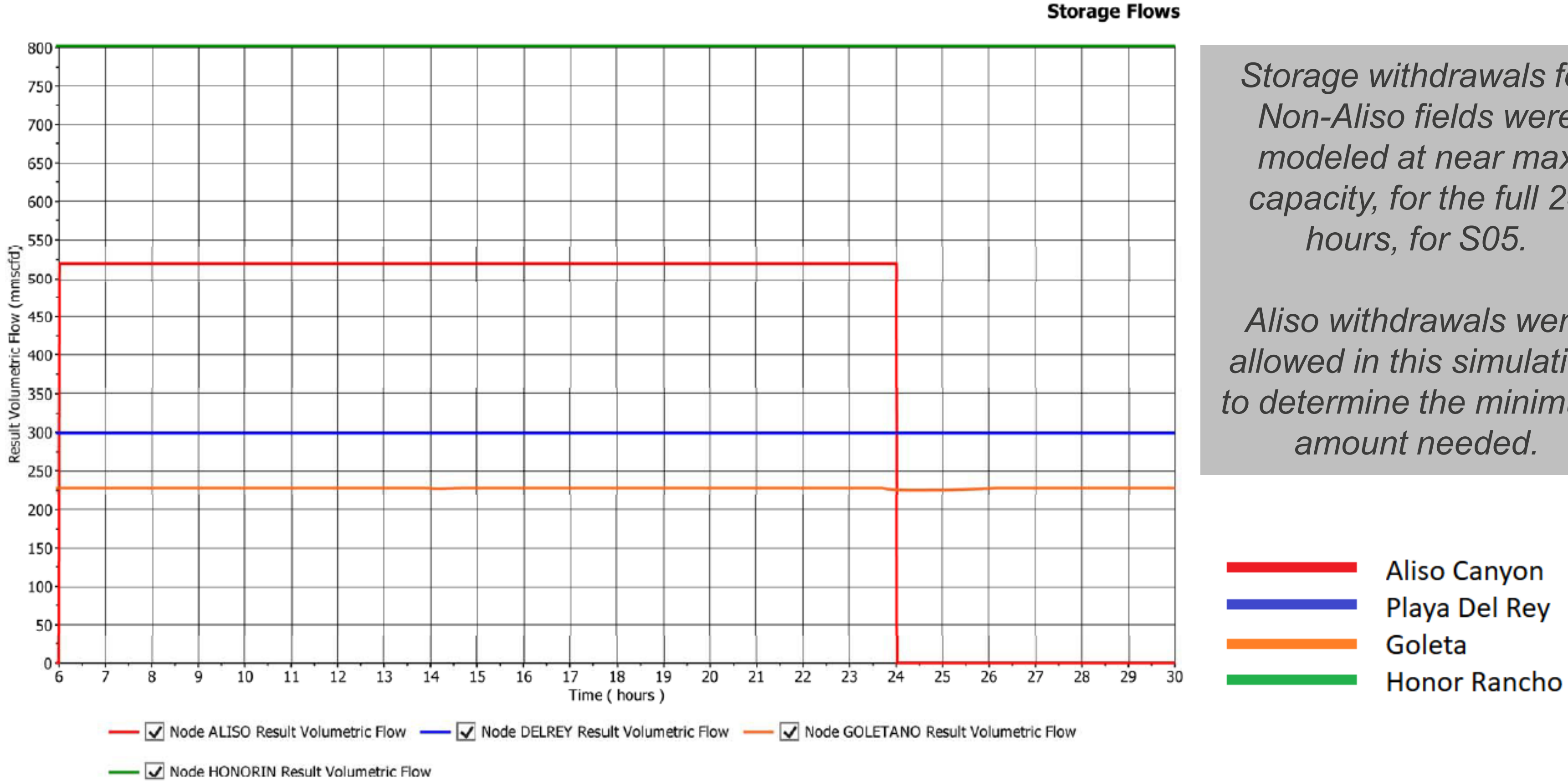
S05 WINTER 2030 PRESSURES



S05 pressure failure occurs at the boundary of the system in the San Joaquin Valley.



S05 WINTER 2030 STORAGE WITHDRAWALS



Storage withdrawals for Non-Aliso fields were modeled at near max capacity, for the full 24 hours, for S05.

Aliso withdrawals were allowed in this simulation to determine the minimum amount needed.

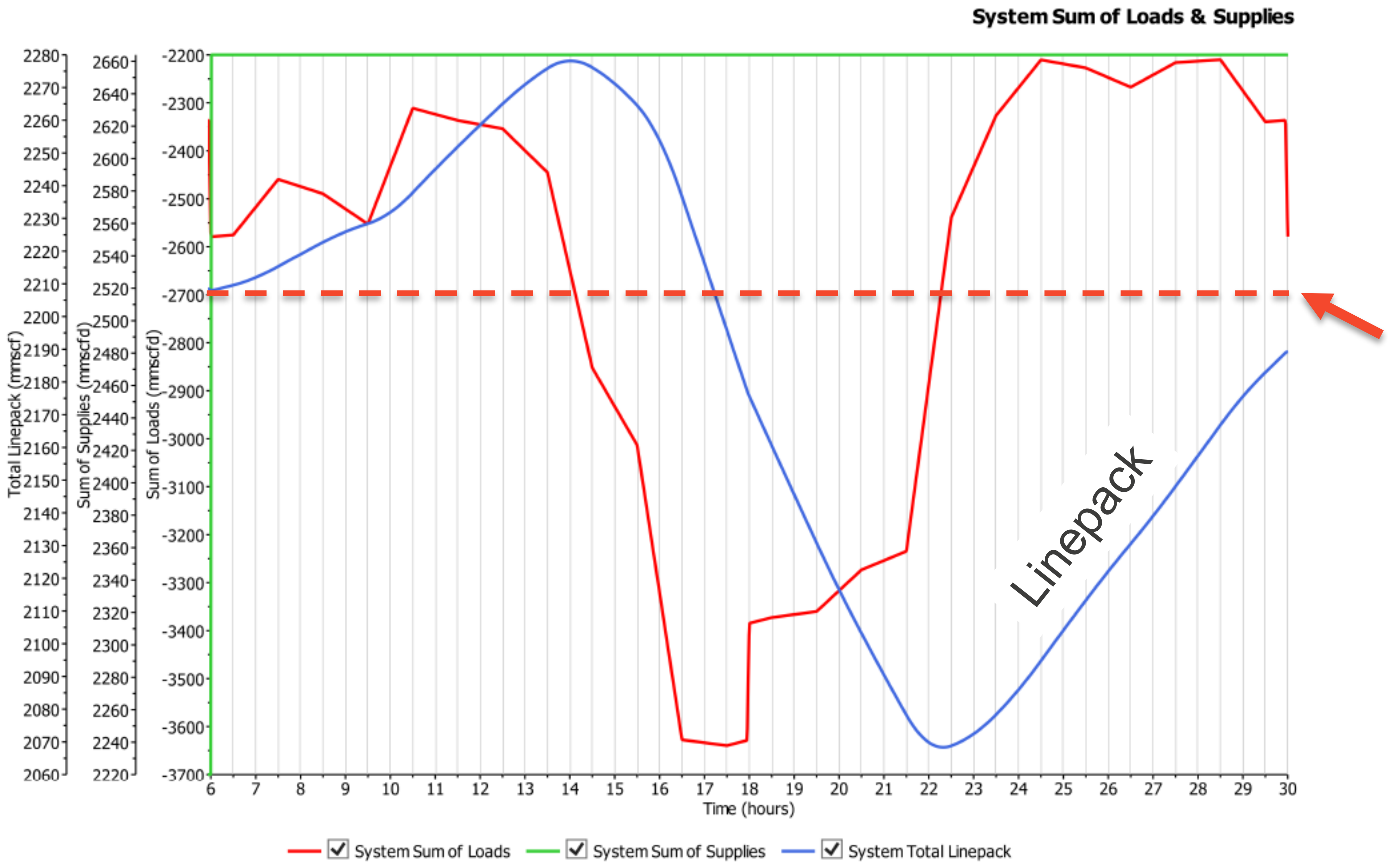
S05 OPERATIONAL ACTIONS

T=6 Start of simulation

T=18 Evening Peak

S05: Non Aliso storage flows and City Gate pressures were near maximum capacity at the start of the day. Once Aliso withdrawals began, City Gate pressures were modified to balance the system. However, pressures failed in the SJV. SoCalGas is investigating.

S06 SUMMER 2030 LINEPACK

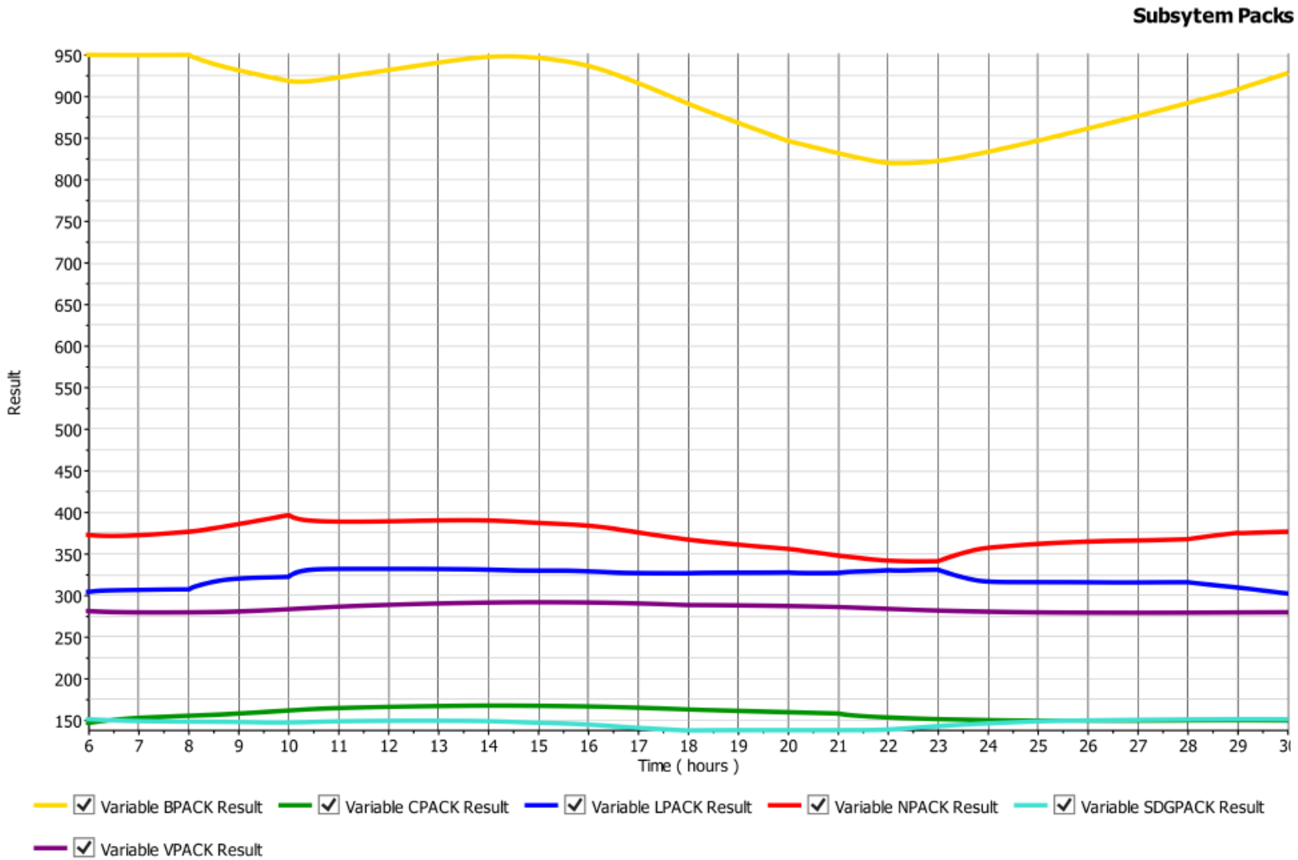


S06 Linepack Loss is ~25 mmcfd

Linepack must recover to this level for a successful simulation

Lowest Pressures: None

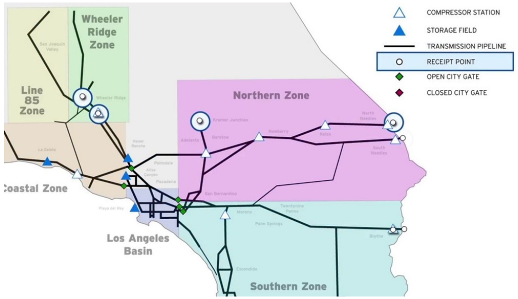
S06 SUMMER 2030 LINEPACK



S06 Linepack Loss is ~25 mmcfd

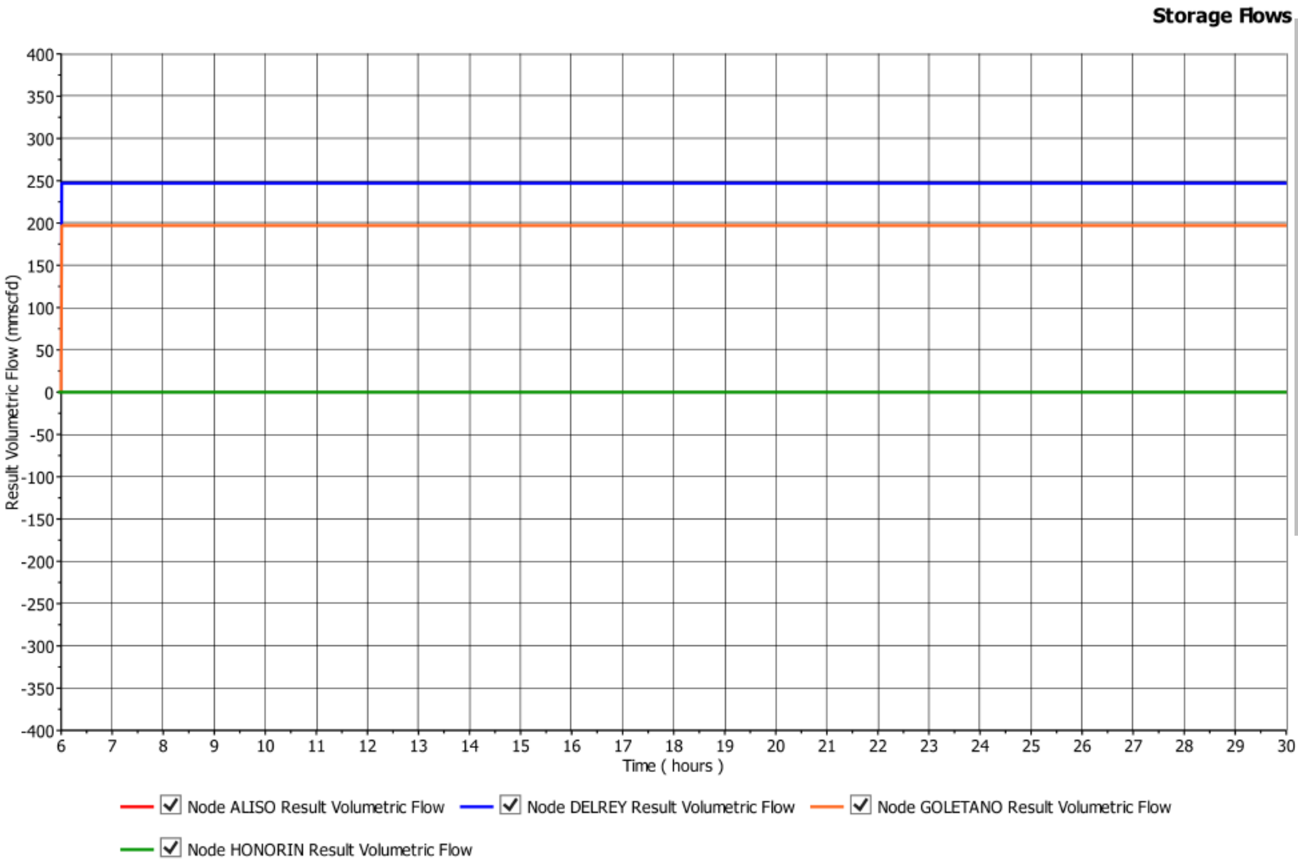
Lowest Pressures:
None

Linepack Loss:
Blythe



- Blythe (Southern Zone)
- Coastal zone
- Loop (LA Basin)
- Northern zone
- San Diego
- Valley (San Joaquin Valley)

S06 SUMMER 2030 STORAGE WITHDRAWALS



S06 modeled a storage outage at Honor Rancho. The remaining Non-Aliso fields were used to balance the system. PDR and LG were only needed at ~83% of the maximum withdrawal rate, however the sim still failed to recover linepack at the boundary of the system

S06 OPERATIONAL ACTIONS

T=6 Start of simulation

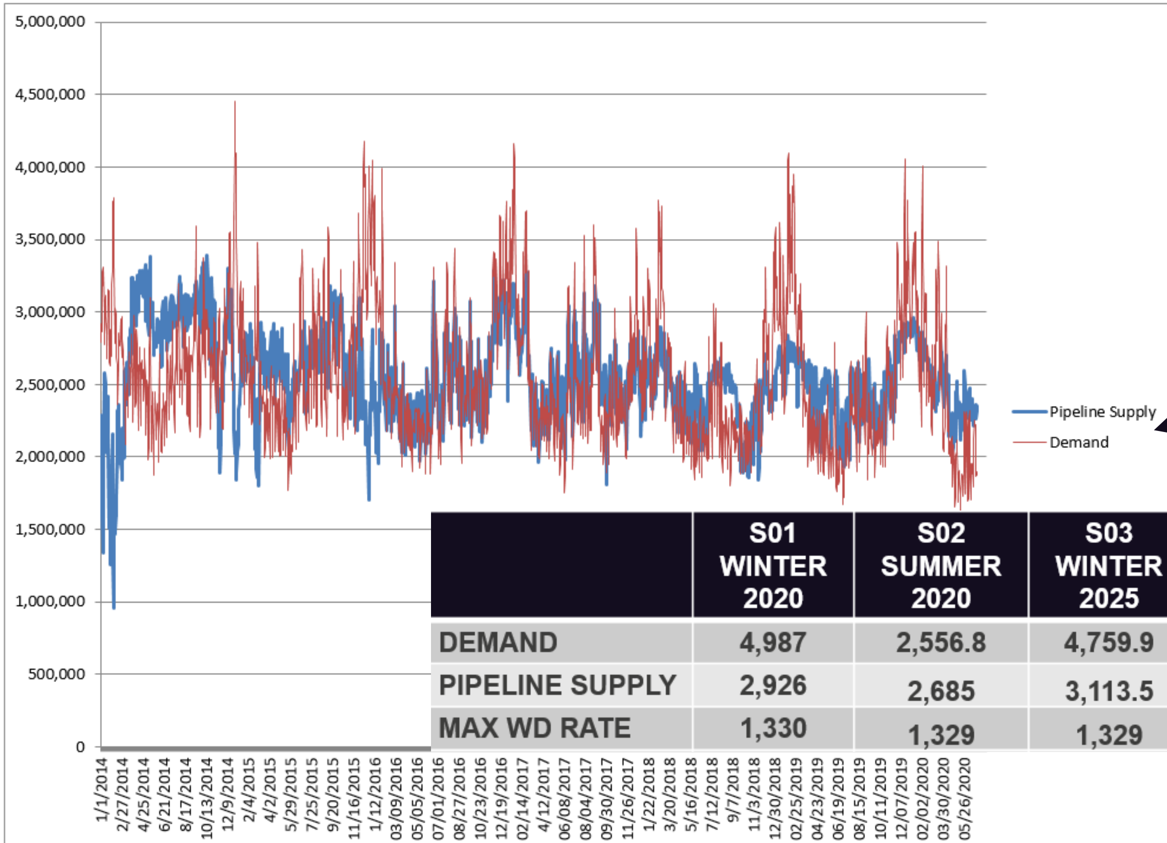
T=18 Evening Peak

S06: Honor Rancho is not available, so City Gate pressures were increased to keep the Basin above MINOP. However, the linepack did not recover in the Southern System.

Break for Questions

Examination of Inputs

Demand and Pipeline Supply

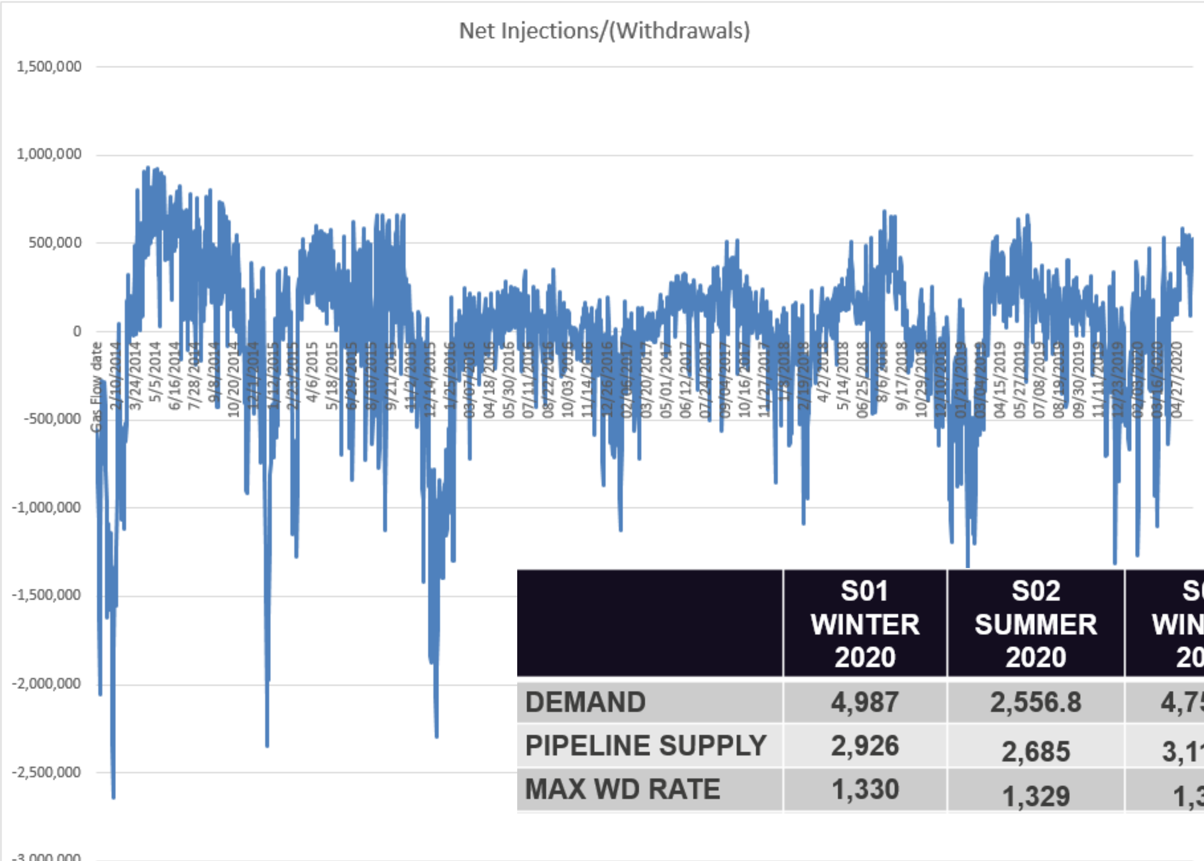


Compare Inputs to Historical Pipeline Supply and Historical Demand

	S01 WINTER 2020	S02 SUMMER 2020	S03 WINTER 2025	S04 SUMMER 2025	S05 WINTER 2030	S06 SUMMER 2030
DEMAND	4,987	2,556.8	4,759.9	2,618.4	4,821.2	2675
PIPELINE SUPPLY	2,926	2,685	3,113.5	2,220	3,115	2220
MAX WD RATE	1,330	1,329	1,329	1,116	2,594	527

**CPUC intent was not to model the extreme peak day demand but rather model cases where fuel burn is within 90th percentile. Clarification document on CPUC demand modeling is located:*
https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2020/FurtherHydraulicModelingClarifications-05272020.pdf

Storage Withdrawal Rate



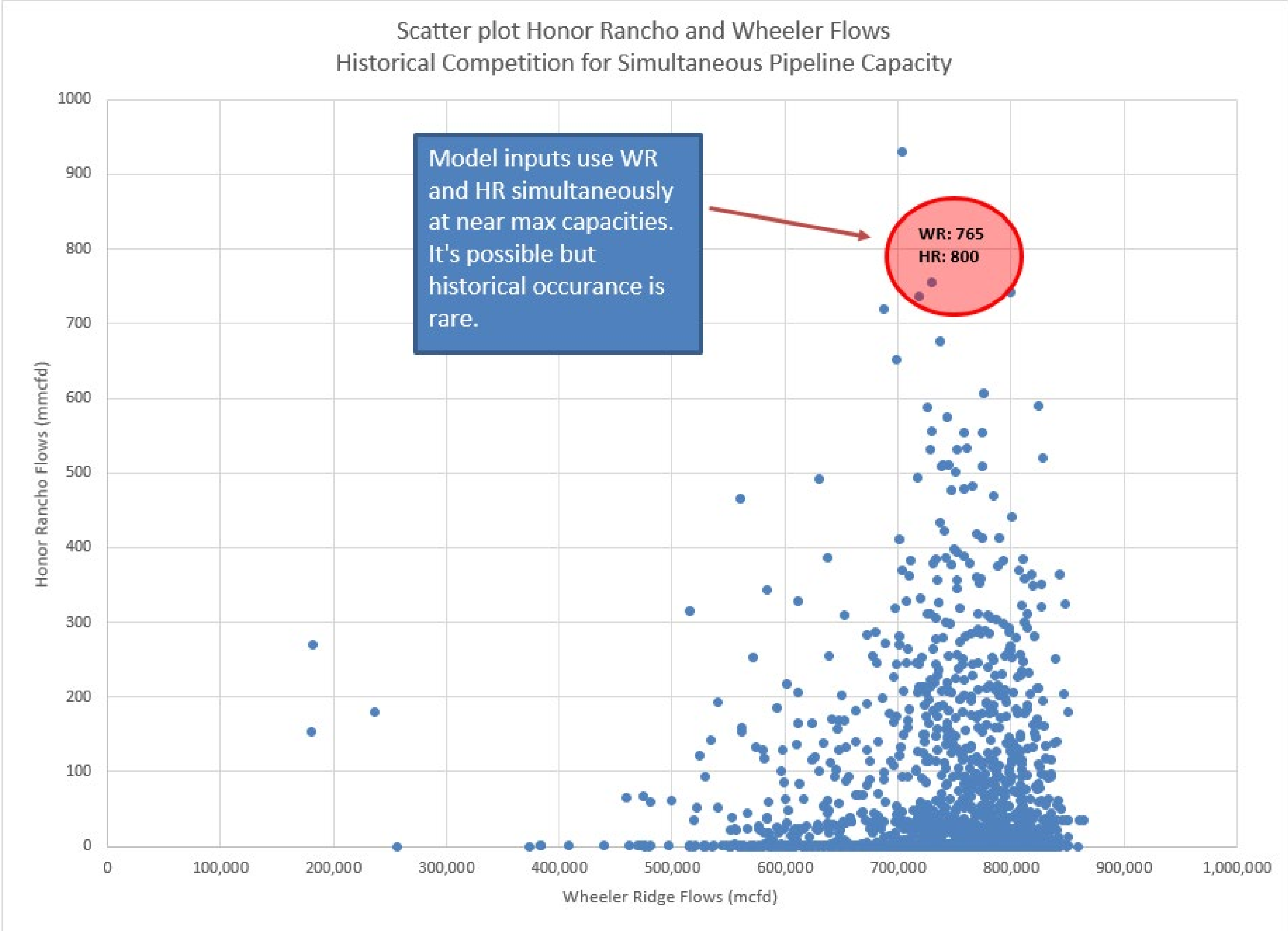
Compare Historical Withrawals to Max WD Rate

S05 includes Aliso

	S01 WINTER 2020	S02 SUMMER 2020	S03 WINTER 2025	S04 SUMMER 2025	S05 WINTER 2030	S06 SUMMER 2030
DEMAND	4,987	2,556.8	4,759.9	2,618.4	4,821.2	2675
PIPELINE SUPPLY	2,926	2,685	3,113.5	2,220	3,115	2220
MAX WD RATE	1,330	1,329	1,329	1,116	2,594	527

**CPUC intent was not to model the extreme peak day demand but rather model cases where fuel burn is within 90th percentile. Clarification document on CPUC demand modeling is located:*
https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2020/FurtherHydraulicModelingClarifications-05272020.pdf

Honor Rancho and Wheeler Ridge Competition for Pipeline Capacity



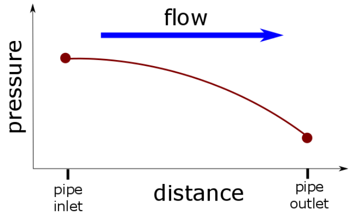
Winter scenarios 1, 3, 5 max WR and HR simultaneously. This is only possible if gas demand is high. High demand will cause pressure gradients to decrease, allowing for increased flows.

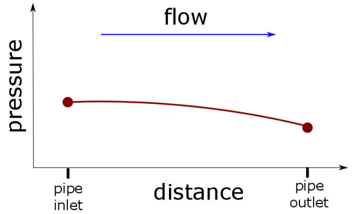
Minimum inventory needed for 800 mmcfd w/d at HR is ~18 BCF (From 2017 Technical Assessment)

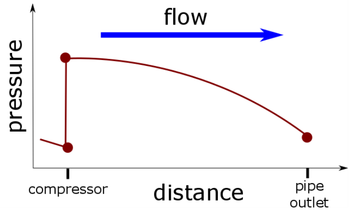
Physics of Pressure and Flow Tradeoffs

- Flow is created by compressors, or by pressure gradient

$$p_{in}^2 - p_{out}^2 = \beta\phi|\phi|$$

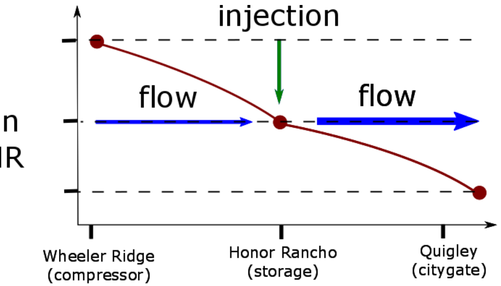




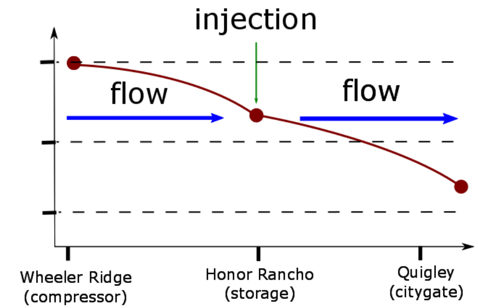


- Flow cannot come into the system from some supply points simultaneously
  - Wheeler Ridge interconnection (Kern pipeline)
  - Honor Rancho storage facility – Quigley city gate

Desired Configuration Using WR+HR



Sub-optimal Configuration Partial HR use



  - Increasing HR injection decreases WR inflow

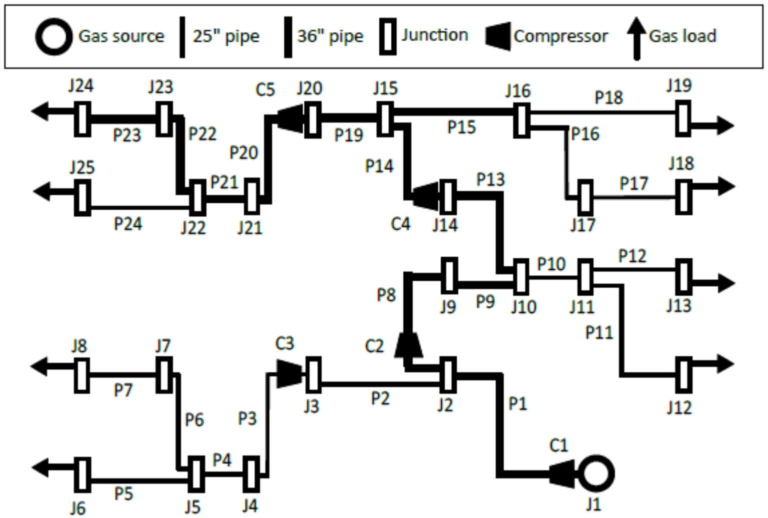
Future Methodology

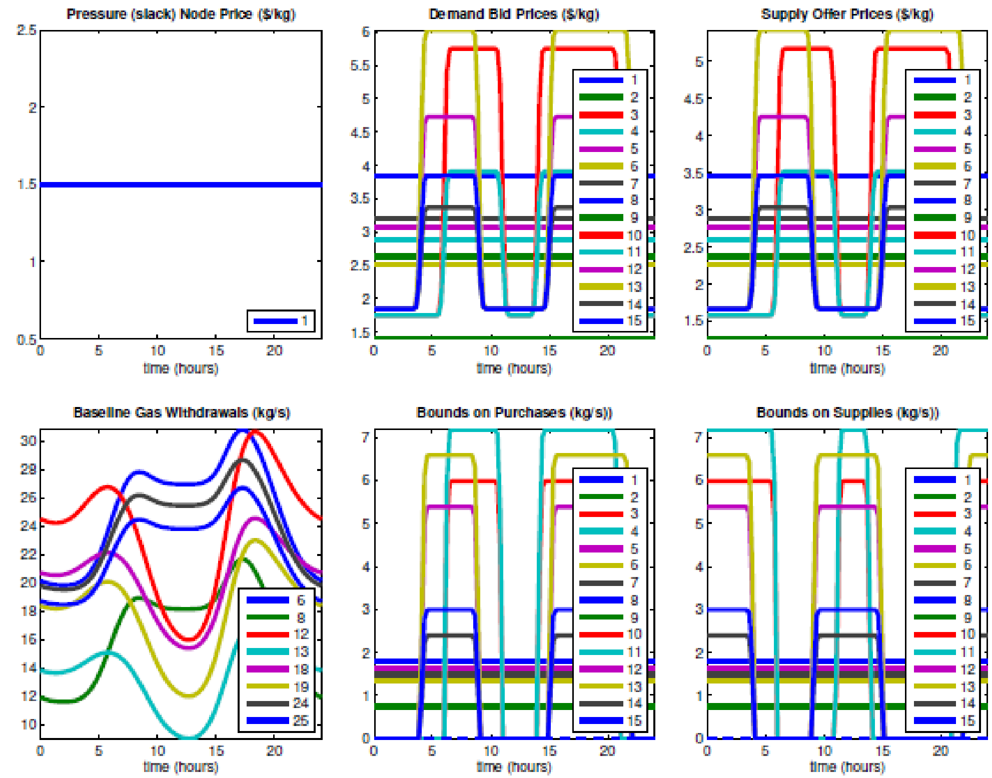
Gas Pipeline Control Analytics

- **Input: static network model**
  - Junctions (nodes)
  - pipes (edges)
  - compressor stations (controllers)
  - custody transfer meters (at nodes)
- **Input: hourly bids of shippers**
  - Pre-existing (ratable) flow schedule
  - Bid or offer prices
  - Upper limits on gas injections and withdrawals at each price level (hourly)
- **Output: physical solution**
  - Pressures & flows through the pipeline
  - Compressor control (discharge pressure)
  - **Regulator control (downstream pressure and/or flow)**
- **Output: market solution**
  - Locational trade values (LTVs) give real-time and forward prices
  - Flow profiles of increment or decrease w.r.t. ratable nomination (private to each shipper)

Synthetic Case Study

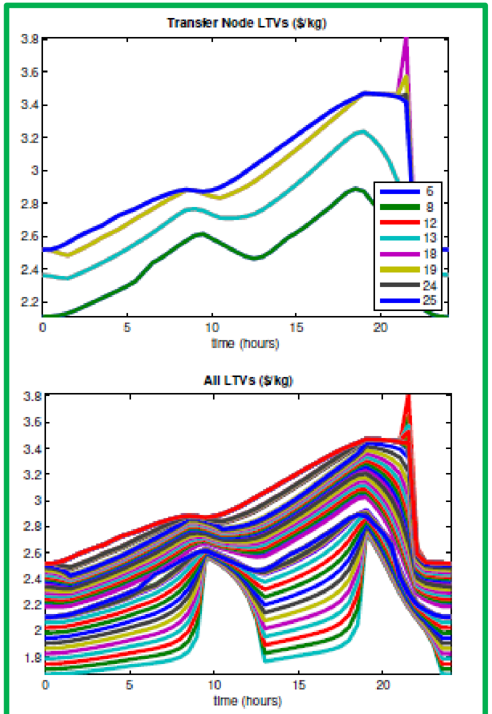
Pipeline test network: 24 pipes, 5 compressors, 477 km
Input data: baseline flows and price/quantity bids

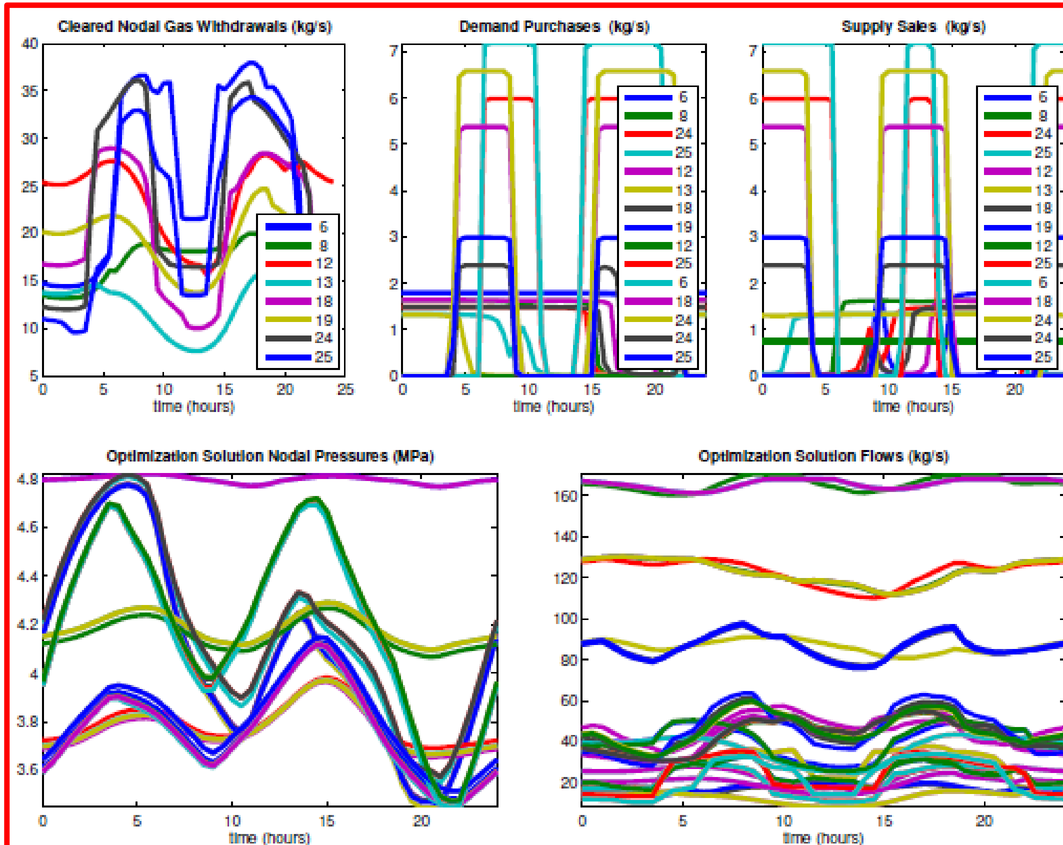




Synthetic Case Study

Output: physical and price solutions





Transient Optimization for SCG System

- Could be used to evaluate zonal capacity, optimally test scenarios
- Could eventually be used in daily marketing and operations

- To be developed for Southern California Gas Co. Hydraulic model
- Additional R&D to enable regulator and valve control

- *Zlotnik, Anatoly, Kaarthik Sundar, Aleksandr M. Rudkevich, Aleksandr Beylin, and Xindi Li. "Optimal Control for Scheduling and Pricing Intra-day Natural Gas Transport on Pipeline Networks." In 2019 IEEE 58th Conference on Decision and Control (CDC), pp. 4887-4884. IEEE, 2019.*

Acknowledgement

- Los Alamos National Laboratory
  - National Nuclear Security Administration of the U.S. Department of Energy Contract No. 89233218CNA000001
- Advanced Grid Modeling Program
  - D.O.E. Office of Electricity

Los Alamos NATIONAL LABORATORY EST.1943

STATE OF CALIFORNIA ENERGY COMMISSION

PUBLIC UTILITIES COMMISSION STATE OF CALIFORNIA EUREKA

advanced network science initiative

PSIG Pipeline Simulation Interest Group