Aliso Canyon Modeling Scenarios
Independent Review of Hydraulic Modeling

Anatoly Zlotnik and Mary Ewers
7-28-2020
Agenda

7-28-2020

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

<table>
<thead>
<tr>
<th></th>
<th>S01 WINTER 2020</th>
<th>S02 SUMMER 2020</th>
<th>S03 WINTER 2025</th>
<th>S04 SUMMER 2025</th>
<th>S05 WINTER 2030</th>
<th>S06 SUMMER 2030</th>
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<tbody>
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<td>808</td>
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<td>Non-EG noncore</td>
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<tr>
<td>EG</td>
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<td>1,030.2 CPUC</td>
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<tr>
<td>TOTAL</td>
<td>4,987</td>
<td>2,556.8</td>
<td>4,759.9</td>
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<td>4,821.2</td>
<td>2675</td>
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## PIPELINE SUPPLY (MMCFD)

<table>
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<tr>
<th></th>
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</tr>
<tr>
<td>North Needles</td>
<td>340</td>
<td>300</td>
<td>430</td>
<td>0</td>
<td>430</td>
<td>0</td>
</tr>
<tr>
<td>Topock</td>
<td>446.25</td>
<td>200</td>
<td>400</td>
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<td>400</td>
<td>0</td>
</tr>
<tr>
<td>Kramer Junction</td>
<td>276.25</td>
<td>550</td>
<td>420</td>
<td>700</td>
<td>420</td>
<td>700</td>
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<tr>
<td>Wheeler Ridge</td>
<td>765</td>
<td>765</td>
<td>765</td>
<td>600</td>
<td>765</td>
<td>600</td>
</tr>
<tr>
<td>Kern River Sta.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ehrenberg</td>
<td>833</td>
<td>750</td>
<td>728.5</td>
<td>920</td>
<td>980</td>
<td>920</td>
</tr>
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<td>Otay Mesa</td>
<td>195.5</td>
<td>50</td>
<td>300</td>
<td>0</td>
<td>50</td>
<td>0</td>
</tr>
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<td>CA producers</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>0</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,926</td>
<td>2,685</td>
<td>3,113.5</td>
<td>2,220</td>
<td>3,115</td>
<td>2220</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
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<th>S01 WINTER 2020</th>
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<td>3,115</td>
<td>2220</td>
</tr>
<tr>
<td>Aliso Canyon</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1265</td>
<td>0</td>
</tr>
<tr>
<td>Honor Rancho</td>
<td>800</td>
<td>802</td>
<td>802</td>
<td>672</td>
<td>802</td>
<td>0</td>
</tr>
<tr>
<td>La Goleta</td>
<td>230</td>
<td>228</td>
<td>228</td>
<td>197</td>
<td>228</td>
<td>228</td>
</tr>
<tr>
<td>Playa del Rey</td>
<td>300</td>
<td>299</td>
<td>299</td>
<td>247</td>
<td>299</td>
<td>299</td>
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<tr>
<td>TOTAL</td>
<td>1,330</td>
<td>1,329</td>
<td>1,329</td>
<td>1,116</td>
<td>2,594</td>
<td>527</td>
</tr>
</tbody>
</table>

- **S05** includes **Aliso** determines minimum amount needed from Aliso
- **S06** excludes **Honor Rancho and Aliso**
## MAXIMUM INJECTION RATE (MMCFD)

<table>
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<tr>
<td>MAX WD RATE</td>
<td>1,330</td>
<td>1,329</td>
<td>1,329</td>
<td>1,116</td>
<td>2,594</td>
<td>527</td>
</tr>
<tr>
<td>Aliso Canyon</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Honor Rancho</td>
<td>184</td>
<td>184</td>
<td>184</td>
<td>251</td>
<td>184</td>
<td>0</td>
</tr>
<tr>
<td>La Goleta</td>
<td>109</td>
<td>109</td>
<td>109</td>
<td>116</td>
<td>109</td>
<td>109</td>
</tr>
<tr>
<td>Playa del Rey</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>TOTAL</td>
<td>368</td>
<td>368</td>
<td>368</td>
<td>442</td>
<td>368</td>
<td>184</td>
</tr>
</tbody>
</table>
## SIMULATION RESULTS

<table>
<thead>
<tr>
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<td>368</td>
<td>368</td>
<td>442</td>
<td>368</td>
<td>184</td>
</tr>
<tr>
<td>Pressures above MinOP?</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Pressures below MOP?</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Linepack recovered?</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Facilities operated within capacity?</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

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 mmcf/d

Linepack must recover to this level for a successful simulation

**Lowest pressures:**
South Basin
Orange County
Citygates
San Diego
S01 Linepack Loss is ~750 mmcf/day

Lowest pressures:
- South Basin
- Orange County
- Citygates
- San Diego
S01 pressure failures occur inside and outside the Loop. All subsystems are impacted.
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S01 pressure failures occur inside and outside the Loop. All subsystems are impacted.
Storage withdrawals for Non-Aliso fields were modeled at near max capacity, for the full 24 hours, for S01

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Storage Flows

- **Aliso Canyon**
- **Playa Del Rey**
- **Goleta**
- **Honor Rancho**
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 Linepack Loss is ~360 mmcf/d

Linepack must recover to this level for a successful simulation

Lowest Pressures:
San Joaquin Valley
Blythe
Line 4000
S03 Linepack Loss is ~360 mmcf/d

Lowest Pressures:
San Joaquin Valley

Linepack Failures:
Blythe and Northern Zone
S03 pressure failures mainly occur at the boundaries of the system: San Joaquin Valley. Linepack failures occur in Northern Zone and Blythe.
S03 pressure failures mainly occur at the boundaries of the system: San Joaquin Valley. Linepack failures occur in Northern Zone and Blythe.
Storage withdrawals for Non-Aliso fields were modeled at near max capacity, for the full 24 hours, for S03.
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 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 pressure failure occurs at the boundary of the system in the San Joaquin Valley.
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

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 mmcmd.

Linepack must recover to this level for a successful simulation.

 Lowest Pressures: None
S06 SUMMER 2030 LINEPACK

S06 Linepack Loss is ~25 mmcf/d

Lowest Pressures:
None

Linepack Loss:
Blythe
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

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

*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:
Storage Withdrawal Rate

Compare Historical Withdrawals to Max WD Rate

S05 includes Aliso

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
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 mmcf/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

– Increasing HR injection decreases WR inflow

Desired Configuration Using WR+HR

Sub-optimal Configuration Partial HR use
Future Methodology
Gas Pipeline Control Analytics

• **Input: static network model**
  – Junctions (nodes)
  – pipes (edges)
  – compressor stations (controllers)
  – custody transfer meters (at nodes)

• **Output: physical solution**
  – Pressures & flows through the pipeline
  – Compressor control (discharge pressure)
  – **Regulator control (downstream pressure and/or flow)**

• **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: 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

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