PG&E Safety Valve History and Risk Assessment

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Together, Building
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Agenda

- Gas Storage Landscape in Northern California
- PGE Gas Storage Fields
- PG&E History of Subsurface Safety Valves
- PG&E Risk Mitigation

Gas Storage Landscape in Northern California

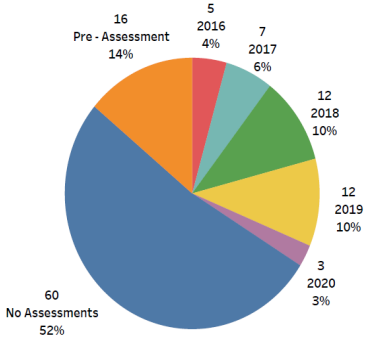
- PG&E-owned
- Independent Storage Provider (ISP)
- Joint ownership[1]

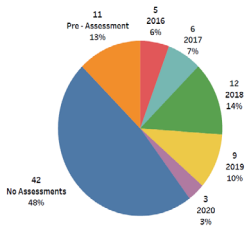
[1] PG&E has 25% ownership in Gill Ranch

PG&E Storage Supports the Natural Gas System by:

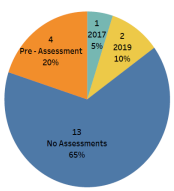
- ❑ Providing pipeline balancing
  - Inventory management
  - Reserve capacity
- ❑ Meeting core customer obligations
- ❑ Meeting non-core customer obligations

Casing Assessment Status

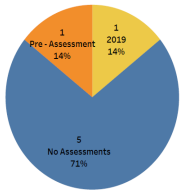




McDonald Island



Los Medanos

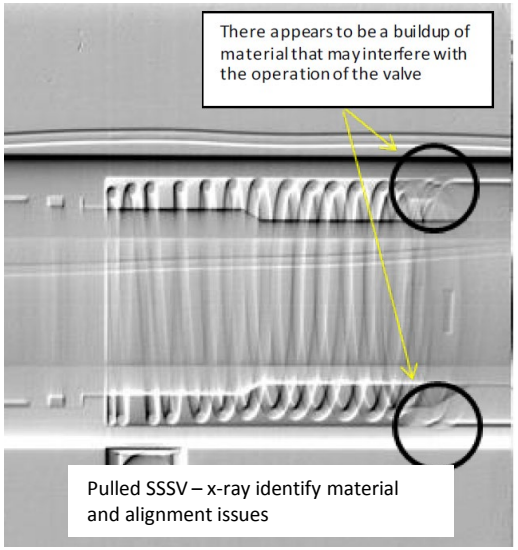


Pleasant Creek

PG&E Gas Storage Facilities

- PG&E operates 3 underground gas storage facilities
  - Los Medanos
  - McDonald Island
  - Pleasant Creek
- Majority of wells directionally drilled

Pulled SSSV – not reusable once pulled



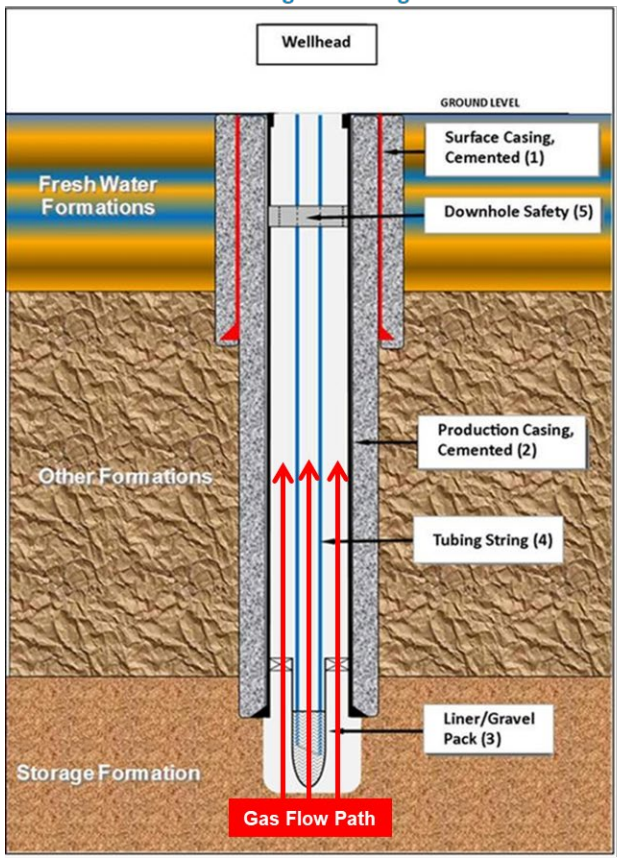
Pulled SSSV – x-ray identify material and alignment issues

Field	Discovery Year	In Service Year	Avg Depth	Max Field Pressure (psig)	Number of wells with SSSV	Number of Active Wells
McDonald Island	1936	1975	5200	2070	68	86
Los Medanos	1958	1973	4100	1600	18	19
Pleasant Creek	1948	1960	2800	1250	0	6

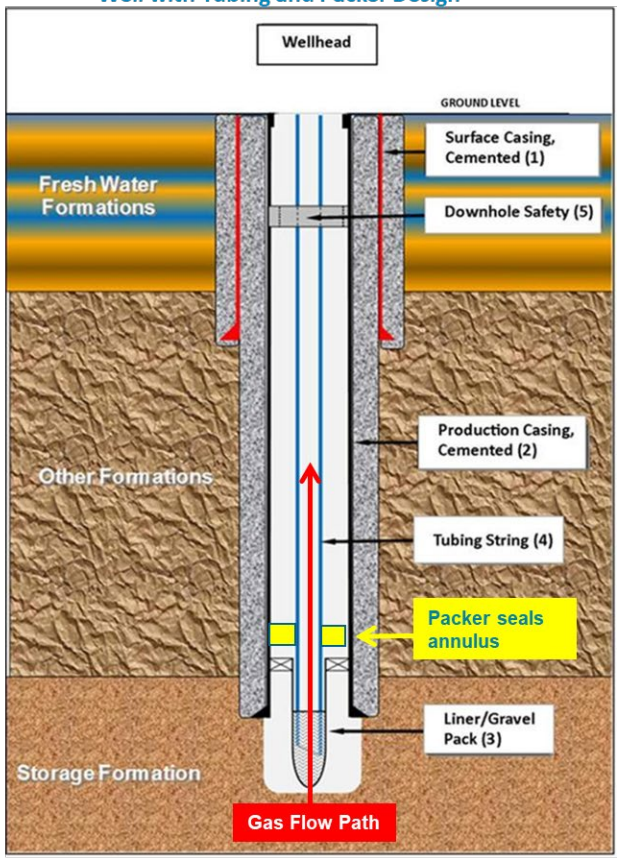
PG&E Typical Storage Well Gas Flow Without Packer and with Packer

- Wells at MDI and LM located on pads (25-150 foot from well to well)
- Many wells directionally drilled from pad
- Wells completed with gravel pack and liner and no tubing set on a packer (see below figures)
- All wells converted to tubing and packer by end of 2025 and baseline assessed

Well with Tubing and Casing Flow

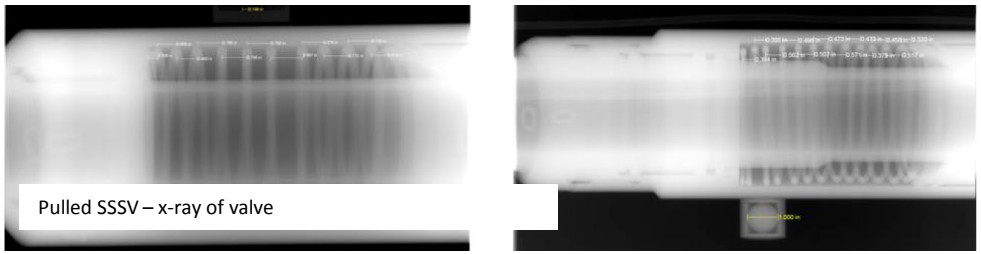


Well with Tubing and Packer Design



PG&E History of SSSV Valves

- 1960 Pleasant Creek in service storage – no incidents
- 1973 Los Medanos in service storage – no incidents wells on ~150 ft spacing
- 1974 MI 14W blowout for 14 days until relief well drilled during field development
- 1975 MDI in service storage wells on ~25 foot spacing
- Following 1974 event
  - Los Medanos and MDI equipped with tubing and casing SSSV at approximately 250 foot below ground level
  - MDI fire system built to provide partial water curtain at platforms
- Valve designs have changed with time to improve reliability of the SSSV
  - Cause of failure
    - Seal or seat is worn due to usage or particulates in flow stream
    - Controller mechanism is not functioning properly
    - Not Maintained properly (appears to be relation to exercising valves frequency)
  - 2015 redesign of casing SSSV to change material and seat to improve reliability and deployed in 2016-18
  - 2018 redesign of SSSV due to installation of tubing and packer and deployed in 2019



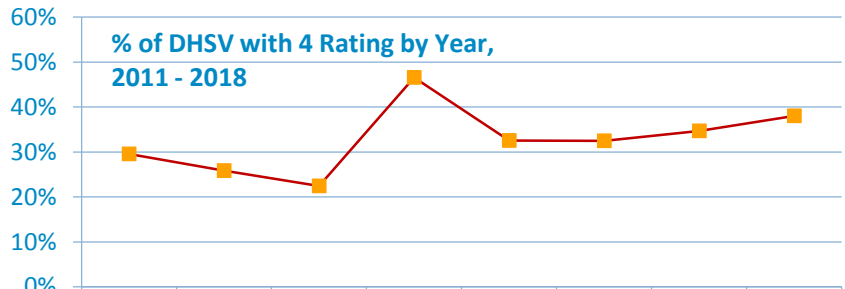
Pulled SSSV – x-ray of valve

PG&E History of SSSV Valves

- 2014-15 PG&E completed Qualitative Risk Analysis to understand risks associated with SSSV
  - Study concluded a slight increase of risk due to installation of SSSV
  - Risk associated with increase in personal in proximity to wells to replace SSSV or conduct other maintenance and inspection.
- 2013-present
  - Casing integrity inspection program has identified mechanical induced defects as a result of prior years SSSV or liner replacement every 7-12 years
  - 2018 Design took into considerations that would reduce well work.
- Testing and Inspection – Functional and Leak-By testing been part of the operations (followed testing as include API practices)
  - Beginning in 2019 rating system to include category can’t blowdown during leak-by testing.
  - Internal discussion on historical results in assessing valve reliability and risk assessments in the future with new SSSV design for tubing and packer.

PG&E History of SSV Valves (Inspection/Testing Results)

Rating	Condition
0	No Leakage
1	1 - 100 psig
2	101 - 200 psig
3	201 - 300 psig
4	301 psig or higher



	2011	2012	2013	2014	2015	2016	2017	2018
Percentage of DHSV with 4 Rating	30%	26%	22%	47%	33%	32%	35%	38%
Number of DHSV with 4 Rating	26	23	20	41	29	25	26	27

2018 Year-End Safety Valve Condition Results

	DHSV			UHSV			
	MI	LM	Total	MI	LM	PC	Total
# Valves Available for Testing	52	19	71	126	38	14	178
4 Rating	22	5	27	16	2	0	18
% of Total	42%	26%	38%	16%	7%	0%	3%
# Replacing in 2019	8	1	9	9	1	0	10
# Removing/Abandoning in 2019	0	2	2	9	3	2	14
2019 Target (% of 4 Rating to Total # of Valves)	30%	10%	25%	<5%	<5%	0%	6%

Source: PG&E 2019 Storage Asset Management Plan

PG&E Risk Mitigation
Asset Management and History

Risk Management is built into PG&E's Gas Operations Asset Management Program and consists of four steps.

- Integrity Asset Treat Categorization
- Risk Identification and Evaluation
- Risk Response
- Risk monitoring and reporting

Evaluations of each of these is performed annually by each asset family. Evaluates impacts to Safety, Environment, Compliance, Reliability, Trust, and Financial with consideration of frequency for P95 events.

Asset Type	Partial Listing of Potential Threats or Hazards
Wells	Corrosion/Erosion, Manufacturing, Equipment
	Construction/Fabrication
	Incorrect Operations (O&M)
	Incorrect Operations (Well Intervention)
Reservoir	Construction/Fabrication, 1st, 2nd, 3rd Party Damage
	Outside Forces (geologic uncertainty)
	Incorrect Operations (Reservoir Fluid Compatibility Issues
Surface	1st, 2nd, 3rd Party Damage (Surface Encroachments)
	1st, 2nd, 3rd Party Damage (Damage to Equipment)
	Weather & Outside Forces (Natural Causes)

Gas storage Asset Family Threat and Hazard Evaluation categories based on ASME B31.8 and API RP 1171

2012
- PG&E initiates Well Integrity Management Program

2013
- PG&E develops Asset Management Programs
- Development of First well Risk Model

2014
- PG&E receives PAS 55 and ISO 55001 certifications

2015
- API RP 1171 is published

2016
- PG&E publishes first Integrity & Risk Management Plan

2017
- PG&E publishes revision to Integrity & Risk Management Plan
- Evaluate downhole tools

2018
- R&D and evaluation of downhole Tools

2019
- PG&E publishes Implementation plan to convert to tubing & packer
- Ran thru tubing inspection tools
- Release revised well Risk Model

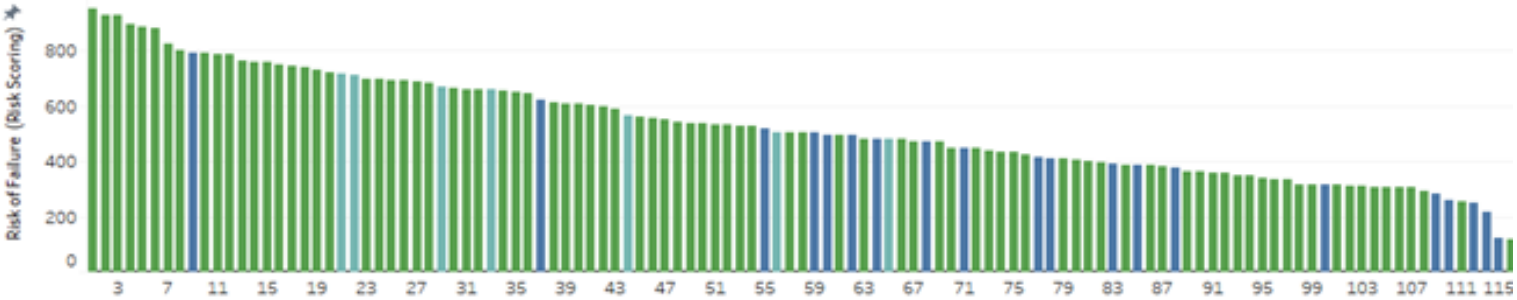
Today
- Completion of year 1 or 7 to convert to tubing & packer.
- Evaluating thru tbg inspection tools and other R&D

Reservoir Modeling – Well Risk Ranking 2019 Profile

Mitigation Prioritization (Preventive and Mitigative Measures Work)

- Relative Risk Ranking model informs the prioritization
- Preventive and Mitigative measures results used to determine the likelihood and consequence used within the risk model
- Tubing & Packer and Safety Valve Installations incorporated into risk model along with operating conditions of Safety Valve
- The Relative Risk Ranking has informed the work plan since 2014
- Model under went revisions in 2019 to eliminate any one input from dominating risk scores
- Know unknown conditions are scored and incorporated into scoring (for example as well that has not been inspected downhole may have a higher scoring than a well that has been inspected and no anomalies found)

Overall Risk Ranking



Likelihood Score Components

- *Natural Forces Impact
- *Monitoring Condition Impact
- *Tubing Condition Impact
- *Casing Condition Impact
- *Adjusted Reworks Impact
- *Usage Factor Impact
- *Wellhead Security Factor

Consequence Score Components

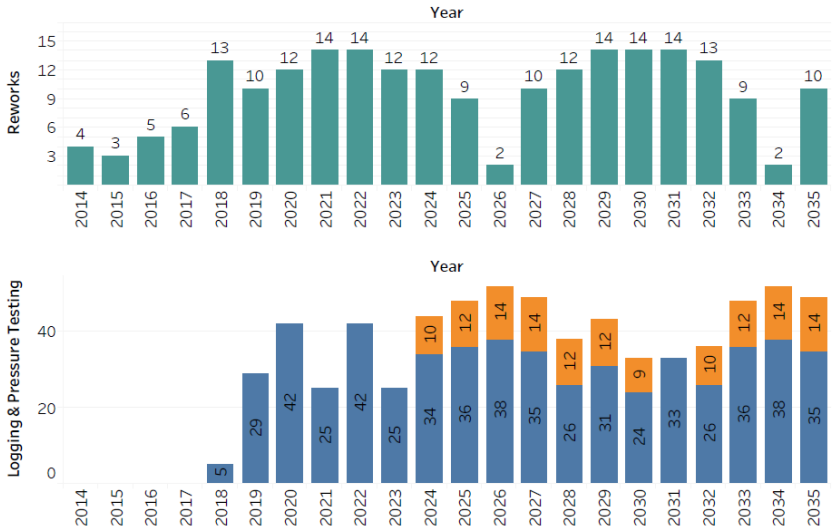
- *Rate Impact
- *Well Operation Impact
- *Proximity Factors
- *Valve Factor Impact*
- *Configuration Impact*

PG&E Risk Mitigation and the Changing Risk

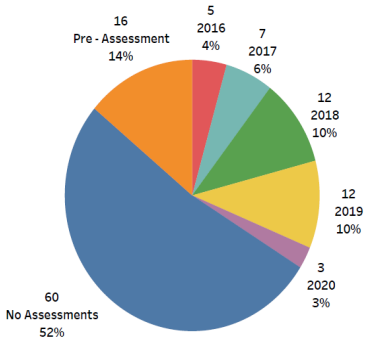
- The primary risk mitigations include completion of a baseline casing inspection on all wells and the elimination of the single point of failure by converting the design configuration of all wells to tubing and packer by the end of 2025
- Although the assessments mentioned above are proactive measures to identify incipient integrity issues, they also introduce a level of operational risk as there is inherent risk every time a tool is introduced in the well with a potential for mechanical damage to the casing
- 3 to 4 fold increase in well reworks and inspections per year
- Well reworks and inspection schedule informed by the results of Integrity Management's risk model
- Additional reduced risk exposure through Plugging and Abandonment (P&As) and decommissioning
- Active R&D to continue finding inspection technology that reduces operational risk (fiber optic, guided wave)

Key Risk Metric Performance

Integrity Management – Compliance Work Units



Casing Assessment Status All Fields



Notes

Mitigation Status:

- All programs are on track
- 2020 compliance work started in Q4 2019

Notes:

1. Future outlook rework units include allotment for potential break-in work of 2 units per year and assumes Division acceptance of PG&E's proposed re-inspection frequency
2. Pressure testing and thru-tubing inspection are high risk activities

Wrap Up

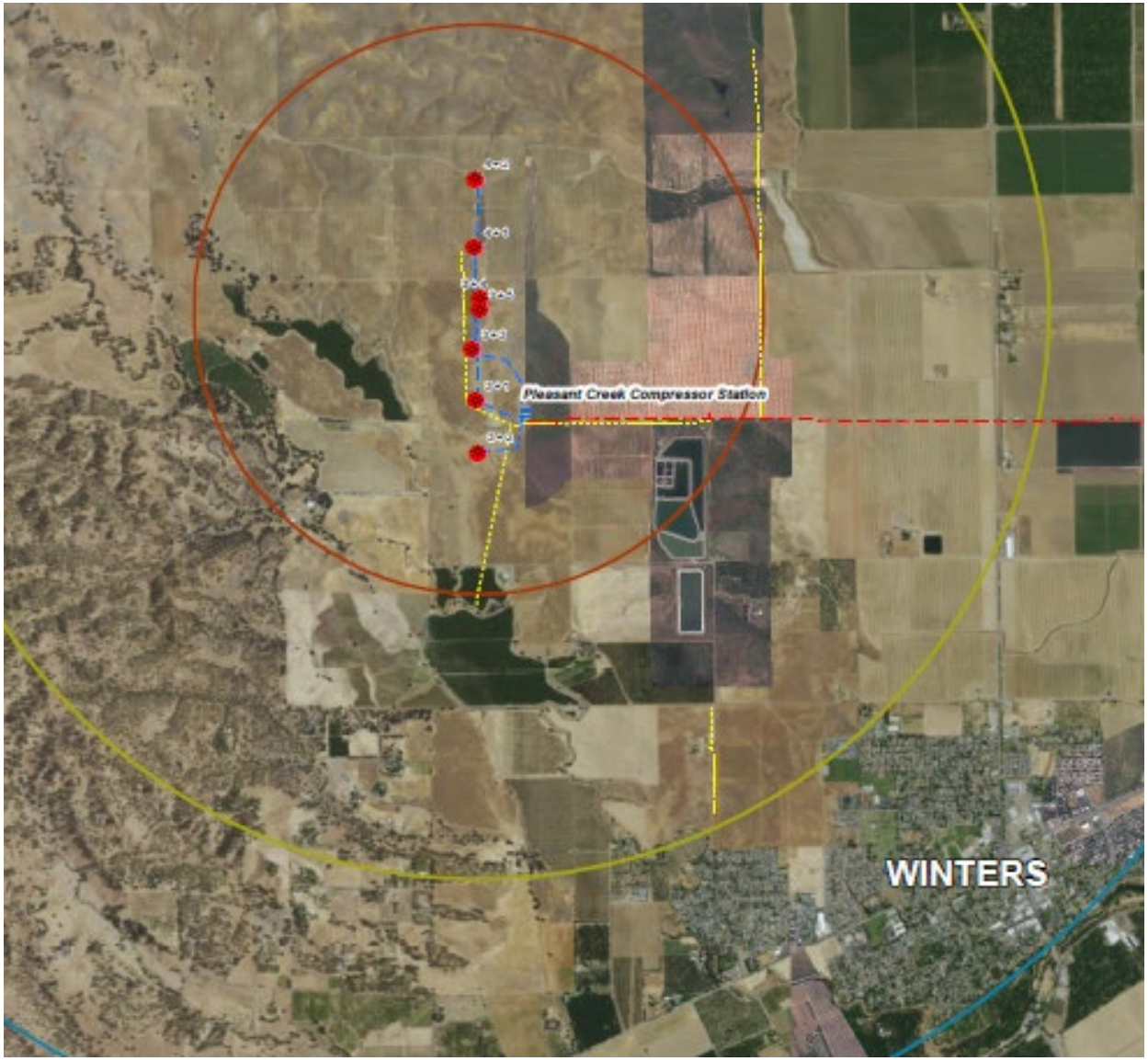
Questions?

Appendix

Field Maps

McDonald Island Overview

McDonald Island – Turner Cut & Whiskey Slough

Los Medanos Overview

Pleasant Creek Overview