



ResFrac Tutorial – Enhanced Geothermal Systems (EGS)

Support@resfrac.com

September 4, 2026

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Background - EGS and ResFrac Geothermal Models

Outline

- Recent EGS advances
- Classical vs. modern EGS designs
- Reservoir modeling objectives
- EGS Resources

Geothermal: A new era of opportunity

The New York Times

There's a Vast Source of Clean Energy Beneath Our Feet. And a Race to Tap It.

The United States has enough geothermal energy to power the entire country. Some are trying to unlock it by using techniques from the fracking boom.



A drilling rig used by Fervo Energy outside Milford, Utah. The geothermal start-up aims to extract heat from underground granite to produce electricity. Brandon Thibodeaux for The New York Times

By Brad Plumer
Brad Plumer traveled to Beaver County, Utah to visit geothermal projects there and spoke with dozens of people involved in the industry.
Aug. 28, 2023

The Economist

Menu Weekly edition The world in brief Search

Science & technology | Hot stuff

Geothermal energy could outperform nuclear power

Tricks from the oil industry have produced a hot-rocks breakthrough



Fervo secures \$206m for Cape Station development



Construction at the Cape Station project site, Beaver County, Utah (source: Fervo Energy)



Alexander Richter
11 Jun 2025

Fervo Energy secures \$206 million in new financing to accelerate its Cape Station EGS project following key technical milestones and high-level site visits.

JPT JOURNAL OF PETROLEUM TECHNOLOGY

Fervo and FORGE Report Breakthrough Test Results, Signaling More Progress for Enhanced Geothermal

Recent geothermal tests in Utah show major advancements in flow rates and efficiency, bringing enhanced geothermal systems closer to commercial viability.

September 16, 2024 By Trent Jacobs
Journal of Petroleum Technology

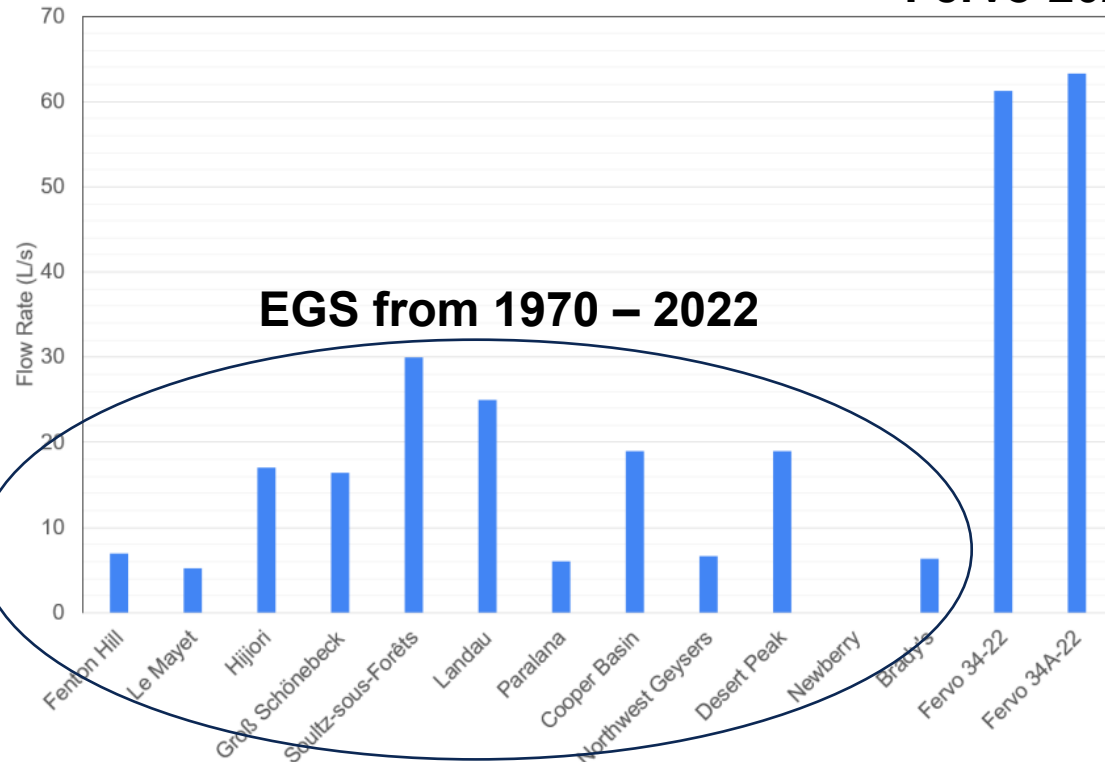


A geothermal well test at the Utah Frontier Observatory for Research in Geothermal Energy (FORGE) site. Source: Utah FORGE

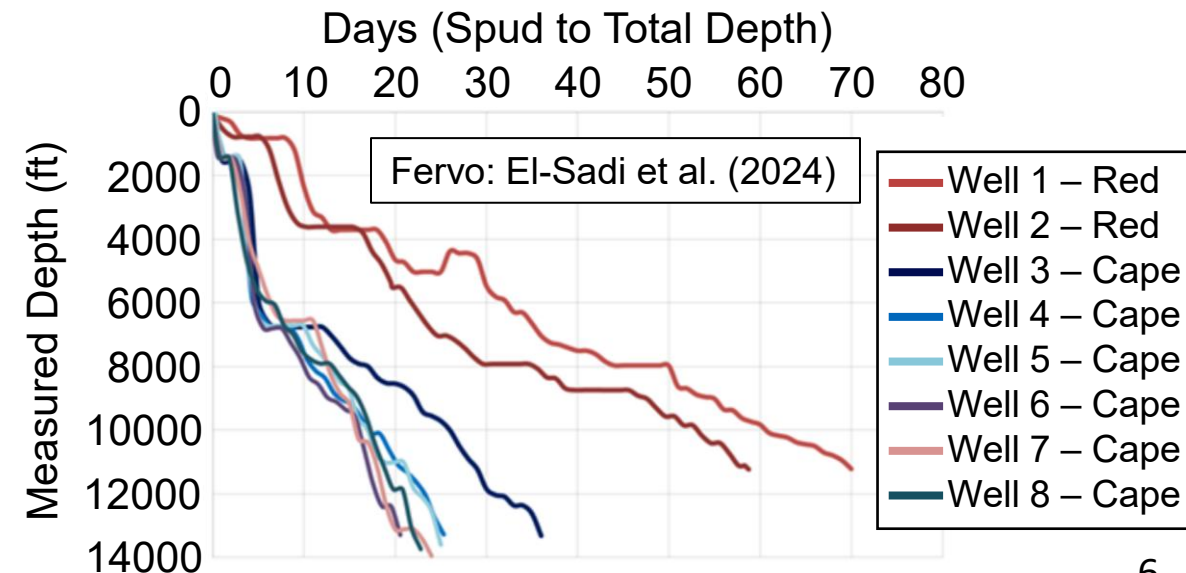
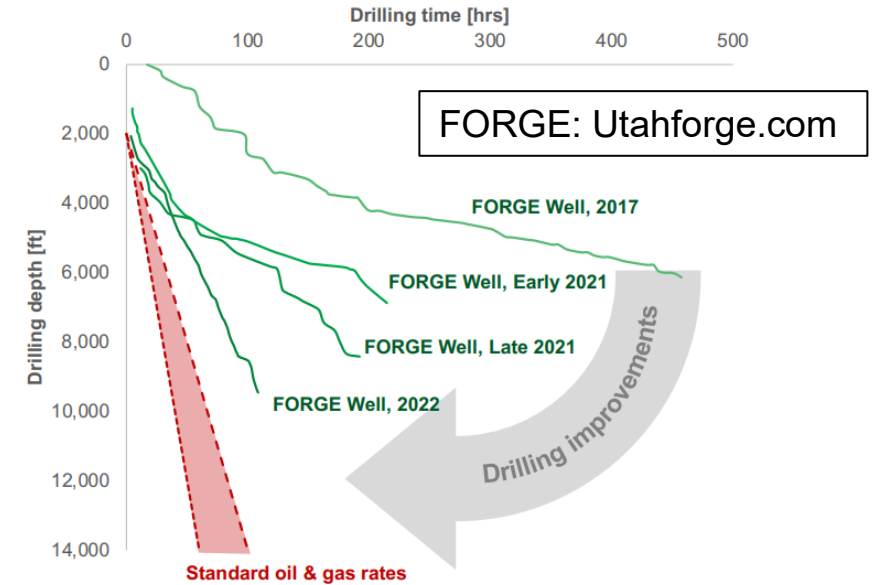
Huge, rapid improvements for Enhanced Geothermal Systems

- Multistage hydraulic fracturing has proven extraordinarily successful at stimulating geothermal wells, just like O&G.
- Geothermal well drilling has grown much closer in cost parity with O&G. **Fervo 2024**
- This resource is virtually unlimited in size, though mostly limited to the western half of the U.S. with current tech.

Fervo 2023

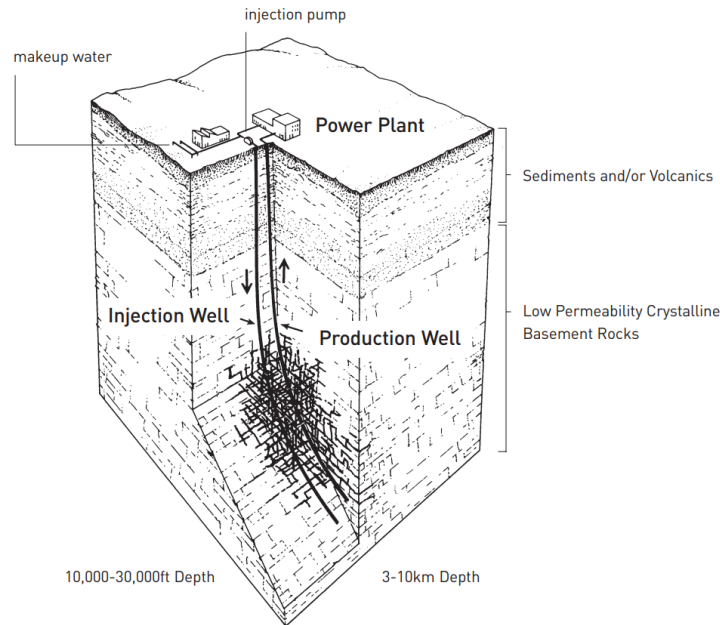


Norbeck and Latimer (2023)



Modern EGS designs leverage O&G developed technology

Classical EGS designs focused on near-vertical wells, shear stimulation, no proppant, open-hole completions and no multi-stage fracturing. Poor performance obtained and several challenges encountered including early thermal breakthrough, too much or too little connectivity, too few discrete flow paths and induced seismicity



Tester et al. (2006)

Modern EGS designs consider long horizontal laterals, multi-stage hydraulic fracturing, cased wellbores, plug-and-perf completions with limited entry design and proppants. Initial results indicate large number of flow paths are created and high circulation flow rates are achieved

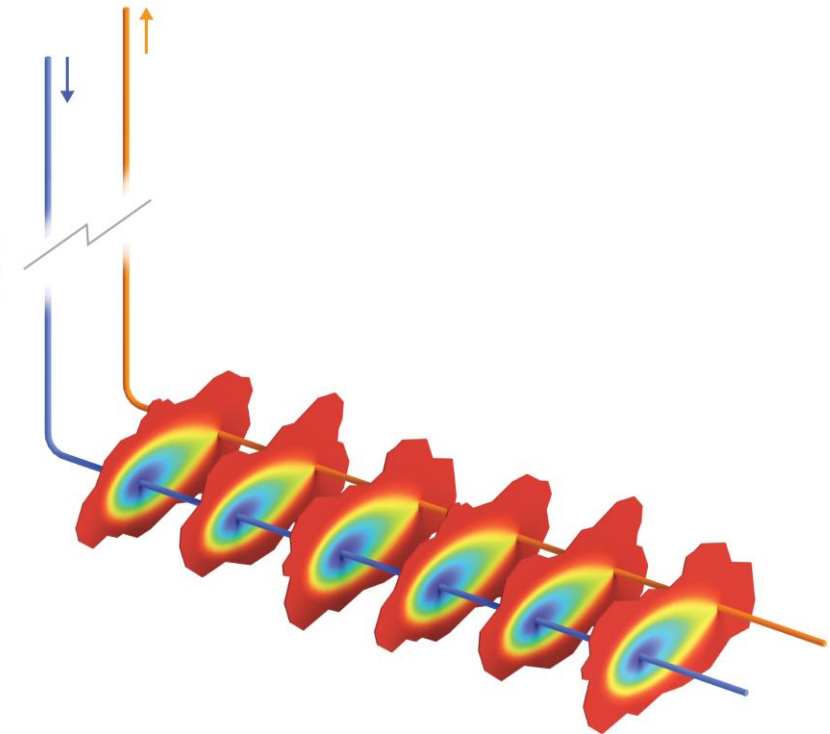
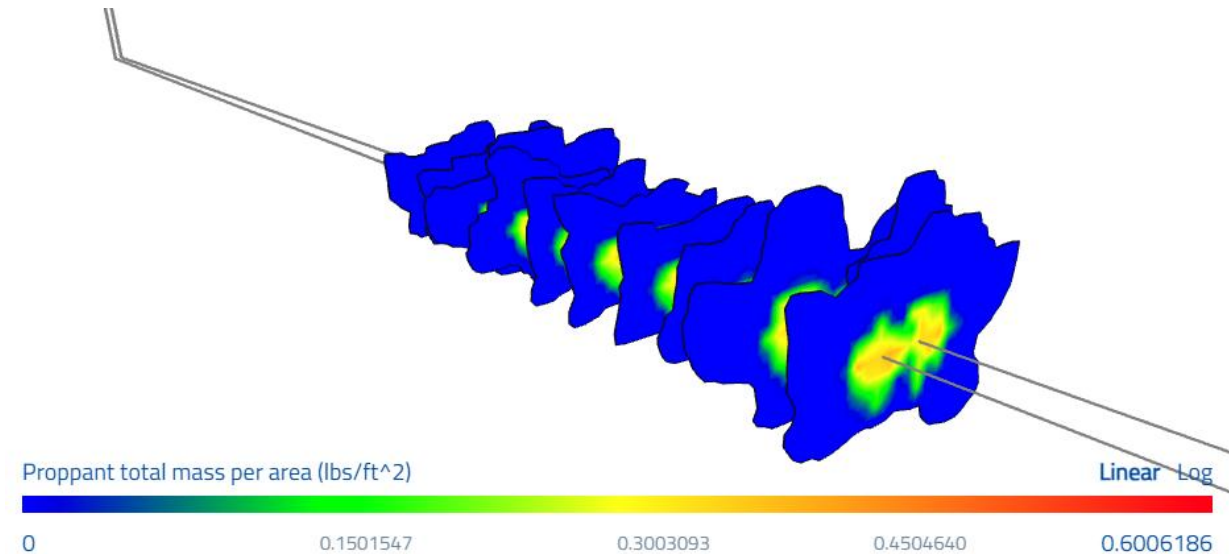
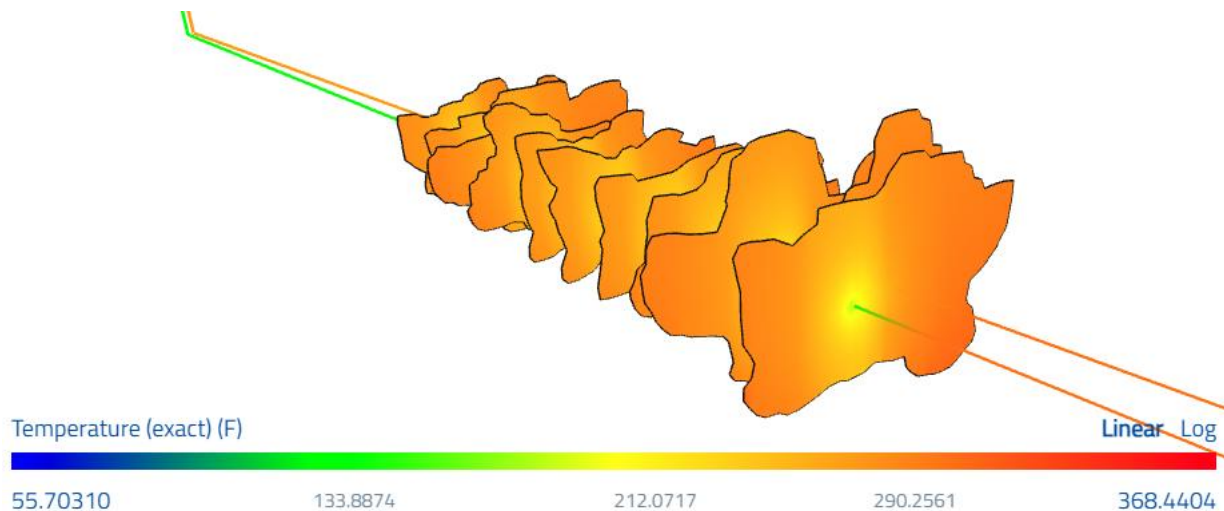
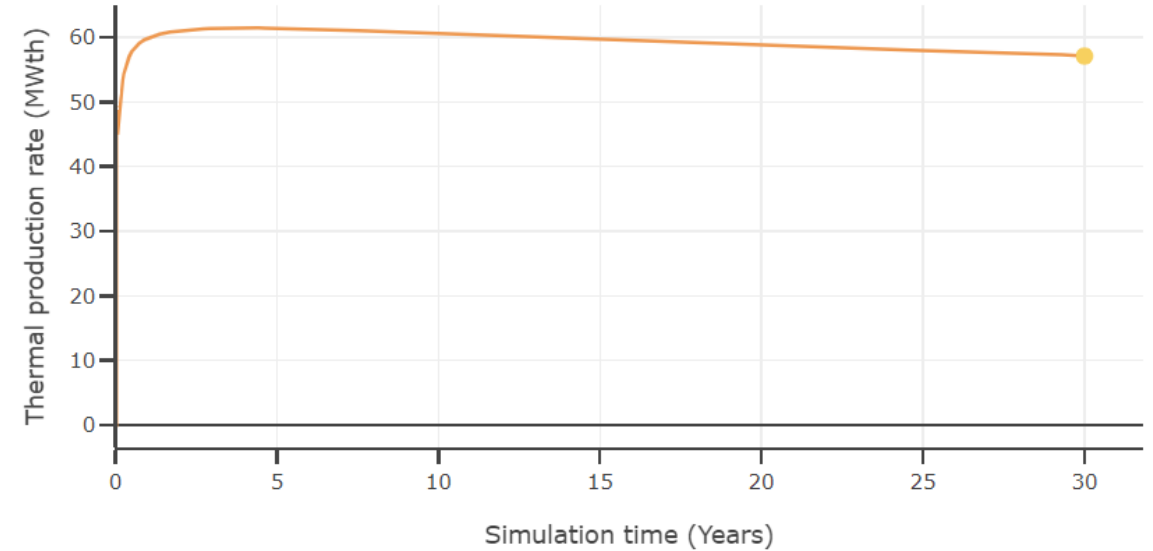


Photo Credit: DOE/NREL

Why we simulate: Optimizing geothermal well fields, frac jobs, and economics

EGS reservoir modeling helps answer key questions:

- What is the expected rate of thermal decline over time?
- How long should the laterals be, and how many stimulation stages are optimal?
- What is the optimal spacing between wells?
- How much fluid and proppant should be injected during stimulation?
- What are the projected gross and net electricity outputs?
- Is the project economically viable — will it make money?



EGS Resources



URTeC: 4245311

SPE-209186-MS

Optimization and Design of Next-Generation Geothermal Systems Created by Multistage Hydraulic Fracturing

Mark McClure, Charles Kang, and Garrett Fowler, ResFrac Corporation

Copyright 2022, Society of Petroleum Engineers DOI 10.2118/209186-MS

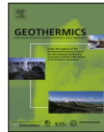
This paper was prepared for presentation at the SPE Hydraulic Fracturing Technology Conference and Exhibition, The Woodlands, Texas, USA, 1 - 3 February 2022.



Contents lists available at ScienceDirect

Geothermics

journal homepage: www.elsevier.com/locate/geothermics



Thermal breakthrough calculations to optimize design of a multiple-stage Enhanced Geothermal System

Tianyu Li, Sogo Shiozawa, Mark W. McClure*

The University of Texas at Austin, Department of Petroleum and Geosystems Engineering, 200 E. Dean Keeton, C0300, Austin, TX 78704, United States



Contents lists available at ScienceDirect

International Journal of
Rock Mechanics & Mining Sciences

journal homepage: www.elsevier.com/locate/ijrmms



An investigation of stimulation mechanisms in Enhanced Geothermal Systems

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^a Petroleum and Geosystems Engineering, University of Texas at Austin, Austin, TX, USA

^b Energy Resources Engineering, Stanford University, Stanford, CA, USA



Designing the Record-Breaking Enhanced Geothermal System at Project Cape

Ankush Singh^{*1}, Gerame Galban², Mark McClure¹, Kat Briggs², Jack Norbeck²
1. ResFrac Corporation, 2. Fervo Energy.

Copyright 2025, Unconventional Resources Technology Conference (URTeC) DOI 10.15530/urtec-2025-4245311

This paper was prepared for presentation at the Unconventional Resources Technology Conference held in Houston, Texas, USA, 9-11 June 2025.

PROCEEDINGS, 49th Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, February 12-14, 2024
SGP-TR-227

Numerical Modeling of Hydraulic Stimulation and Long-Term Fluid Circulation at the Utah FORGE Project

Mark W. McClure¹, Rohan Irvin¹, Kevin England², and John McLennan³

¹ResFrac Corporation, www.resfrac.com

²E-K Petro Consulting LLC

³University of Utah



Topics ▾ D:

GEO THERMAL

Why Multistage Stimulation Could Transform the Geothermal Industry

Flow rate is a major challenge for geothermal. However, the techniques used in shale to prevent flow localization can be applied directly to geothermal. If we can create hundreds or thousands of flowing fracture pathways around a horizontal or deviated geothermal well, then we will have truly "changed the game."

October 1, 2021 By Mark McClure
Journal of Petroleum Technology



GRC Transactions, Vol. 45, 2021

A Feasibility Study on Three Geothermal Designs: Deep Closed-Loop (with and without Conductive Fractures) and Open-Loop Circulation Between Multifractured Laterals

Garrett Fowler, Mark McClure

ResFrac Corporation

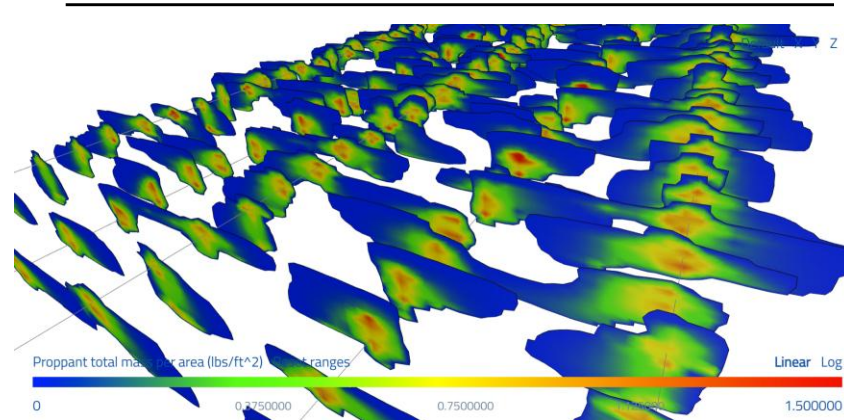
Overview – ResFrac Workflow

Outline

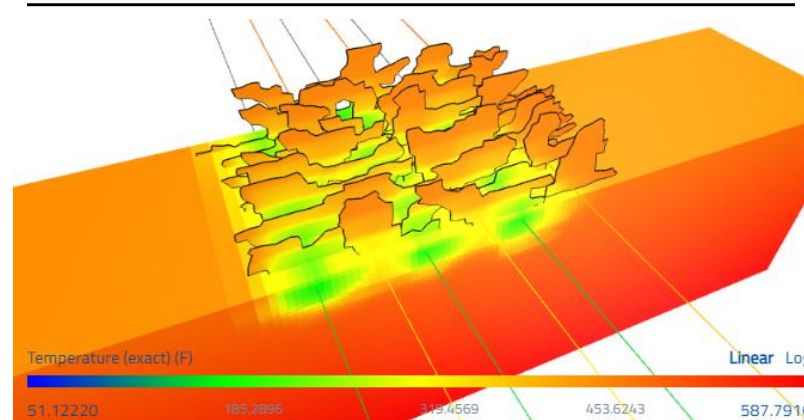
- ResFrac introduction
- ResFrac geothermal applications
- ResFrac EGS example results
- ResFrac geothermal model inputs
- EGS special modeling considerations

ResFrac simulates the entire lifecycle of the wells and reservoir in a single, comprehensive simulation

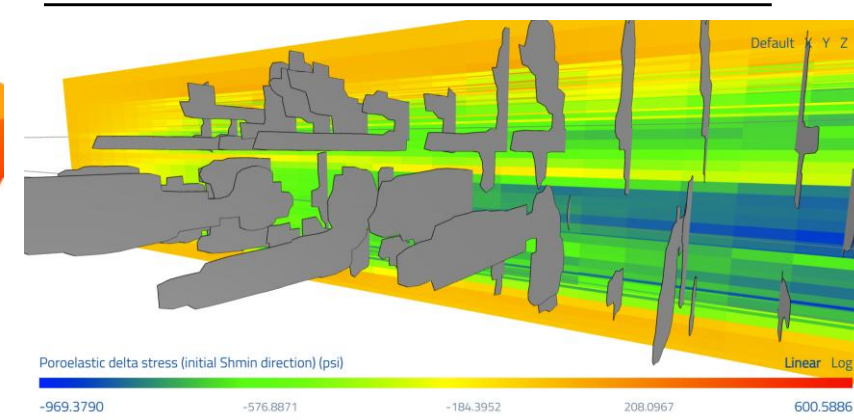
Proppant total mass per area (lbs/ft²)



Temperature (°F)



Poroelastic Stress Change (psi)



Fracture Propagation

3D Fracture Initiation & Propagation
Proppant Transport in Fracture & Distribution

+

Wellbore, Matrix and Fracture Flow and Heat Transfer

Full Compositional & Fluid Characterization

+

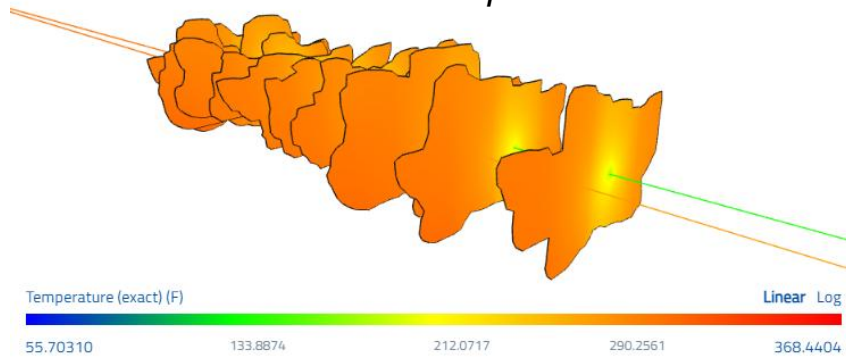
Geomechanics

Poroelastic Stress
Thermoelastic Stress

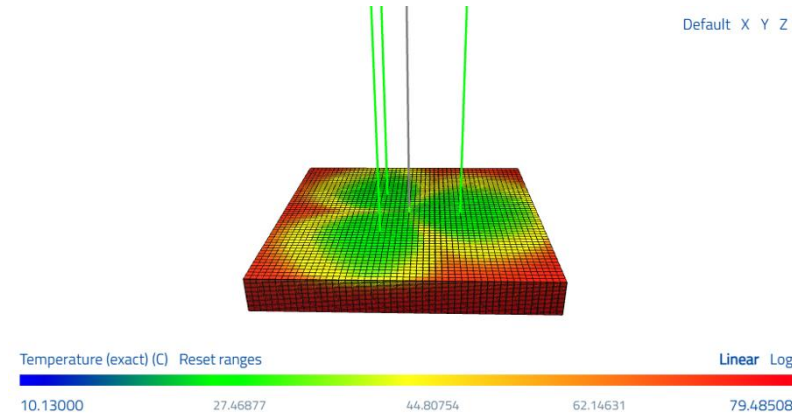
Various geothermal applications can be simulated with ResFrac

EGS

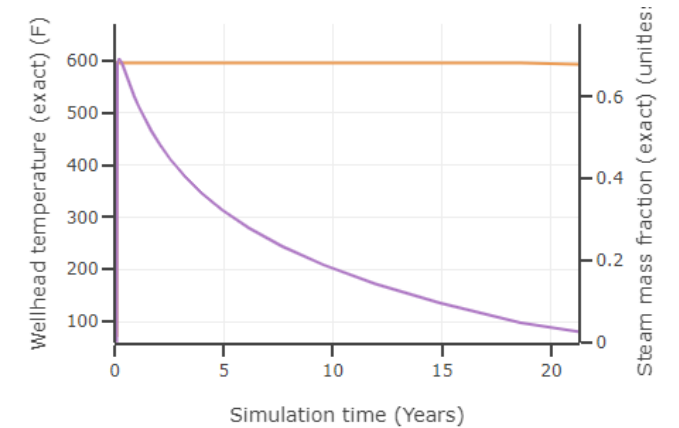
Template available



Dual Porosity Systems

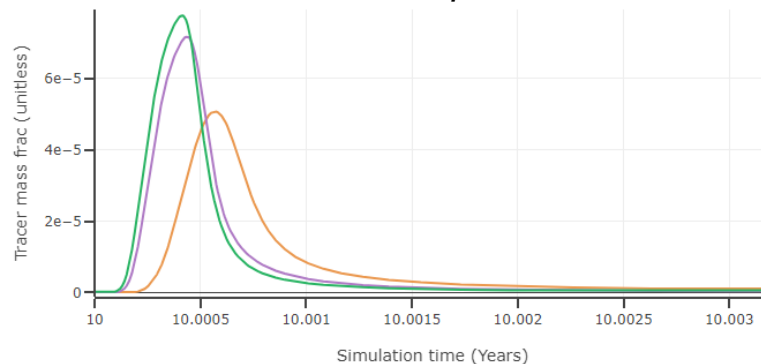


Superhot Geothermal

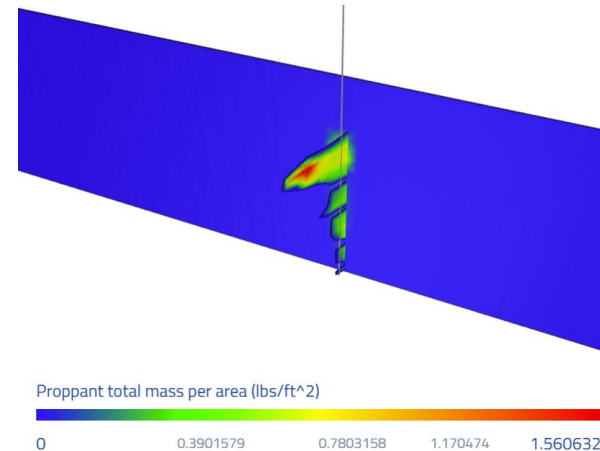


Tracer Response

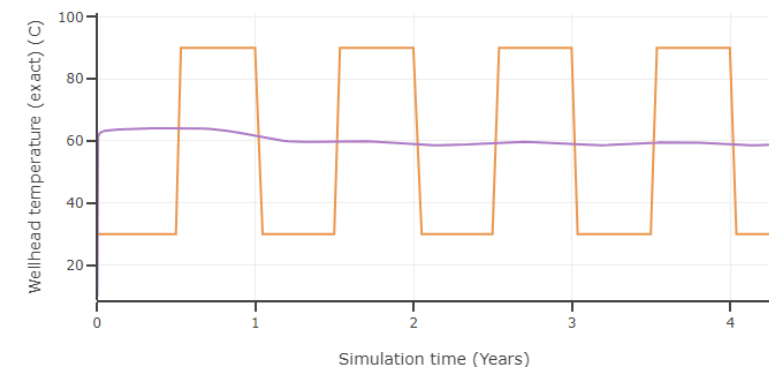
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Hydraulic Fracturing in Conventionals

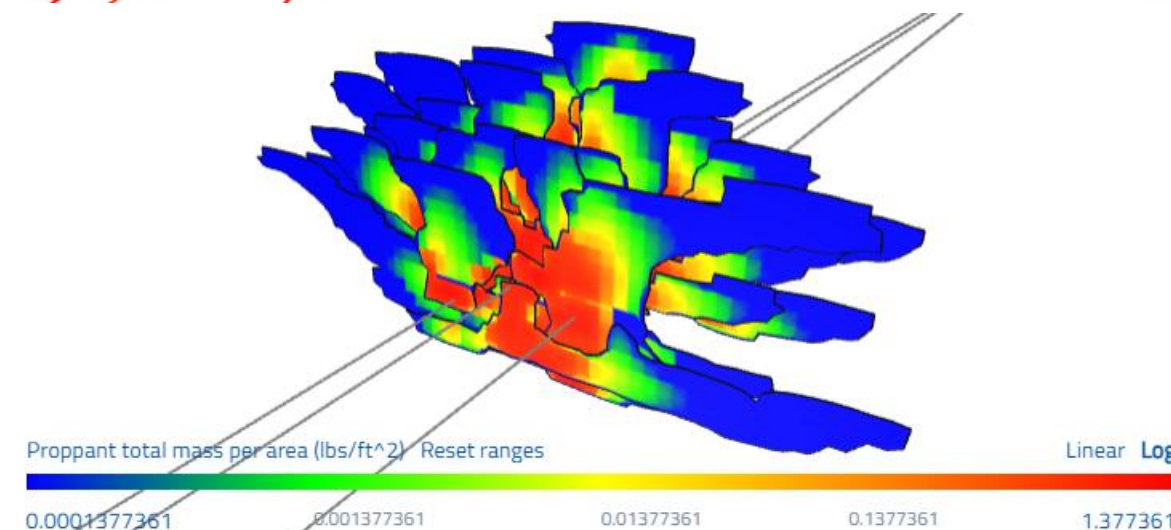
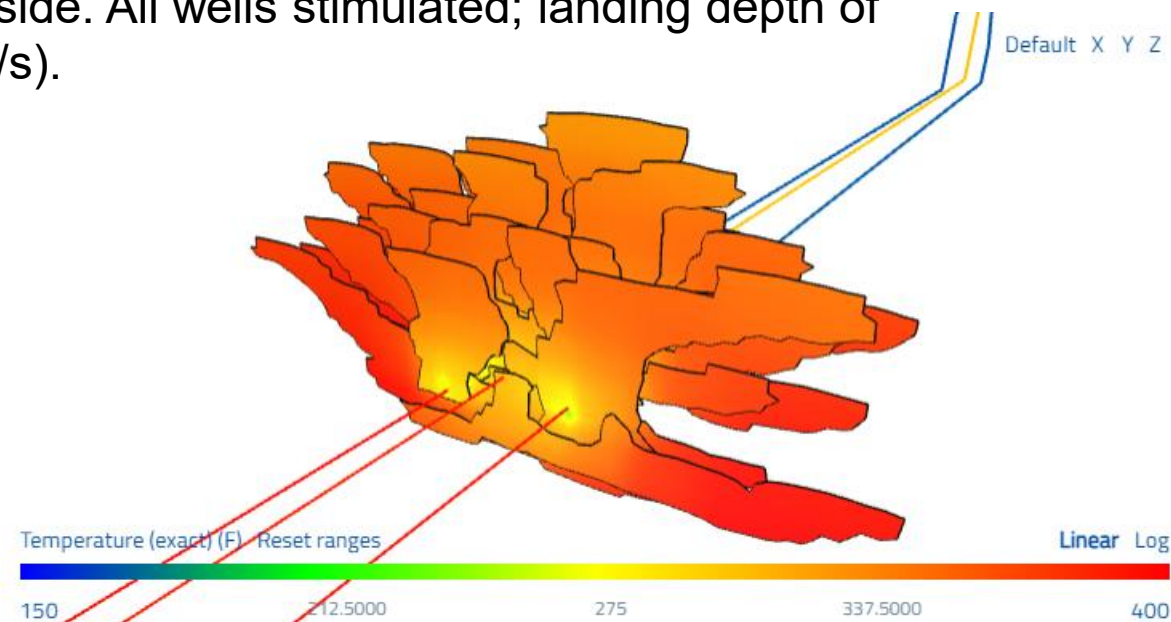
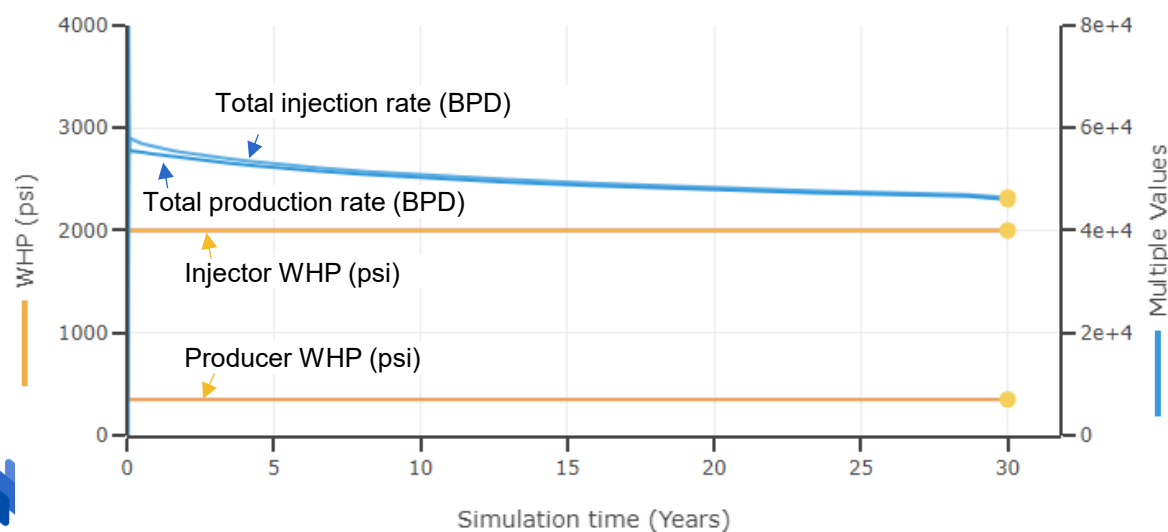
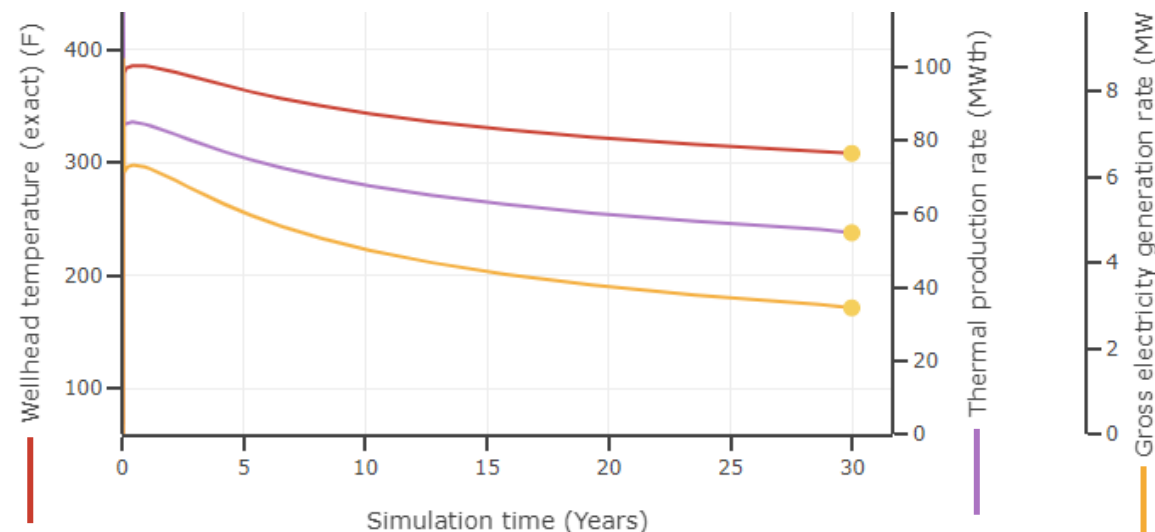


Seasonal Thermal Energy Storage



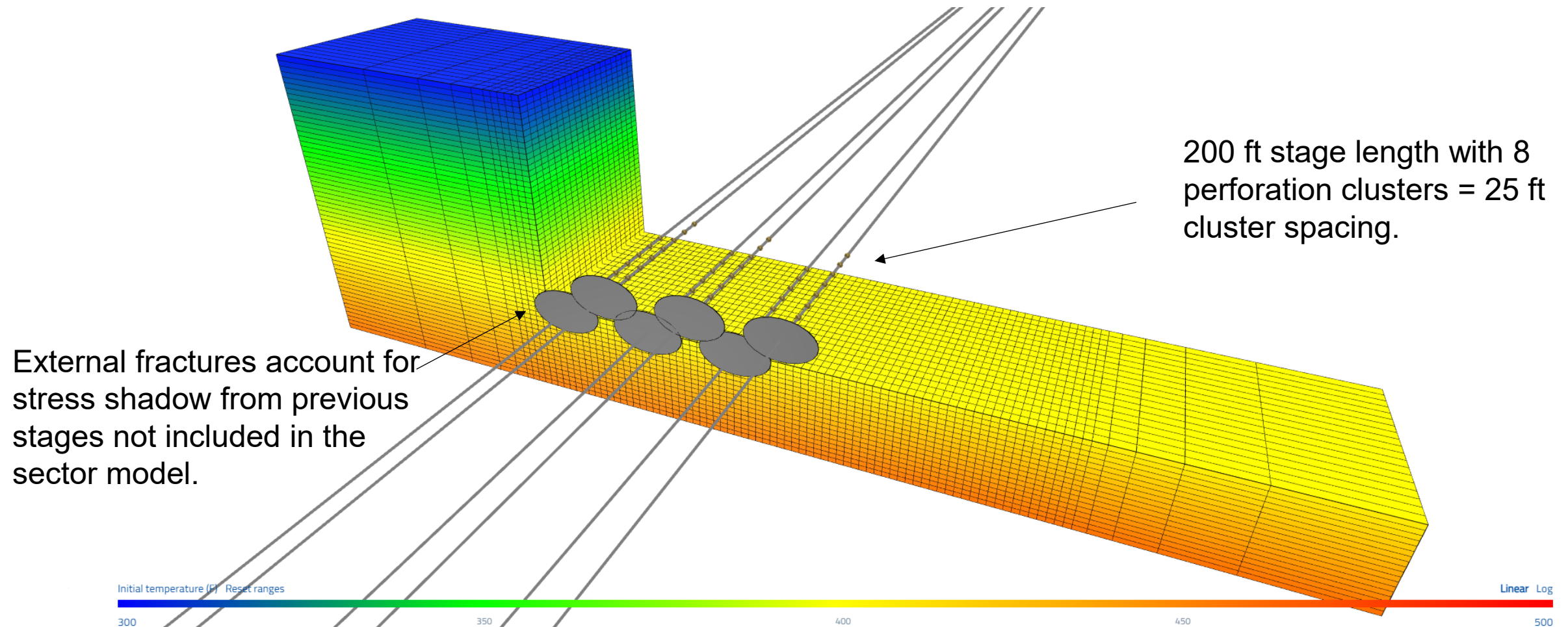
ResFrac EGS example

3-well model with central producer and injectors on both side. All wells stimulated; landing depth of 7,500 ft at 390°F. Production rate of ~50,000 BPD (~90 L/s).



ResFrac's approach: sector model scaled up to full reservoir

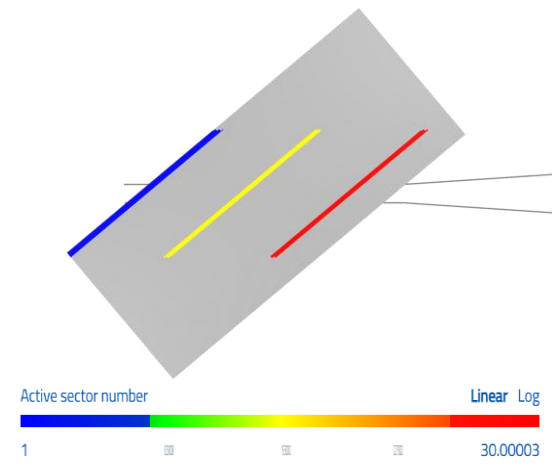
- Simulate only one or a few stages instead of the full lateral to save on computational time
- Stages are often identical, and external fractures can account for previous stages
- Well flow scalars allow you to simulate full flow rate in injection and production wells



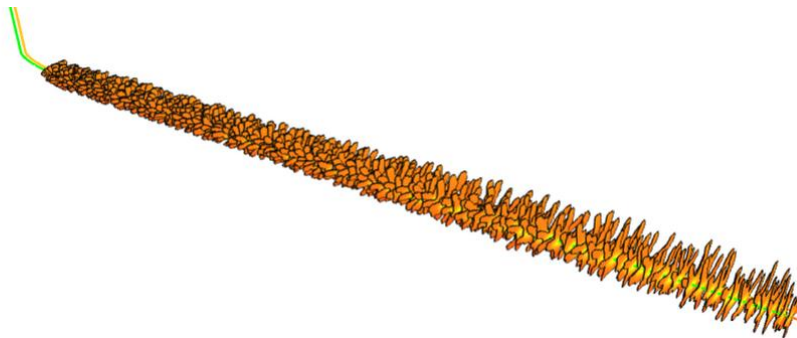
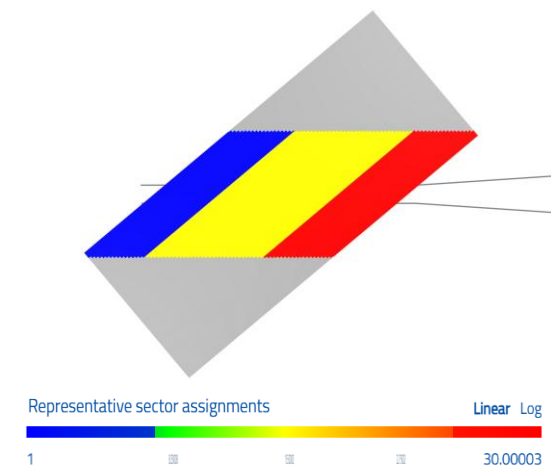
ResFrac's multi-sector option

- ResFrac's new multi-sector option allows you to join multiple sectors into a single full lateral model
- This functionality may be used to assess geologic or design variabilities along the laterals
- Start with a single sector approach for computational efficiency
- If interested, a separate multisector tutorial is available (this current tutorial is a pre-requisite)

Representative
sectors



Full lateral model



Key ResFrac model inputs for geothermal simulations (1/5)

- **Startup Panel:**

- Select “Thermal” for Thermal option in Startup Panel to include energy balance and heat transfer calculations in matrix, fractures and wellbores.
- Turn on thermo-elastic stress changes in the matrix if you want to include thermo-elastic effects (e.g., fracture propagation due to thermal stresses caused by cold water injection.)

- **Static Model and Initial Conditions Panel:**

- Specify rock properties required for thermal calculations: density, heat capacity, thermal conductivity, and, if including thermo-elastic stress changes in the matrix, coefficient of linear expansion.
- Specify surface temperature and initial reservoir temperature at reference depth. Alternatively, a temperature versus depth table can be provided under advanced options.

Thermal option ?

☐ Isothermal

☒ Thermal

☒ Thermoelastic stress changes in the matrix ?

Rock solid matrix density [lbs/ft ³] ?	Rock heat capacity [BTU/(lb-R)] ?	Thermal conductivity [BTU/(hr-ft-R)] ?	Coefficient of linear expansion [1/F] ?
156	0.24	1.45	0.000005

Surface temperature [F] ?
68

Initial temperature at reference depth [F] ?
400

Key ResFrac model inputs for geothermal simulations (2/5)

- **Curve Sets Panel:**
 - We don't require relative permeability curves but specifying pressure-dependent permeability (PDP) multiplier may be important to capture enhanced leak-off due to presence of natural fractures
- **Wells and Perforations Panel:**
 - Specify trajectory and completion design (open-hole or cased with perforations) for both injection and production wells in Wells and Perforations Panel.
- **Meshing Options Panel:**
 - Coarse mesh with 1D submesh algorithm is recommended for heat transfer calculation between matrix and fracture elements. Grid width should be approximately equal to cluster spacing in Shmin direction.
- **Fluid model Options Panel:**
 - Built-in water property correlations can be utilized, including steam correlations when modeling steam production. CO₂ as heat transfer fluid can be specified as compositional fluid.

Lower deltaP threshold for reversible permeability increase [psi] ?

Upper deltaP threshold for reversible permeability increase [psi] ?

Perm multiplier for reversible permeability increase ?

☒ 1D submesh calculation for fracture-matrix connections ?

Water viscosity and density calculation method ?

- ☐ Specify constant viscosity, constant compressibility, and reference density
- ☒ Correlations based on pressure, temperature, and salinity

☒ Use steam correlations ?

Key ResFrac model inputs for geothermal simulations (3/5)

- **Fracture Options Panel:**

- Contains key parameters including “Relative fracture toughness per square root fracture size” and “Effective fracture aperture conductivity factor”, which control fracture geometry and are tuned to match field data.
- Under advanced options, consider specifying a time for the “Symmetric fracture stress shadow boundary condition start time” to account for stress shadow from neighboring stages when modeling an EGS sector model with thermo-elastic stresses.

- **Proppants Panel:**

- No different than hydrothermal simulations. Specify proppant properties with k0 being the key parameter to history match flow rate versus pressure data from long-term circulation tests

- **Water Solutes Panel:**

- No different than hydrothermal simulations. Specify your slickwater or cross-link gel fluid properties here.

Relative fracture toughness per square root fracture size [1.0/ft^{1.5}]
0.1

☐ Scale toughness by larger dimension

Effective fracture aperture conductivity factor
0.4

Symmetric fracture stress shadow boundary condition start time [days]
15

	Name ?	Diameter of grains [mesh] ?	Density of grains [lbs/ft ³] ?	Proppant pack compressibility [psi ⁻¹] ?	k0 ?
1	40/70	55	165	0.0000758423302406	0.012
2	100	100	165	0.0000758423302406	0.0075

	Name ?	Type ?	Molar mass ?	Viscosity multiplier per 0.001 mass fraction ?	Power law exponent - n ?
1	Xlinkgel	Modified Power Law ▼	1000000	882.72	0.6
2	Xlinkgel_degraded	Inert Solute ▼	1000000		
3	Slickwater	Modified Power Law ▼	1000000	30	0.6

Key ResFrac model inputs for geothermal simulations (4/5)

- **Well Controls Panel:**

- Specify frac job design for each well, the injection conditions for the injectors (i.e., maximum WHP and injection rate) and production conditions for the producers (i.e., minimum WHP and maximum production rate).
- Use well flow scalers under Advanced Options to scale up sector model to full lateral model. Their start time should match the start time of long-term circulation.

- **Other Physics Options Panel:**

- Likely no changes need here. The parameter “Near-wellbore complexity erosion factor” may be useful to history-match treatment pressures

- **Numerical Options Panel:**

- Recommended to use the latest available Numerics version number.
- When simulating thermo-elasticity, recommended to turn on the parameter “Numerical options for long-term EGS circulation.”

Well_Prod ? ⚠ Well_Inj_1 ? ⚠ Well_Inj_2 ? ⚠

Number of Blocks: 3

Previous 1 Next

> 1. Injection Sequence	Start time: 0 Minutes	Duration: 182 Minutes	Number of controls: 16
> 2. Shut-in	Start time: 3.0333 Hours	Duration: 356.97 Hours	Number of controls: 1
> 3. General Constraint	Start time: 15 Days	Duration: (Blank) Days	Number of controls: 1

WELL FLOW SCALERS ? 📄

	Well name ?	MD [ft] ?	Flow multiplier ?	Start time [days] ?
1	Well_Inj_1 ▼	11600	28	15
2	Well_Inj_2 ▼	11600	28	15
3	Well_Prod ▼	11300	28	15

Numerics version number

122

⚙ ?

☒ Numerical options for long-term EGS circulation ⚙ ?

Key ResFrac model inputs for geothermal simulations (5/5)

- **Output Options Panel:**
 - Specify geothermal economic module to include calculating electricity generation, and economic metrics such as NPV and LCOE
 - Table with temperature-dependent power plant conversion efficiency can be provided
 - Review reference temperature for heat in place, enthalpy outputting and electricity generation
- **Advanced Options Panel:**
 - Input Selectors table allows to show/hide individual items in each panel. If certain geothermal input parameters or tables are not visible in the panels, they were likely turned off in this table.
 - User can manually select units for unit category in the Units table.

GEO THERMAL ECONOMIC MODULES ?

	Price of electricity [\$/kW-hr] ?	Tax and royalty rate ?	Optional net power plant efficiency ?	Lower cutoff temperature [F] ?	Up-front cost [\$] ?
1	0.1	0		300	0

Reference temperature for heat in place [F] ?

Reference temperature for enthalpy outputting [F] ?

☒ Calculate electricity output with respect to 'reference temperature for enthalpy outputting' ?

EGS – special modeling considerations (1 of 3)

- Because pore pressure in the fractures is much higher than what we see during primary depletion in a shale well, the fracture conductivity during circulation should be much higher (10s of md-ft to 100s of md-ft – this is a key modeling uncertainty that has a big effect on the performance of the system).
- EGS settings typically lack stress layering. Nevertheless, available data from granitic EGS applications suggest fracture geometries with fracture lengths that exceed height. This is the result of anisotropy in fracture toughness and/or vertical conductivity. This is a key modeling uncertainty that requires more data to help constrain.
- Reversible pressure dependent permeability needs to be carefully calibrated so that the matrix perm is elevated during stimulation but not during circulation as this can lead to overly optimistic results. Our testing has found that setting ‘lower deltaP threshold for reversible permeability increase (psi)’ to at least 500 psi, achieves this.
- *Coming soon:* flow control devices, which can help mitigate short-circuiting.

EGS – special modeling considerations (2 of 3)

- Set the global friction adjustment factor to 1.0. Friction in the well during long-term circulation is important, and you will not be using friction reducers. Instead, for the fracturing fluid, specify a friction adjustment factor for the 'water solute' fluid additive.
- Wellbore diameter will be larger in an EGS well. 7 inches is a good default for inner diameter.
- You should inject and produce to the surface. Most likely, the production wellhead will not be pumped, but will have a relatively low pressure, around 350 psi WHP. Injection wellhead can have elevated pressure of up to a few 1000 psi (but don't inject at pressure greater than Shmin or you'll see runaway fracture propagation!). Make sure that you specify a max injection rate that is modestly higher than the max production rate. This is needed to maintain fluid balance and sufficient production rate.
- To avoid water hammer, slowly ramp up production in the production well, and set a small non-zero production rate in the injection well.
- The parameter 'numericaloptionsforlongtermegscirculation' (found under Numerical Options panel) can improve convergence and reduce runtimes when thermoelasticity is turned on in the Startup panel.

GENERAL SEQUENCE SUMMARY ?						
	Production type ?	Control applied at ?	Check to use gas units (not liquid) for injection ?	Time units ?	Boundary condition MD (optional) [ft] ?	Duration to truncate sequence [Days] ?
1	LiquidRate ▾	Wellhead ▾	☐	Days ▾	0	

GENERAL WELLBORE BOUNDARY CONDITION CONTROL RECORDS ?						
	Start time [Days] ?	Duration [Days] ?	Min stage ?	Max stage ?	Maximum production rate [bbl/day] ?	Maximum injection rate [bpm] ?
1	0		All stages ▾	All stages ▾	1000	37

PRODUCTION SEQUENCE SUMMARY ?					
	Production type ?	Time units ?	Boundary condition MD (optional) [ft] ?	Duration to truncate sequence [Days] ?	Optional secondary production type ?
1	LiquidPlusGasRate ▾	Days ▾	0		LiquidPlusGasRate ▾

PRODUCTION SEQUENCE BOUNDARY CONDITION CONTROL RECORDS ?					
	Start time [Days] ?	Duration [Days] ?	Maximum production rate [bbl/day] ?	Minimum production pressure [psi] ?	Inactive time fraction ?
1	15	1	500	350	0
2	16	1	1000	350	0
3	17	1	5000	350	0
4	18	1	10000	350	0
5	19	1	20000	350	0
6	20	1	150000	350	0

EGS – special modeling considerations (3 of 3)

For insights on calibration parameters from the Utah FORGE project, and specifically on how to prevent excessive vertical fracture growth, refer to the following paper:

McClure, M. 2023. [Calibration Parameters Required to Match the Utah FORGE 16A\(78\)-32 Stage 3 Stimulation with a Planar Fracturing Model](#). Forty-Eighth Workshop on Geothermal Reservoir Engineering, Stanford, CA.

PROCEEDINGS, 48th Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, February 6-8, 2023
SGP-TR-224

Calibration Parameters Required to Match the Utah FORGE 16A(78)-32 Stage 3 Stimulation with a Planar Fracturing Model

Mark McClure
ResFrac Corporation
mark@resfrac.com

Thermoelastic stress and thermal breakthrough (1 of 2)

For advanced investigations, you can consider turning on ‘Thermoelastic stress changes in the matrix’. This accounts for contraction of the rock under cooling conditions, increasing fracture aperture and conductivity over time. Most of the time we turn off thermoelastic stress because of the increased computational burden and uncertainty about its effects.

With thermoelastic stress active, special numerical options should be applied to improve performance:

✓ Numerical options for long-term EGS circulation  

More discussion on thermoelasticity effect can be found in the ResFrac blog post on [“Thermoelastic fracturing and buoyancy-driven convection – Surprising sources of longevity for EGS circulation”](#).

Additional Publications:

McClure, M. W., Irvin, R., England, K., & McLennan, J. (2024). Numerical modeling of hydraulic stimulation and long-term fluid circulation at the Utah FORGE project. In *Proceedings of the 49th Workshop on Geothermal Reservoir Engineering (SGP-TR-227)*, Stanford, CA, USA.

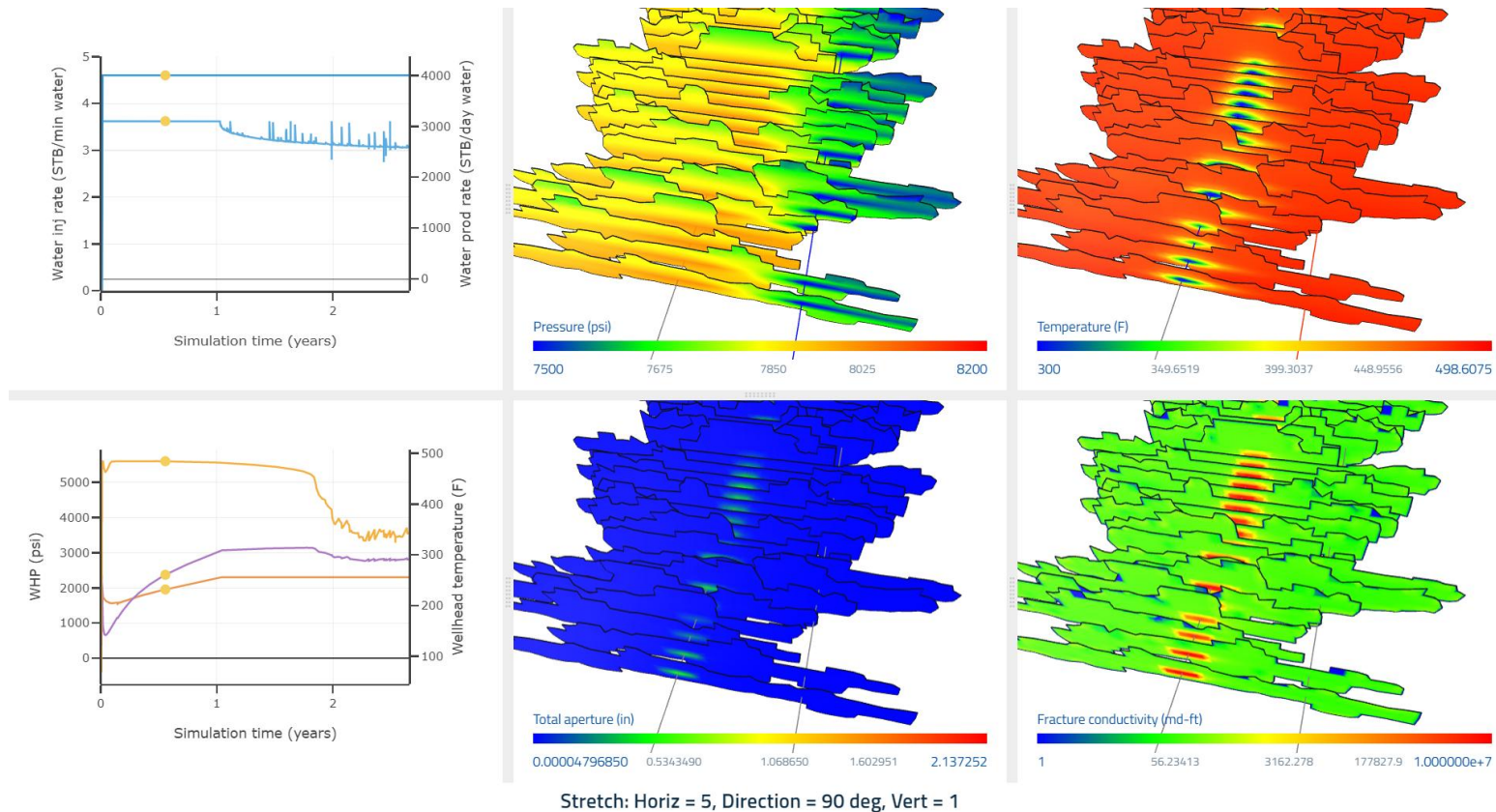
McClure, M., Kang, C., & Fowler, G. (2022). Optimization and Design of Next-Generation Geothermal Systems Created by Multistage Hydraulic Fracturing. SPE-209186-MS. *Paper presented at the SPE Hydraulic Fracturing Technology Conference and Exhibition, The Woodlands, TX.*

Thermoelastic stress and thermal breakthrough (2 of 2)

Thermal short-circuiting occurs when rock contraction causes a continuous path of mechanically ‘open’ fractures to form between the wells. This can also cause the simulation to slow down dramatically. at this point, because the production temperature will have also dropped off (see the temperature (yellow) line in the lower left panel below (McClure et al., 2022)).

This scenario shows that under a constant rate condition (blue line), the WHP (purple line) drops as the fracture aperture increase.

Conversely, constant pressure conditions could cause runaway flow rates, exacerbating thermal breakthrough.

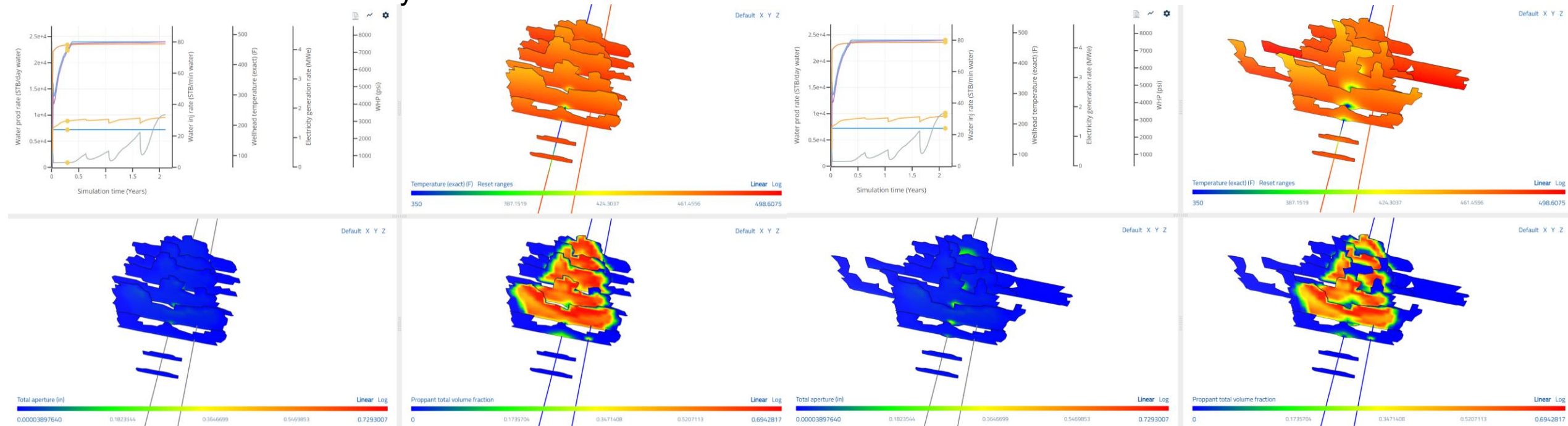


Injection pressure

Be careful to limit your injection WHP. In the example below, fracture propagation is happening during long-term injection because of excessive injection WHP. Because injection volume is greater than production volume, pressure is building up over time, causing produced WHP to increase over time. Some amount of propagation during long-term circulation is OK and inevitable. But be careful to avoid injecting at an excessive pressure and causing too much fracture growth.

0.3 years

2.1 years



Step-by-Step Tutorial

Setting up an EGS simulation in the ResFrac Builder

Content

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- [Model overview](#)

Phase 1:

- [Job manager and Builder](#)
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- [Curve sets](#)
- [Wells and perforations](#)
- [Meshing options](#)
- [Fluid model options](#)
- [Fracture options](#)
- [Well controls](#)

- [Other physics options](#)
- [Numerical options](#)
- [Output options](#)
- [Advanced options](#)
- [Submitting the job](#)

Phase 2:

- [Fracture options](#)
- [Water solutes](#)
- [Proppants](#)
- [Well controls](#)
- [Submitting the job](#)

Exercise will set up a simple 2-well EGS model in ResFrac

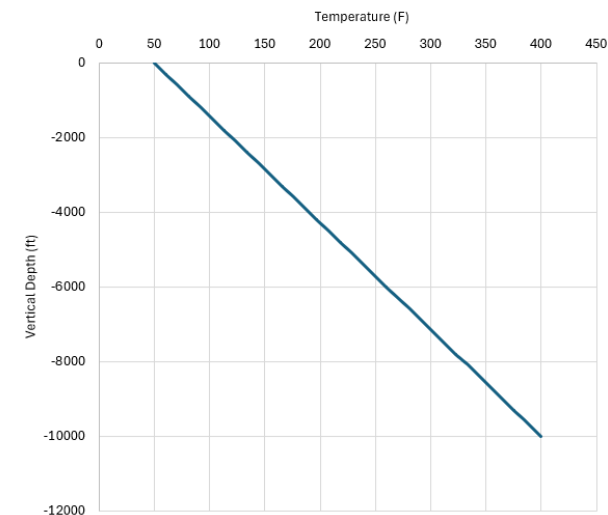
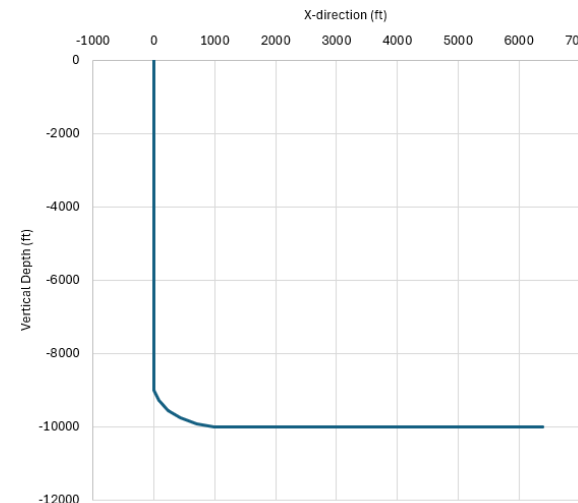
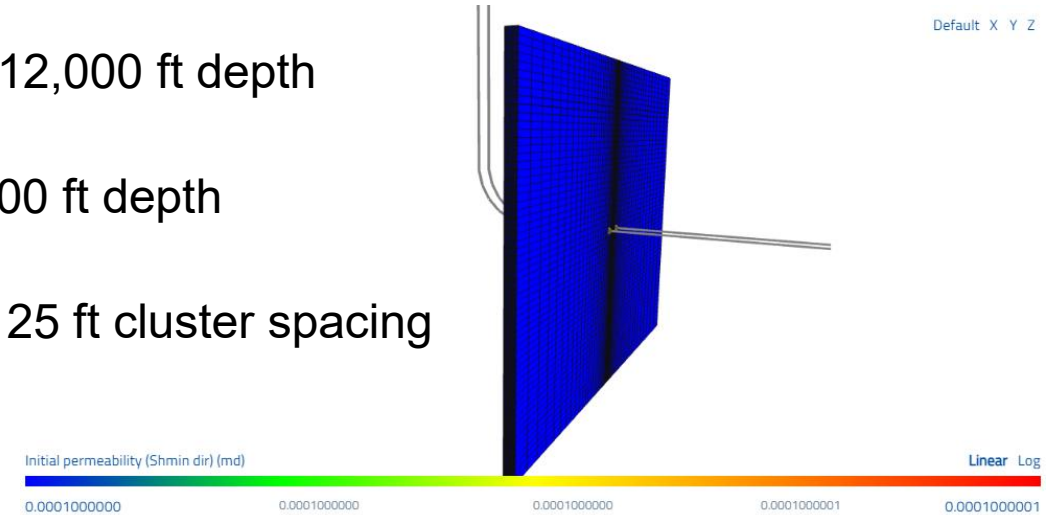
Problem description:

- You would like to evaluate a site for EGS development.
- Start with a preliminary design to get an initial estimate of the MW potential of the site.
- A quick way to iterate through certain design scenarios is in ResFrac, while using significantly less computational time, is to set-up a two-well reservoir model using pre-existing fractures to represent hydraulic fractures. We will do that here first.
 - With pre-existing fractures, you can quickly test how parameters like lateral length, well depth, cluster spacing, well spacing, and fracture conductivity will impact the MW thermal output and the parasitic load.
 - You may also evaluate how non-uniform fracture conductivity changes the results.
- Once you have a preliminary design target, you can replace the pre-existing fractures with hydraulic fractures
 - Optimize the pump job design to reach your target fracture conductivity.
- Advanced options
 - Run a sensitivity analysis on reservoir properties to evaluate uncertainty.
 - Try turning on thermo-elastic stresses
 - Build out a multi-well bench to further evaluate well spacing and water loss rates.

Exercise will set up a simple 2-well EGS model in ResFrac

Model overview:

- Simple granitic formation with initial temperature of 450°F at 12,000 ft depth
 - Set up static model
- Two staggered wells with horizontal laterals centered at 12,000 ft depth
 - Import wellbore trajectory
- Create a single stage sector model, 8 clusters per stage and 25 ft cluster spacing
 - Set up pre-existing fractures in Phase 1
 - Set up frac job in Phase 2
- Total lateral length is 28 stages
 - Well flow scaler
- Injection at 37 BPM (100 L/s) and 120°F
 - Set up long-term well controls
- What is electricity output and LCOE?
 - Set up geothermal economics module
- Pre-run model files are available at these links:
 - [Phase I](#)
 - [EGS Template](#) (starting point)
 - [Phase II](#)

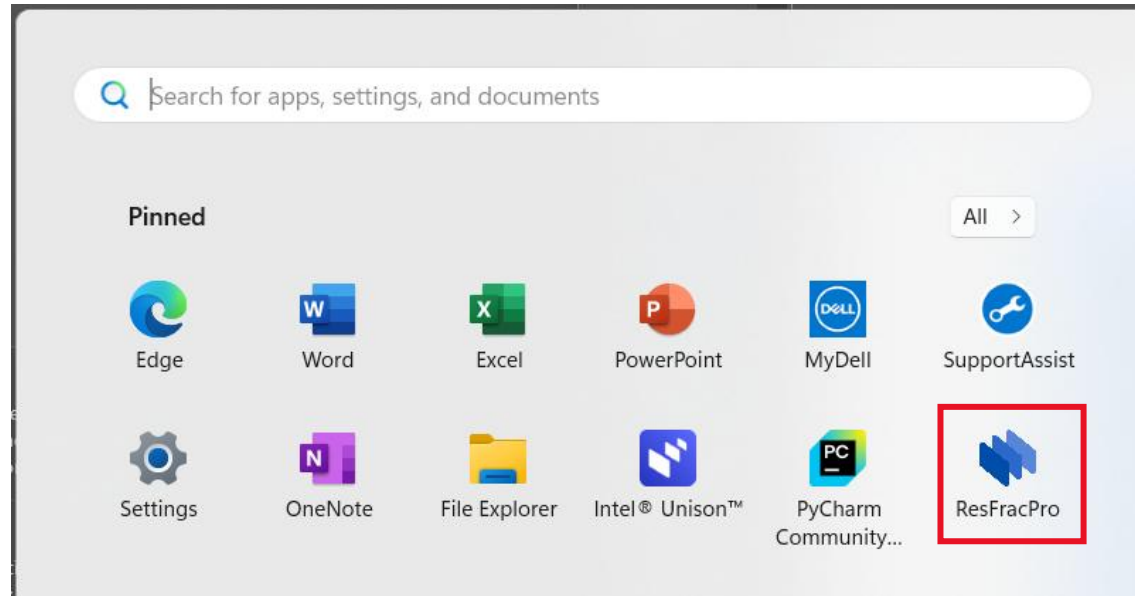




Tutorial Phase 1 – Pre-existing Fractures

Open ResFrac

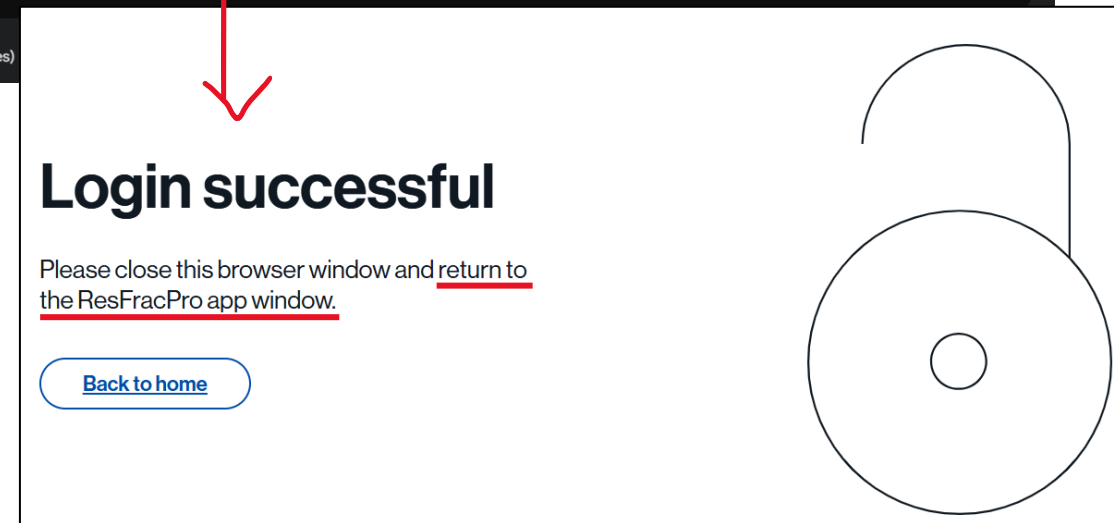
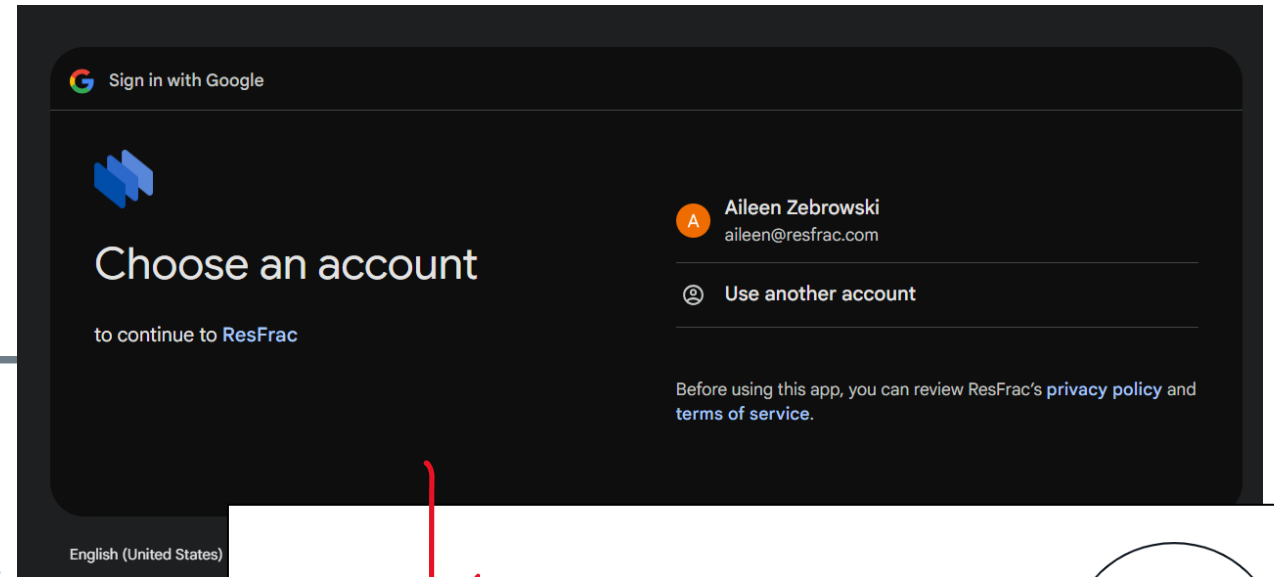
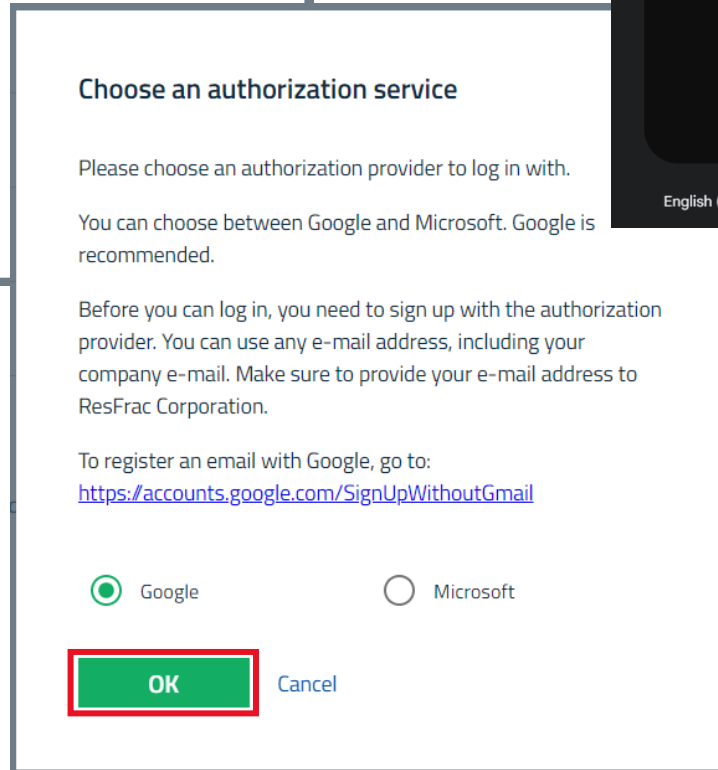
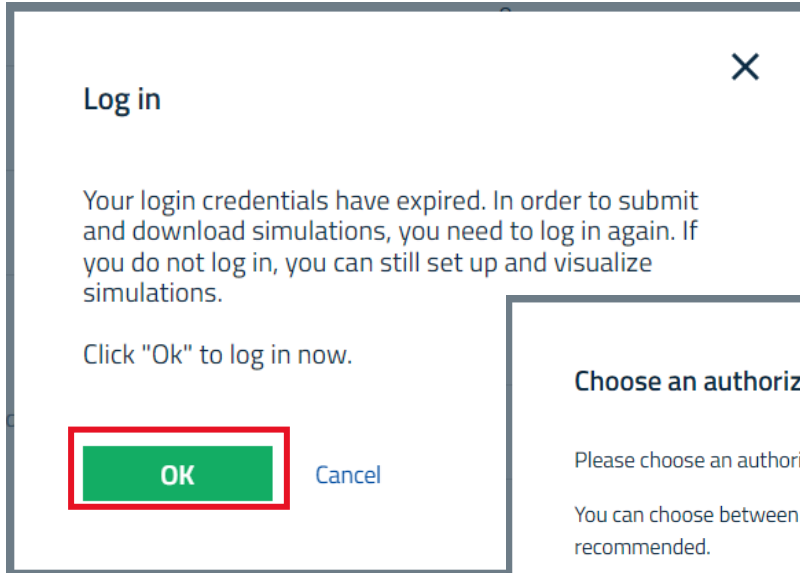
Make sure you have downloaded and installed the ResFrac Pro App and have an active license.



Find (or search for) the ResFracPro App and open.

Login to ResFrac

If prompted, log in.



ResFrac Job Manager

ResFrac Pro

ResFrac Corporation-Prod-Internal

Download Manager

Running Calculations

Log out

Home

Projects (8) ?

Search

Show Active Projects

Create Project

>	PROJECT NAME	LOCATION OF DATA	# OF WORKFLOWS	RUNNING CALCULATIONS	LAST MODIFIED ↓	
>	Remote Customer Test Projects	Remote	4	0	Jun 3, 2025 at 4:00 pm	...
>		Remote	1	0	May 14, 2025 at 9:26 pm	...
>		Remote	7	0	May 12, 2025 at 11:11 am	...
>	Geothermal Templates	Local	11	0	Mar 18, 2025 at 12:17 pm	...
>	Customer Test Projects	Local	6	0	Mar 18, 2025 at 10:52 am	...
>		Local	3	0	Feb 21, 2025 at 4:10 pm	...
>		Local	16	0	Feb 5, 2025 at 12:23 pm	...
>	Onboarding Test Projects	Local	5	0	Jan 29, 2025 at 4:58 pm	...

You have reached the end of the list

All Projects Activity

Show More

Highlights

Activity Log

The simulation "Fervo_very_small_model v2" was submitted.
Jul 3, 2025 at 9:29 pm

The simulation "Fervo_very_small_model v2" was updated.
Jul 3, 2025 at 9:29 pm

The simulation "Fervo_very_small_model v2" was created.
Jul 3, 2025 at 9:28 pm

The simulation "Fervo_very_small_model v2" was copied from
"Fervo_very_small_model".
Jul 3, 2025 at 9:28 pm

The simulation "PM v8 THM Seas v2 Copy 1" was submitted.
Jul 3, 2025 at 7:18 pm

The simulation "Fervo_very_small_model" was shared with
the following email address(es): koenraad@resfrac.com.
Jul 3, 2025 at 4:28 pm

The simulation "Fervo_very_small_model" was submitted.
Jul 3, 2025 at 11:48 am

The simulation "Fervo_very_small_model" was updated.
Jul 3, 2025 at 11:47 am

ResFrac Job Manager: Create new project

The screenshot shows the ResFrac Job Manager interface. The top navigation bar includes 'ResFrac Pro', 'ResFrac Corporation-Prod-Internal', and links for 'Download Manager', 'Running Calculations', and 'Log out'. The main content area is titled 'Projects (8)' and features a table of projects. A red box highlights the 'Create Project' button in the top right corner, with an arrow pointing to it from a text box that says 'Click create project to create new project folder with workflows'.

PROJECT NAME	LOCATION OF DATA	# OF WORKFLOWS	RUNNING CALCULATIONS	LAST MODIFIED
Remote Customer Test Projects	Remote	4	0	Jun 3, 2025 at 4:00 pm
	Remote			
	Remote			
Geothermal Templates	Local			
Customer Test Projects	Local	6	0	Mar 18, 2025 at 10:52 am
	Local	3	0	Feb 21, 2025 at 4:10 pm
	Local	16	0	Feb 5, 2025 at 12:23 pm
Onboarding Test Projects	Local	5	0	Jan 29, 2025 at 4:58 pm

You have reached the end of the list

All Projects Activity

Highlights Activity Log

- The simulation "Fervo_very_small_model v2" was submitted. Jul 3, 2025 at 9:29 pm
- The simulation "Fervo_very_small_model v2" was updated. Jul 3, 2025 at 9:29 pm
- The simulation "Fervo_very_small_model v2" was created. Jul 3, 2025 at 9:28 pm
- The simulation "Fervo_very_small_model v2" was copied from "Fervo_very_small_model". Jul 3, 2025 at 9:28 pm
- The simulation "PM v8 THM Seas v2 Copy 1" was submitted. Jul 3, 2025 at 7:18 pm
- The simulation "Fervo_very_small_model" was shared with the following email address(es): koenraad@resfrac.com. Jul 3, 2025 at 4:28 pm
- The simulation "Fervo_very_small_model" was submitted. Jul 3, 2025 at 11:48 am
- The simulation "Fervo_very_small_model" was updated. Jul 3, 2025 at 11:47 am

ResFrac Job Manager: Create new project

ResFrac Pro ResFrac Corporation-Prod-Internal

Home

Projects (8) ?

PROJECT NAME

Remote Customer

Geothermal

Customer Te

Onboarding Tr

Create Project

Project Name*
Training Course Examples

☒ Store simulations in the local directory.

☐ Store simulations in the remote directory.

This is a one-time decision that can not be changed later for this project.

Description

0/35000

Create Cancel

Create Project

projects

IFIED ↓

2025 at 4:00 pm ...

2025 at 9:26 pm ...

2025 at 10:52 am ...

2025 at 4:10 pm ...

025 at 12:23 pm ...

2025 at 4:58 pm ...

All Projects Activity

Show More

Highlights Activity Log

The simulation "Fervo_very_small_model v2" was submitted.
Jul 3, 2025 at 9:29 pm

The simulation "Fervo_very_small_model v2" was updated.

The simulation "Fervo_very_small_model v2" was copied from
"Fervo_very_small_model".
Jul 3, 2025 at 9:28 pm

The simulation "PM v8 THM Seas v2 Copy 1" was submitted.
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Jul 3, 2025 at 4:28 pm

The simulation "Fervo_very_small_model" was submitted.
Jul 3, 2025 at 11:48 am

The simulation "Fervo_very_small_model" was updated.
Jul 3, 2025 at 11:47 am

ResFrac Job Manager: Create new project

ResFrac Pro ResFrac Corporation-Prod-Internal						Download Manager
Home						
Projects (9) ?			Show Active Projects		Create Project	
>	PROJECT NAME	LOCATION OF DATA	# OF WORKFLOWS	RUNNING CALCULATIONS	LAST MODIFIED ↓	
>	Training Course Examples	Local	0	0	Jul 6, 2025 at 8:00 pm	...
>	Remote Customer Test Projects				Jun 3, 2025 at 4:00 pm	...
>					May 14, 2025 at 9:26 pm	...
>		Remote	7	0	May 12, 2025 at 11:11 am	...
>	Geothermal Templates	Local	11	0	Mar 18, 2025 at 12:17 pm	...
>	Customer Test Projects	Local	6	0	Mar 18, 2025 at 10:52 am	...
>		Local	3	0	Feb 21, 2025 at 4:10 pm	...
>		Local	16	0	Feb 5, 2025 at 12:23 pm	...
>	Onboarding Test Projects	Local	5	0	Jan 29, 2025 at 4:58 pm	...

Click on newly created folder to open project

ResFrac Job Manager: Create Sandbox

The screenshot displays the ResFrac Pro web interface. The top navigation bar includes the ResFrac logo, the text 'ResFrac Corporation-Prod-Internal', and several utility links: 'Download Manager', 'Running Calculations', 'Log out', a settings gear icon, and window controls. Below the navigation bar, the breadcrumb trail shows 'Home > Training Course Examples'.

The main content area is divided into two panels. The left panel, titled 'Project Details', contains the following information:

- Name:** Training Course Examples
- Workflows:** 0
- Creation timestamp:** Jul 6, 2025 at 8:00 pm
- Description:**
- Location of data:** Local : C:\ResFracProdInternal\data

The right panel, titled 'Project Activity', features a 'Show More' link and two tabs: 'Highlights' and 'Activity Log'. The 'Highlights' tab is active, showing a list of messages: 'All trashed items were successfully deleted.' with timestamps ranging from Jun 11, 2025 to Jun 20, 2025.

Below the 'Project Details' panel, there is a section for 'Workflows (0)'. It includes a search icon, a 'Show Active Workflows' link, and three buttons: 'Create Sandbox' (highlighted with a red box), 'Import Workflow', and 'Create Workflow From Template'. Below these buttons is a table with columns: 'WORKFLOW NAME', 'TYPE', 'STATUS', 'DATE CREATED ↓', and 'LAST MODIFIED'. The table is empty, and a message 'You have reached the end of the list' is displayed below it.

A text box with a black border is positioned below the 'Create Sandbox' button, containing the text: 'Create new sandbox in your project to set up individual simulation models'. A red arrow points from this text box to the 'Create Sandbox' button.

ResFrac Job Manager: Create Sandbox

The screenshot displays the ResFrac Pro interface for 'ResFrac Corporation-Prod-Internal'. The main navigation bar includes 'Home', 'Training Course Examples', and a 'Download Manager' section with 'Running Calculations' and 'Log out' options. The 'Project Details' tab is active, showing the project name 'Training Course Examples', description, and location of data. Below this, the 'Workflows (0)' section is visible, with a red box highlighting the 'Create Sandbox' button. A modal window titled 'Create Sandbox Workflow' is open, featuring a text input for 'Sandbox Workflow Name*' (containing 'EGS Training Course July 22nd') and a larger text area for 'Description'. The modal includes 'Create' and 'Cancel' buttons at the bottom. A text box with the instruction 'Write name for your new sandbox and press "Create"' is overlaid on the workflow list, with a red arrow pointing to the 'Create Sandbox' button. The bottom status bar shows the date and time: 'Jun 11, 2025 at 3:57 pm'.

Project Details ?

Name
Training Course Examples

Workflows
0

Description

Location of data
Local : C:\ResFracProdInternal\data

Workflows (0)

Show Active Workflows

Create Sandbox

Import W

WORKFLOW NAME

TYPE

STATUS

DATE CREATED ↓

You have reached the end of the list

Write name for your new sandbox and press "Create"

Create Sandbox Workflow

Sandbox Workflow Name*

EGS Training Course July 22nd

Description

0/35000

Create

Cancel

Jun 11, 2025 at 3:57 pm

ResFrac Job Manager: Open newly create sandbox

The screenshot displays the ResFrac Job Manager interface. The top navigation bar includes 'ResFrac Pro', 'ResFrac Corporation-Prod-Internal', and buttons for 'Download Manager', 'Running Calculations', 'Log out', and settings. The breadcrumb trail shows 'Home > Training Course Examples'.

Project Details (with an 'Edit' link):

- Name: Training Course Examples
- Workflows: 1
- Creation timestamp: Jul 6, 2025 at 8:00 pm
- Description:
- Location of data: Local : C:\ResFracProdInternal\data

Workflows (1) (with a search icon and 'Show Active Workflows' link):

Buttons: **Create Sandbox**, **Import Workflow**, **Create Workflow From Template**

WORKFLOW NAME	TYPE	STATUS	DATE CREATED ↓	LAST MODIFIED	
EGS Training Course July 22nd	Sandbox	N/A	Jul 6, 2025 at 8:06 pm	Jul 6, 2025 at 8:06 pm	...

A red box highlights the 'EGS Training Course July 22nd' workflow name. A callout box points to it with the text: 'Click on newly created sandbox'.

Project Activity (with 'Show More' link):

- Highlights** / **Activity Log**
- The sandbox "EGS Training Course July 22nd" was created. Jul 6, 2025 at 8:06 pm
- All trashed items were successfully deleted. Jun 20, 2025 at 9:45 am
- All trashed items were successfully deleted. Jun 17, 2025 at 5:27 pm
- All trashed items were successfully deleted. Jun 17, 2025 at 5:27 pm
- All trashed items were successfully deleted. Jun 16, 2025 at 6:31 pm
- All trashed items were successfully deleted. Jun 11, 2025 at 4:30 pm
- All trashed items were successfully deleted. Jun 11, 2025 at 4:26 pm
- All trashed items were successfully deleted. Jun 11, 2025 at 3:57 pm

ResFrac Job Manager: Create new simulation

The screenshot displays the ResFrac Job Manager interface. The top navigation bar includes the ResFrac logo, the text 'ResFrac Corporation-Prod-Internal', and several utility links: 'Download Manager', 'Running Calculations', 'Log out', and a settings icon. Below the navigation bar, the breadcrumb trail reads 'Home > Training Course Examples > EGS Training Course July 22nd'.

The main content area is divided into two primary sections. On the left, the 'Sandbox Details' section provides information about the current workflow: 'Workflow name: EGS Training Course July 22nd', 'Simulations: 0', and 'Creation timestamp: Jul 6, 2025 at 8:06 pm'. It also includes a 'Description' field and the 'Location of data' set to 'Local : C:\ResFracProdInternal\data'. On the right, the 'Workflow Activity' section shows a list of events under the 'Highlights' tab, including the creation of the sandbox and several messages about deleted trashed items.

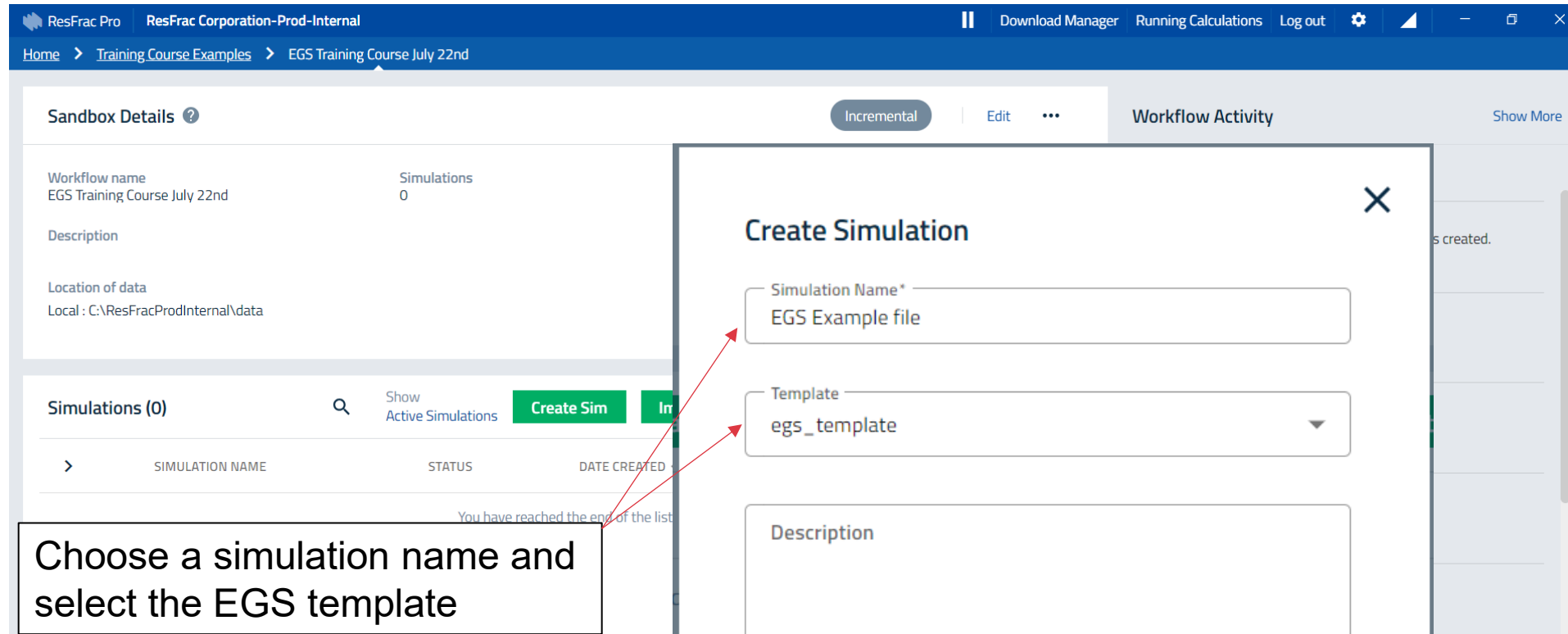
Below the 'Sandbox Details' section, there is a 'Simulations (0)' section. It features a search icon, a 'Show Active Simulations' link, and four action buttons: 'Create Sim', 'Import Sim', 'Batch Run Simulations', and 'Multiplot'. The 'Create Sim' button is highlighted with a red rectangular box. A red arrow points from a text box below to this button. The text box contains the instruction: 'Press button to create new simulation model'. Below the buttons, a table header is visible with columns for 'SIMULATION NAME', 'STATUS', 'DATE CREATED', and 'LAST MODIFIED'. The table is currently empty, displaying the message 'You have reached the end of the list'.

ResFrac Job Manager: Create new simulation based on EGS template

The screenshot shows the ResFrac Job Manager interface. The top navigation bar includes 'ResFrac Pro', 'ResFrac Corporation-Prod-Internal', and a status bar with 'Download Manager', 'Running Calculations', and 'Log out'. The breadcrumb trail is 'Home > Training Course Examples > EGS Training Course July 22nd'. The main content area is divided into 'Sandbox Details' and 'Simulations (0)'. The 'Sandbox Details' section shows 'Workflow name: EGS Training Course July 22nd', 'Simulations: 0', 'Description', and 'Location of data: Local: C:\ResFracProdInternal\data'. The 'Simulations (0)' section has a search icon, 'Show Active Simulations', and a red box around the 'Create Sim' button. A red box highlights the 'Create Sim' button, and red arrows point from it to the 'Create Simulation' dialog box. The dialog box has a title 'Create Simulation' and a close button. It contains three fields: 'Simulation Name*' with the value 'EGS Example file', 'Template' with the value 'egs_template', and 'Description'. At the bottom of the dialog box are 'Create' and 'Cancel' buttons. A text box on the left says 'Choose a simulation name and select the EGS template'.

Choose a simulation name and select the EGS template

ResFrac Job Manager: Create new simulation based on EGS template



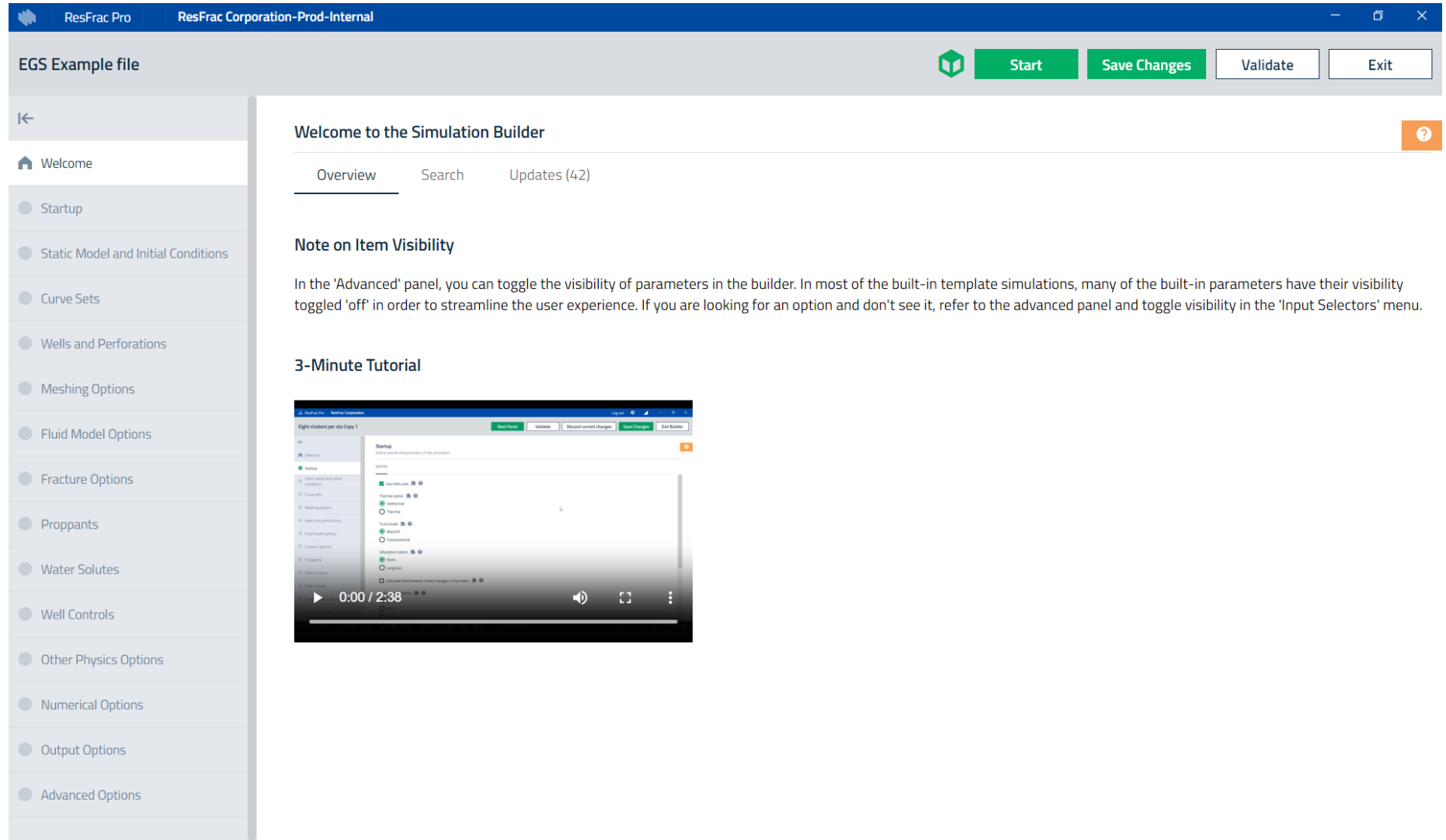
Choose a simulation name and select the EGS template

The geothermal_preexisting_fractures template may also be useful for full lateral modeling.

You can find documentation for any of the geothermal templates in the ResFracPro app folder.

Name	Date modified	Type	Size
EGS Template	11/21/2025 1:21 PM	Adobe Acrobat D...	2,638 KB
Fracture turning template	11/21/2025 1:21 PM	Adobe Acrobat D...	1,313 KB
Geothermal Pre-Existing Fractures Template	11/21/2025 1:21 PM	Adobe Acrobat D...	1,125 KB
Geothermal Slug Tracer Test Template	11/21/2025 1:21 PM	Adobe Acrobat D...	1,205 KB

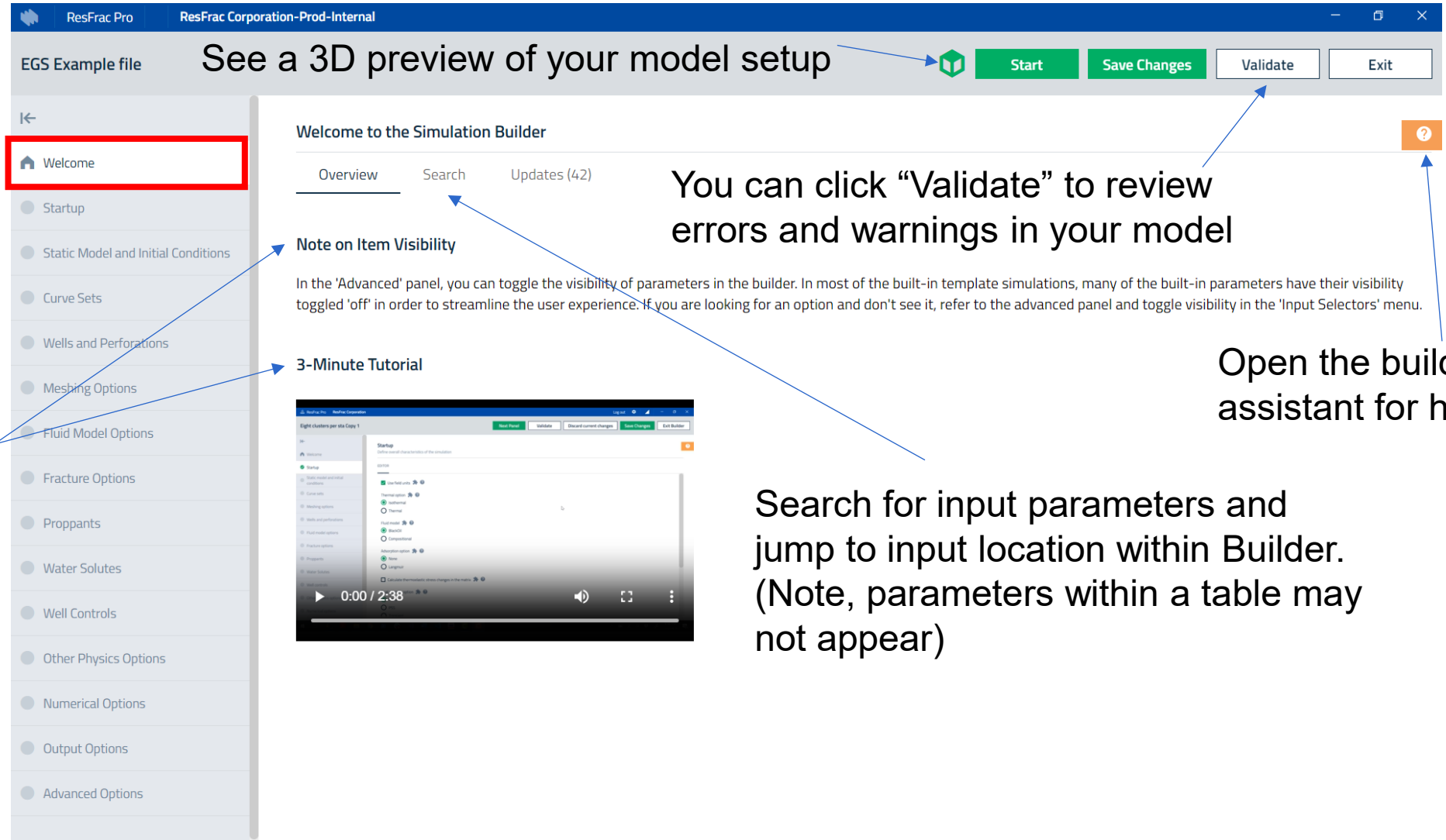
After clicking “Create”, your new simulation will open in the Builder



Welcome Panel (no modifications necessary)

Panel List: You will work through each panel (approx. sequentially) to set up your model

Read the 'Note on Item Visibility' and watch the 3-minute tutorial to get oriented.



Start-up panel: Overview



Startup

Define overall characteristics of the simulation

Editor Search

Recommended settings wizard

☐ Use advanced unit system

☒ Use field units

Thermal option

☐ Isothermal

☒ Thermal

Fluid model

☐ BlackOil

☒ Compositional

Dual porosity option

☒ None

☐ PSS

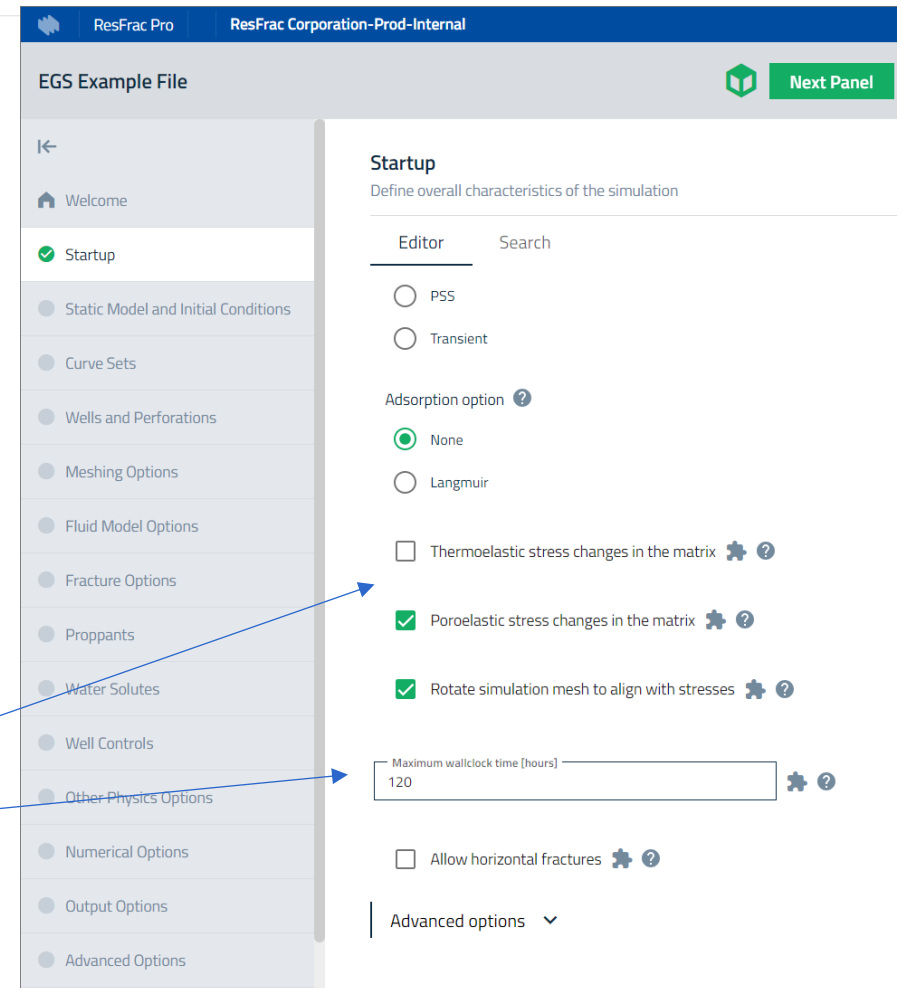
☐ Transient

Adsorption option

Scroll...

Setup overall model characteristics by specifying:

- Recommended settings wizard
- Unit system
- Isothermal or thermal
- Fluid model
- Dual porosity mode
- Absorption mode
- Thermo-poro-elasticity
- Max wall clock time



Start-up panel: Recommended Settings Wizard

The screenshot shows the ResFrac Pro software interface. The top bar includes the ResFrac logo, the text 'ResFrac Corporation-Prod-Internal', and a set of buttons: 'Next Panel' (green), 'Discard Current Changes' (white), 'Save Changes' (green), 'Validate' (white), and 'Exit' (white). The left sidebar contains a list of settings categories: 'EGS Example file', 'Welcome', 'Startup' (selected with a green checkmark), 'Static Model and Initial Conditions', 'Curve Sets', 'Wells and Perforations', 'Meshing Options', 'Fluid Model Options', 'Fracture Options', 'Proppants', 'Water Solutes', 'Well Controls', 'Other Physics Options', 'Numerical Options', 'Output Options', and 'Advanced Options'. The main panel is titled 'Startup' with the subtitle 'Define overall characteristics of the simulation'. It has two tabs: 'Editor' and 'Search'. A red box highlights the 'Recommended settings wizard' button, which has a question mark icon. Below this, there are several options: 'Use advanced unit system' (unchecked), 'Use field units' (checked), 'Thermal option' (radio buttons for 'Isothermal' and 'Thermal', with 'Thermal' selected), 'Fluid model' (radio buttons for 'BlackOil' and 'Compositional', with 'Compositional' selected), 'Dual porosity option' (radio buttons for 'None', 'PSS', and 'Transient', with 'None' selected), and 'Adsorption option' (radio buttons for 'None', 'PSS', and 'Transient', with 'None' selected). A blue arrow points from the 'Recommended settings wizard' button to a callout box on the right.

Recommended Settings Wizard

- ResFrac updates the recommended values for parameters periodically. This wizard allows you to batch apply those updates all at once.
- There are two options: 'Yes' or 'No'. If you select 'No', recommended settings will still be updated, but only for those that don't significantly impact sim behavior.
- 'No' is recommended since we're starting from the EGS template to keep EGS specific settings.
- To ID what changes were made, use WinMerge to compare the settings files for the original and new simulation.

The screenshot shows the 'Recommended settings wizard' dialog box. It has a title bar with a close button (X) and a question mark icon. The main text reads: 'Sets numerical settings to their 'recommended' values. Often, when we roll out changes, we don't apply them automatically in order to maintain back-compatibility. Instead, we give users warnings to recommend making a change. Over time, these options have become rather numerous, and it is inconvenient to have to modify all of them manually. To avoid this inconvenience, you can avoid this wizard to automatically apply all of them. Note that you may still get 'warnings' after running this wizard. It focuses on setting recommended numerical parameters, not addressing all possible simulation warnings. To see what specific changes have been made, we recommend using a program like 'Winmerge' to compare the settings file before and after.' Below the text is a dropdown menu with the text 'Apply full set of recommended settings, even those that significantly impact code behavior?' and the selected option 'No'. A red box highlights the dropdown menu. At the bottom is a green 'Apply' button.

Start-up panel: Units

The screenshot shows the ResFrac Pro software interface. The top bar includes the title 'ResFrac Pro' and 'ResFrac Corporation-Prod-Internal'. Below this is a toolbar with buttons: 'Next Panel' (green), 'Discard Current Changes' (white), 'Save Changes' (green), 'Validate' (white), and 'Exit' (white). The left sidebar contains a list of panels: 'Welcome', 'Startup' (selected with a green checkmark), 'Static Model and Initial Conditions', 'Curve Sets', 'Wells and Perforations', 'Meshing Options', 'Fluid Model Options', 'Fracture Options', 'Proppants', 'Water Solutes', 'Well Controls', 'Other Physics Options', 'Numerical Options', 'Output Options', and 'Advanced Options'. The main content area is titled 'Startup' with the subtitle 'Define overall characteristics of the simulation'. It features a 'Recommended settings wizard' button (green) and a search bar. The 'Units' section is highlighted with a red box and a blue arrow. It contains two options: 'Use advanced unit system' (unchecked) and 'Use field units' (checked). Below this are sections for 'Thermal option' (Isothermal, Thermal), 'Fluid model' (BlackOil, Compositional), 'Dual porosity option' (None, PSS, Transient), and 'Adsorption option'.

EGS Example file

ResFrac Pro ResFrac Corporation-Prod-Internal

Next Panel Discard Current Changes Save Changes Validate Exit

Startup

Define overall characteristics of the simulation

Editor Search

Recommended settings wizard

☐ Use advanced unit system

☒ Use field units

Thermal option

☐ Isothermal

☒ Thermal

Fluid model

☐ BlackOil

☒ Compositional

Dual porosity option

☒ None

☐ PSS

☐ Transient

Adsorption option

Units

- Select field, metric, or custom ('advanced') units (set-up in the Advanced Options panel).

Start-up panel: Thermal Option

The screenshot shows the ResFrac Pro software interface. The top bar includes the ResFrac logo, the text 'ResFrac Corporation-Prod-Internal', and a set of buttons: 'Next Panel' (green), 'Discard Current Changes' (white), 'Save Changes' (green), 'Validate' (white), and 'Exit' (white). The left sidebar contains a list of options: 'Welcome', 'Startup' (selected with a green checkmark), 'Static Model and Initial Conditions', 'Curve Sets', 'Wells and Perforations', 'Meshing Options', 'Fluid Model Options', 'Fracture Options', 'Proppants', 'Water Solutes', 'Well Controls', 'Other Physics Options', 'Numerical Options', 'Output Options', and 'Advanced Options'. The main panel is titled 'Startup' with the subtitle 'Define overall characteristics of the simulation'. It features a 'Recommended settings wizard' button and two checkboxes: 'Use advanced unit system' (unchecked) and 'Use field units' (checked). The 'Thermal option' section is highlighted with a red box and contains two radio buttons: 'Isothermal' and 'Thermal' (selected). Below this are sections for 'Fluid model' (with 'BlackOil' and 'Compositional' options), 'Dual porosity option' (with 'None', 'PSS', and 'Transient' options), and 'Adsorption option'. A blue arrow points from the text 'Thermal Option' to the 'Thermal' radio button.

ResFrac Pro ResFrac Corporation-Prod-Internal

EGS Example file

Next Panel Discard Current Changes Save Changes Validate Exit

Startup

Define overall characteristics of the simulation

Editor Search

Recommended settings wizard

☐ Use advanced unit system

☒ Use field units

Thermal option

☐ Isothermal

☒ Thermal

Fluid model

☐ BlackOil

☒ Compositional

Dual porosity option

☒ None

☐ PSS

☐ Transient

Adsorption option

Thermal Option

- Thermal option must be selected to account for heat transport

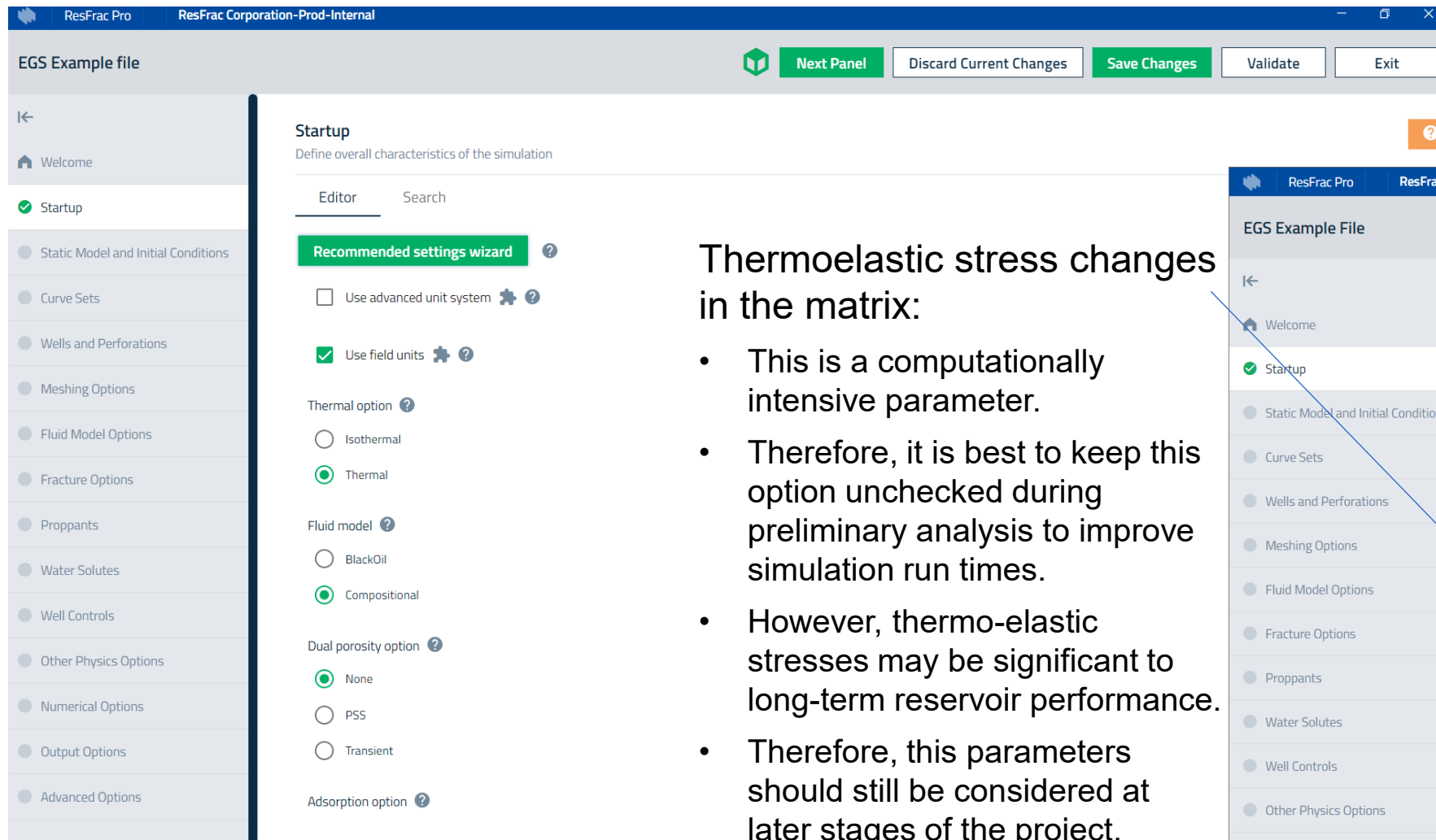
Start-up panel: Fluid Model

The screenshot shows the ResFrac Pro software interface. The top bar includes the ResFrac logo, the text 'ResFrac Pro', and 'ResFrac Corporation-Prod-Internal'. Below this is a toolbar with buttons: 'Next Panel', 'Discard Current Changes', 'Save Changes', 'Validate', and 'Exit'. The left sidebar contains a list of panels: 'Welcome', 'Startup' (selected), 'Static Model and Initial Conditions', 'Curve Sets', 'Wells and Perforations', 'Meshing Options', 'Fluid Model Options', 'Fracture Options', 'Proppants', 'Water Solutes', 'Well Controls', 'Other Physics Options', 'Numerical Options', 'Output Options', and 'Advanced Options'. The main area is titled 'Startup' with the subtitle 'Define overall characteristics of the simulation'. It has tabs for 'Editor' and 'Search'. A green button labeled 'Recommended settings wizard' is at the top. Below it are checkboxes for 'Use advanced unit system' (unchecked) and 'Use field units' (checked). The 'Thermal option' section has radio buttons for 'Isothermal' and 'Thermal' (selected). The 'Fluid model' section, highlighted with a red box, has radio buttons for 'BlackOil' and 'Compositional' (selected). Below this is the 'Dual porosity option' section with radio buttons for 'None' (selected), 'PSS', and 'Transient'. At the bottom is the 'Adsorption option' section.

Fluid Model

- Fluid model must be compositional because this is a thermal simulation. A compositional model applies an equation of state (EOS) to compute phase behavior based on P/T conditions.
- This applies even if the geothermal project is in an oil reservoir.

Start-up panel: Thermoelastic stress



ResFrac Pro ResFrac Corporation-Prod-Internal

EGS Example file

Next Panel Discard Current Changes Save Changes Validate Exit

Startup
Define overall characteristics of the simulation

Editor Search

Recommended settings wizard

☐ Use advanced unit system

☒ Use field units

Thermal option

☐ Isothermal

☒ Thermal

Fluid model

☐ BlackOil

☒ Compositional

Dual porosity option

☒ None

☐ PSS

☐ Transient

Adsorption option

☐ PSS

☐ Transient

Adsorption option

☐ None

☐ Langmuir

☐ Thermoelastic stress changes in the matrix

☒ Poroeleastic stress changes in the matrix

☒ Rotate simulation mesh to align with stresses

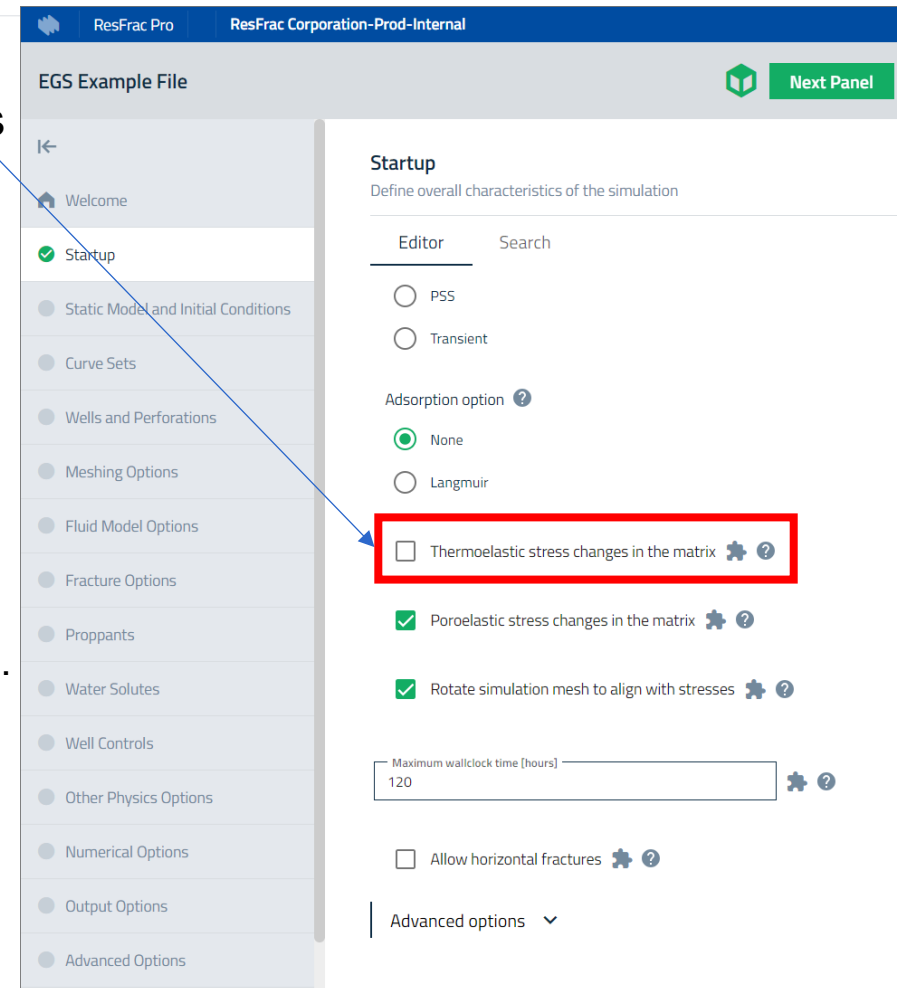
Maximum wallclock time [hours]
120

☐ Allow horizontal fractures

Advanced options

Thermoelastic stress changes in the matrix:

- This is a computationally intensive parameter.
- Therefore, it is best to keep this option unchecked during preliminary analysis to improve simulation run times.
- However, thermo-elastic stresses may be significant to long-term reservoir performance.
- Therefore, this parameters should still be considered at later stages of the project.



ResFrac Pro ResFrac Corporation-Prod-Internal

EGS Example File

Next Panel

Startup
Define overall characteristics of the simulation

Editor Search

☐ PSS

☐ Transient

Adsorption option

☒ None

☐ Langmuir

☐ Thermoelastic stress changes in the matrix

☒ Poroeleastic stress changes in the matrix

☒ Rotate simulation mesh to align with stresses

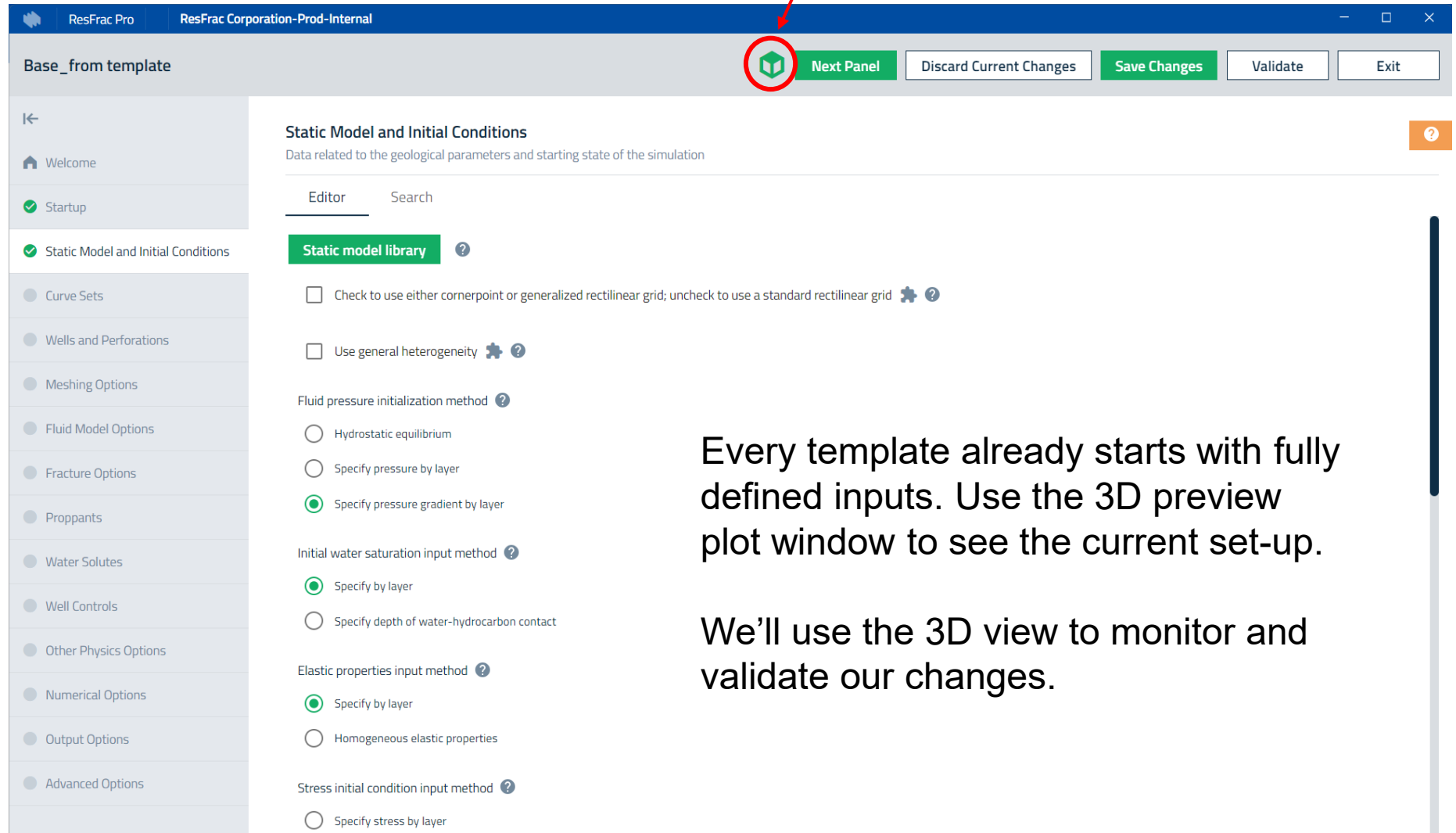
Maximum wallclock time [hours]
120

☐ Allow horizontal fractures

Advanced options

Static Model and Initial Conditions: Preview

Before we begin, let's open the 3D Preview Plot



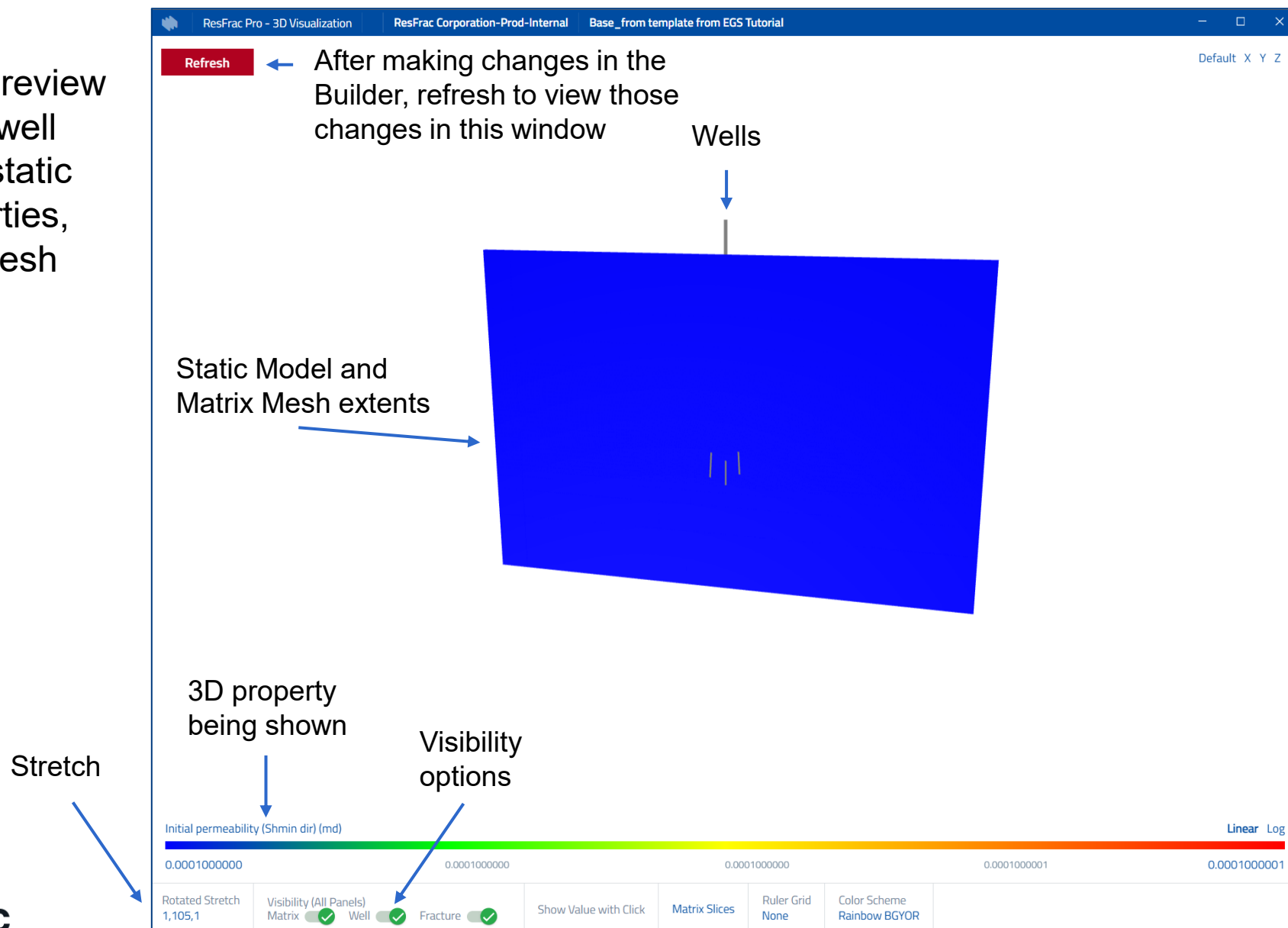
In this panel we define the properties that make up the static model.

Every template already starts with fully defined inputs. Use the 3D preview plot window to see the current set-up.

We'll use the 3D view to monitor and validate our changes.

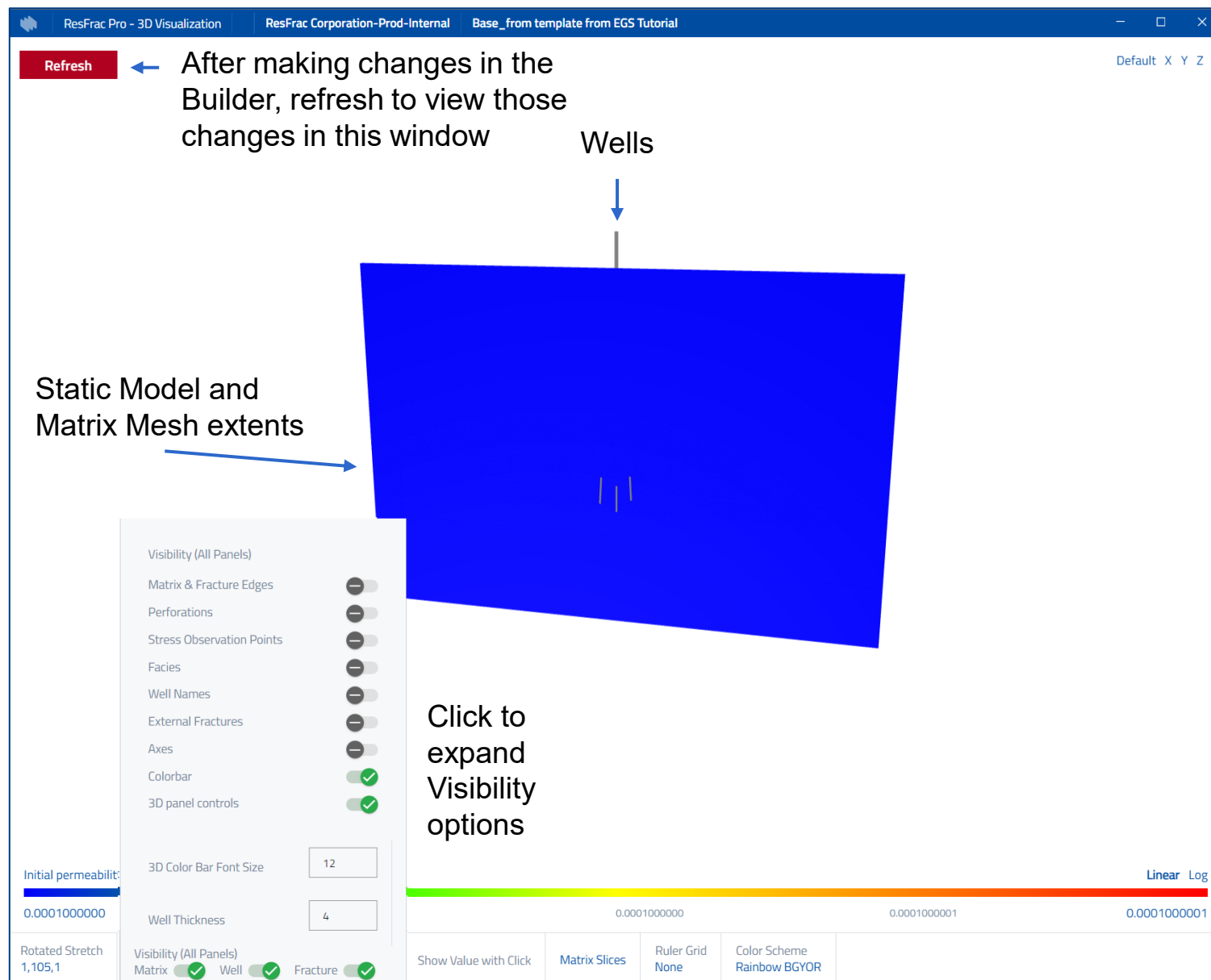
3D Preview Plot: Overview (1 of 2)

Use the 3D preview to check the well trajectories, static model properties, and matrix mesh extents.



3D Preview Plot: Overview (2 of 2)

Use the 3D preview to check the well trajectories, static model properties, and matrix mesh extents.



Static Model and Initial Conditions: Overview

Static Model and Initial Conditions
Data related to the geological parameters and starting state of the simulation

Editor Search

Static model library ?

☐ Check to use either cornerpoint or generalized rectilinear grid; uncheck to use a standard rectilinear grid ?

☐ Use general heterogeneity ?

Fluid pressure initialization method ?

- ☐ Hydrostatic equilibrium
- ☐ Specify pressure by layer
- ☒ Specify pressure gradient by layer

Initial water saturation input method ?

- ☒ Specify by layer
- ☐ Specify depth of water-hydrocarbon contact

Elastic properties input method ?

- ☒ Specify by layer
- ☐ Homogeneous elastic properties

Stress initial condition input method ?

- ☐ Specify stress by layer
- ☐ Specify frac gradient overall and stress deviation by layer
- ☒ Specify frac gradient by layer

- Import pre-existing static model, or save current one
- Option to import grid from Petrel or Leapfrog, or other non-layer cake model
- Initialization methods ('by layer', 'gradient by layer', or constant value)
- Define geological properties with depth
- Surface and reservoir temperature

Startup

Static Model and Initial Conditions

Curve Sets

Wells and Perforations

Meshing Options

Fluid Model Options

Fracture Options

Proppants

Water Solutes

Well Controls

Other Physics Options

Numerical Options

Output Options

Advanced Options

Builder autosave active

Editor Search

Properties versus depth wizard ?

☒ Depth on vertical axis for geological preview ?

GEOLOGICAL UNITS (FACIES LIST) ?

	Layer name ?	Top [ft] ?
1	Formation	0

New Row Resize Table

Global permeability multiplier 1 ?

Reference depth (datumdepth) [ft] 7370 ?

Direction of SHmax [degrees clockwise from the positive y-axis direction] 15 ?

☐ Randomized 'effective' tensile strength ?

Surface temperature [F] 68 ?

Initial temperature at reference depth [F] 385 ?

ResFrac

Scroll...

Static Model and Initial Conditions: Initialization methods

EGS Example File

ResFrac Pro ResFrac Corporation-Prod-Internal

Next Panel Discard Current Changes Save Changes Validate Exit

Static Model and Initial Conditions

Data related to the geological parameters and starting state of the simulation

Editor Search

Static model library ?

☐ Check to use either cornerpoint or generalized rectilinear grid; uncheck to use a standard rectilinear grid ?

☐ Use general heterogeneity ?

Fluid pressure initialization method ?

☐ Hydrostatic equilibrium

☐ Specify pressure by layer

☒ Specify pressure gradient by layer

Initial water saturation input method ?

☒ Specify by layer

☐ Specify depth of water-hydrocarbon contact

Elastic properties input method ?

☒ Specify by layer

☐ Homogeneous elastic properties

Stress initial condition input method ?

☐ Specify stress by layer

☐ Specify frac gradient overall and stress deviation by layer

☒ Specify frac gradient by layer

We will not be importing a model, but rather setting up one of our own

Advance option: a general heterogeneity temperature model may be used when there's a non-uniform temperature gradient across the domain

We'll use 'by layer' or 'gradient by layer' as the initialization method for all four properties

- This means these properties will be defined within the Geological Units table (as opposed to a separate input box)

Advance option: import geological model from Petrel or Leapfrog

Static Model and Initial Conditions:

- The default in ResFrac is to use a layer-cake model.
- Often EGS is modeled as a single homogenous layer (as opposed to O&G, which are typically layered sedimentary formations).
- Therefore, the Properties versus depth wizard is rarely used in EGS sims. If you have log data you would like to apply, see the Bakken tutorial for step-by-step instructions.

Properties versus depth wizard ?

GEOLOGICAL UNITS (FACIES LIST) ?

	Layer name ?	Top [ft] ?	Bottom [ft] ?	X (or Shmin) direction permeability [md] ?	Y (or Shmax) direction permeability [md] ?	Vertical permeability [md] ?	Curve set name (rel perm and PDPF) ?	Porosity compressibility [psi ⁻¹] ?	Initial porosity ?	Initial water saturation ?	Fracture gradient [psi/ft] ?	Rock solid matrix density [lbs/ft ³] ?
1	Formation	0	20000	0.0001	0.0001	0.0001	Base curve set ▼	0.00001	0.01	1	0.73	165.434096087405

New Row Resize Table

Global permeability multiplier ?

1

Reference depth (datumdepth) [ft] ?

10000

Direction of Shmax [degrees clockwise from the positive y-axis direction] ?

0

☐ Randomized 'effective' tensile strength ?

Surface temperature [F] ?

50

Initial temperature at reference depth [F] ?

400

Specify surface and reservoir temperature (at 12,000 ft depth)

Specify formation properties (see spreadsheet)

- Enter manually, or you can copy + paste from the spreadsheet
- The initialization methods and start up panel selections may change the number of columns in this table.
- Therefore, it is important that those are correctly selected, particularly if you are pasting in values.

Static Model and Initial Conditions: specify formation properties (1 of 7)

GEOLOGICAL UNITS (FACIES LIST) ?

	Layer name ?	Top [ft] ?	Bottom [ft] ?	X (or Shmin) direction permeability [md] ?	Y (or Shmax) direction permeability [md] ?	Vertical permeability [md] ?
1	Formation	0	20000	0.0001	0.0001	0.00001
Curve set name (rel perm and PDPF) ?	Porosity compressibility [psi^-1] ?	Initial porosity ?	Initial water saturation ?	Fracture gradient [psi/ft] ?	Rock solid matrix density [lbs/ft^3] ?	
Base curve set ▼	0.00001	0.005	1	0.76	165	
Rock heat capacity [BTU/(lb-R)] ?	Thermal conductivity [BTU/(hr-ft-R)] ?	delta(poro) per delta(temp) [1/F] ?	Biot coefficient ?	'Effective' tensile strength [psi] ?	K1c horizontal [psi-in^1/2] ?	
0.23	1.65	0	0.35	0		
K1c vertical [psi-in^1/2] ?	E0max [ft] ?	90% closure stress [psi] ?	Eresmax [ft] ?	Maximum flowing molar mass ?	Initial pore pressure gradient [psi/ft] ?	
7500	0.0008	500	0.00000328	100000		
Horizontal Young's modulus [psi] ?	Poisson's ratio ?	Vert over horiz modulus ?	Proppant embedment [lbs/ft^2] ?	Show in viz tool ?		
6000000	0.24	0.8	0.02	☒		
Effective x-permeability [md] ?	Effective x-permeability to water [md] ?	Effective x-permeability to oil [md] ?	Effective x-permeability to gas [md] ?	Reservoir leakoff coefficient [ft/min^0.5] ?		
0.0001	0.0001			0.000288836066796255		



- Vertical extent of the facies. In a single-facies model, this is somewhat arbitrary, as long as it encompasses the matrix mesh extents (see Meshing panel).

Static Model and Initial Conditions: specify formation properties (2 of 7)

GEOLOGICAL UNITS (FACIES LIST) ?

	Layer name ?	Top [ft] ?	Bottom [ft] ?	X (or Shmin) direction permeability [md] ?	Y (or SHmax) direction permeability [md] ?	Vertical permeability [md] ?
1	Formation	0	20000	0.0001	0.0001	0.00001

Curve set name (rel perm and PDPF) ?	Porosity compressibility [psi^-1] ?	Initial porosity ?	Initial water saturation ?	Fracture gradient [psi/ft] ?	Rock solid matrix density [lbs/ft^3] ?
Base curve set ▼	0.00001	0.005	1	0.76	165

Rock heat capacity [BTU/(lb-R)] ?	Thermal conductivity [BTU/(hr-ft-R)] ?	delta(poro) per delta(temp) [1/F] ?	Biot coefficient ?	'Effective' tensile strength [psi] ?	K1c horizontal [psi-in^(1/2)] ?
0.23	1.65	0	0.35	0	

K1c vertical [psi-in^(1/2)] ?	E0max [ft] ?	90% closure stress [psi] ?	Eresmax [ft] ?	Maximum flowing molar mass ?	Initial pore pressure gradient [psi/ft] ?
7500	0.0008	500	0.00000328	100000	

Horizontal Young's modulus [psi] ?	Poisson's ratio ?	Vert over horiz modulus ?	Proppant embedment [lbs/ft^2] ?	Show in viz tool ?
6000000	0.24	0.8	0.02	☒

Effective x-permeability [md] ?	Effective x-permeability to water [md] ?	Effective x-permeability to oil [md] ?	Effective x-permeability to gas [md] ?	Reservoir leakoff coefficient [ft/min^0.5] ?
0.0001	0.0001			0.00028883606679625

ResFrac

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- Permeability

Static Model and Initial Conditions: specify formation properties (3 of 7)

GEOLOGICAL UNITS (FACIES LIST) ?

	Layer name ?	Top [ft] ?	Bottom [ft] ?	X (or Shmin) direction permeability [md] ?	Y (or SHmax) direction permeability [md] ?	Vertical permeability [md] ?
1	Formation	0	20000	0.0001	0.0001	0.00001
	Curve set name (rel perm and PDPF) ?	Porosity compressibility [psi^-1] ?	Initial porosity ?	Initial water saturation ?	Fracture gradient [psi/ft] ?	Rock solid matrix density [lbs/ft^3] ?
	Base curve set ▼	0.00001	0.005	1	0.76	165
	Rock heat capacity [BTU/(lb-R)] ?	Thermal conductivity [BTU/(hr-ft-R)] ?	delta(poro) per delta(temp) [1/F] ?	Biot coefficient ?	'Effective' tensile strength [psi] ?	K1c horizontal [psi-in^(1/2)] ?
	0.23	1.65	0	0.35	0	3500
	K1c vertical [psi-in^(1/2)] ?	E0max [ft] ?	90% closure stress [psi] ?	Eresmax [ft] ?	Maximum flowing molar mass ?	Initial pore pressure gradient [psi/ft] ?
	7500	0.0008	500	0.00000328	100000	0.45
	Horizontal Young's modulus [psi] ?	Poisson's ratio ?	Vert over horiz modulus ?	Proppant embedment [lbs/ft^2] ?	Show in viz tool ?	
	6000000	0.24	0.8	0.02	☒	
	Effective x-permeability [md] ?	Effective x-permeability to water [md] ?	Effective x-permeability to oil [md] ?	Effective x-permeability to gas [md] ?	Reservoir leakoff coefficient [ft/min^0.5] ?	
	0.0001	0.0001			0.00028883606679625	

- Curve set (defined in the Curve Sets panel)

Static Model and Initial Conditions: specify formation properties (4 of 7)

GEOLOGICAL UNITS (FACIES LIST) ?

	Layer name ?	Top [ft] ?	Bottom [ft] ?	X (or Shmin) direction permeability [md] ?	Y (or SHmax) direction permeability [md] ?	Vertical permeability [md] ?
1	Formation	0	20000	0.0001	0.0001	0.00001
	Curve set name (rel perm and PDPF) ?	Porosity compressibility [psi ⁻¹] ?	Initial porosity ?	Initial water saturation ?	Fracture gradient [psi/ft] ?	Rock solid matrix density [lbs/ft ³] ?
	Base curve set ▼	0.00001	0.005	1	0.76	165
	Rock heat capacity [BTU/(lb-R)] ?	Thermal conductivity [BTU/(hr-ft-R)] ?	delta(poro) per delta(temp) [1/F] ?	Biot coefficient ?	'Effective' tensile strength [psi] ?	K1c horizontal [psi-in ^(1/2)] ?
	0.23	1.65	0	0.35	0	3500
	K1c vertical [psi-in ^(1/2)] ?	E0max [ft] ?	90% closure stress [psi] ?	Eresmax [ft] ?	Maximum flowing molar mass ?	Initial pore pressure gradient [psi/ft] ?
	7500	0.0008	500	0.00000328	100000	0.45
	Horizontal Young's modulus [psi] ?	Poisson's ratio ?	Vert over horiz modulus ?	Proppant embedment [lbs/ft ²] ?	Show in viz tool ?	
	6000000	0.24	0.8	0.02	☒	
	Effective x-permeability [md] ?	Effective x-permeability to water [md] ?	Effective x-permeability to oil [md] ?	Effective x-permeability to gas [md] ?	Reservoir leakoff coefficient [ft/min ^{0.5}] ?	
	0.0001	0.0001			0.00028883606679625	5

- Rock / formation properties (red)
- Thermal rock properties (blue) – these values are only included in 'thermal' simulations (selected in the startup panel).

Static Model and Initial Conditions: specify formation properties (5 of 7)

GEOLOGICAL UNITS (FACIES LIST) ?

	Layer name ?	Top [ft] ?	Bottom [ft] ?	X (or Shmin) direction permeability [md] ?	Y (or SHmax) direction permeability [md] ?	Vertical permeability [md] ?
1	Formation	0	20000	0.0001	0.0001	0.00001

Curve set name (rel perm and PDPF) ?	Porosity compressibility [psi ⁻¹] ?	Initial porosity ?	Initial water saturation ?	Fracture gradient [psi/ft] ?	Rock solid matrix density [lbs/ft ³] ?
Base curve set ▼	0.00001	0.005	1	0.76	165

Rock heat capacity [BTU/(lb-R)] ?	Thermal conductivity [BTU/(hr-ft-R)] ?	delta(poro) per delta(temp) [1/F] ?	Biot coefficient ?	'Effective' tensile strength [psi] ?	K1c horizontal [psi-in ^(1/2)] ?
0.23	1.65	0	0.35	0	3500

K1c vertical [psi-in ^(1/2)] ?	E0max [ft] ?	90% closure stress [psi] ?	Eresmax [ft] ?	Maximum flowing molar mass ?	Initial pore pressure gradient [psi/ft] ?
7500	0.0008	500	0.00000328	100000	0.45

Horizontal Young's modulus [psi] ?	Poisson's ratio ?	Vert over horiz modulus ?	Proppant embedment [lbs/ft ²] ?	Show in viz tool ?
6000000	0.24	0.8	0.02	☒

Effective x-permeability [md] ?	Effective x-permeability to water [md] ?	Effective x-permeability to oil [md] ?	Effective x-permeability to gas [md] ?	Reservoir leakoff coefficient [ft/min ^{0.5}] ?
0.0001	0.0001			0.00028883606679625

- Parameters related to the aperture of closed fractures.

Static Model and Initial Conditions: specify formation properties (6 of 7)

GEOLOGICAL UNITS (FACIES LIST) ?

	Layer name ?	Top [ft] ?	Bottom [ft] ?	X (or Shmin) direction permeability [md] ?	Y (or SHmax) direction permeability [md] ?	Vertical permeability [md] ?
1	Formation	0	20000	0.0001	0.0001	0.00001

Curve set name (rel perm and PDPF) ?	Porosity compressibility [psi^-1] ?	Initial porosity ?	Initial water saturation ?	Fracture gradient [psi/ft] ?	Rock solid matrix density [lbs/ft^3] ?
Base curve set ▼	0.00001	0.005	1	0.76	165

Rock heat capacity [BTU/(lb-R)] ?	Thermal conductivity [BTU/(hr-ft-R)] ?	delta(poro) per delta(temp) [1/F] ?	Biot coefficient ?	'Effective' tensile strength [psi] ?	K1c horizontal [psi-in^(1/2)] ?
0.23	1.65	0	0.35	0	3500

K1c vertical [psi-in^(1/2)] ?	E0max [ft] ?	90% closure stress [psi] ?	Eresmax [ft] ?	Maximum flowing molar mass ?	Initial pore pressure gradient [psi/ft] ?
7500	0.0008	500	0.00000328	100000	0.45

Horizontal Young's modulus [psi] ?	Poisson's ratio ?	Vert over horiz modulus ?	Proppant embedment [lbs/ft^2] ?	Show in viz tool ?
6000000	0.24	0.8	0.02	☒

Effective x-permeability [md] ?	Effective x-permeability to water [md] ?	Effective x-permeability to oil [md] ?	Effective x-permeability to gas [md] ?	Reservoir leakoff coefficient [ft/min^0.5] ?
0.0001	0.0001			0.00028883606679625

ResFrac

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- Parameters governing completion fluid and proppant interactions with rock

Static Model and Initial Conditions: specify formation properties (7 of 7)

GEOLOGICAL UNITS (FACIES LIST) ?

	Layer name ?	Top [ft] ?	Bottom [ft] ?	X (or Shmin) direction permeability [md] ?	Y (or Shmax) direction permeability [md] ?	Vertical permeability [md] ?
1	Formation	0	20000	0.0001	0.0001	0.00001

Curve set name (rel perm and PDPF) ?	Porosity compressibility [psi ⁻¹] ?	Initial porosity ?	Initial water saturation ?	Fracture gradient [psi/ft] ?	Rock solid matrix density [lbs/ft ³] ?
Base curve set ▼	0.00001	0.005	1	0.76	165

Rock heat capacity [BTU/(lb-R)] ?	Thermal conductivity [BTU/(hr-ft-R)] ?	delta(poro) per delta(temp) [1/F] ?	Biot coefficient ?	'Effective' tensile strength [psi] ?	K1c horizontal [psi-in ^(1/2)] ?
0.23	1.65	0	0.35	0	3500

K1c vertical [psi-in ^(1/2)] ?	E0max [ft] ?	90% closure stress [psi] ?	Eresmax [ft] ?	Maximum flowing molar mass ?	Initial pore pressure gradient [psi/ft] ?
7500	0.0008	500	0.00000328	100000	0.45

Horizontal Young's modulus [psi] ?	Poisson's ratio ?	Vert over horiz modulus ?	Proppant embedment [lbs/ft ²] ?	Show in viz tool ?
6000000	0.24	0.8	0.02	☒

Effective x-permeability [md] ?	Effective x-permeability to water [md] ?	Effective x-permeability to oil [md] ?	Effective x-permeability to gas [md] ?	Reservoir leakoff coefficient [ft/min ^{0.5}] ?
0.0001	0.0001			0.00028883606679625

- Grayed out boxes are not user-input values, but rather values calculated from the user-inputs. These cells are not directly editable.

Static Model and Initial Conditions: Temperature & orientation

Global permeability multiplier ?

Reference depth (datumdepth) [ft] ?

Direction of SHmax (degrees clockwise from the positive y-axis direction) ?

☐ Randomized 'effective' tensile strength ?

Surface temperature [F] ?

Initial temperature at reference depth [F] ?

Specify the stress orientation, so that it's at the correct angle relative to the well orientation (to be specified in the Wells and Perforations panel)

If the direction is non-zero, ensure this property (below) is selected in the Startup panel. (it is by default)

☒ Rotate simulation mesh to align with stresses ?

Changing the stress direction will cause current perf clusters to no longer be located within the matrix. This may cause an error in the 3D preview plot until new wells and/or stages are set-up.

Specify surface and reservoir temperature (at 12,000 ft depth)

Static Model and Initial Conditions: Matrix edge boundary conditions

Depending on your application, you may wish to change the matrix edge BCs from the default 'No Flow' conditions to 'Constant Pressure' conditions.

- 'No flow' conditions represent closed boundaries, such as with a sealing fault or interference from neighboring wells or stages. This may also be appropriate in very low perm conditions.
- Constant pressure can be used to simulate an "infinite reservoir". It allows for fluid loss or recharge from the greater reservoir. The boundary should be far enough away that pressure changes can be assumed to be negligible.

Set the SHmax direction boundaries to a constant pressure boundary

Advanced options ^

⋮

MATRIX EDGE BOUNDARY CONDITIONS ?

	Boundary ?	Matrix edge boundary conditions ?
1	Top	NoFluidOrHeatFlow ▼
2	Bottom	NoFluidOrHeatFlow ▼
3	NegX	NoFluidOrHeatFlow ▼
4	PosX	NoFluidOrHeatFlow ▼
5	NegY	ConstantPressure ▼
6	PosY	ConstantPressure ▼

Low z-perm

Neighboring stages

Infinite reservoir

NoFluidOrHeatFlow

ConstantPressure

Surface depth [ft]
0

Curve Sets: Overview

The screenshot shows the 'Curve Sets' configuration page in ResFrac. The left sidebar contains navigation links: Welcome, Startup, Static Model and Initial Conditions, Curve Sets (selected), Wells and Perforations, Meshing Options, Fluid Model Options, Fracture Options, Proppants, Water Solutes, Well Controls, Other Physics Options, Numerical Options, Output Options, and Advanced Options.

The main content area is titled 'Curve Sets' and includes a sub-header 'Specify parameters related to the relative permeabilities and pressure dependent permeability'. It features an 'Editor' tab and a 'Search' bar. Below these are two buttons: 'Curve sets library' and 'Pressure dependent permeability wizard'. A checkbox 'Use parameterized PDP curves' is checked.

The 'CURVE SETS FOR MATRIX RELATIVE PERMEABILITY AND PRESSURE DEPENDENT PERMEABILITY' section shows 'Number of Curves: 1' and a 'Previous 1 Next' navigation bar. A red arrow points from the 'Base curve set' label to a detailed inset of the 'Base curve set' configuration.

The 'Base curve set' configuration is shown in a detailed inset. It includes a 'Name' field (Base curve set) and a 'Relative permeability model type' dropdown (BrooksCorey). Below this is the 'BROOKS COREY RELATIVE PERMEABILITY MODEL' section with fields for 'Max Sor' (0.2), 'Max Sgr' (0.03), 'Water phase exponent' (2), 'Oil phase exponent' (2), 'Gas phase exponent' (1.2), 'k_{rw} multiplier' (1), 'k_{ro} multiplier' (1), and 'k_{rg} multiplier' (1).

Below the Brooks Corey model is a section for '10x reversible permeability loss per pressure increment [psi]' (500), '10x irreversible permeability loss per pressure increment [psi]' (2400), 'Lower deltaP threshold for reversible permeability increase [psi]' (500), 'Upper deltaP threshold for reversible permeability increase [psi]' (2400), 'Perm multiplier for reversible permeability increase' (55.3840630469185), 'Lower deltaP threshold for irreversible permeability increase [psi]', 'Upper deltaP threshold for irreversible permeability increase [psi]', 'Perm multiplier for irreversible permeability increase', and 'Permeability multiplier' (1).

At the bottom of the main content area is the 'Three phase rel perm model (with OilThreePhase option)' section, which includes radio buttons for 'Stonel', 'Stonell', 'BakerOnlykrol', and 'BakerOnlykroll' (selected). There is also an 'Advanced options' dropdown.

Annotations include a red bracket labeled 'Expand curve set' pointing to the 'Base curve set' label. A blue box highlights the 'BrooksCorey' model type and its parameters. Blue arrows point from a list of parameters to their respective fields in the configuration. A red arrow points from the 'Permeability multiplier' field to the 'Advanced options' dropdown.

Parameters listed in the annotations:

- Relative permeability
- Negative reversible PDP
- Negative irreversible PDP
- Positive reversible PDP
- Positive irreversible PDP
- Perm multiplier
- Water bank

Water bank parameters (from the inset):

- Water bank thickness to rel perm increase scaling thickness [ft]
- Water bank thickness to rel perm decrease scaling thickness [ft]
- Water bank immobile fraction
- Maximum immobilized proppant mass per area (per curve set) [lbs/ft²]

Curve Sets: specify pressure-dependent matrix permeability

Curve Sets
Specify parameters related to the relative permeabilities and pressure dependent permeability factors

Editor Search

Curve sets library ?

Pressure dependent permeability wizard ?

☒ Use parameterized PDP curves ?

CURVE SETS FOR MATRIX RELATIVE PERMEABILITY AND PRESSURE DEPENDENT PERMEABILITY ?

Number of Curves: 1

Previous 1 Next

> Base curve set

☒ Shift PDP table with stress depletion ?

Three phase rel perm model (with OilThreePhase option) ?

☐ Stonel

☐ Stonell

☐ BakerOnlykrol

☒ BakerOnlykroll

Advanced options ▾

Expand curve set

Positive reversible PDP means the permeability increases at high pressures (during stimulation), then returns to normal.

Base curve set

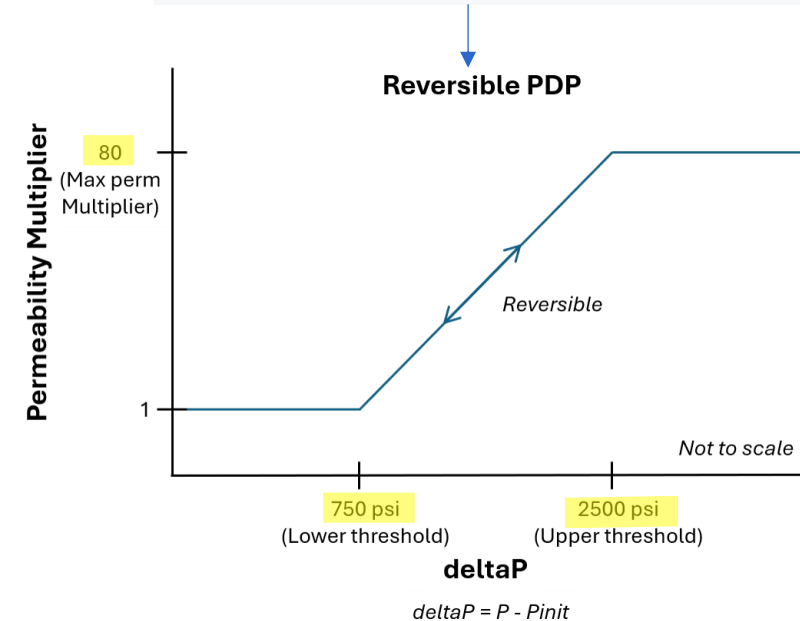
scroll

Lower deltaP threshold for reversible permeability increase [psi] 750 ?

Upper deltaP threshold for reversible permeability increase [psi] 2500 ?

Perm multiplier for reversible permeability increase 80 ?

Set positive reversible pressure dependent permeability (PDP)



Wells and Perforations: Overview

Wells and Perforations
Specify parameters related to wells and perforations

Editor Search

Wells and perforations library ?

Convert perforation clusters wizard ?

Perforation cluster location specification method ?

☐ Specify perforation clusters one-at-a-time

☒ Specify using 'inline' method (e.g., number of clusters per stage)

Use length per cluster to specify perforation cluster locations ?

☒ Specify clusters per stage

☐ Specify length per cluster

Wellbore survey import wizard ?

Adjust well landing depth wizard ?

Well stages setup wizard ?

Well shift wizard ?

WELL TRAJECTORIES AND PERFORATION LOCATIONS ? ⚠

Number of Items: 2

Previous 1 Next

>	Well_Inj	Measured depth at toe: 15912.6 ft	Total stages: 1
>	Well_Prod	Measured depth at toe: 15912.6 ft	Total stages: 1

- Import saved wells
- Cluster specification methods
- Import or move wells, setup stages
- Well vertex and stage info (expandable for each well)
- External fractures (represents stress shadowing)
- Perf phasing

EXTERNAL FRACTURES ? 📄

	Well name ?	Approx distance from edge of matrix region [ft] ?	Center x-coordinate [ft] ?	Center y-coordinate [ft] ?
1	Well_Inj ▼	9		
2	Well_Prod ▼	9		

New Row Resize Table

Perforation phasing option ?

☒ NoEffect

☐ Builtin

☐ Custom

Advanced options ▼

Wells and Perforations: Cluster specification methods

The screenshot shows the 'Wells and Perforations' configuration page in the ResFrac software. The left sidebar contains a navigation menu with the following items: Welcome, Startup, Static Model and Initial Conditions, Curve Sets, Wells and Perforations (highlighted), Meshing Options, Fluid Model Options, Fracture Options, Proppants, Water Solutes, Well Controls, Other Physics Options, Numerical Options, Output Options, and Advanced Options.

The main content area is titled 'Wells and Perforations' with the subtitle 'Specify parameters related to wells and perforations'. It features an 'Editor' tab and a 'Search' bar. Below these are several green buttons: 'Wells and perforations library', 'Convert perforation clusters wizard', 'Wellbore survey import wizard', 'Adjust well landing depth wizard', 'Well stages setup wizard', and 'Well shift wizard'. Each button has a help icon.

The 'Perforation cluster location specification method' section contains two radio button options: 'Specify perforation clusters one-at-a-time' and 'Specify using 'inline' method (e.g., number of clusters per stage)'. The second option is selected and circled in red. A red arrow points from a text box 'Set up cluster location using in-line method' to this option.

The 'Use length per cluster to specify perforation cluster locations' section contains two radio button options: 'Specify clusters per stage' and 'Specify length per cluster'. The first option is selected and circled in red. A red arrow points from a text box 'Specify clusters per stage' to this option.

Below these sections is a table titled 'WELL TRAJECTORIES AND PERFORATION LOCATIONS' with a warning icon. It shows 'Number of Items: 2' and a pagination bar with 'Previous', '1', and 'Next' buttons. The table lists two wells:

Well	Measured depth at toe	Total stages
> Well_Inj	15912.6 ft	1
> Well_Prod	15912.6 ft	1

Wells and Perforations: delete existing wells from template

Delete default wells

Wells and Perforations
Specify parameters related to wells and perforations

Editor Search

Wellbore survey import wizard ?
Adjust well landing depth wizard ?
Well stages setup wizard ?
Well shift wizard ?

WELL TRAJECTORIES AND PERFORATION LOCATIONS ?

Number of Items: 3 [Add Item](#)

Previous 1 Next

> Well_1p	Measured depth at toe: 13041.6 ft	Total stages: 1	Duplicate 
> Well_3p	Measured depth at toe: 13153.2 ft	Total stages: 1	Duplicate 
> Well_2i	Measured depth at toe: 13370 ft	Total stages: 1	Duplicate 

EXTERNAL FRACTURES ? 

Wells and Perforations: import well from survey (slide 1 of 2)

Create **Well_Prod** using Wellbore survey import wizard (see excel sheet, Wells tab)

Wells and Perforations

Specify parameters related to wells and perforations

Editor Search

Wells and perforations library ?

Convert perforation clusters wizard ?

Perforation cluster location specification method ?

- ☐ Specify perforation clusters one-at-a-time
- ☒ Specify using 'inline' method (e.g., number of clusters per stage)

Use length per cluster to specify perforation cluster locations ?

- ☒ Specify clusters per stage
- ☐ Specify length per cluster

Wellbore survey import wizard ?

Adjust well landing depth wizard ?

Well stages setup wizard ?

Well shift wizard ?

Wellbore survey import wizard ?

This wizard imports data from a wellbore survey. Before using this wizard, refer to the help content in the 'Well inputted in a table with MD, inclination, and azimuth. You also need to provide the (x,y,z) coordinates of the well along a series of line-segments defined between these points. This 'Wellbore survey import' wizard converts fr

We recommend that you set up the coordinate system so that the X and Y axes are aligned with NS-EW. In add stresses'. With this setting, the simulation mesh will rotate from the X-Y coordinate directions to align with the choose to use Northing-Easting, or may find it convenient to place the (0,0) origin of the coordinate system at

Well name ?

Wellhead x-position [ft] ?

Wellhead y-position [ft] ?

Wellhead z-position [ft] ?

Wellbore inner diameter [inches] ?

Optional recentering MD [ft] ?

Important: when importing the first well, re-center the matrix around 15,260 MD. This is the center of the well lateral (Prod Interval).

	A	B	C	D
1		MD (ft)	Inclination (deg)	Azimuth (deg)
44	Curve	12410.6	75.0	140
45	Production Interval	12710.6	90.0	140
46	Production Interval	13010.6	90.0	140
47	Production Interval	13310.6	90.0	140
48	Production Interval	13610.6	90.0	140
49	Production Interval	13910.6	90.0	140
50	Production Interval	14210.6	90.0	140
51	Production Interval	14510.6	90.0	140
52	Production Interval	14810.6	90.0	140
53	Production Interval	15110.6	90.0	140
54	Production Interval	15410.6	90.0	140
55	Production Interval	15710.6	90.0	140
56	Production Interval	16010.6	90.0	140
57	Production Interval	16310.6	90.0	140
58	Production Interval	16610.6	90.0	140
59	Production Interval	16910.6	90.0	140
60	Production Interval	17210.6	90.0	140
61	Production Interval	17510.6	90.0	140
62	Production Interval	17810.6	90.0	140
63	Production Interval	17811.6	90.0	140
64	Production Interval	17812.6	90.0	140

SURVEY TABLE ?

MD [ft]	Inclination [degrees]	Azimuth [degrees]
---------	-----------------------	-------------------

Wells and Perforations: import well from survey (slide 2 of 2)

Copy the well survey data from the excel sheet into the wizard

	A	B	C	D
1		MD (ft)	Inclination (deg)	Azimuth (deg)
2	Vertical Section	0	0	140
3	Vertical Section	300	0	140
4	Vertical Section	600	0	140
5	Vertical Section	900	0	140
6	Vertical Section	1200	0	140
7	Vertical Section	1500	0	140
8	Vertical Section	1800	0	140
9	Vertical Section	2100	0	140
10	Vertical Section	2400	0	140
11	Vertical Section	2700	0	140
12	Vertical Section	3000	0	140
13	Vertical Section	3300	0	140
14	Vertical Section	3600	0	140
15	Vertical Section	3900	0	140
16	Vertical Section	4200	0	140
17	Vertical Section	4500	0	140
18	Vertical Section	4800	0	140
19	Vertical Section	5100	0	140
20	Vertical Section	5400	0	140

⋮ scroll

The azimuth of the well is perpendicular to SHmax ($50^\circ + 90^\circ$)

Wellbore survey import wizard ?

Wellbore inner diameter [inches] ?
9.56

Optional recentering MD [ft] ?
15260

SURVEY TABLE ?

	MD [ft] ?	Inclination [degrees] ?	Azimuth [degrees] ?	
1	0	0	140	≡
2	300	0	140	≡
3	600	0	140	≡
4	900	0	140	≡
5	1200	0	140	≡
6	1500	0	140	≡
7	1800	0	140	≡
8	2100	0	140	≡
9	2400	0	140	≡

Add a new row first to paste in the spreadsheet contents

New Row Resize Table

Apply

Reset to default values

Wells and Perforations: Confirm import

To view the imported well information, expand Well_Prod under the 'Well Trajectories and Perforation Locations' section. There you'll find 1) the Well Vertices table, and 2) stage information (not yet defined).

WELL TRAJECTORIES AND PERFORATION LOCATIONS ? ⚠

Number of Items: 1

Previous 1 Next

Well_Prod Measured depth at toe: 17812.6 ft Total stages: 1

Well names
Well_Prod ?

WELL VERTICES [FT] ? 📄

	Measured depth [ft] ?	x-location [ft] ?	y-location [ft] ?	z-location [ft] ?	Inner diameter [in] ?
1	0	0	-3.7298831273496e-13	0	9.56
2	300	0	-3.7298831273496e-13	300	9.56
3	600	0	-3.7298831273496e-13	600	9.56
4	900	0	-3.7298831273496e-13	900	9.56
5	1200	0	-3.7298831273496e-13	1200	9.56
6	1500	0	-3.7298831273496e-13		
7	1800	0	-3.7298831273496e-13		
8	2100	0	-3.7298831273496e-13		
9	2400	0	-3.7298831273496e-13		

New Row Resize Table

Confirm the well locations and ID defined in the import wizard

If the ID changes with depth, manually edit here

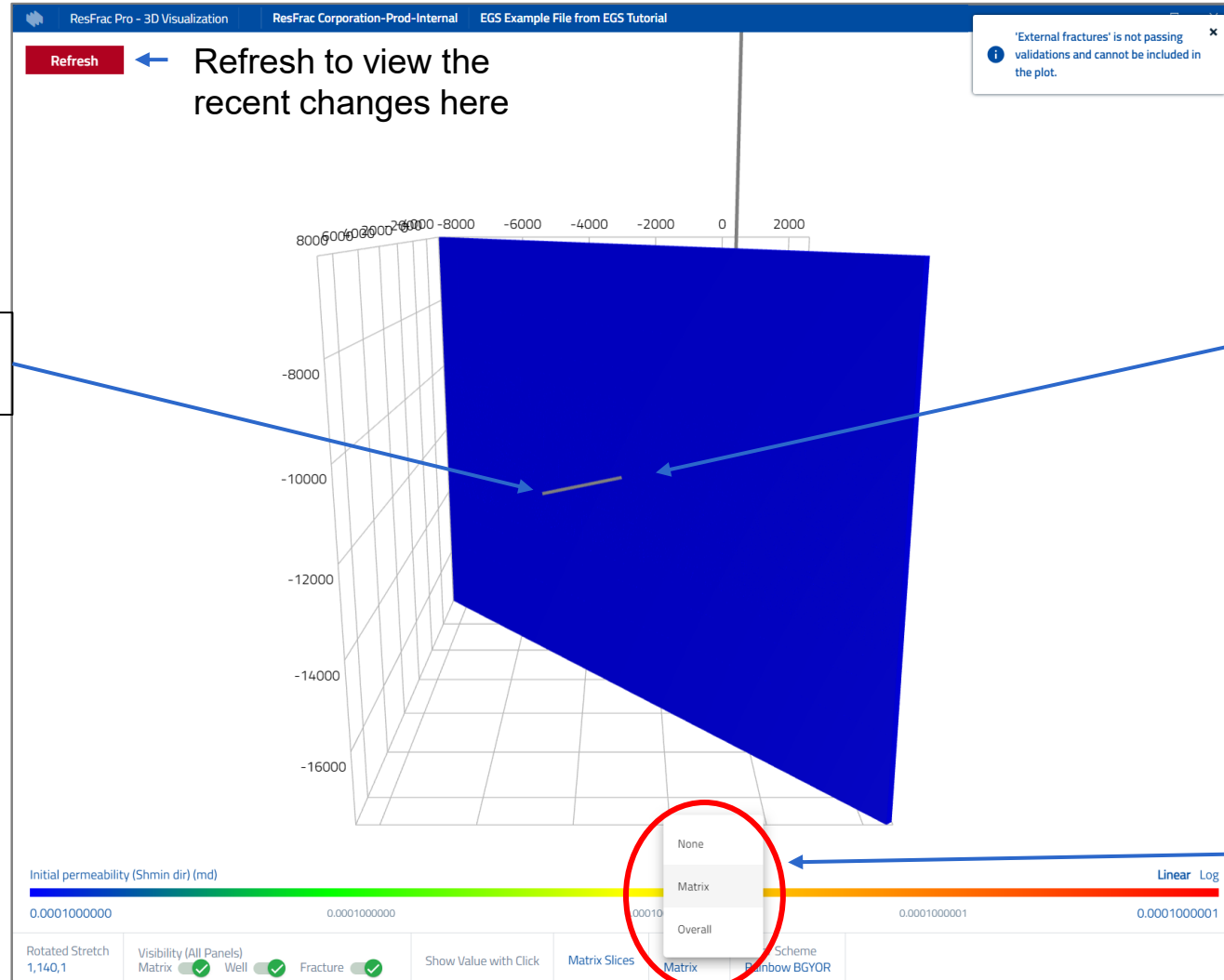
The rest of these parameters have been assigned default values

Absolute roughness [in] ?	Check if cased (not openhole) ?	Stage number ?	Heat transfer coefficient [BTU/(ft ² ·2-hr-F)] ?	NW complexity exponent ?	NW complexity coefficient [psi/(bpm) ^{exponent}] ?	Conductivity of 'flow outside casing' [md-ft] ?
0.00196850393700787	✓	1	8.987631079738	0.5	0	
0.00196850393700787	✓	1	8.987631079738	0.5	0	
0.00196850393700787	✓	1	8.987631079738	0.5	0	
0.00196850393700787	✓	1	8.987631079738	0.5	0	
0.00196850393700787	✓	1	8.987631079738	0.5	0	
0.00196850393700787	✓	1	8.987631079738	0.5	0	
0.00196850393700787	✓	1	8.987631079738	0.5	0	
0.00196850393700787	✓	1	8.987631079738	0.5	0	
0.00196850393700787	✓	1	8.987631079738	0.5	0	

Wells and Perforations: 3D preview plot check (slide 1 of 2)

At this point you can re-open or refresh the 3D preview plot. Observe:

- A) The newly imported well replaces the original 3 from the template.
- B) The matrix location has been recentered. You can check this by turning on the ruler grid for the matrix.



A) Confirm new well is in the correct location.

Toaster message indicates we need to correct the external fractures. That will be next, after we add the second well.

B) Confirm the matrix is centered along the lateral (15,260 ft MD, 11,900 ft TVD).

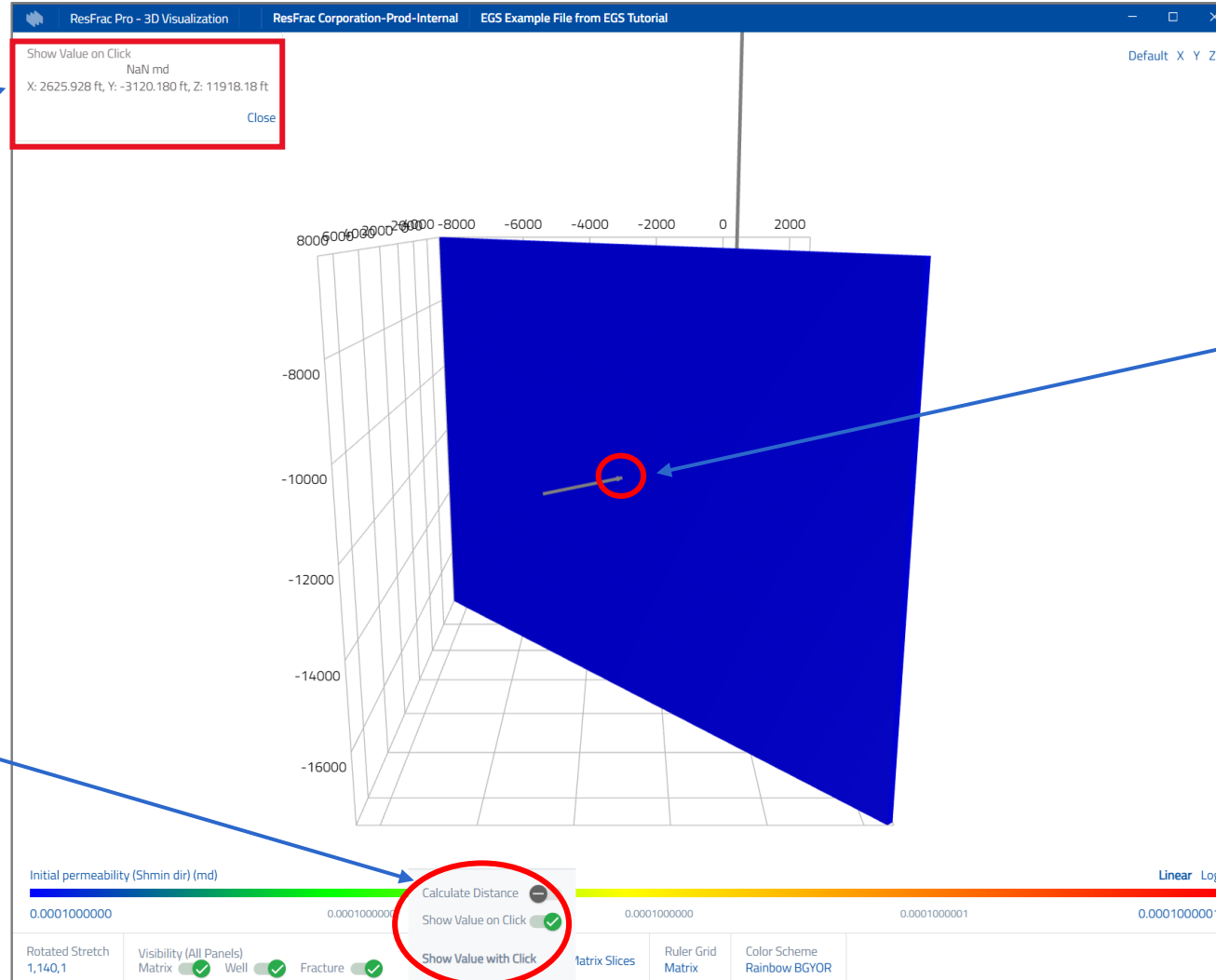
The matrix can also be re-centered as part of the Stages setup wizard (next) or the Meshing panel.

Select 'Ruler Grid' to verify the depth of the well and matrix

Wells and Perforations: 3D preview plot check (slide 2 of 2)

Confirm your well and matrix placement using 'Show value with click'.

'Show value with click'
shows x, y, z
coordinates



Wells and Perforations: create second well (option A) - import

Repeat for second well - Enter wellbore info, shifting the wellhead position

Wellbore survey import wizard

This wizard imports data from a wellbore survey. Before using this wizard, refer to the help content in the 'Well inputted in a table with MD, inclination, and azimuth. You also need to provide the (x,y,z) coordinates of the well along a series of line-segments defined between these points. This 'Wellbore survey import' wizard converts fr

We recommend that you set up the coordinate system so that the X and Y axes are aligned with NS-EW. In add stresses'. With this setting, the simulation mesh will rotate from the X-Y coordinate directions to align with the choose to use Northing-Easting, or may find it convenient to place the (0,0) origin of the coordinate system at

Well name
Well_Prod

Wellhead x-position [ft]
0

Wellhead y-position [ft]
0

Wellhead z-position [ft]
0

Wellbore inner diameter [inches]
9.56

Optional recentering MD [ft]
15260

Wellbore spacing of
400 ft horizontally
and 200 ft vertically

Wellbore survey import wizard

This wizard imports data from a wellbore survey. Before using this wizard, refer to the help content in the 'Well inputted in a table with MD, inclination, and azimuth. You also need to provide the (x,y,z) coordinates of the well along a series of line-segments defined between these points. This 'Wellbore survey import' wizard converts fr

We recommend that you set up the coordinate system so that the X and Y axes are aligned with NS-EW. In add With this setting, the simulation mesh will rotate from the X-Y coordinate directions to align with the direction use Northing-Easting, or may find it convenient to place the (0,0) origin of the coordinate system at one of the

Well name
Well_Inj

Wellhead x-position [ft]
306

Wellhead y-position [ft]
257

Wellhead z-position [ft]
200

Wellbore inner diameter [inches]
9.64

Optional recentering MD [ft]

To account for the SHmax direction (50° in this case), apply the following equations:

$$x = 400 \text{ ft} * \sin(50^\circ)$$
$$y = 400 \text{ ft} * \cos(50^\circ)$$

Positive z values represent depth.

When importing the second well, you **do not** need to re-center the matrix. It has already been centered around the first well.

SURVEY TABLE

	MD [ft]	Inclination [degrees]	Azimuth [degrees]	
1	0	0	140	
2	300	0	140	
3	600	0	140	

SURVEY TABLE

	MD [ft]	Inclination [degrees]	Azimuth [degrees]	
1	0	0	140	
2	300	0	140	
3	600	0	140	

Wells and Perforations: create second well (option B) – copy (1 of 3)

Alternatively, you may copy the existing Well_Prod, and shift its location (using this 4-step process)

The screenshot displays the 'WELL TRAJECTORIES AND PERFORATION LOCATIONS' section of the ResFrac software. At the top, a vertical list of wizards includes 'Wellbore survey import wizard', 'Adjust well landing depth wizard' (circled in red), 'Well stages setup wizard', and 'Well shift wizard' (circled in red). To the right of these, 'Step 4. Shift well down 200 ft**' and 'Step 3. Shift well over (in the SHmax direction) by 400 ft*' are indicated. Below the wizards, a table lists existing wells. The first row shows 'Well_Prod' with a 'Duplicate' button circled in red. A red arrow points from 'Step 1. Duplicate' to this button. The second row shows 'Well_Prod_2_' with a 'Duplicate' button. A blue arrow points from 'New well' to this row. Below the table, a text input field for 'Well names' contains 'Well_Inj', with a red arrow pointing from 'Step 2. Rename copy to Well_Inj' to it. The interface also includes a 'Previous' button, a page indicator '1', a 'Next' button, and an 'Add Item' link.

Step 4. Shift well down 200 ft**

Step 3. Shift well over (in the SHmax direction) by 400 ft*

Step 1. Duplicate

Step 2. Rename copy to Well_Inj

New well →

* The 'Well shift wizard' can also be used to test different well spacings.

** The 'Adjust well landing depth wizard' is useful for testing different depths (and temperatures).

[illegible]

Step 3: Well shift wizard

Well shift wizard ?

This wizard shifts the wells side-to-side by the specified distance. You can choose to enter the shift distance either as a distance along the SHmax azimuth or as a distance perpendicular to the well azimuth. A positive shift distance moves the well in the direction of SHmax, as defined in the 'Static Model and Initial Conditions' panel. A negative distance shifts the well in the direction 180 degrees opposed to SHmax.

Well shift distance specification method ?

☒ Distance in SHmax direction

☐ Distance in perpendicular to the well azimuth ('gun barrel' distance)

WELL SHIFT DISTANCE [FT] ? 📄

	Well name ?	Well shift distance [ft] ?
1	Well_Inj	0
2	Well_Prod	400

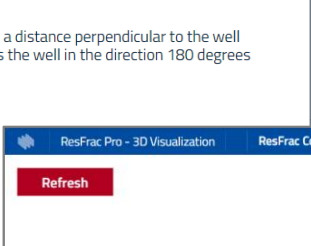
Apply Reset to default values

View new well location

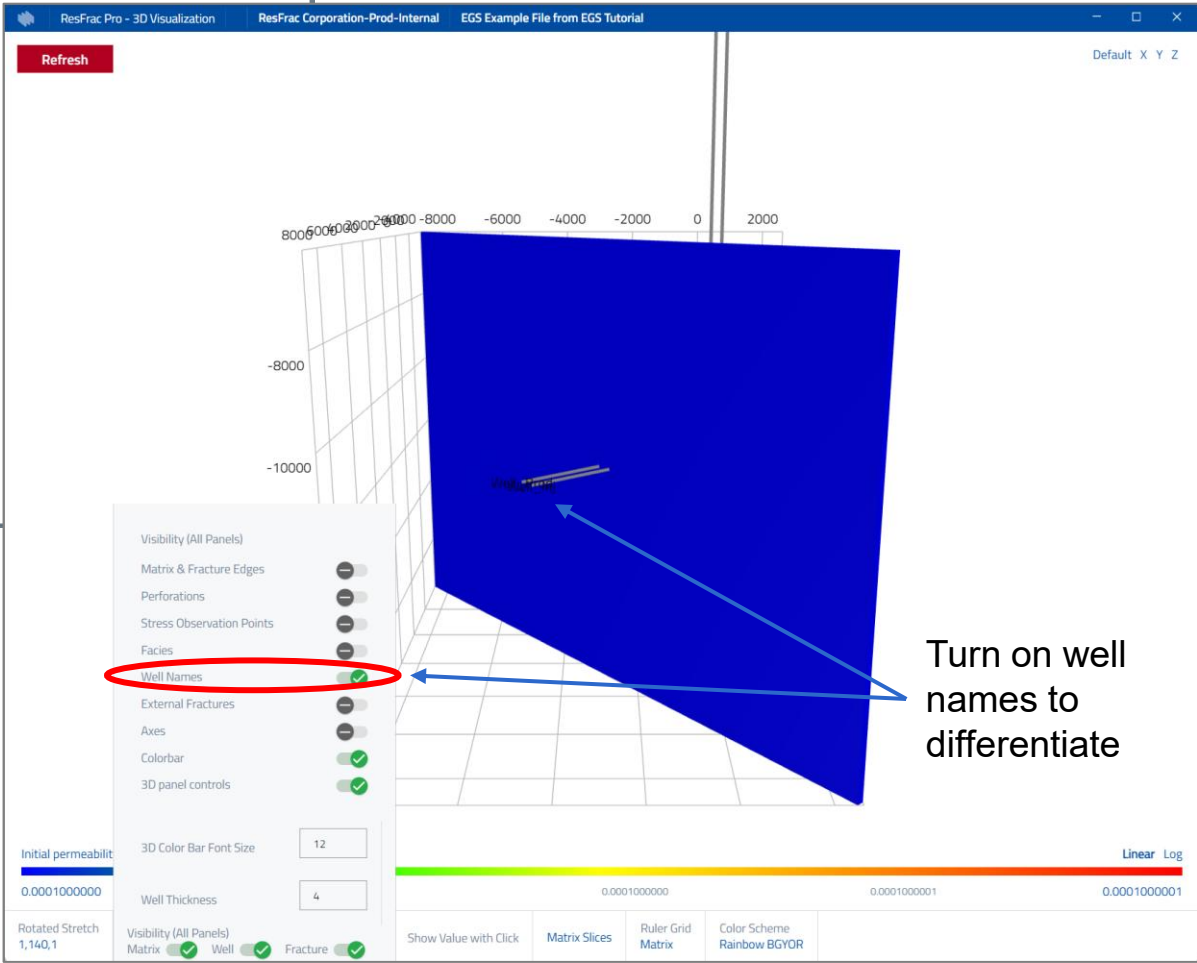


ResFrac Pro - 3D Visualization

Refresh



Goal: Shift Well_Inj over 400 ft



Wells and Perforations: create second well (option B) – copy (3 of 3)

Step 4: Adjust well landing depth

Adjust well landing depth wizard

This wizard adjusts the wellbore landing depth to make sure that it is landed in the correct formation. Before using this wizard, refer to the help content for the 'Wells and perforations' panel for background information.

In ResFrac, we typically define formation properties versus depth and model only a section of the wellbore. A problem arises because if you import a wellbore survey, the well may be dipping up or down to follow the natural dip of the formation, which isn't captured in the 'properties versus depth' table. Therefore, you need to adjust the wellbore landing depth in the model up or down in order to make sure that the well is completed in the correct zone within the 'matrix region' that defines the section of the well that is being modeled.

IMPORTANT: The wizard identifies the section of the well that crosses the center of matrix region (measured along the line running in the direction of SHmax). The exception leaving the wellhead at surface, in order to land that section of the well within the user-specified depth interval. Make sure that the center of the matrix region location that you want landed at the specified zone!

Well name

Well_Inj

Well landing zone

Formation

Adjust the matrix region depth?

No

Position within landing zone

0.605

Apply

Reset to default values

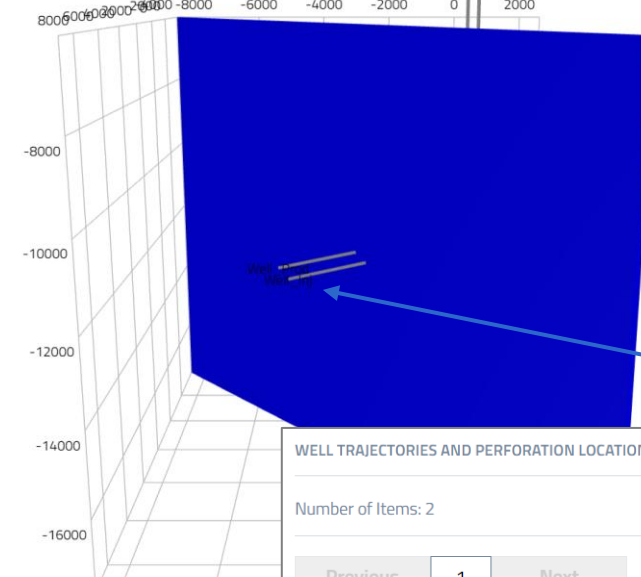
We already re-centered the matrix during Well_Prod import

ResFrac Pro - 3D Visualization

ResFrac Corporation-Prod-Internal

EGS Example File from EGS Tutorial

Refresh



Well_Inj has shifted down

WELL TRAJECTORIES AND PERFORATION LOCATIONS

Number of Items: 2

Previous

1

Next

> Well_Prod

Measured depth at toe: 17812.6 ft

Total stages: 0

> Well_Inj

Measured depth at toe: 18012.6 ft

Total stages: 0

Goal: Shift Well_Inj down 200 ft (to 12,100 ft TVD)

The landing zone is our single layer in the static model: Formation. Calculate the desired position in the landing zone. In this case: $12,100 \text{ ft (target depth)} / 20,000 \text{ ft (formation thickness)} = 0.605$.

Wells and Perforations: add stages

- We will be simulating a single stage, so the MD distance in the model (Shmin direction) is set to be the same as the stage length.

Use length per cluster to specify perforation cluster locations ?

☒ Specify clusters per stage

☐ Specify length per cluster

Wellbore survey import wizard ?

Adjust well landing depth wizard ?

Well stages setup wizard ?

Well shift wizard ?

WELL TRAJECTORIES AND PERFORATION LOCATIONS ? ⚠

Excel file data:

	A	B	C
1	Stage length	200 ft	
2	Shots per cluster	6	
3	Perforation shot diameter	0.28 in	
4	Perforation discharge coefficient	0.9	
5	Number of clusters per stage	8	
6			
7	Stage setup identical for injector and producer		

Well stages setup wizard ?

The section of the well near the toe that is not in any stage is assigned to stage '0'. The section of the well at the heel that is not in any number. So for example, if you are modeling three stages, then Stage '4' is the section of the well from the heel side to the well head to

After the wizard has run, it is strongly recommended that you pull up the 3D preview image to visualize the wells, the matrix region, and looks correct. The element size in the Shmin direction may be changed by this wizard.

MD distance in model [ft] 200 ?

STAGE LENGTH PER WELL ?

	Well name ?	Stage length per well [ft] ?
1	Well_Prod	200
2	Well_Inj	200

When modeling a single stage, the stage and sector lengths are equal

$$stage\ length = \frac{sector\ length}{number\ of\ stages}$$

(Optional) New matrix region center x-coordinate [ft] ?

(Optional) New matrix region center y-coordinate [ft] ?

The matrix center dictates where the stages are located along the lateral. In this case, we already recentered from the Wellbore survey import wizard. This can also be done in the Meshing Options panel.

Averaging option Modify MD ?

Apply

Reset to default values

Wells and Perforations: expand well details and add clusters

Expand each well. Confirm the stage numbers have been updated in the Well Vertices table. Then scroll past the table to define the clusters and perf data (see the Perfs tab in the excel file).

Well_Prod Measured depth at toe: 17812.6 ft Total stages: 1

Well names
Well_Prod

WELL VERTICES [FT] ?

	Measured depth [ft] ?	Stage number ?	x-location [ft] ?
49	14210.6	2	1792.96805046558
50	14510.6	2	1985.80433337155
51	14810.6	2	2178.64061627751
52	15110.6	2	2371.47689918347
53	15159.9999999995	1	2403.23060710166
54	15359.9999999995	0	2531.78812903897
55	15410.6	0	2564.31318208943
56	15710.6	0	2757.14946499539
57	16010.6	0	2949.98574790135

New Row Resize Table

■ scroll

Shots per cluster
6

Perforation shot diameter [in]
0.28

Perforation coefficient of discharge
0.9

CLUSTERS PER STAGE ?

	Clusters per stage ?
1	8

Excel file data:

	A	B	C
1	Stage length	200	ft
2	Shots per cluster	6	
3	Perforation shot diameter	0.28	in
4	Perforation discharge coefficient	0.9	
5	Number of clusters per stage	8	
6			
7	Stage setup identical for injector and producer		

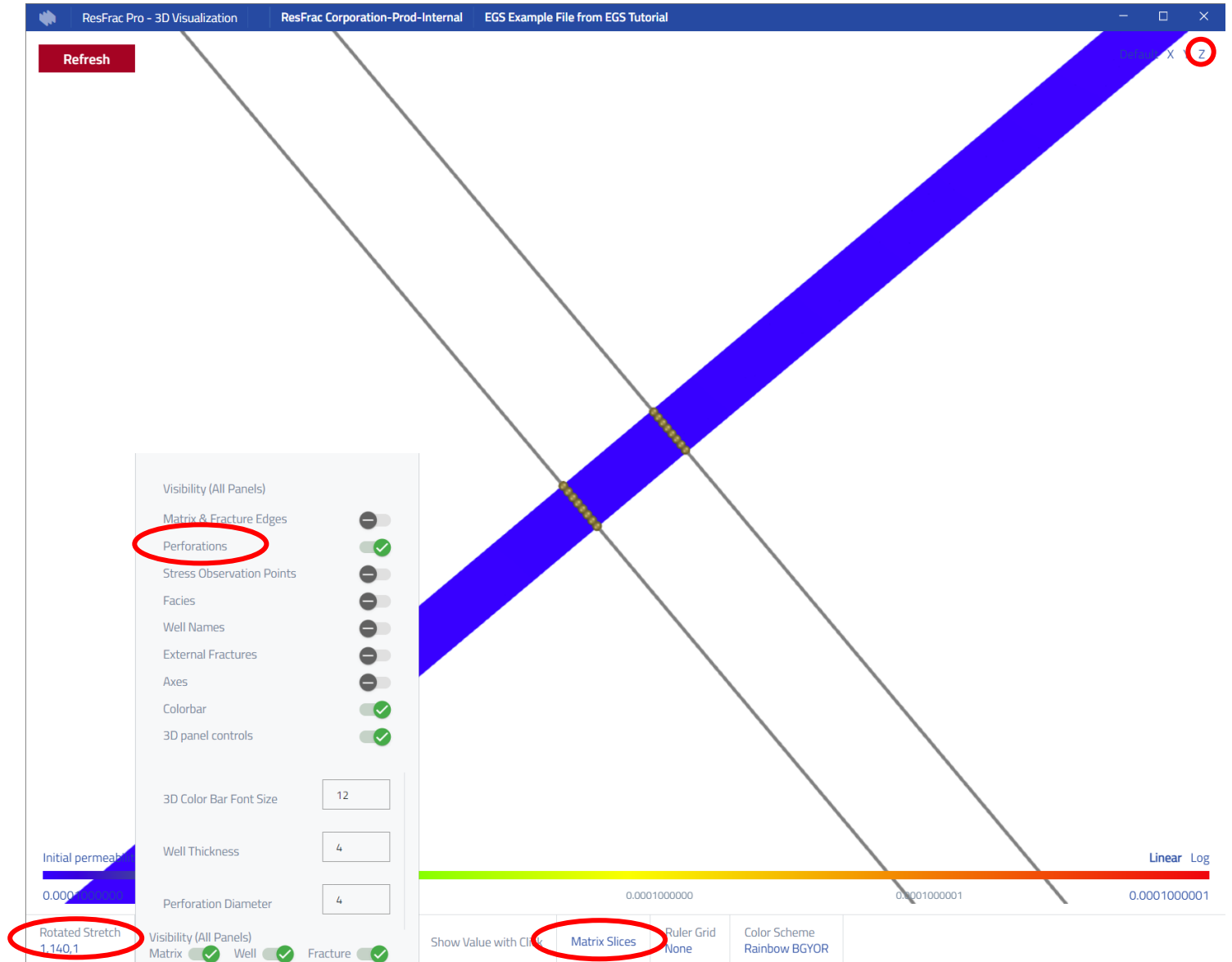
Repeat for Well_Inj

Observe: the well stages set-up wizard automatically reassigned the stage numbers.

$$\begin{aligned}\text{Cluster spacing} &= \text{Stage length} / \text{clusters per stage} \\ &= 200 \text{ ft} / 8 = 25 \text{ ft}\end{aligned}$$

Wells and Perforations: check perforations in 3D image

1. Open (or refresh) 3D preview
2. Use “matrix slices” at the bottom of the screen to hide upper layers and reveal wells (z-layers 1 - 35 are displayed in this image)
3. Hover over visibility toggles (green sliders at bottom of screen), and turn on “Perforations” visibility
4. Check that each well has 8 clusters. Use horizontal stretch to help view the individual perforations.
5. This image is viewed from above (by selecting the “Z” display in the upper right corner, then zooming in)



Wells and Perforations: Remove external fractures

External fractures are used to capture stress shadowing from previous stages, which is important for accurately simulating hydraulic fracturing. However, for this initial pass we will not be simulating hydraulic fracturing but instead using pre-existing fractures (to be defined next in the Static Model and Initial Conditions panel). We will revisit external fractures in the second phase of this tutorial.

EXTERNAL FRACTURES ? ? ? ?

	Well name ?	Approx distance from edge of matrix region [ft] ?	Center x-coordinate [ft] ?	Center y-coordinate [ft] ?	Center z-coordinate [ft]
1	Well 1p ▾	9			
2		9			
3		9			

Remove Row

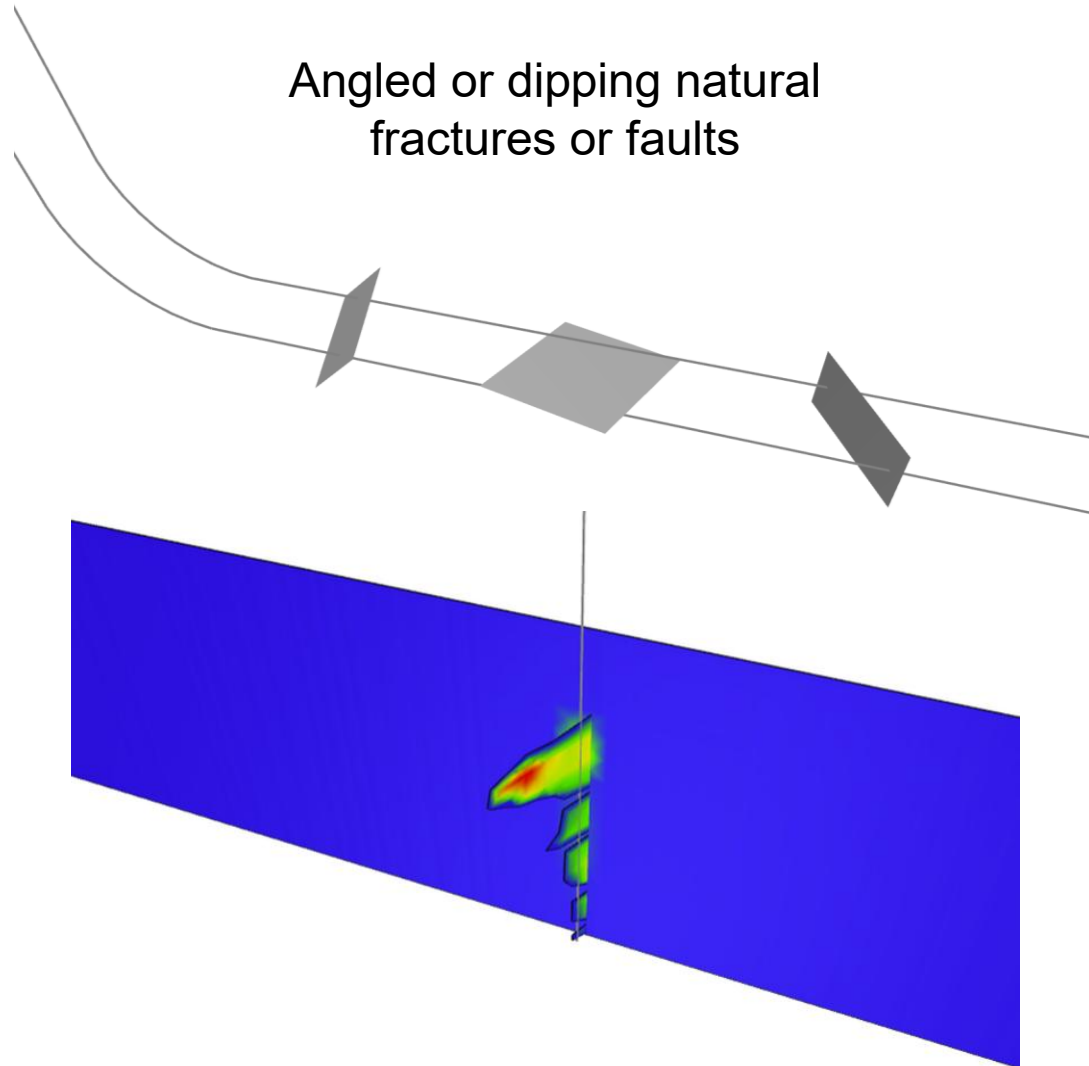
New Row Resize Table

- Highlight all three rows from the template and right-click to remove.
Or else resize table to 0.

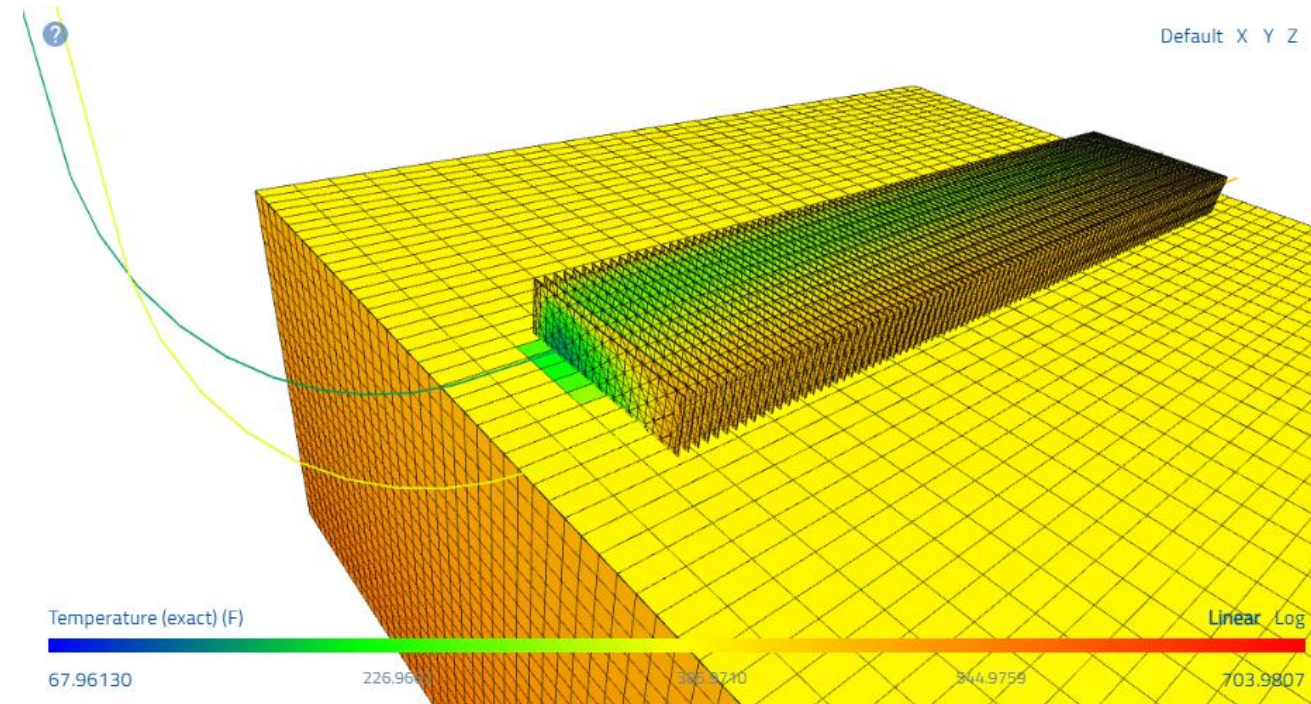
New Row

New number of rows for table*
0

Pre-existing fractures can represent natural fractures, faults, or hydraulic fractures



Hydraulic fractures



A ResFrac Mini-Guide on Preexisting Fractures is also available at this [link](#).

Static Model: Pre-existing Fractures (1 of 2)

Return to the Static Model and Initial Conditions panel. Pre-existing fractures can be defined in the Advanced options section. Pre-existing fractures can also be used to represent natural fractures, but here we'll just use them to represent hydraulic fractures (to remove the computational time required for stimulation).

Each individual fracture can be defined explicitly in this table. Alternatively, define a single representative fracture to serve as a 'template'. In this case, we want to place identical fractures at every perf cluster, so we will define a single fracture in the 'Preexisting fractures' table, which will serve as a template.

When a pre-existing fracture is used as a template, the x, y, z coordinates are arbitrary and do not need to be specified.

Fracture size & orientation

PREEXISTING FRACTURES ?   (warning will go away after next step)

	Center x-coordinate [ft] ?	Center y-coordinate [ft] ?	Center z-coordinate [ft] ?	Fracture full-length [ft] ?	Fracture full-height [ft] ?	Orientation (clockwise from positive y-direction) [degrees] ?
1				1000	500	50

New Row  Resize Table

EO (optional) [ft] ?	Eres (optional) [ft] ?	90% closure stress (optional) [psi] ?	Unpropped conductivity (optional) [md-ft] ?	Unpropped conductivity stress dependence (optional) [psi^-1] ?	Dip (optional) [degrees] ?
			50		

These can override the unpropped fracture aperture options in the static model.

Here, set a fixed fracture conductivity (and optionally apply stress dependence).

Static Model: Pre-existing Fractures (2 of 2)

Then use the 'Autoplaced Preexisting Fractures' feature to position a pre-existing fractures centered at each perforation (which were just defined in the Wells and Perfs panel).

Use row 1 of the 'Preexisting fractures' table as the template, and apply to each well.

AUTOPLACED PREEXISTING FRACTURES ? 📄

	Preexisting fracture template row index ?	Well name ?	
1	1	Well_Prod ▼	☰
2	1	Well_Inj ▼	☰

The warning for not placing x, y, z coordinates in the 'preexisting fractures' table will disappear once the fracture is assigned as a template.

Note: pre-existing fractures defined using the auto-placement feature will not appear in the 3D preview. They will appear in the viz tool after the simulation is run.

Meshing Options: Overview

←

Welcome

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Fluid Model Options

Fracture Options

Proppants

Water Solutes

Well Controls

Other Physics Options

Numerical Options

Output Options

Advanced Options

Meshing Options

Specify spatial discretization parameters for wells, fractures, and matrix.

Editor Search

Meshing wizard ?

Wellbore element length [ft]
5

Fracture element length [ft]
100

Fracture element aspect ratio
1

CENTER OF MATRIX REGION [FT]

Matrix center in x direction [ft]
2773.50936807158

Matrix center in y direction [ft]
-2683.66315415687

Matrix center in z direction [ft]
12099.9631169069

MATRIX REGION LENGTH ALONG THE SHMIN DIRECTION

Apply logarithmic matrix mesh refinement in the Shmin direction ?

☒ Use uniform matrix elements in the Shmin direction? ?

Number of matrix elements
22

Matrix region length in the Shmin direction [ft]
200.0002

MATRIX REGION LENGTH ALONG THE SHMAX DIRECTION

Apply logarithmic matrix mesh refinement in the SHmax direction ?

☐ Use uniform matrix elements in the SHmax direction? ?

Number of matrix elements
93

Matrix region length in the SHmax direction [ft]
17083.3333333333

MATRIX BLOCK LENGTH (EITHER SHMAX OR Y) [FT]

	Matrix block length (either SHmax or y) [ft]	Min position along SHmax [ft]	Max position along SHmax [ft]	
1	1000	-11225.3298208235	-10225.3298208235	
2	900	-10225.3298208235	-9325.32982082355	
3	800	-9325.32982082355	-8525.32982082355	

MATRIX REGION LENGTH ALONG THE VERTICAL DIRECTION

Vertical mesh alignment tool ?

☐ Use uniform matrix elements in the vertical direction? ?

Number of matrix elements
75

Matrix region length in the z direction [ft]
11533.4

MATRIX BLOCK LENGTH (VERTICAL) [FT]

	Matrix block length (vertical) [ft]	Top [ft]	Bottom [ft]	
1	2000	6333.26311690687	8333.26311690687	

Meshing wizard – auto creates matrix mesh

Wellbore and fracture element size

Matrix Mesh

Location

Size

Shmin direction

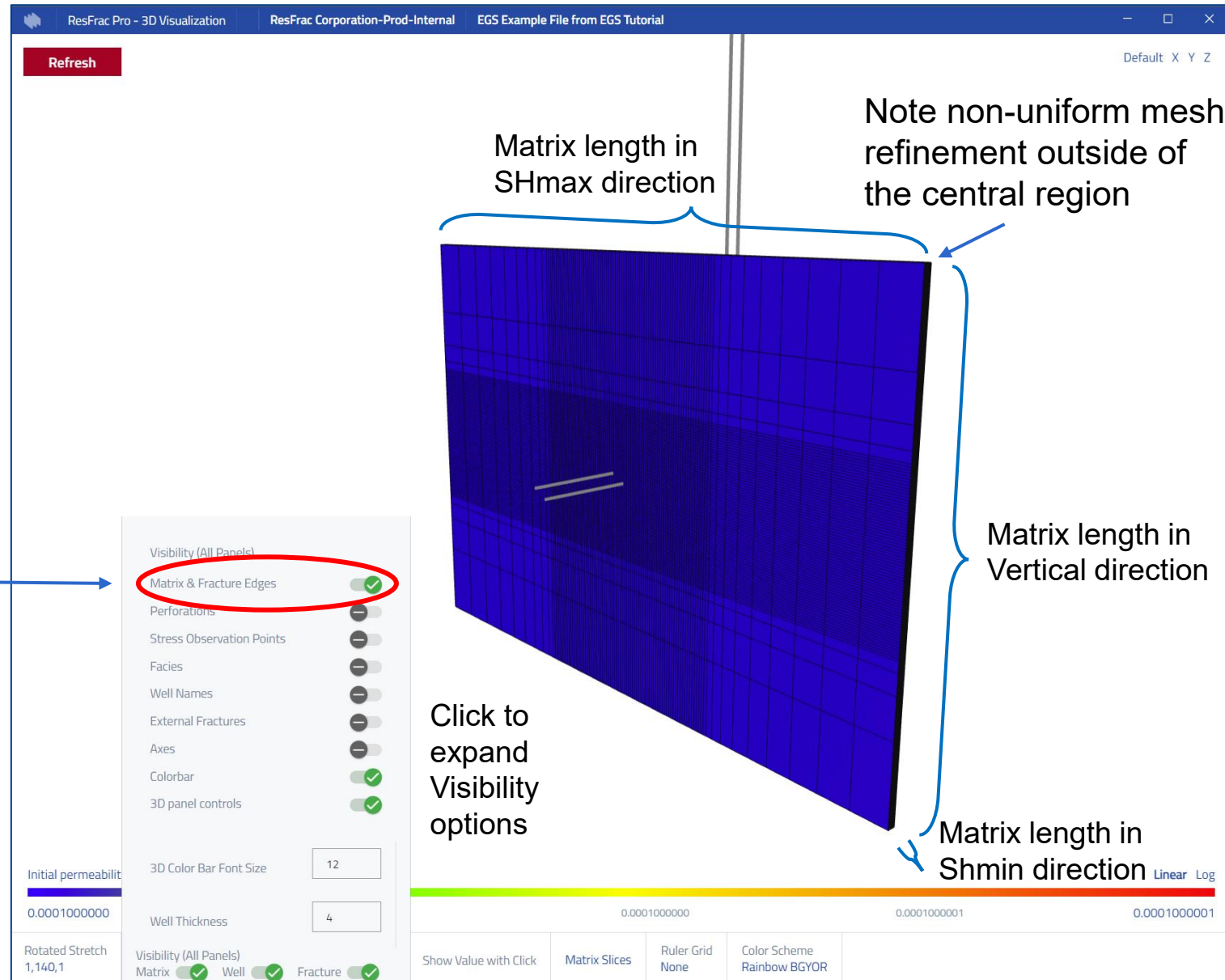
SHmax direction

Vertical direction

Meshing Options: Preview

Use the 3D preview to check the matrix mesh extents and refinement.

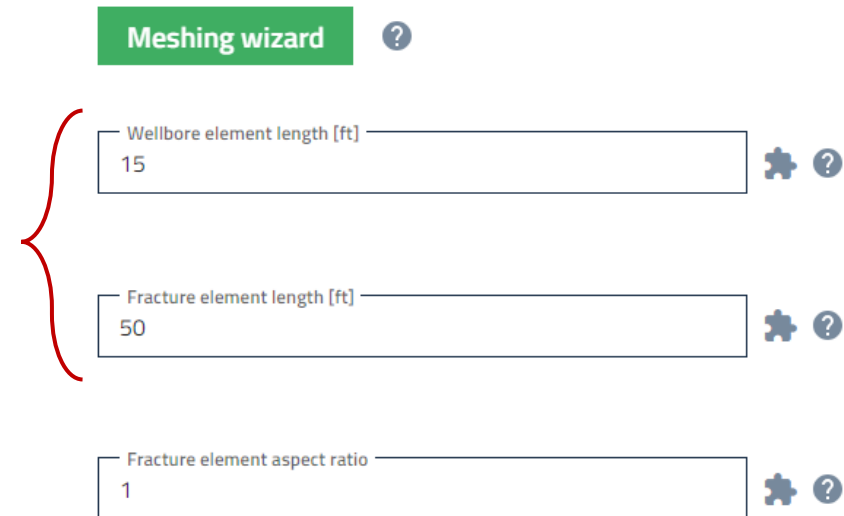
Turn on matrix & fracture edges to view the individual mesh elements



Meshing Options: specify wellbore and fracture mesh sizes

- Meshing guidance:
 - Wellbore element length should be less than cluster spacing (currently 25 ft)
 - Number of fracture elements is the number one impact on computational time
 - Recommended number of fracture elements: 1,000 to 5,000

In this case: 20 fractures, each with dimensions 1000 ft x 500 ft = 10 million ft² total fracture area. If each fracture element is 50 ft x 50 ft, that's 2,500 ft² area per element. $10,000,000 \text{ ft}^2 / 2,500 \text{ ft}^2 = \mathbf{4,000}$ fracture elements. That falls within the recommended amount. *If the fractures collide, the total number of fracture elements will be less.*



The screenshot shows a 'Meshing wizard' interface with three input fields. A red bracket groups the first two fields. Each field has a gear icon and a question mark icon to its right.

Parameter	Value
Wellbore element length [ft]	15
Fracture element length [ft]	50
Fracture element aspect ratio	1

Meshing Options: matrix mesh location and Shmin refinement

Currently centered around Well_Prod
(at 15,260 MD and 11,900 TVD)

CENTER OF MATRIX REGION [FT]

Matrix center in x direction [ft]

2467.50936807094



Matrix center in y direction [ft]

-2940.66315415691



Matrix center in z direction [ft]

11899.9631169039



MATRIX REGION LENGTH ALONG THE SHMIN DIRECTION

Apply logarithmic matrix mesh refinement in the Shmin direction



Use uniform matrix elements in the Shmin direction?



Number of matrix elements

8



Matrix region length in the Shmin direction [ft]

200.0002



Matrix element size in Shmin direction
= 200 ft / 8 = 25 ft

Typical element size ranges from 5 – 25 ft

The 1D submesh fracture algorithm typically makes refinement unnecessary

Specify 8 matrix elements in direction of Shmin (1 per cluster)

Keep at 200 ft – this was automatically updated by the stages setup wizard based on the sector length we defined

Meshing Options: SHmax matrix mesh refinement

The default SHmax direction matrix mesh is small in the center, then grows gradually to the matrix edges. This trick creates a large mesh without an excessive number of elements. Here, we'll refine the mesh logarithmically around each well, since that's where most of the activity is occurring.

MATRIX REGION LENGTH ALONG THE SHMAX DIRECTION

Apply logarithmic matrix mesh refinement in the SHmax direction

Mesh refinement in the SHmax direction wizard

☒ Use uniform matrix elements in the SHmax direction?

Number of matrix elements

29

Matrix region length in the SHmax direction [ft]

9000

Alternatively, you could refine the mesh around a single central point

Mesh refinement in the SHmax direction wizard

This wizard refines the mesh in the SHmax direction towards each of the direction' tool can be used instead since it refines the matrix from a single refine the matrix mesh size toward each of the wells.

Specify two parameters - the size of the matrix elements centered on the Optionally, you may specify a third parameter to indicate the maximum el

Center element size [ft]

40

Element growth rate

1.25

Optional: maximum element length in the SHmax direction [ft]

☐ Use the original algorithm for mesh refinement around each perf

Apply

Typical element size ranges from 30 - 150 ft

MATRIX REGION LENGTH ALONG THE SHMAX DIRECTION

Apply logarithmic matrix mesh refinement in the SHmax direction

Mesh refinement in the SHmax direction wizard

☐ Use uniform matrix elements in the SHmax direction?

Number of matrix elements

35

Matrix region length in the SHmax direction [ft]

9000

When 'Use uniform matrix elements' is deselected, the custom 'Matrix block length' table becomes active

MATRIX BLOCK LENGTH (EITHER SHMAX OR Y) [FT]

	Matrix block length (either SHmax or y) [ft]	Min position along SHmax [ft]	Max position along SHmax [ft]	
14	50	-3010.66315415788	-2960.66315415788	
15	40	-2960.66315415788	-2920.66315415788	
16	50	-2920.66315415788	-2870.66315415788	
17	62.5	-2870.66315415788	-2820.66315415788	
18	134.606015283848	-2808.16315415788	-2740.66315415788	
19	62.5	-2673.55713887403	-2611.05713887403	
20	50	-2611.05713887403	-2551.05713887403	
21	40	-2561.05713887403	-2521.05713887403	
22	50	-2521.05713887403	-2471.05713887403	

Outward growth from center elements

Meshing Options: vertical matrix mesh refinement

There is no logarithmic refinement wizard in the vertical direction, so we will apply uniformly sized vertical matrix elements here.

- Meshing guidance:
 - Recommended number of matrix elements: no more than 200,000

In this case: 8 elements (Shmin direction)
x 35 elements (SHmax direction)
x 60 elements (Vertical direction)
= **16,800** matrix mesh elements.

This falls well below the maximum amount.

When you select uniform matrix elements, the custom matrix block length table will disappear.

MATRIX REGION LENGTH ALONG THE VERTICAL DIRECTION

Vertical mesh alignment tool

☒ Use uniform matrix elements in the vertical direction?

Number of matrix elements
60

Matrix region length in the z direction [ft]
4500

Typical element size (in non-layered formations) ranges from 30 - 150 ft

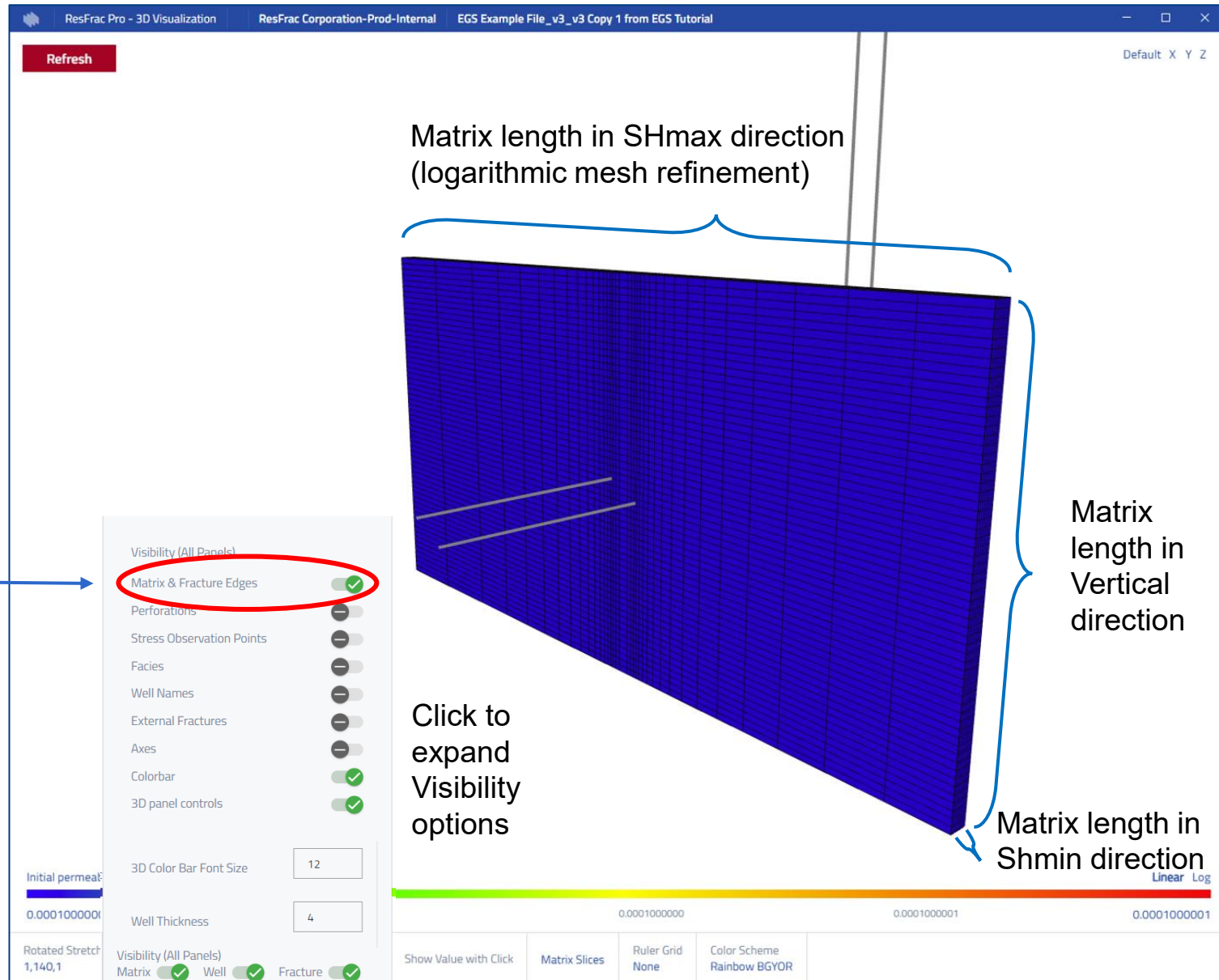
Matrix element size in Vertical direction
= 4500 ft / 60 = 75 ft

	Matrix block length (vertical) [ft]	Top [ft]	Bottom [ft]	
1	2000	990.8000000000005	2990.8	
2	1000	2990.8	3990.8000000000001	
3	500	3990.8000000000001	4490.8	
4	250	4490.8	4740.8	
5	60.2	4740.8	4801	
6	60.2	4801	4861.2000000000001	
7	60.2	4861.2000000000001	4921.4000000000001	
8	60.2	4921.4000000000001	4981.6	
9	60.2	4981.6	5041.8	

Meshing Options: 3D preview plot check

Use the 3D preview to check the matrix mesh extents and refinement.

Turn on matrix & fracture edges to view the individual mesh elements



Fluid Model Options: Overview

This panel defines the properties of the reservoir fluid. As a water-only system, most of this can be ignored. No changes to the template are needed.

←

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Advanced Options

Fluid Model Options

Specify parameters related to fluid model (black oil or compositional)

Editor Search

Compositional library

Compositional wizard

COMPONENTS [VARIOUS UNITS USED]

	Name	Molar mass
1		

New Row Resize Table

INITIAL FLASH COMPONENT COMPOSITION

	Component name	Initial flash component composition
1		

FLASH COMPONENT BINARY INTERACTION COEFFICIENTS

	Component
1	

Water density and viscosity will be based on its temperature and pressure

Water viscosity and density calculation method

☐ Specify constant viscosity, constant compressibility, and reference density

☒ Correlations based on pressure, temperature, and salinity

Flash components viscosity model

- ☐ Simplified viscosity model
- ☒ Lohrenz-Bray-Clark (LBC) correlation

LBC model parameter source

- ☒ Specify critical molar volume of each component, and the LBC coefficients
- ☐ Use default LBC model parameters

CRITICAL MOLAR VOLUME [FT³/LBMOL]

	Component name	Critical molar volume [ft ³ /lbmol]
1		

**Constant values might be preferred if comparing results to an analytical solution (e.g. Gringarten)*

LBC COEFFICIENTS

	LBC Coefficients
1	0.1023
2	0.023364
3	0.058533
4	-0.040758
5	0.0093324

INITIAL COMPOSITION BY LAYER

	Layer name
1	Formation

NON-WATER ENTHALPY OPTION FLUID TYPES

	Component name	Non-water enthalpy option fluid types
1		

Advanced options

- ☒ Use steam correlations

We will use steam correlations

Fracture Options: Parameters relevant to pre-existing fractures

This panel defines options for fractures. Some of the parameters apply only to hydraulic fractures, while others apply to pre-existing fractures as well. The following parameters are relevant to our pre-existing fractures (though no changes to the template are needed yet). We will also revisit this panel when we start creating hydraulic fractures in Phase 2.

Allow flow behind casing if fractures are within 10 ft of perforation (creating a hydraulic connection)

Cased well and fracture connection distance [ft]

10



Conductivity of the 'connect frac through 'cased well fracture collision dis

10000



Propped wellbore-to-fracture connection conductivity multiplier

100



Allows fractures (originating from different wells) to collide if they come within this distance of each other.

The 'relative' distance $\times$ the fracture element length = the absolute 'collision' distance:
 $0.2 \times 50 \text{ ft} = 10 \text{ ft}$

Fracture collision relative distance (different wells)

0.2



Because the pre-existing fractures are already initiated in-line with each other, the collision distance parameters aren't critical here.

Proppants and Water Solutes: Skip

These two panels would be next if generating hydraulic fractures. We will consider these in Phase 2 of this tutorial. Skip these panels for now.

Well Controls: Overview



Well Controls

Specify injection and production schedules

Editor Search

Well controls library ?

Maximum simulation time [hours]
262980

Injection sequence wizard ?

Production sequence wizard ?

WELLBORE BOUNDARY CONDITION CONTROLS ?

Well_Prod ?

Well_Inj ?

Number of Blocks: 0

Previous

1

Next

Advanced options ^

WELL FLOW SCALERS ?

	Well name ?	MD [ft] ?	Flow multiplier ?	Start time [days] ?	End time [days] ?	Coefficient of variation penalty scaler ?
1	Well_1p	10090	54	15		
2	Well_3p	9990	54	15		
3	Well_2i	9820	27	15		

Well Controls define the injection, production, and shut-in sequences.

When you arrive at this panel, there will be Errors because the well names have changed and no well controls are defined.

- Import or export well control blocks
- Simulation end time
- Wizards to assist in creating injection and production blocks
- Well Control blocks
 - Each well has a tab
 - For each well, create injection, production, shut-in, and/or general sequence blocks to define the
 - No blocks are currently populated
- Well flow scalars (in Advanced options)

A ResFrac Mini-Guide on Boundary Conditions is also available at this [link](#).

Well Controls: Simulation time

Well Controls

Specify injection and production schedules

Editor

Search

Well controls library



Maximum simulation time [hours]

262800



Specify simulation time:
 $30 \text{ yrs} \times 8,760 \text{ hrs/yr} = 262,800 \text{ hours}$

Well Controls: Create new production block for Well_Prod

WELLBORE BOUNDARY CONDITION CONTROLS ? ⚠ ⚠

Well_Prod ? ⚠ ⚠

Well_Inj ? ⚠ ⚠

Ensure the Well_Prod tab is selected.

Number of Blocks: 1

Add Block ...

'Add Block'

Previous

1

Next

1. Shut-in

Start time: 0 Hours

Duration: (Blank) Hours

Number of controls: 1

⋮

Type
NoFluidOrHeatFlow

?



NoFluidOrHeatFlow



?

InjectionSequence

ProductionSequence

?

General

Then change the block type from Shut-in to ProductionSequence.

Well Controls: add long-term production condition

1. Production Sequence

Start time: 0 Days

Duration: (Blank) Days

Number of controls: 4

Type
ProductionSequence

PRODUCTION SEQUENCE SUMMARY

	Production type	Time units	Boundary condition MD (optional) [ft]	Duration to truncate sequence [Days]	Optional secondary production type
1	LiquidPlusGasRate	Days	0		LiquidPlusGasRate

As no oil or gas is present, 'LiquidPlusGasRate', 'LiquidRate', and 'WaterRate' will all yield the same result

PRODUCTION SEQUENCE BOUNDARY CONDITION CONTROL RECORDS

	Start time [Days]	Duration [Days]	Maximum production rate [bbl/day]	Minimum production pressure [psi]	Inactive time fraction	Optional secondary maximum production rate [bbl/day]
1	0	0.1	1500	500	0	
2	0.1	0.1	7500	500	0	
3	0.2	0.1	25000	500	0	
4	0.3		53280	500	0	

New Row Resize Table

☒ Isolate well controls reset wellbore pressure

To include the full wellbore in the simulation, set BC MD to 0 (uses WHP as the pressure constraint). If placing a pump in the production well, set MD to the pump depth.

Rate and Pressure controls –

- Production rate ramps up to avoid water hammer issues.
- Max production rate is set equal to the injection rate. Since production will always be less than injection, the system will be pressure limited.
- Well_Prod WHP will be kept above 500 psi. (Production pressure must be above the saturation pressure to maintain single-phase flow).

Well Controls: Create new general block for Well_Inj

WELLBORE BOUNDARY CONDITION CONTROLS ? ⚠

Well_Prod ? ⚠

Well_Inj ? ⚠

← Ensure the Well_Inj tab is selected.

Number of Blocks: 1

Add Block ...

← 'Add Block'

Previous

1

Next

▼ 1. Shut-in

Start time: 0 Hours

Duration: (Blank) Hours

Number of controls: 1

☰ ...

Type

NoFluidOrHeatFlow

?



NoFluidOrHeatFlow



?

InjectionSequence

ProductionSequence

General

?

Then change the block type from Shut-in to General.

Alternatively, an injection sequence may be used. However, a General condition is more flexible and is useful to prevent water hammer, as we'll see on the next slide.

Well Controls: add long-term injection conditions

1. General Constraint

Start time: 0 Days Duration: (Blank) Days Number of controls: 1

Type: General

GENERAL SEQUENCE SUMMARY

	Production type	Control applied at	Check to use gas units (not liquid) for injection	Time units	Boundary condition MD (optional) [ft]	Duration to truncate sequence [Days]	Optional secondary production type
1	LiquidRate	Wellhead	☐	Days	0		LiquidRate

Injection is liquid only

GENERAL WELLBORE BOUNDARY CONDITION CONTROL RECORDS

	Start time [Days]	Duration [Days]	Min stage	Max stage	Maximum production rate [bbl/day]	Maximum injection rate [bpm]	Pressure [psi]	Temperature [F]	Inactive time fraction	Relative water injection fraction
1	0		All stages	All stages	1000	37	3000	150	0	1

Injection is entirely water (no water solutes)

Re-injection temperature

Additional columns in General BC control table dictate water solute and proppant quantities – all must be set to 0

Isolate well controls reset wellbore pressure

Long-term circulation occurs in all stages (though there's only 1 in this sim)

Max production rate is set >0 to avoid issues with water hammer at the start of injection. This is only possible using a General constraint. Otherwise, ramp up injection rate (like production).

Rate and Pressure controls –

- Well_Inj has a target total injection rate of 37 bpm (~100L/s).
- WHP must also be kept below 3000 psi during injection (due to pump limitations).
- Downhole pressure must also be <Shmin to avoid fracture growth
- The controlling factor may change over time.

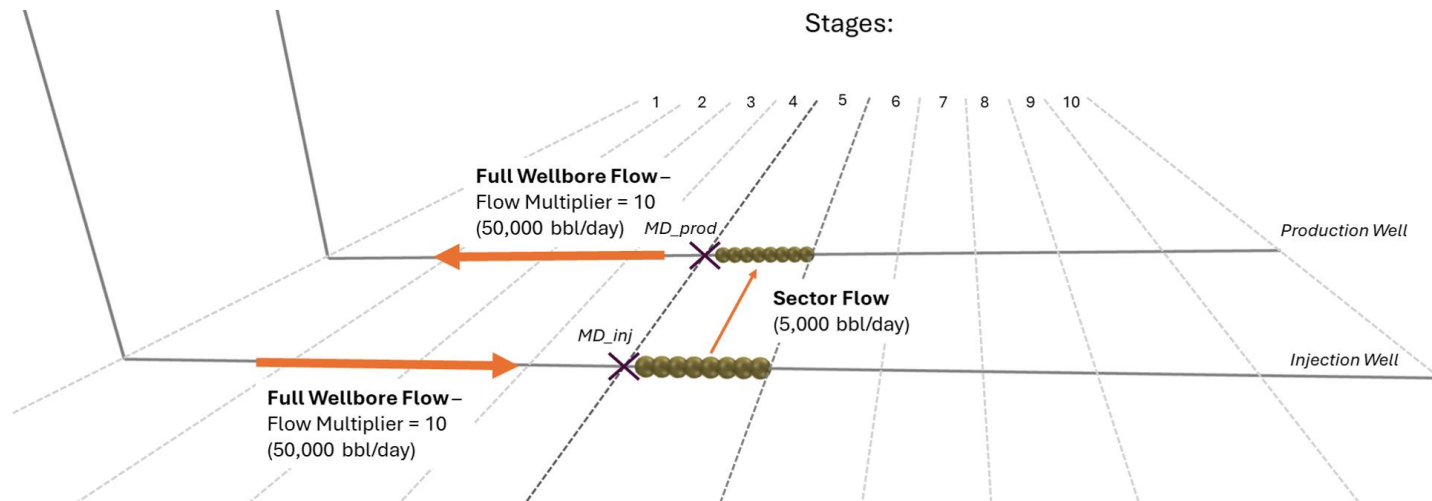
Well Controls: well flow scalers - introduction

‘Well flow scalers’ are used to scale the flow from the wellbore (representing full lateral flow) to the sector model (which represents only a fraction of the reservoir).

In the example shown in the schematic below, **50,000 bbl/day** is the target flow rate **for the full lateral**. However, because we are using a sector model that represents only **1 of the 10 total stages**, only **1/10 of the total flow** should pass through the modeled reservoir.

By setting the injector **well flow scaler to 10**, the 50,000 bbl/day wellhead boundary condition is scaled down by a factor of 10, resulting in **5,000 bbl/day being injected into the modeled stage**. On the production side, a **well flow scaler of 10** scales the produced flow back up by a factor of 10, from 5,000 to **50,000 bbl/day in the wellbore**, representing the combined contribution of all 10 stages along the lateral.

In this way, the **reservoir experiences the appropriate single-sector flow rate**, while the **wellbore calculations reflect the full-lateral flow rate**, allowing friction and heat-loss effects to be represented more accurately.



Well Controls: well flow scalers

Find under 'Advanced options'. Delete all existing rows (which contain the old well names and template values).

- Option A: select all rows > right-click > 'Remove row'
- Option B: Resize Table > 0

Create two new rows, one for each well

WELL FLOW SCALERS ?

	Well name ?	MD [ft] ?	Flow multiplier ?	Start time [days] ?	End time [days] ?	Coefficient of variation penalty scaler ?	
1	Well_Prod ▼	15110.6	28	0			≡
2	Well_Inj ▼	15110.6	28	0			≡

Start time of 0 days corresponds to when long-term circulation starts in the model.

Well_Prod Measured depth at toe: 17812.6 ft Total stages: 1

Well names
Well_Prod ?

WELL VERTICES [FT] ?

	Measured depth [ft] ?	Stage number ?	x-location [ft] ?
51	14810.6	2	2178.64061627751
52	15110.6	2	2371.47689918347
53	15159.8195866822	1	2403.11463965668
54	15359.8195866822	0	2531.67216159399

The production interval of the well is 5,100 ft long, which can fit 28 identical stages (180 ft each). Therefore we will scale up the well flow rate by a factor of 28.

Choose an MD just upstream from our sector model. The MD can be chosen using the Well Vertices table (Wells and Perfs panel). The heel end of the stage in Well_Prod is 15,110.6 ft MD.

Note: The Well_Inj MD may or may not match the Well_Prod MD, depending on how you set-up your second well. Check both well vertices tables.

Other Physics Options: Generally, no changes are required

←

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Numerical Options

Output Options

Advanced Options

Other Physics Options

Specify other physics options

Editor Search

Near-wellbore complexity erosion factor [bbf]
3000

Advanced options

Near-wellbore complexity variance
0

☐ Transient dual porosity applies to thermal

Modulus averaging technique

☐ FromElement

☒ VoigtReussHill

☐ Clean proppant from well at start of production or shut-in

☐ Don't clean proppant from well at shutin

☒ Clean out well at start of MD production

CONSTANT COMPOSITION EXPANSIONS

	Temperature [F]	Minimum pressure [psi]	Maximum pressure [psi]
1			
⋮			

Preexisting fracture conductivity multiplier
1

This parameter can be used to quickly scale up the fracture conductivity of all pre-existing fractures together. Useful for sensitivity analysis workflows.

Numerical Options: Use latest numerics version

No changes to the template are needed.

Numerical Options

Change settings relation to numerical solution applied in the simulation. You generally will not need to change any of these settings from their default values

Editor Search

Numerics version number 206

☒ Update to compositional effect on multiphase flow

☐ Component affinity with compositional multiphase flow adjustment

'Min composition difference' with 'update to compositional effect on mu'

'Max composition difference' with 'update to compositional effect on mu'

'Gas bias in oil ref composition' with 'update to compositional effect on n'

'Oil bias in gas ref composition' with 'update to compositional effect on n'

☐ Numerical options for long-term thermoelastic fracturing

☐ Numerical options for long-term EGS circulation

Utilize latest available numerics version (unless you're working with an already history-matched model based on a prior numerics version). Selecting the puzzle piece will auto-apply latest.

De-activate, *unless* thermoelastic stresses are turned on in the Startup panel. This improves numerical performance in thermoelastic sims, but can impact results.

Output Options: Geothermal economics module (1 of 8)

Create a new economic model, and select 'geothermal' to calculate electricity generated, net present value (NPV) and levelized cost of electricity (LCOE).

The screenshot shows the 'Output Options' interface for the Geothermal Economics module. At the top, there's a title 'Output Options' with a subtitle 'Specify options related to simulator outputs' and a help icon. Below this are tabs for 'Editor' and 'Search'. A section titled 'ECONOMIC MODELS' with a question mark and warning icon is shown. Below this, it says 'Number of Items: 1'. There are 'Previous', '1', and 'Next' buttons. The main section is titled 'Geothermal Economics' with a 'Duplicate' button and a trash icon. Inside this section, there's a 'Name' field with the value 'Geothermal Economics' and a help icon. Below this are two options: 'Oil and gas' (unchecked) and 'Geothermal' (checked). Below these are 'Geothermal end use option' choices: 'Electricity' (selected) and 'Direct-use heat' (unselected). A red bracket on the left side of the 'Geothermal' and 'Geothermal end use option' sections indicates the selection area. A red circle highlights the 'Add Item' button on the right side of the interface.

Output Options
Specify options related to simulator outputs

Editor Search

ECONOMIC MODELS ? ⚠

Number of Items: 1

Previous 1 Next

Geothermal Economics Duplicate

Name
Geothermal Economics ?

☐ Oil and gas ?

☒ Geothermal ?

Geothermal end use option ?

☒ Electricity

☐ Direct-use heat

Add Item

A ResFrac Mini-Guide on Economic Models is also available at this [link](#).

Output Options: Geothermal economics module (2 of 8)

This table compiles the parameters that are specific to the Geothermal economic model. Meanwhile, the parameters below this table are applicable to all economic models (oil and gas included).

GEOTHERMAL ECONOMIC MODEL INPUTS ?

	Price of electricity [\$/kW-hr] ?	(Optional) Cost of electricity for pumping power [\$/kW-hr] ?	Time when surface plant cost is applied [days] ?	Surface plant cost [\$] ?	Surface plant cost per gross capacity (electric) [\$/kWe] ?	Additional surface plant cost per net capacity (electric) [\$/kWe] ?
1	0.15	0.15	0		2500	

Installed gross plant capacity (electric) [MWe] ?	Time to start calculating peak output for surface plant cost [day...]	Geothermal facilities cost per well [dollars/well] ?	Fixed geothermal operational cost per year [\$/year] ?	Surface plant OPEX per year as a fraction of up-front cost ?	Investment tax credit (ITC) [%]
	30	200000	0	0.01	

Production tax credit (PTC) [\$/kW-hr] ?	Number of years to apply PTC ?	Tax and royalty rate on geothermal revenue ?	Optional power plant efficiency (not including inj/prod well pump...) ?	Lower cutoff temperature [F] ?	Replacement water cost [\$/bbl] ?
		0		220	

Injection pump inlet pressure [psi] ?	Injection pump efficiency ?	Production pump outlet pressure [psi] ?	Production pump efficiency ?	Fraction of produced water lost in power plant ?
450	0.8			0

- Incoming electricity revenue

Output Options: Geothermal economics module (3 of 8)

This table compiles the parameters that are specific to the Geothermal economic model. Meanwhile, the parameters below this table are applicable to all economic models (oil and gas included).

GEOTHERMAL ECONOMIC MODEL INPUTS ?

	Price of electricity [\$/kW-hr] ?	(Optional) Cost of electricity for pumping power [\$/kW-hr] ?	Time when surface plant cost is applied [days] ?	Surface plant cost [\$] ?	Surface plant cost per gross capacity (electric) [\$/kWe] ?	Additional surface plant cost per net capacity (electric) [\$/kWe] ?
1	0.15	0.15	0		2500	

- Surface plant CAPEX

Installed gross plant capacity (electric) [MWe] ?	Time to start calculating peak output for surface plant cost [day...]	Geothermal facilities cost per well [dollars/well] ?	Fixed geothermal operational cost per year [\$/year] ?	Surface plant OPEX per year as a fraction of up-front cost ?	Investment tax credit (ITC) ?
	30	200000	0	0.01	0.55

Production tax credit (PTC) [\$/kW-hr] ?	Number of years to apply PTC ?	Tax and royalty rate on geothermal revenue ?	Optional power plant efficiency (not including inj/prod well pump...)	Lower cutoff temperature [F] ?	Replacement water cost [\$/bbl] ?
		0		220	1

Injection pump inlet pressure [psi] ?	Injection pump efficiency ?	Production pump outlet pressure [psi] ?	Production pump efficiency ?	Fraction of produced water lost in power plant ?
450	0.8			0

Output Options: Geothermal economics module (4 of 8)

This table compiles the parameters that are specific to the Geothermal economic model. Meanwhile, the parameters below this table are applicable to all economic models (oil and gas included).

GEOTHERMAL ECONOMIC MODEL INPUTS ?						
	Price of electricity [\$/kW-hr] ?	(Optional) Cost of electricity for pumping power [\$/kW-hr] ?	Time when surface plant cost is applied [days] ?	Surface plant cost [\$] ?	Surface plant cost per gross capacity (electric) [\$/kWe] ?	Additional surface plant cost per net capacity (electric) [\$/kWe] ?
1	0.15	0.15	0		2500	
	Installed gross plant capacity (electric) [MWe] ?	Time to start calculating peak output for surface plant cost [day...] ?	Geothermal facilities cost per well [dollars/well] ?	Fixed geothermal operational cost per year [\$/year] ?	Surface plant OPEX per year as a fraction of up-front cost ?	Investment tax credit (ITC) ?
		30	200000	0	0.01	0.55
	Production tax credit (PTC) [\$/kW-hr] ?	Number of years to apply PTC ?	Tax and royalty rate on geothermal revenue ?	Optional power plant efficiency (not including inj/prod well pump...) ?	Lower cutoff temperature [F] ?	Replacement water cost [\$/bbl] ?
			0		220	1
	Injection pump inlet pressure [psi] ?	Injection pump efficiency ?	Production pump outlet pressure [psi] ?	Production pump efficiency ?	Fraction of produced water lost in power plant ?	
	450	0.8			0	

- Surface plant OPEX

Output Options: Geothermal economics module (5 of 8)

This table compiles the parameters that are specific to the Geothermal economic model. Meanwhile, the parameters below this table are applicable to all economic models (oil and gas included).

GEOTHERMAL ECONOMIC MODEL INPUTS ?						
	Price of electricity [\$/kW-hr] ?	(Optional) Cost of electricity for pumping power [\$/kW-hr] ?	Time when surface plant cost is applied [days] ?	Surface plant cost [\$] ?	Surface plant cost per gross capacity (electric) [\$/kWe] ?	Additional surface plant cost per net capacity (electric) [\$/kWe] ?
1	0.15	0.15	0		2500	
	Installed gross plant capacity (electric) [MWe] ?	Time to start calculating peak output for surface plant cost [day...]	Geothermal facilities cost per well [dollars/well] ?	Fixed geothermal operational cost per year [\$/year] ?	Surface plant OPEX per year as a fraction of up-front cost ?	Investment tax credit (ITC) ?
		30	200000	0	0.01	0.55
	Production tax credit (PTC) [\$/kW-hr] ?	Number of years to apply PTC ?	Tax and royalty rate on geothermal revenue ?	Optional power plant efficiency (not including inj/prod well pump...)	Lower cutoff temperature [F] ?	Replacement water cost [\$/bbl] ?
			0		220	1
	Injection pump inlet pressure [psi] ?	Injection pump efficiency ?	Production pump outlet pressure [psi] ?	Production pump efficiency ?	Fraction of produced water lost in power plant ?	
	450	0.8			0	

- Taxes and tax credits

Output Options: Geothermal economics module (6 of 8)

This table compiles the parameters that are specific to the Geothermal economic model. Meanwhile, the parameters below this table are applicable to all economic models (oil and gas included).

GEOTHERMAL ECONOMIC MODEL INPUTS ?

	Price of electricity [\$/kW-hr] ?	(Optional) Cost of electricity for pumping power [\$/kW-hr] ?	Time when surface plant cost is applied [days] ?	Surface plant cost [\$] ?	Surface plant cost per gross capacity (electric) [\$/kWe] ?	Additional surface plant cost per net capacity (electric) [\$/kWe] ?
1	0.15	0.15	0		2500	

Installed gross plant capacity (electric) [MWe] ?	Time to start calculating peak output for surface plant cost [day...]	Geothermal facilities cost per well [dollars/well] ?	Fixed geothermal operational cost per year [\$/year] ?	Surface plant OPEX per year as a fraction of up-front cost ?	Investment tax credit (ITC) ?
	30	200000	0	0.01	0.55

Production tax credit (PTC) [\$/kW-hr] ?	Number of years to apply PTC ?	Tax and royalty rate on geothermal revenue ?	Optional power plant efficiency (not including inj/prod well pump...) ?	Lower cutoff temperature [F] ?	Replacement water cost [\$/bbl] ?
		0		300	1

Injection pump inlet pressure [psi] ?	Injection pump efficiency ?	Production pump outlet pressure [psi] ?	Production pump efficiency ?	Fraction of produced water lost in power plant ?
450	0.8			0

- Power plant design criteria

Output Options: Geothermal economics module (7 of 8)

Additional economics inputs. Many of these will not be applicable, or are covered by other parameters. The red parameters represent CAPEX, and the blue parameters represent OPEX.

Drilling
and land
costs

Fracturing
and
completions
costs



Discount rate	0.1	?
Drilling cost per well [dollars]	8000000	?
(Optional) Drilling cost per measured depth [dollars/ft]		?
Land cost [dollars/acre]	0	?
Fixed fracturing cost per well [dollars]	8000000	?
(Optional) Completion cost per stage [dollars]		?
☒ Apply fracturing cost at the start of injection		?
Fracturing proppant cost [dollars/lb]	0	?
Injection water cost [dollars/bbl]	0	?
Miscellaneous taxes	0	?
Working interesting in CAPEX	1	?
Working interesting in OPEX	1	?
Overhead rate	0	?
Produced water cost [dollars/bbl]	0	?
Miscellaneous up-front cost [dollars]	0	?
Facilities cost per well [dollars/well]	0	?
Fixed fracturing cost per well per maximum injection rate [dollars/bpm]	0	?
☒ Start discounting from start of simulation		?
Economic calculation start time [days]	0	?
Operations annual cost per well (phase one) [dollars/well/year]	200000	?
'Operations cost' phase one duration [years]		?
Operations annual cost per well (phase two) [dollars/well/year]		?
'Operations cost' phase two duration [year]		?
Operations annual cost per well (phase three) [dollars/well/year]		?
(Optional) produced water cost phase two [dollars/bbl]		?
(Optional) produced water cost phase three [dollars/bbl]		?

Output Options: Geothermal economics module (8 of 8)

For calculating land area costs

LATERAL LENGTH PER WELL [FT] ?		
	Well name ?	Lateral length per well [ft] ?
1	Well_Prod	5600
2	Well_Inj	5600

INCLUDE IN MODEL ?		
	Well name ?	Include in model ?
1	Well_Prod	☒
2	Well_Inj	☒

AVERAGE WELL SPACING PER WELL [FT] ?		
	Well name ?	Average well spacing per well [ft] ?
1	Well_Prod	400
2	Well_Inj	400

WELL SCALING FACTOR ?		
	Well name ?	Well scaling factor ?
1	Well_Prod	28
2	Well_Inj	28

Set equal to the well flow scalers. This is a separate input used for the economics model.

NET-OUT INSTANTANEOUS INJECTION AND PRODUCTION START AND END TIMES BY WELL ?			
	Well name ?	(Optional) Start time of period one to apply cost for net instant...	(Optional) End time of period one to apply cost for net instant...
1	Well_Prod	0	
2	Well_Inj	0	

Since there is no fracturing in this model, we'll set start times to 0 for now.

Output Options: Geothermal economics module - advanced

In the Advanced options section, there are custom options that may be applied in certain circumstances. These are also located near our older version of the geothermal economics model.

A reference temperature is required for enthalpy outputting and electricity generation calculations, since power plant efficiency is based on net thermal output. Typical correlations used in ResFrac expect a 0°C value (which is set by default).

Reference temperature for heat in place [F]

Reference temperature for enthalpy outputting [F]

REFERENCE ENTHALPY FOR ENTHALPY OUTPUTTING (NON-WATER) [BTU/LB] ☐

	Component name	Reference enthalpy for enthalpy outputting (non-water) [BTU/lb]
1		

☒ Calculate electricity output with respect to 'reference temperature for enthalpy outputting'

If you're interested in 'heat-in-place' calculations, enter a reference temperature. Sometimes reinjection temperature is used.

Check this box if you wish to change the reference temperature.

The 'Brine efficiency versus temperature table' can be optionally used to compute the 'Gross electricity generation rate'

BRINE EFFICIENCY VERSUS TEMPERATURE

	Temperature [F]	Brine efficiency	
5	284	0.09	
6	302	0.1	
7	320	0.11	
8	338	0.12	
9	356	0.13	
10	374	0.14	
11	392	0.15	
12	410	0.16	
13	428	0.17	

New Row Resize Table

 ResFrac

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Advanced Options: Overview

Generally, no changes needed in this panel.

Advanced Options
Change miscellaneous settings for this simulation. You generally will not need to change any of these settings from their default values

Editor Search

Additional manual settings

☐ Override input selectors and don't hide any inputs

Input selector import/export wizard

INPUT SELECTORS

	Panel name	Item name	Show item in builder	Name in CLI
1	Startup	Recommended settings wizard	☒	startuppanel.recommendedsettingswizard
2	Startup	Use advanced unit system	☒	startuppanel.useadvancedunitsystem
3	Startup	Use field units	☒	startuppanel.usefieldunits
4	Startup	Thermal option	☒	startuppanel.thermaloption
5	Startup	Fluid model	☒	startuppanel.fluidmodel
6	Startup	Dual porosity option	☒	startuppanel.dualporosityoption
7	Startup	Adsorption option	☒	startuppanel.adsorptionoption
8	Startup	Thermoelastic stress changes in the matrix	☒	startuppanel.calculatethermoelasticstresses
9	Startup	Poroeleastic stress changes in the matrix	☒	startuppanel.calculateporoelelasticstresses
10	Startup	Rotate simulation mesh to align with stresses	☒	startuppanel.rotate_simulation_mesh_to_align_with_stresses

100 1-100 of 683

Special simulator features not yet available in the UI can be entered here. Only use if instructed by ResFrac. Typically used for unique applications or quick bug fixes.

Select which features will be visible in the UI. Some templates restrict feature visibility for a cleaner UI (application specific). The EGS template has all features visible by default.

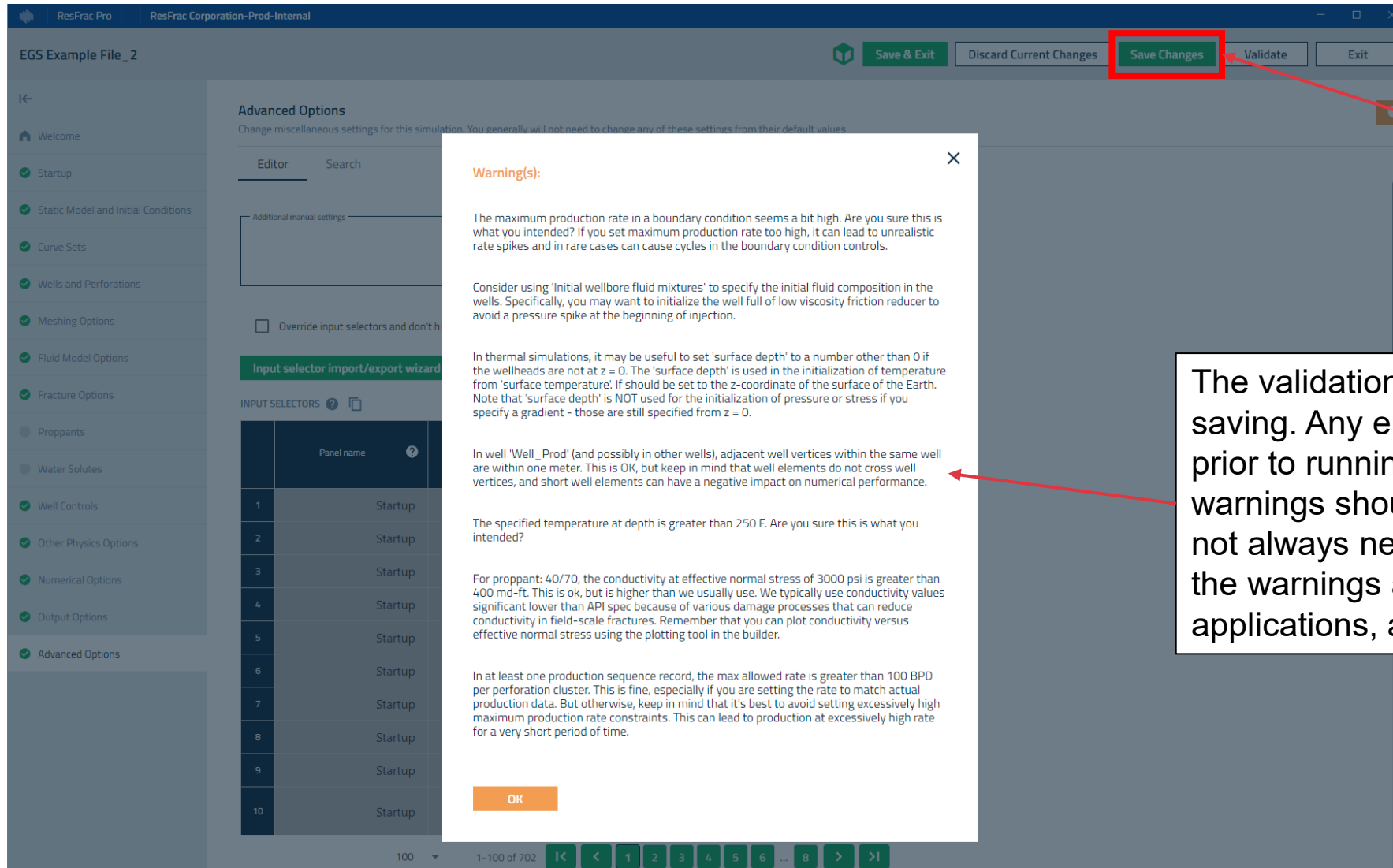
If 'Advanced Units' are selected in the Startup panel, you can customize the units here.

Unit system library

UNITS

	Unit category	SI unit	Selected unit
1	Length	m	ft
2	Diameter	m	in
3	Proppant size	m	mesh
4	Temperature	C	F
5	Pressure	MPa	psi
6	Permeability	m^2	md

Save and Exit Builder



Click Save Changes, which will validate and save your model.

The validation window will appear after saving. Any errors must be addressed prior to running the sim. Meanwhile, warnings should be reviewed, but may not always need addressing. Many of the warnings are targeted to O&G applications, and these may be ignored.

Run Simulation (slide 1 of 2)

Click on the simulation name, or the ellipses on the right, and select “Run Simulation” from the list of actions.

The screenshot shows the ResFrac Pro interface. At the top, there's a header with 'ResFrac Pro' and 'ResFrac Corporation-Prod-Internal'. Below it, a breadcrumb trail shows 'Home > EGS Training > EGS Tutorial'. The main content area is divided into two sections. The top section, 'Sandbox Details', shows information about the 'EGS Tutorial' workflow, including the number of simulations (6) and the creation timestamp (Dec 2, 2025 at 11:20 am). The bottom section, 'Simulations (5)', displays a table of simulations. The first simulation, 'EGS Example File_3', is highlighted. A context menu is open for this simulation, showing various actions. The 'Run Simulation' option is highlighted with a red box.

>	SIMULATION NAME	STATUS	DATE CREATED ↓	LAST MODIFIED	...
>	EGS Example File_3	Not Yet Submitted	Feb 23, 2026 at 4:16 pm	Feb 23, 2026 at 4:16 pm	...
>	EGS Example File_2	Finished running	Feb 4, 2026 at 12:10 pm	Feb 23, 2026 at 4:16 pm	...
>	EGS Example File	Finished running	Dec 15, 2025 at 3:20 pm	Jan 28, 2026 at 12:10 pm	...
>	Preexisting fractures	Not Yet Submitted	Dec 2, 2025 at 12:56 pm	Dec 2, 2025 at 11:58 am	...
>	Base_from template	Not Yet Submitted	Dec 2, 2025 at 11:58 am	Dec 2, 2025 at 11:58 am	...

You have reached the end of the list

- Simulation Details
- Edit Simulation in Builder
- Run Simulation**
- Copy Simulation
- Copy Simulation to a Sandbox
- Check for New Results in Next Sync
- Export Simulation Folder
- Open Simulation Folder in File Explorer
- Open Comments File

Run Simulation (slide 2 of 2)

Click “Run Simulation” to submit the job.

Run Simulation

Simulation Name*

EGS Example File_3

Description

Created as a copy of simulation EGS Example File_2 at 16:16:10 2026-02-23
1) corrected the production WHP minimum to 500 psi vs 200 psi (to maintain single-phase flow in the wellbore)
2) increased the fracture size.

Created as a copy of simulation 08_FullFact_7 at 12:10:18 2026-02-04
Imported from simulations.csv file

Simulator Version *

2026-02-10 10:58:19 -0800 49f9c10

Job Priority *

Normal

Vm Size

Regular (1x new CPUs, 1.2x cost per hour, approx 20 percent reduction in runtime)

Run Simulation

Cancel

- Then wait for simulation to run.
This sim should take <1 hr.

Generally, select latest available simulator version

Job priority has no impact

Choose Vm size depending on how fast you want the sim to run. On Regular, this sim should run in <1 hr.

Builder shows current status of each simulation

Expand the chevron left of the sim to check status details: submitted, running, completed, or cancelled.

- If not complete, it will also show how far along the simulation is, in simulated time and wallclock time.
- If completed, it will indicate how long the simulation took to run, and whether the results have been fully downloaded.

Click here to expand status info for *all* sims in your workflow

Simulation successfully completed, and results are downloaded.

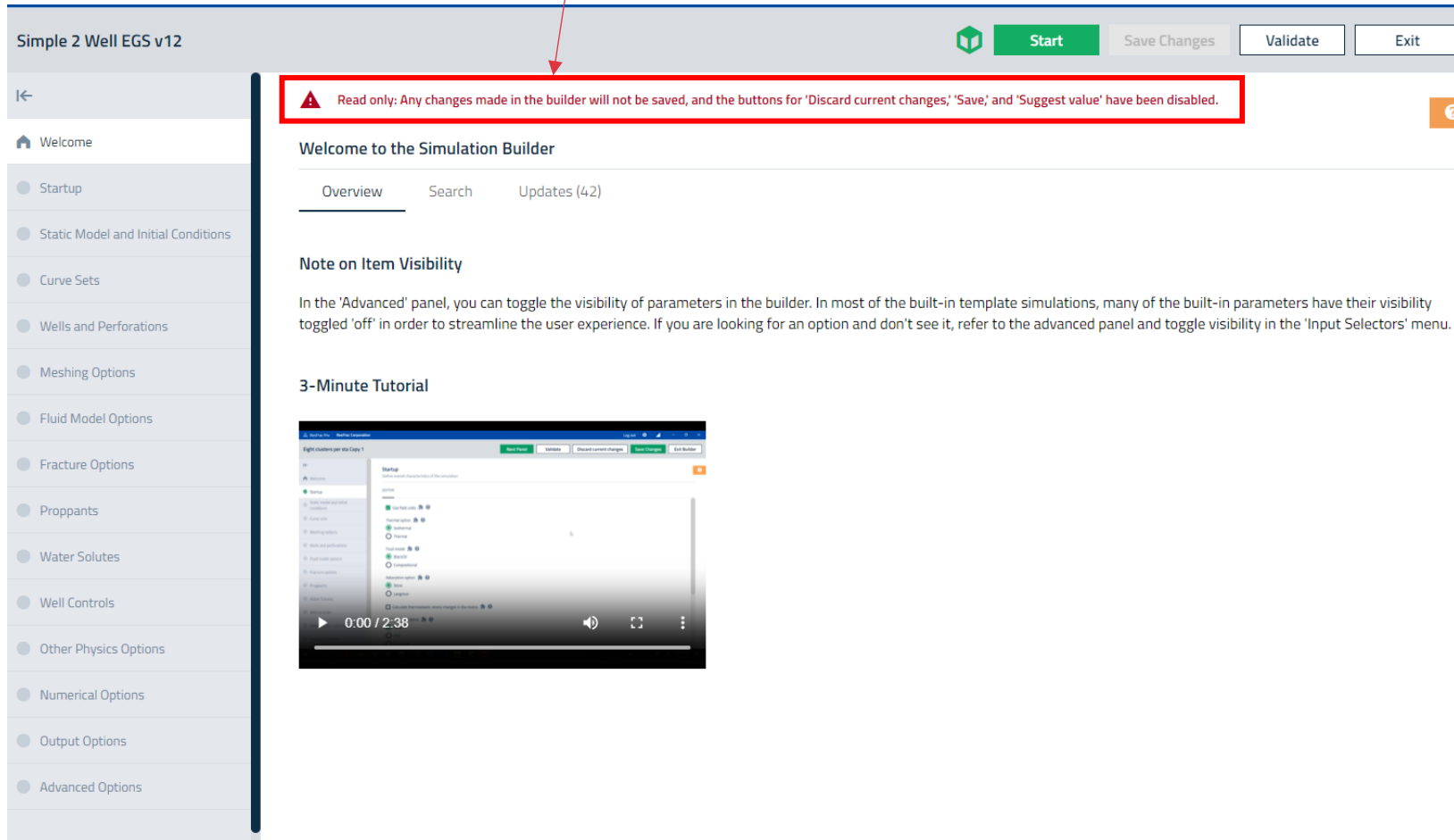
Simulations (11)				
✓	SIMULATION NAME	STATUS	DATE CREATED ↓	LAST MODIFIED
✓	Simple 2 Well EGS v12	Finished running	Jul 8, 2025 at 9:23 am	Jul 8, 2025 at 11:38 am
Job completed successfully. Simulation reached max simulation time and completed successfully. Simulation wallclock time is: 41.3292 min. Current memory usage of 1.3 percent (max ever: 3.1). Results are fully downloaded.				
>	Simple 2 Well EGS v11	Finished running	Jul 7, 2025 at 7:35 pm	Jul 7, 2025 at 9:48 pm
✓	Simple 2 Well EGS v10	Cancelled	Jul 7, 2025 at 7:17 pm	Jul 7, 2025 at 10:14 pm
Cancelled at request of koenraad@resfrac.com Timestep 3469, dt = 1.212 days, cumulative time = 7.20533 years. Simulation wallclock time is: 2.33868 hours. Current memory usage of 3.7 percent (max ever: 3.7). Results are fully downloaded.				

You may still view the results of an in-progress simulation, if some of the results have been downloaded.

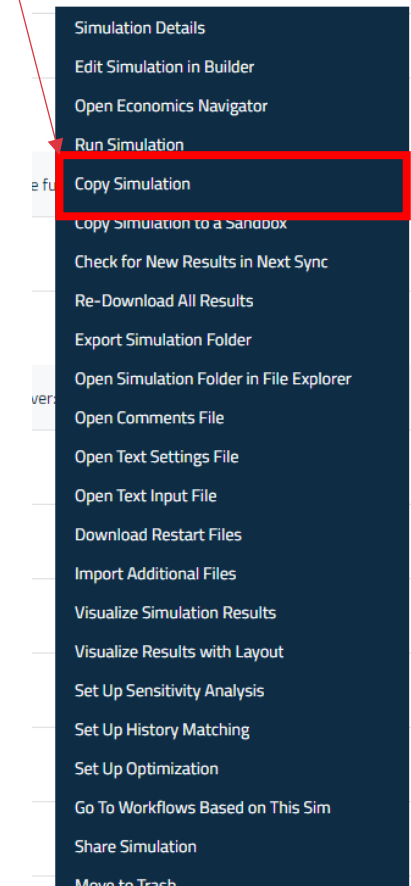
Results will not download while the computer is shut-down. To ensure a timely download, make sure your computer remains on.

Submitted simulations can no longer be edited

When clicking “Edit Simulation in Builder” from the job manager, it will open the simulation but you can no longer make changes

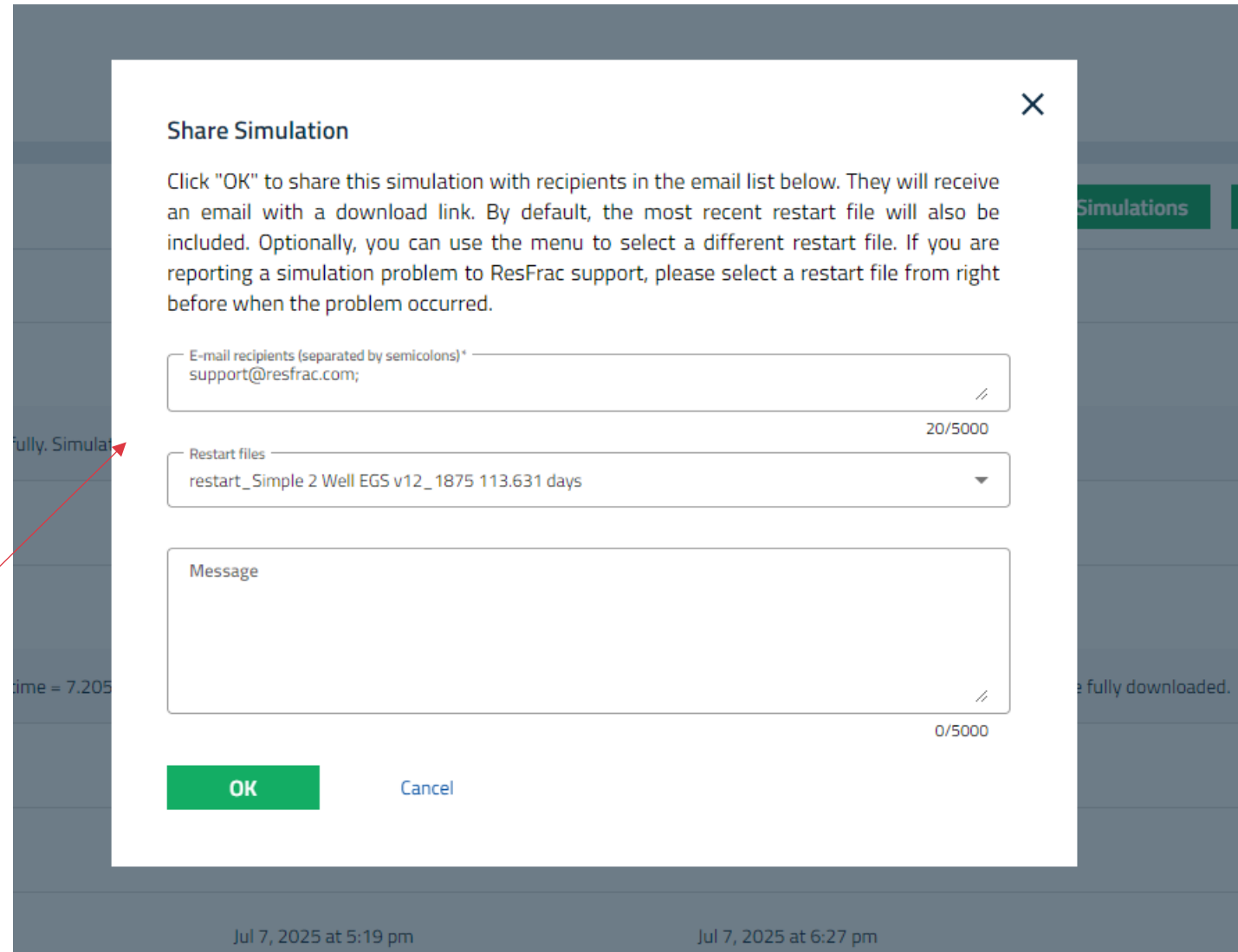
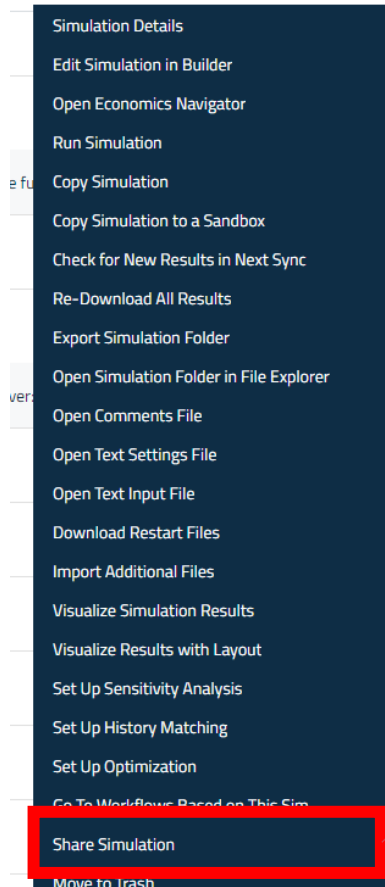


To edit your simulation, you need to create a new version by clicking “Copy Simulation”

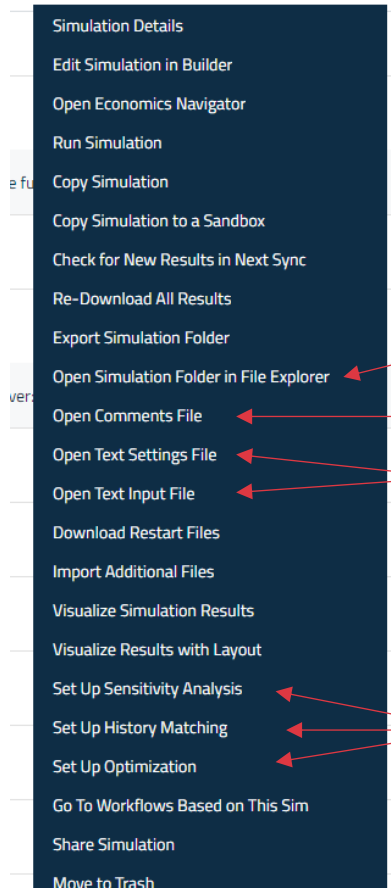


Other Job Manager Options: Share Simulation

Click “Share Simulation” to open a window for emailing the model to support@resfrac.com (default), a colleague, or yourself.



Other Job Manager Options: Open files and Automated Workflows



Open simulation folder in Windows File Explorer

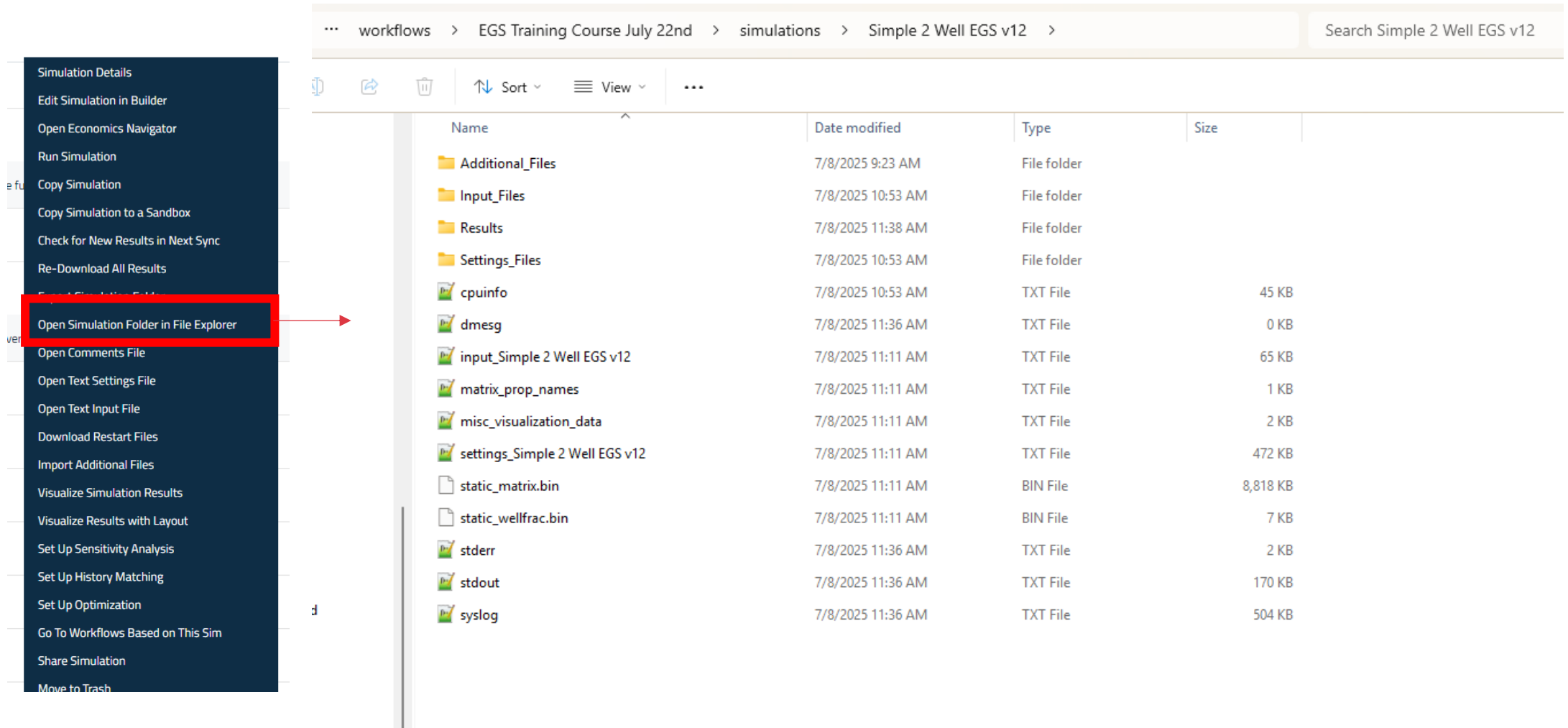
Open comments file for debugging simulations

Entire simulation set up is stored in settings and input text files

Set up automated workflow based on this simulation

Other Job Manager Options: Open Simulation Folder (1 of 2)

Model input files and results are stored in the simulation folder



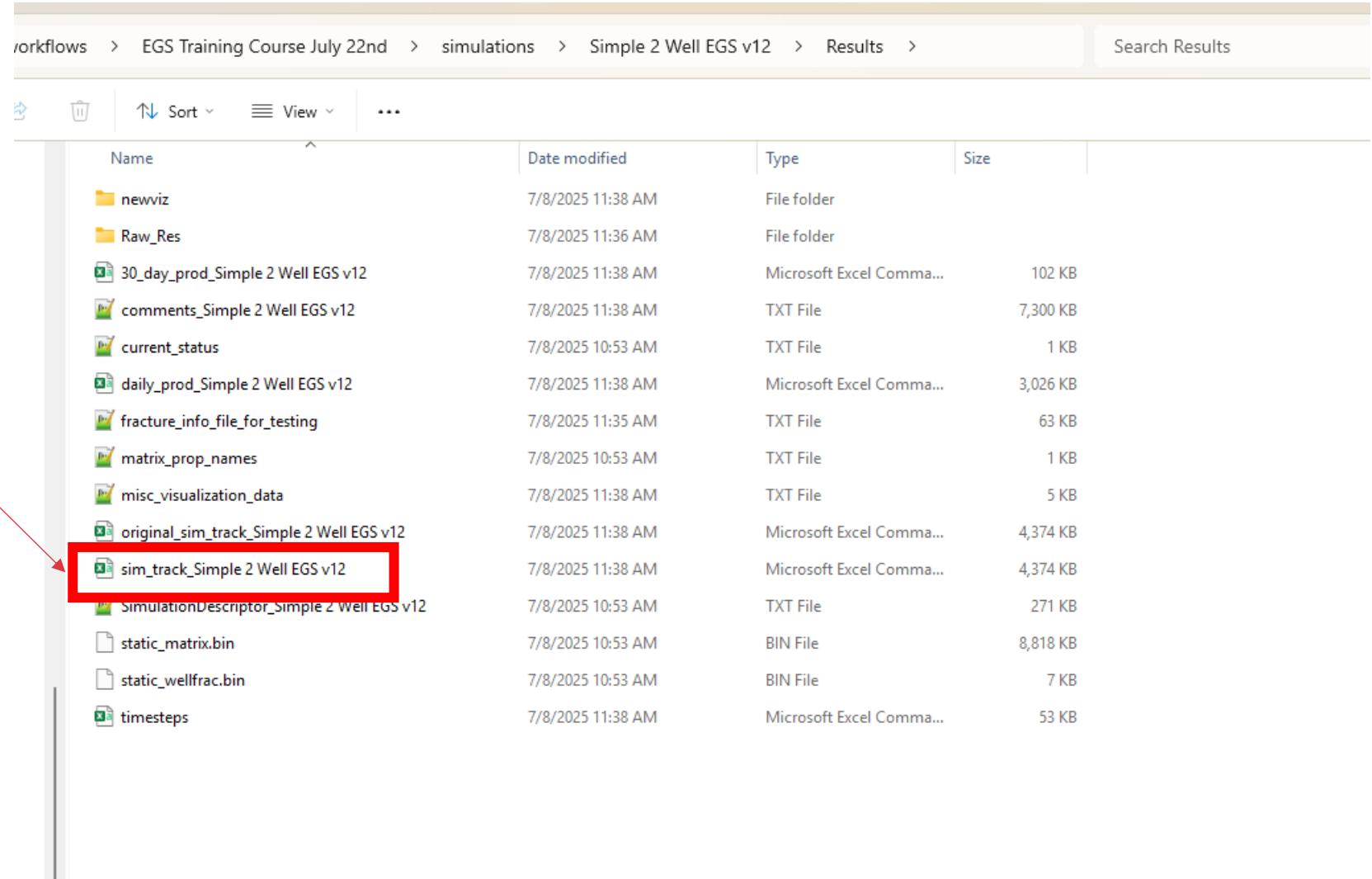
The screenshot displays the ResFrac Job Manager interface on the left and a File Explorer window on the right. The Job Manager menu on the left lists various options, with 'Open Simulation Folder in File Explorer' highlighted by a red rectangle. A red arrow points from this option to the File Explorer window. The File Explorer window shows the path: workflows > EGS Training Course July 22nd > simulations > Simple 2 Well EGS v12. The search bar contains 'Simple 2 Well EGS v12'. The main pane shows a list of files and folders with columns for Name, Date modified, Type, and Size.

Name	Date modified	Type	Size
Additional_Files	7/8/2025 9:23 AM	File folder	
Input_Files	7/8/2025 10:53 AM	File folder	
Results	7/8/2025 11:38 AM	File folder	
Settings_Files	7/8/2025 10:53 AM	File folder	
cpuinfo	7/8/2025 10:53 AM	TXT File	45 KB
dmesg	7/8/2025 11:36 AM	TXT File	0 KB
input_Simple 2 Well EGS v12	7/8/2025 11:11 AM	TXT File	65 KB
matrix_prop_names	7/8/2025 11:11 AM	TXT File	1 KB
misc_visualization_data	7/8/2025 11:11 AM	TXT File	2 KB
settings_Simple 2 Well EGS v12	7/8/2025 11:11 AM	TXT File	472 KB
static_matrix.bin	7/8/2025 11:11 AM	BIN File	8,818 KB
static_wellfrac.bin	7/8/2025 11:11 AM	BIN File	7 KB
stderr	7/8/2025 11:36 AM	TXT File	2 KB
stdout	7/8/2025 11:36 AM	TXT File	170 KB
syslog	7/8/2025 11:36 AM	TXT File	504 KB

Other Job Manager Options: Open Simulation Folder (2 of 2)

Line plot and 3D visualizations stored in the sim_track file, within the “Results” Folder

Sim_track file stores line plot data and can be opened in spreadsheet editor such as Excel



workflows > EGS Training Course July 22nd > simulations > Simple 2 Well EGS v12 > Results > Search Results				
Sort View ...				
Name	Date modified	Type	Size	
newviz	7/8/2025 11:38 AM	File folder		
Raw_Res	7/8/2025 11:36 AM	File folder		
30_day_prod_Simple 2 Well EGS v12	7/8/2025 11:38 AM	Microsoft Excel Comma...	102 KB	
comments_Simple 2 Well EGS v12	7/8/2025 11:38 AM	TXT File	7,300 KB	
current_status	7/8/2025 10:53 AM	TXT File	1 KB	
daily_prod_Simple 2 Well EGS v12	7/8/2025 11:38 AM	Microsoft Excel Comma...	3,026 KB	
fracture_info_file_for_testing	7/8/2025 11:35 AM	TXT File	63 KB	
matrix_prop_names	7/8/2025 10:53 AM	TXT File	1 KB	
misc_visualization_data	7/8/2025 11:38 AM	TXT File	5 KB	
original_sim_track_Simple 2 Well EGS v12	7/8/2025 11:38 AM	Microsoft Excel Comma...	4,374 KB	
sim_track_Simple 2 Well EGS v12	7/8/2025 11:38 AM	Microsoft Excel Comma...	4,374 KB	
SimulationDescriptor_Simple 2 Well EGS v12	7/8/2025 10:53 AM	TXT File	271 KB	
static_matrix.bin	7/8/2025 10:53 AM	BIN File	8,818 KB	
static_wellfrac.bin	7/8/2025 10:53 AM	BIN File	7 KB	
timesteps	7/8/2025 11:38 AM	Microsoft Excel Comma...	53 KB	

Results Phase 1 – Pre-existing Fractures

Visualizing Simulation Results - Overview

Objective: Use the 3D viz tool to visualize the EGS tutorial simulation and analyze the results.

- Line plot 1
 - WHP
 - BHP
- Line Plot 2
 - Water Inj Rate
 - Water Prod Rate
- Line Plot 3
 - Wellhead Temperature
 - Cumulative Net Electricity
- Line Plot 4
 - LCOE
 - NPV
- 3D Images to plot
 - Pressure & temperature distribution
 - Fracture height, length, and conductivity

For an introduction on using the viz tool, watch [Module 4: Visualization Tool](#) on the ResFrac Online Resources page.

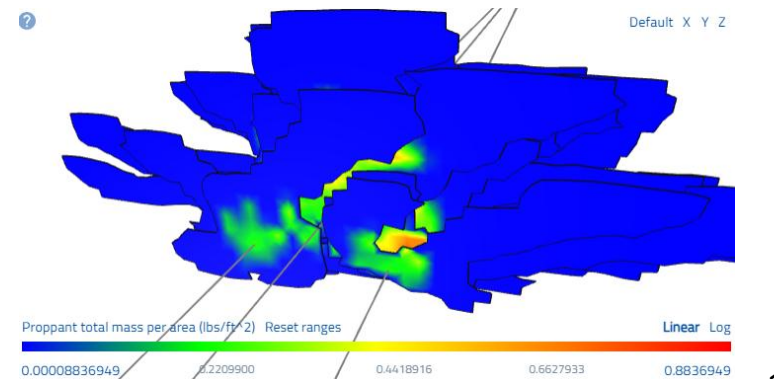
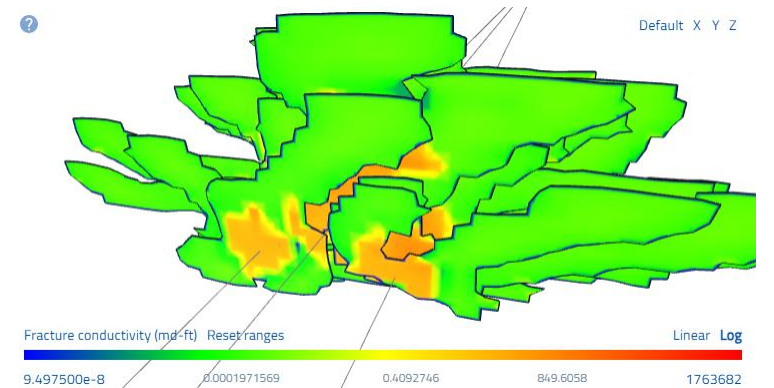
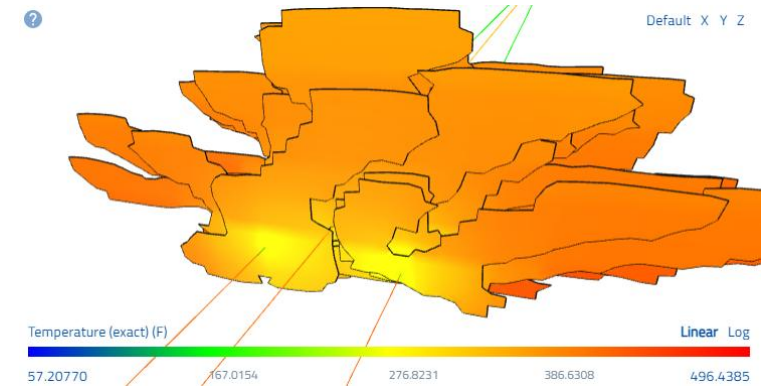
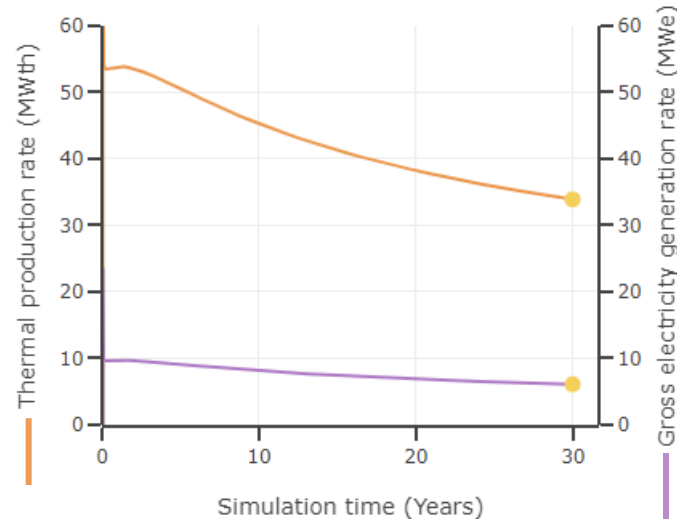
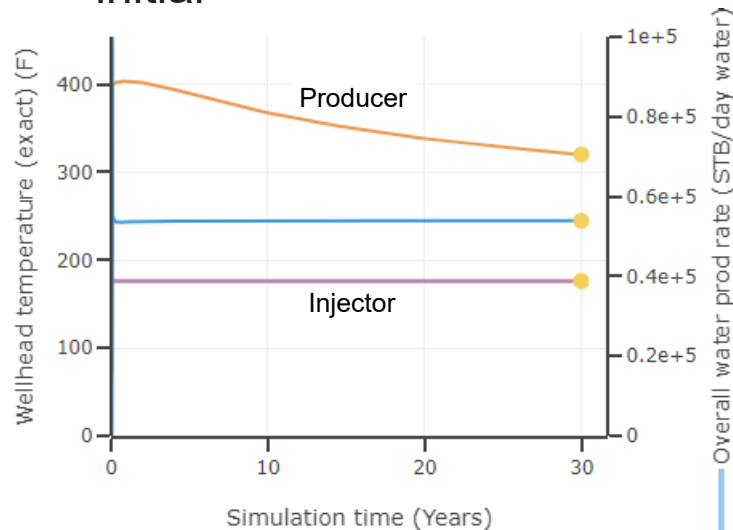
If you have any issues with your sim setup, you may download the results for Phase I at this [link](#).

Content

- Summary of available / recommended parameters to plot
- Visualization tool: line plots and 3D figures
- Exporting and sharing results
- Simulation folder and Sim_track file

Various 2D and 3D visualizations available for geothermal simulations

- **Common 2D line plots for geothermal:** wellhead temperatures, pressures, enthalpy, steam mass fraction, flow rates, thermal output, gross electricity generation, net electricity generation, NPV and LCOE
- **Common 3D visualizations for geothermal:** temperatures, pressures, steam mass fraction, proppant mass per area, fracture conductivity, fracture aperture, thermoporoelastic delta stress
- **Other useful metrics:** net water flow through each perf to evaluate flow uniformity, stress observation planes, temperature change from initial



Visualize Simulation Results

Click on the simulation name, or the ellipses on the right, and select “Visualize Simulation Results” from the list of actions.

The screenshot displays the ResFrac Pro web interface. At the top, the breadcrumb navigation shows 'Home > EGS Training > EGS Tutorial'. The 'Sandbox Details' section provides information about the 'EGS Tutorial' workflow, including 6 simulations and a creation timestamp of Dec 2, 2025 at 11:20 am. Below this, the 'Simulations (5)' table lists five simulations. The 'EGS Example File' simulation is selected, and its context menu is open, showing various actions. The 'Visualize Simulation Results' option is highlighted with a red box.

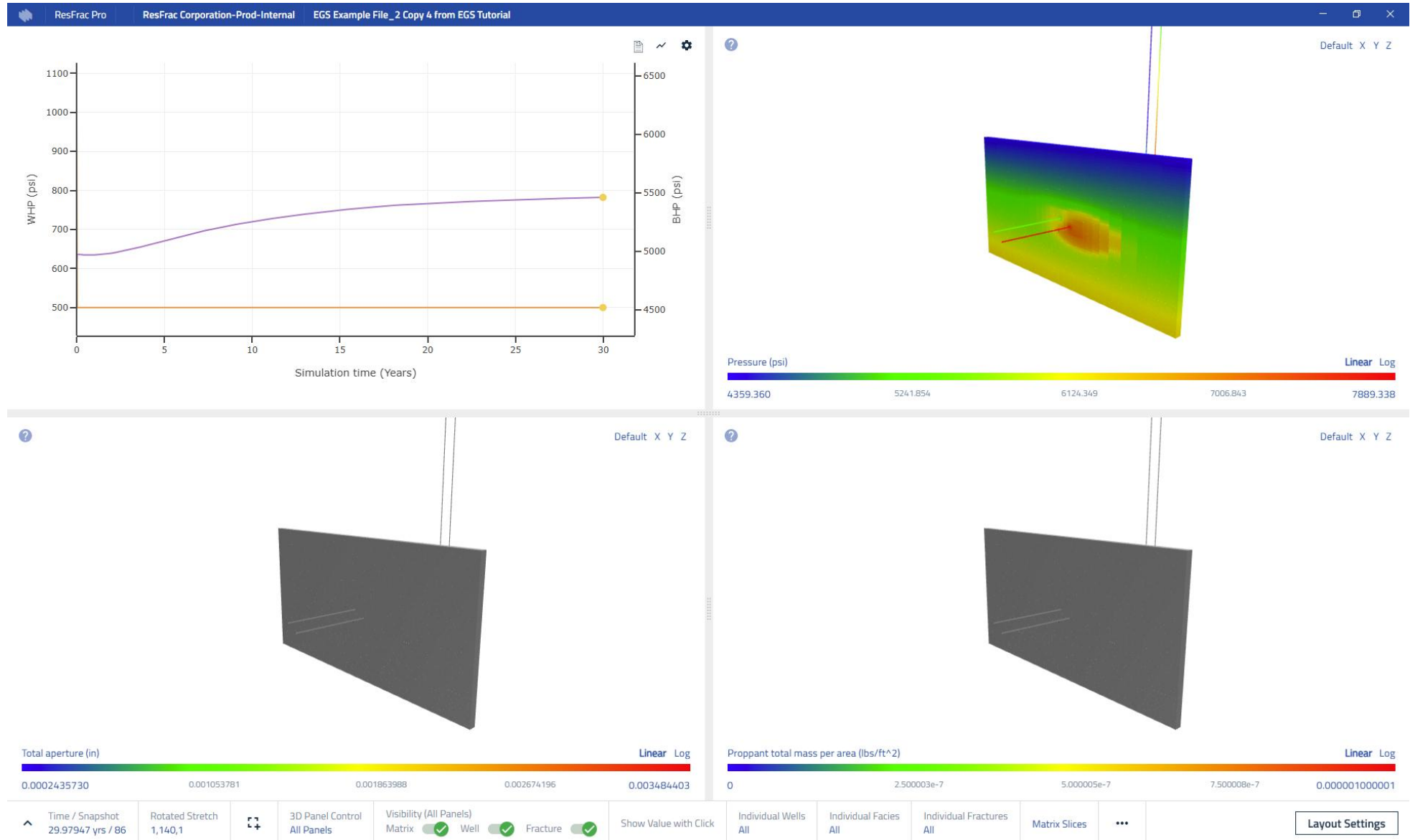
	SIMULATION NAME	STATUS	DATE CREATED ↓	LAST MODIFIED	
>	EGS Example File_3	Not Yet Submitted	Feb 23, 2026 at 4:16 pm	Feb 23, 2026 at 4:16 pm	...
>	EGS Example File_2	Finished running	Feb 4, 2026 at 12:10 pm	Feb 23, 2026 at 3:43 pm	...
>	EGS Example File	Finished running	Dec 15, 2025 at 3:20 pm	Jan 28, 2026 at 11:58 am	...
>	Preexisting fractures	Not Yet Submitted	Dec 2, 2025 at 12:56 pm	Dec 2, 2025 at 11:58 am	
>	Base_from template	Not Yet Submitted	Dec 2, 2025 at 11:58 am	Dec 2, 2025 at 11:58 am	

You have reached the end of the list

- Simulation Details
- Edit Simulation in Builder
- Open Economics Navigator
- Run Simulation
- Copy Simulation
- Copy Simulation to a Sandbox
- Check for New Results in Next Sync
- Re-Download All Results
- Export Simulation Folder
- Open Simulation Folder in File Explorer
- Open Comments File
- Open Text Settings File
- Open Text Input File
- Download Restart Files
- Import Additional Files
- Visualize Simulation Results**
- Visualize Results with Layout

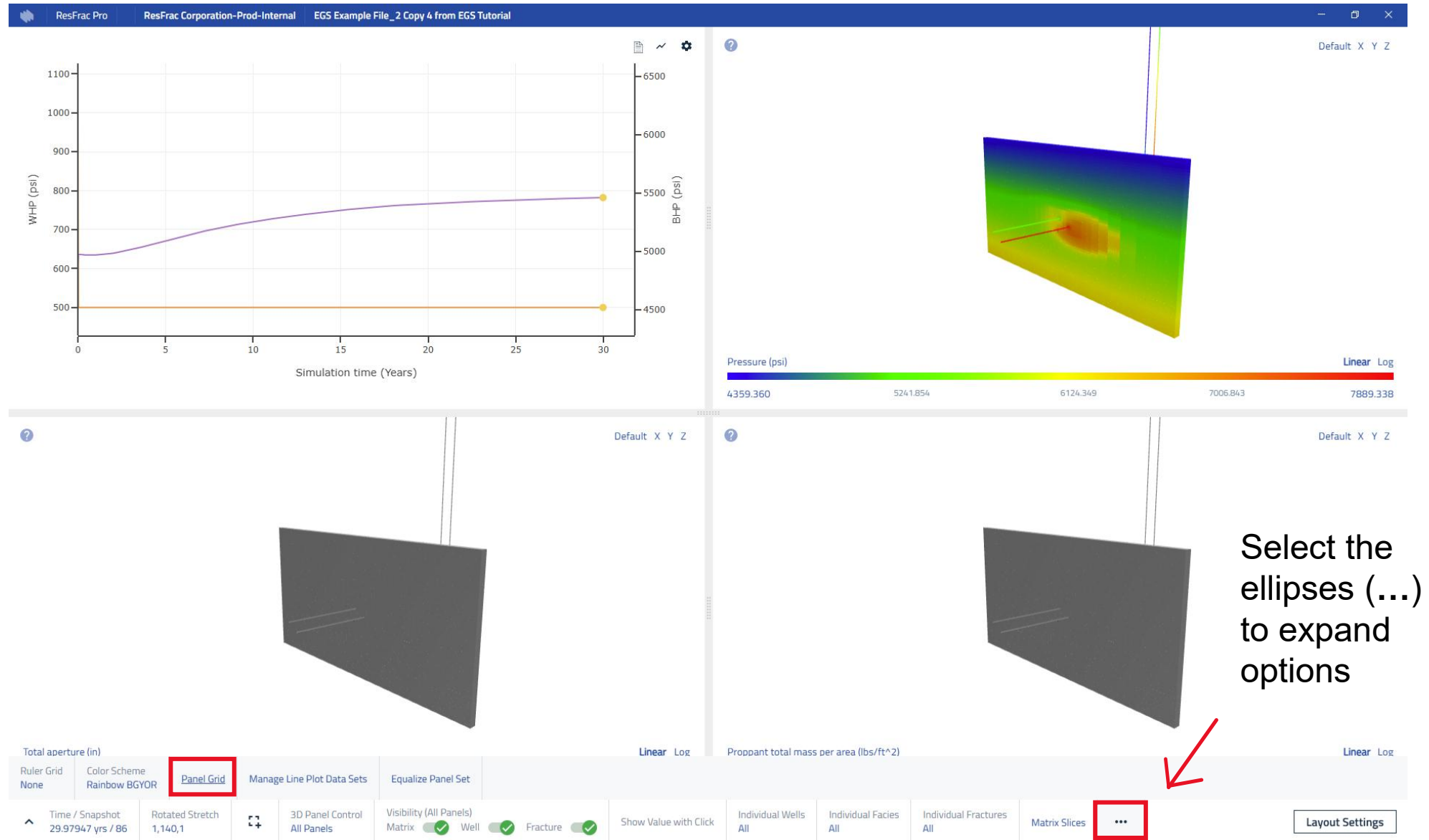
Viz Tool: Default View

By default, the results of the simulation will show one line plot and three 3D plots.



Viz Tool: Panel Grid (slide 1 of 3)

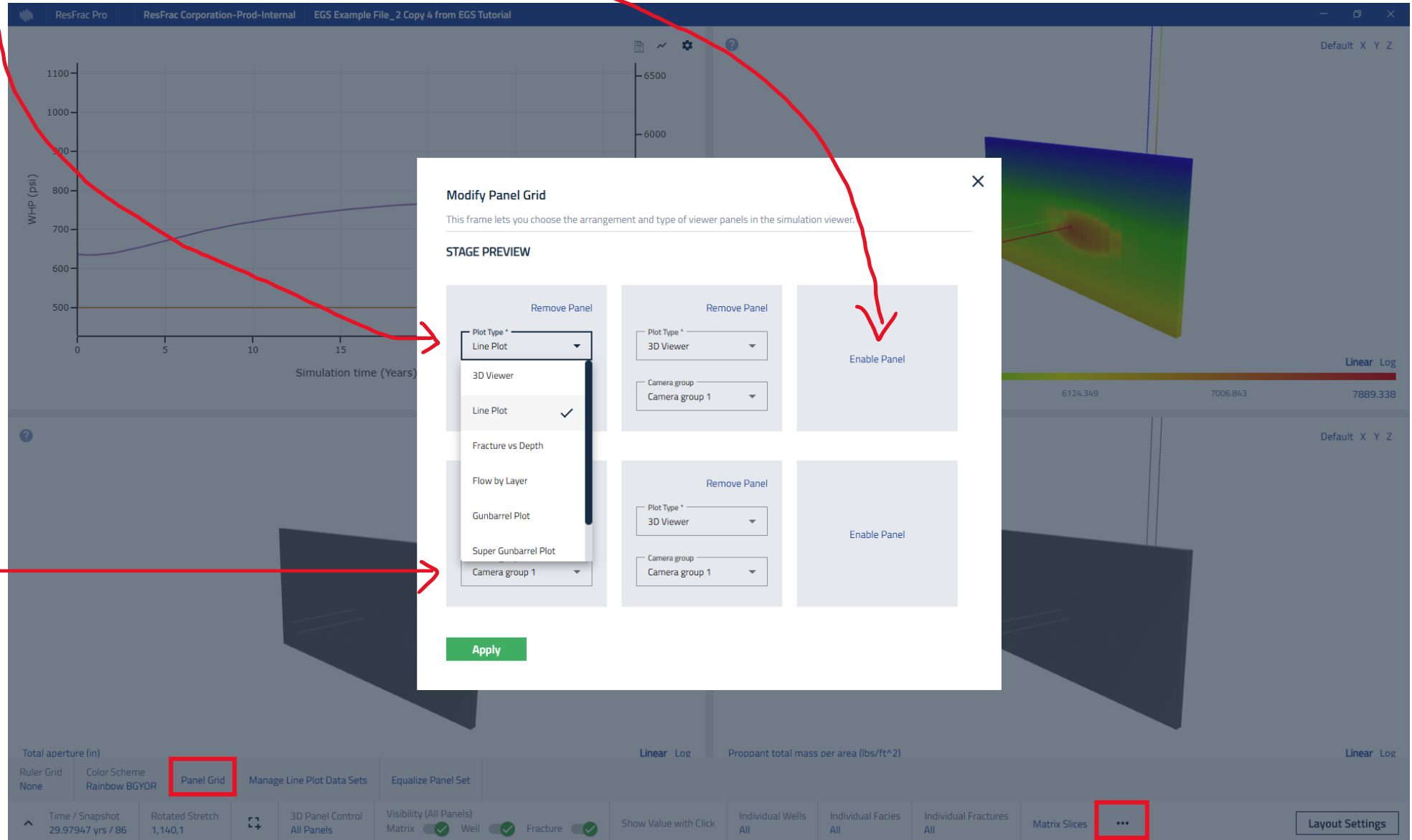
Select “Panel Grid” at the bottom of the Viz tool to change the plots types and number of plots.



Viz Tool: Panel Grid (slide 2 of 3)

Choose plot type or add additional plots (panels).

3D panels
with matching
camera
groups
display the
same angle
and zoom



Viz Tool: Panel Grid (slide 3 of 3)

To analyze this data, we will enable all six panels, and display four line plots and two 3D viewer panels.

ResFrac Pro ResFrac Corporation-Prod-Internal EGS Example File_2 Copy 4 from EGS Tutorial

WHP (psi)

Simulation time (Years)

Modify Panel Grid

This frame lets you choose the arrangement and type of viewer panels in the simulation viewer.

STAGE PREVIEW

Remove Panel

Plot Type *

Line Plot

Remove Panel

Plot Type *

Line Plot

Remove Panel

Plot Type *

Line Plot

Remove Panel

Plot Type *

Line Plot

Remove Panel

Plot Type *

3D Viewer

Camera group

Camera group 1

Remove Panel

Plot Type *

3D Viewer

Camera group

Camera group 1

Apply

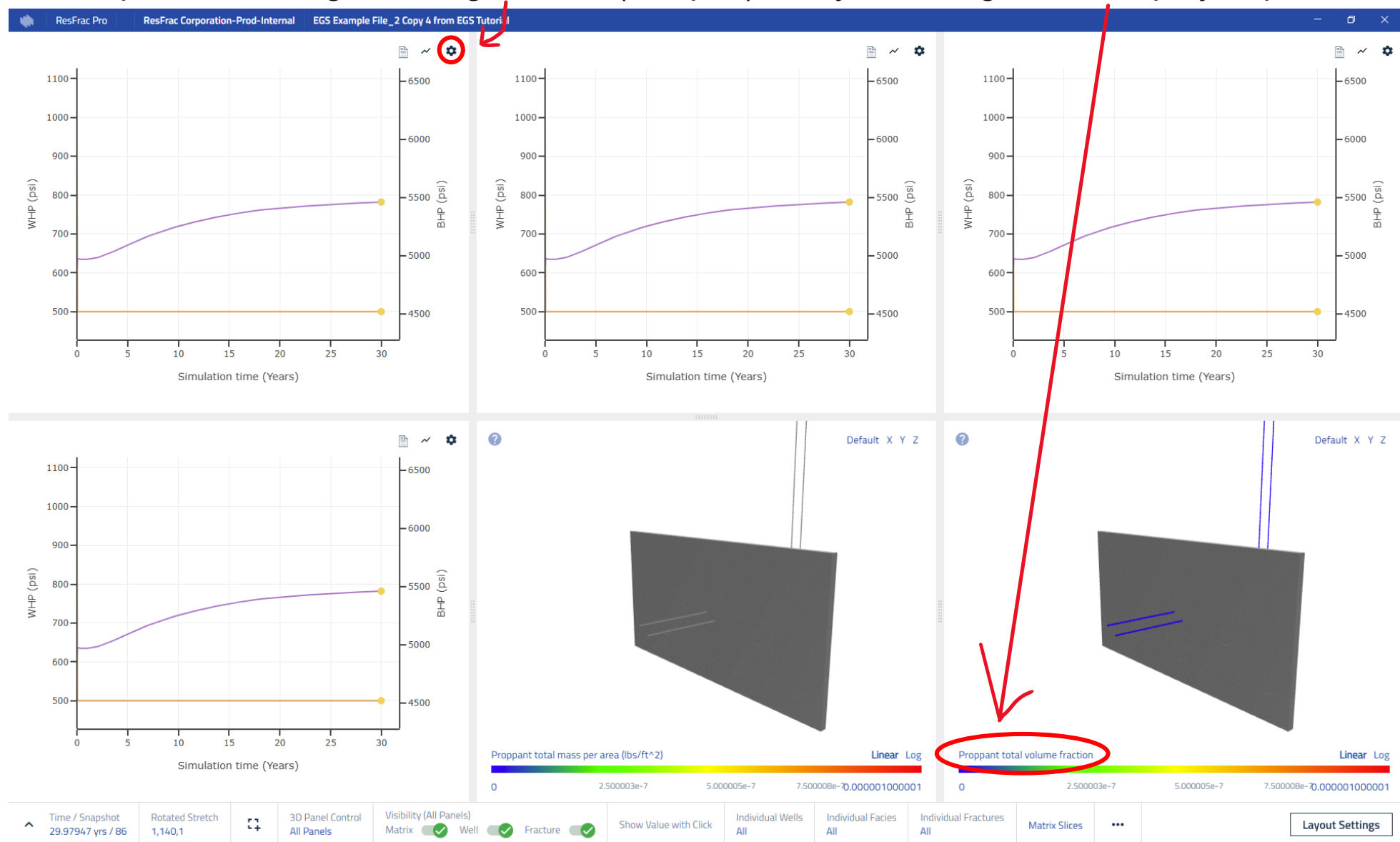
Total aperture (in)

Ruler Grid None Color Scheme Rainbow BGYOR Panel Grid Manage Line Plot Data Sets Equalize Panel Set

Time / Snapshot 29.97947 yrs / 86 Rotated Stretch 1,140,1 3D Panel Control All Panels Visibility (All Panels) Matrix Well Fracture Show Value with Click Individual Wells All Individual Facies All Individual Fractures All Matrix Slices Layout Settings

Viz Tool: Selecting parameters to plot

Choose what each plot is showing via the gear icon (line plot), or by choosing a new displayed parameter (3D plot)

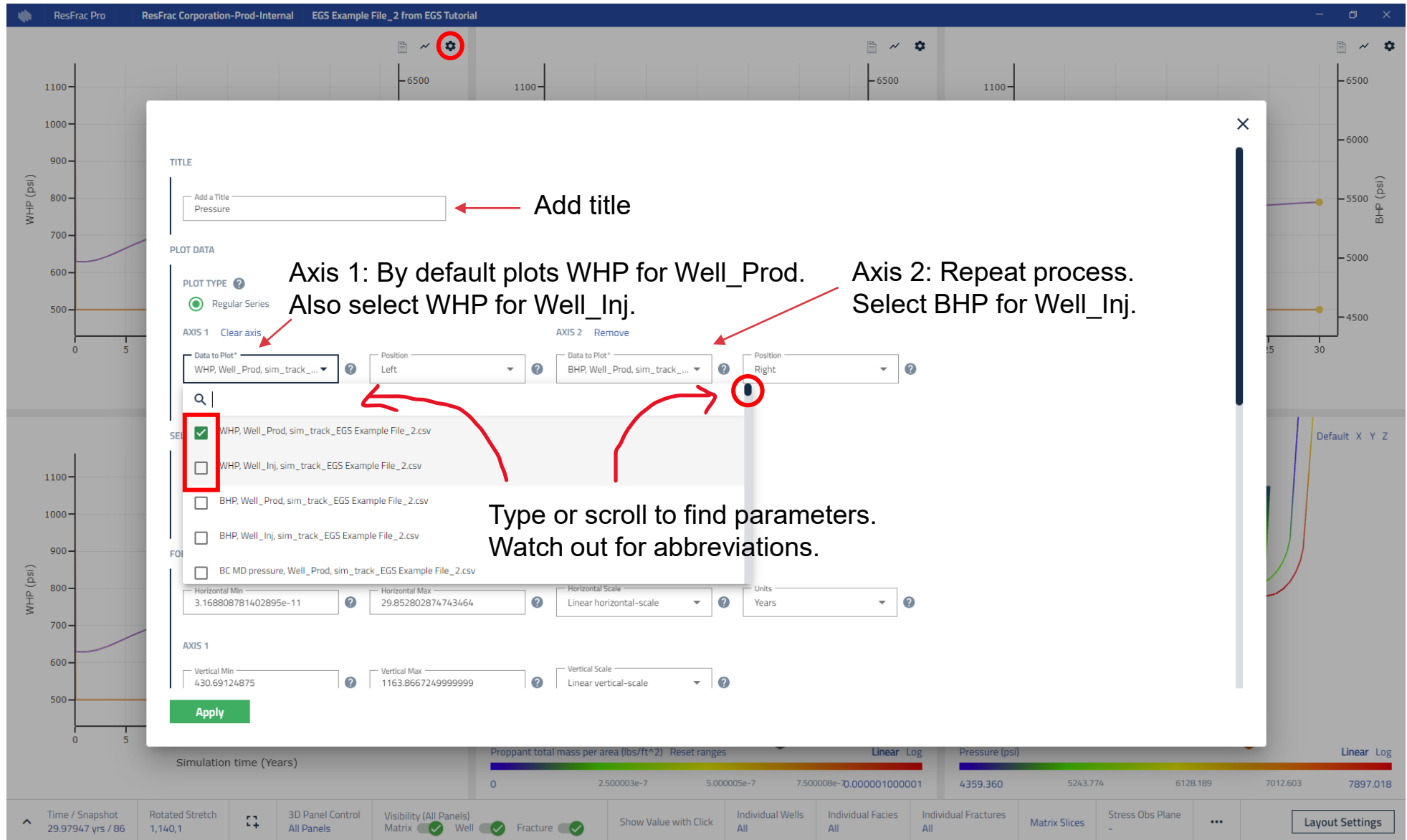


Viz Tool: Line Plots – Pressure (1 of 4)

Select the settings (gear) icon for the first plot to customize.

On **Axis 1**, plot:
WHP

On **Axis 2**, plot:
BHP



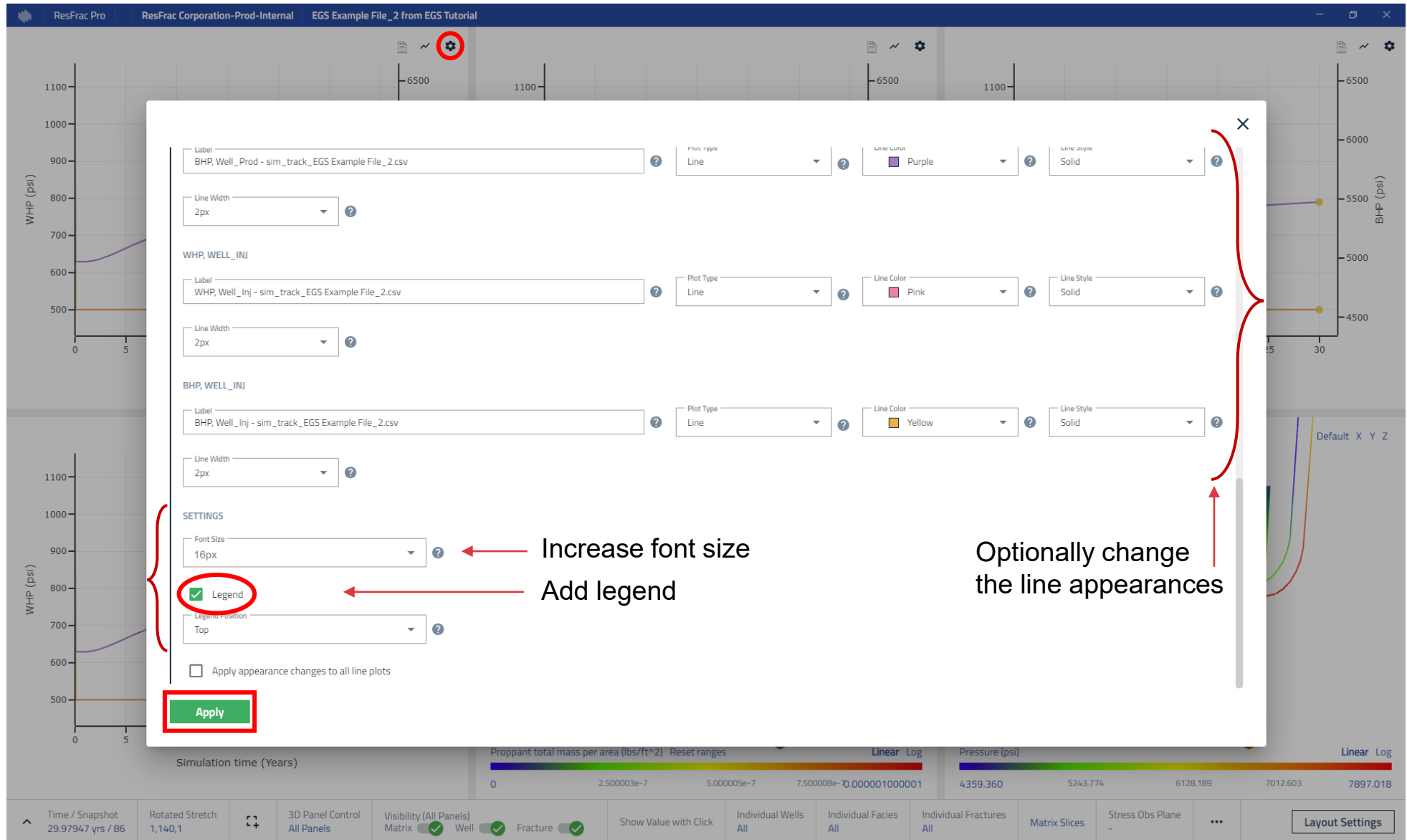
Viz Tool: Line Plots – Pressure (2 of 4)

Select the settings (gear) icon for the first plot to customize.

Scroll down to the **Settings** sections:

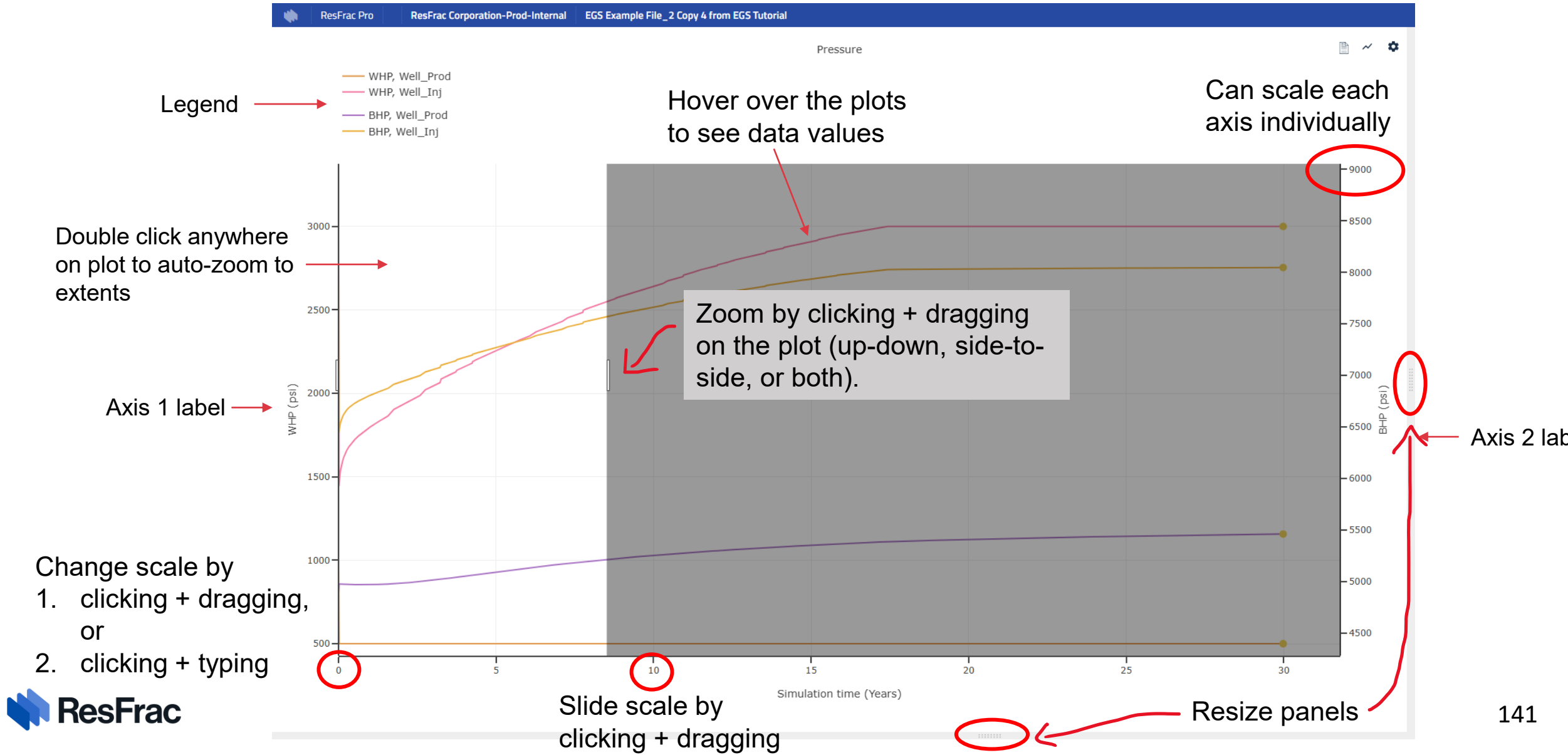
Change font size

Turn on legend



Viz Tool: Line Plots – Pressure (3 of 4)

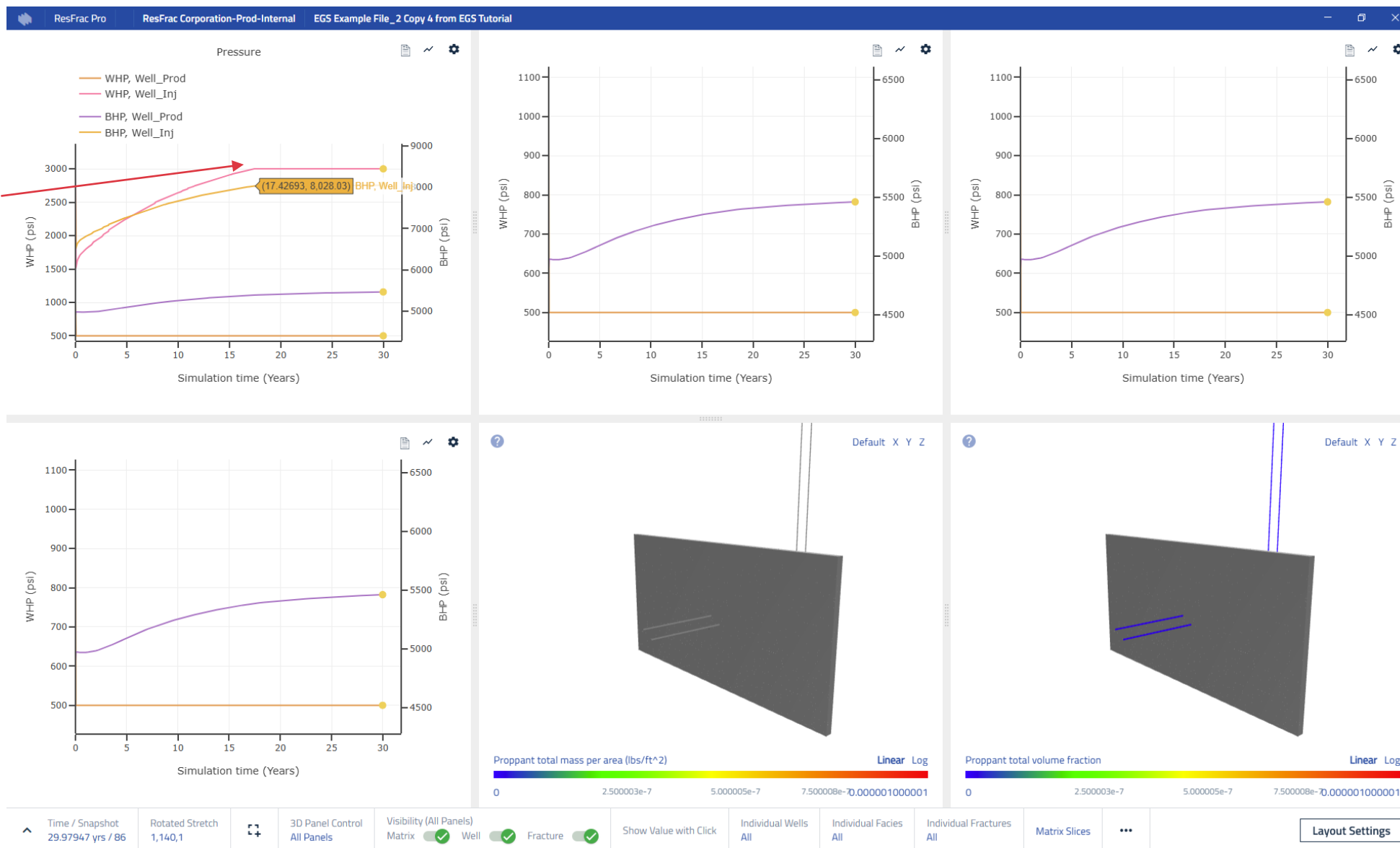
Practice changing the panel size and the zoom features. See tips on how below.



Viz Tool: Line Plots – Pressure (4 of 4)

Return the panel grid to original size, and zoom back to extents on the Pressure plot.

Note: max injection pressure reached after 17.4 yrs



Viz Tool: Line Plots – Injection and Production Rates (1 of 4)

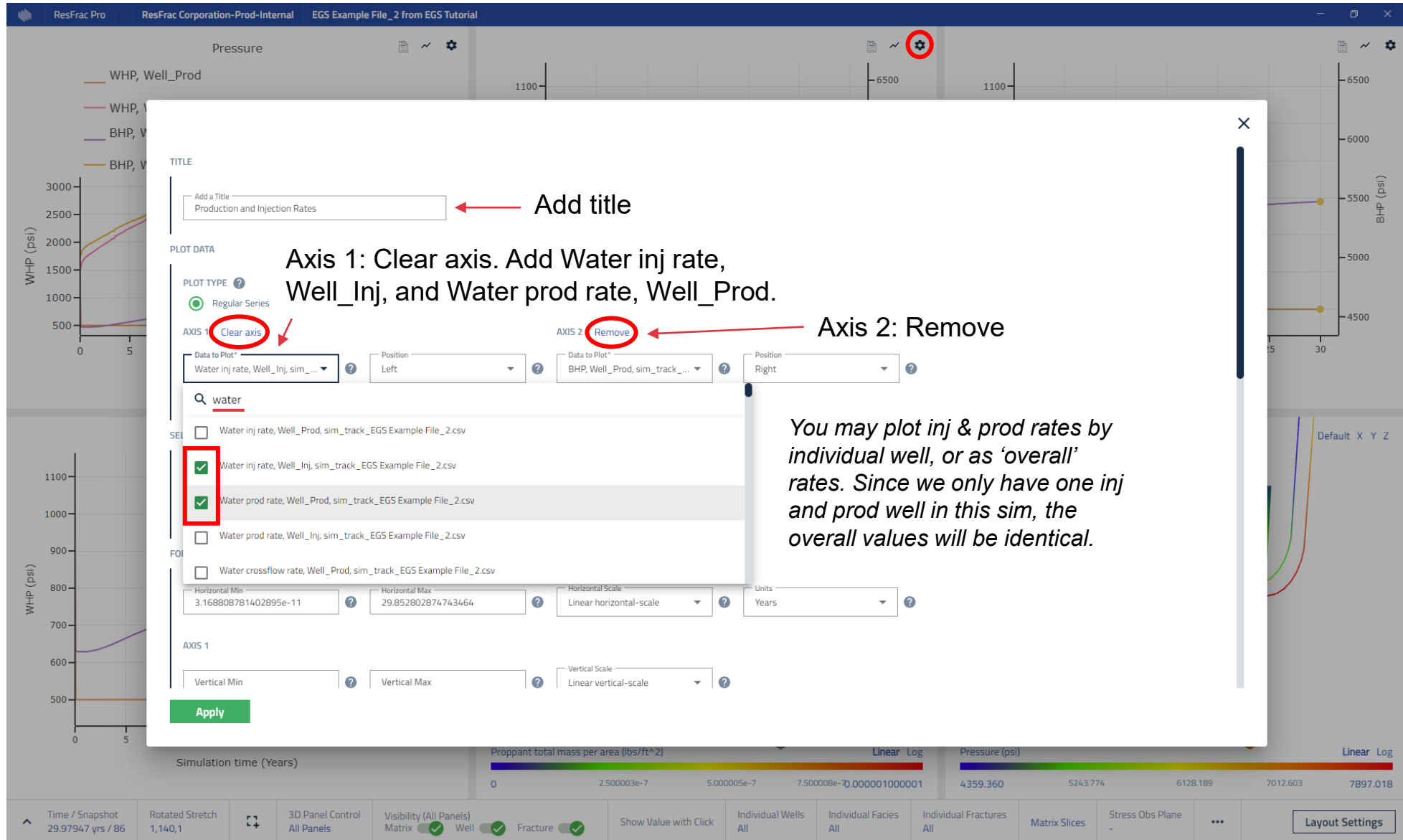
Select the settings (gear) icon for the second plot to customize.

On **Axis 1**, plot:

Water inj rate,
Well_Inj

Water prod rate,
Well_Prod

Remove **Axis 2**



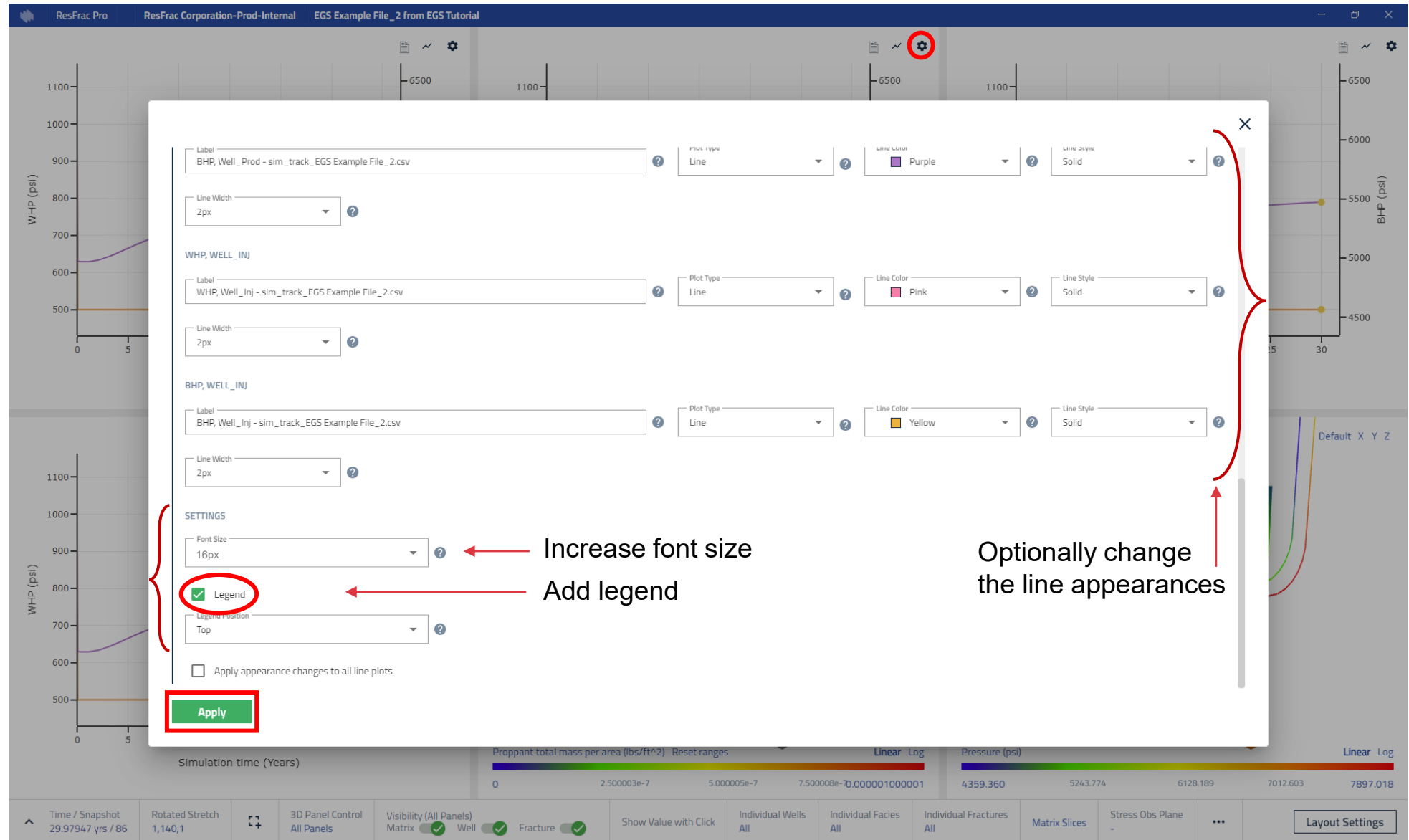
Viz Tool: Line Plots – Injection and Production Rates (2 of 4)

Select the settings (gear) icon for the second plot to customize.

Scroll down to the **Settings** sections:

Change font size

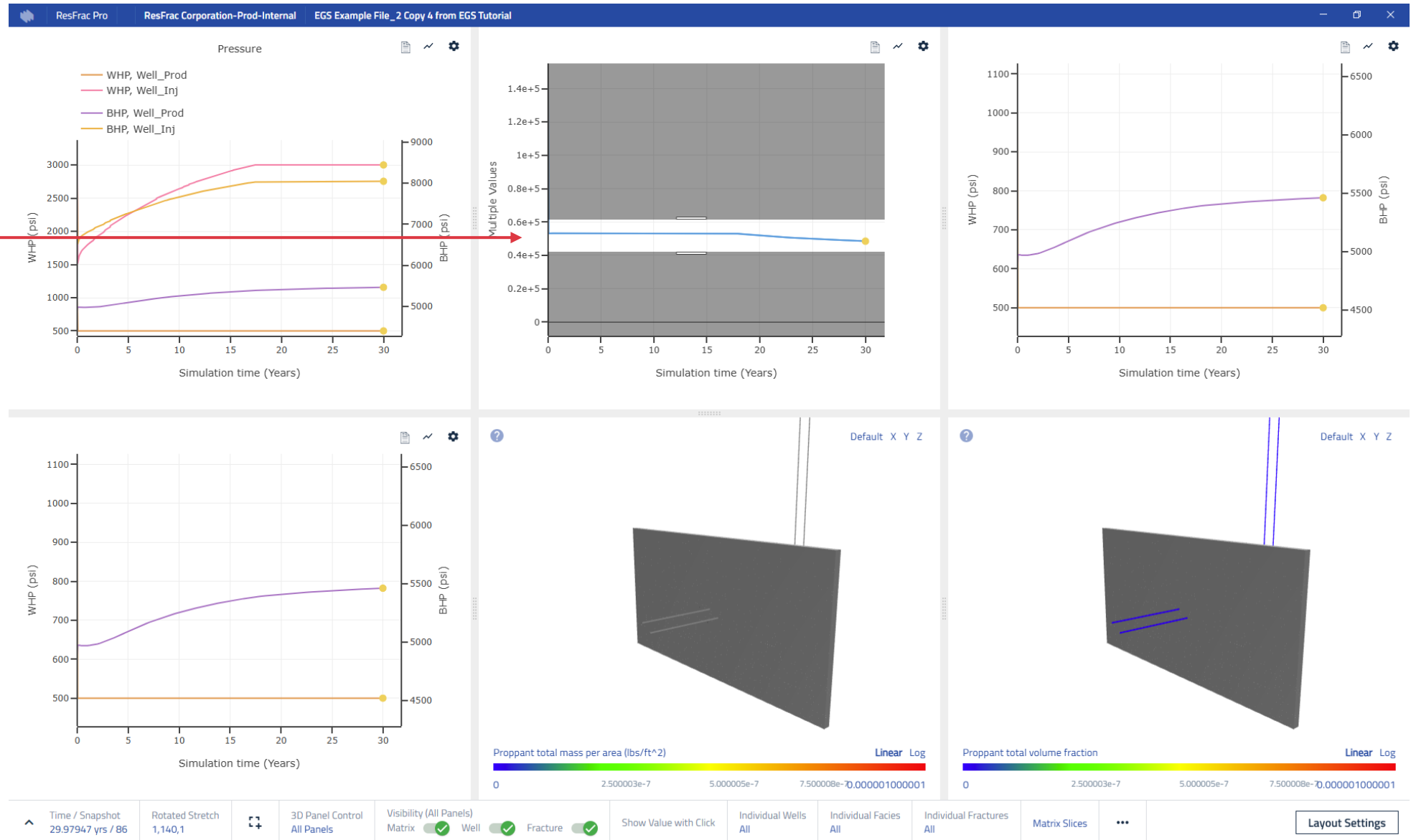
Turn on legend



Viz Tool: Line Plots – Injection and Production Rates (3 of 4)

Zoom in on the Production and Injection Rates curve.

Zoom in



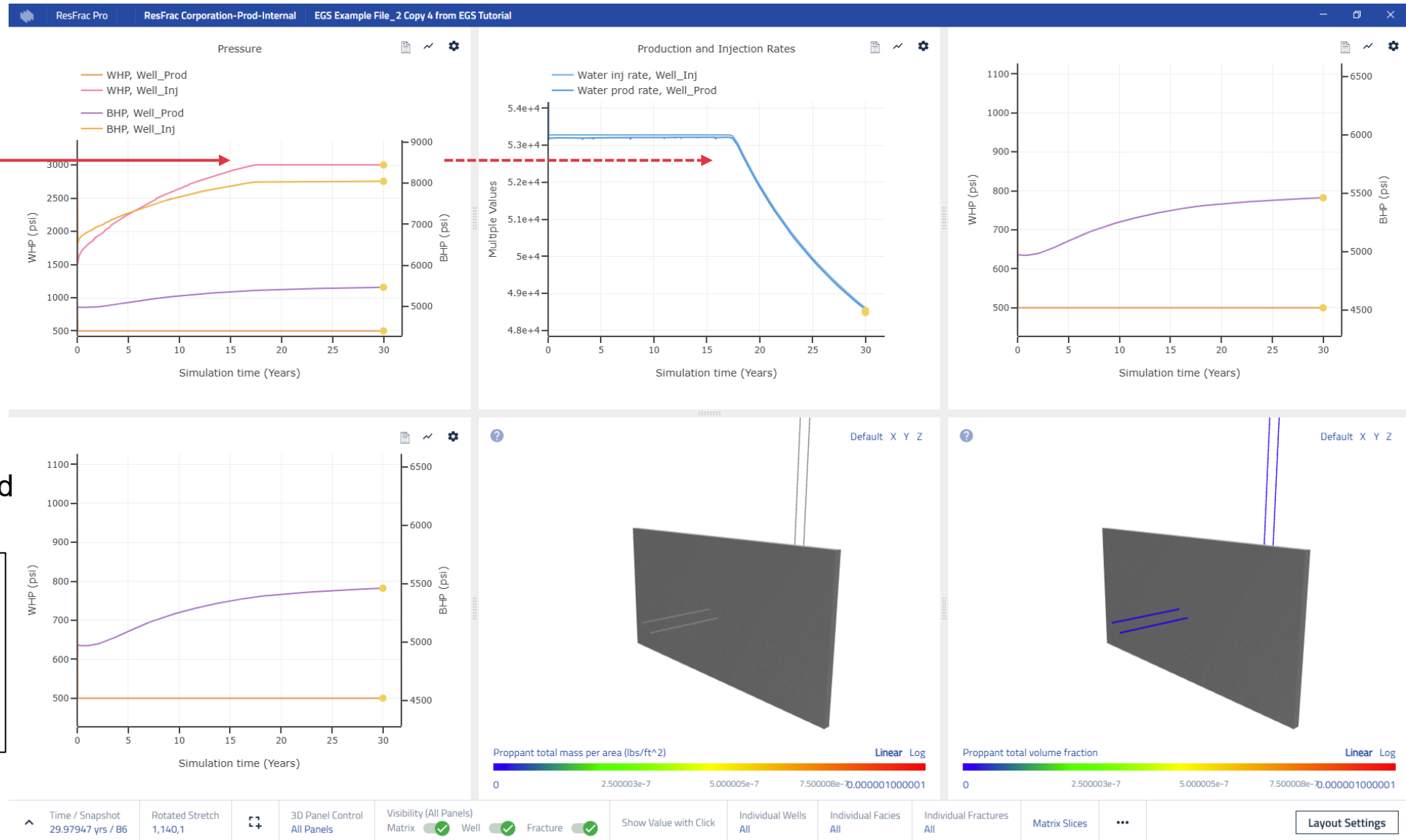
Viz Tool: Line Plots – Injection and Production Rates (4 of 4)

Compare injection and production rates to quantify water loss.

Observations:

- Production and injection rates are almost identical (minimal water loss)
- Rates drop when the max WHP is reached

A ResFrac blog post on water loss in EGS is also available at [this link](#).

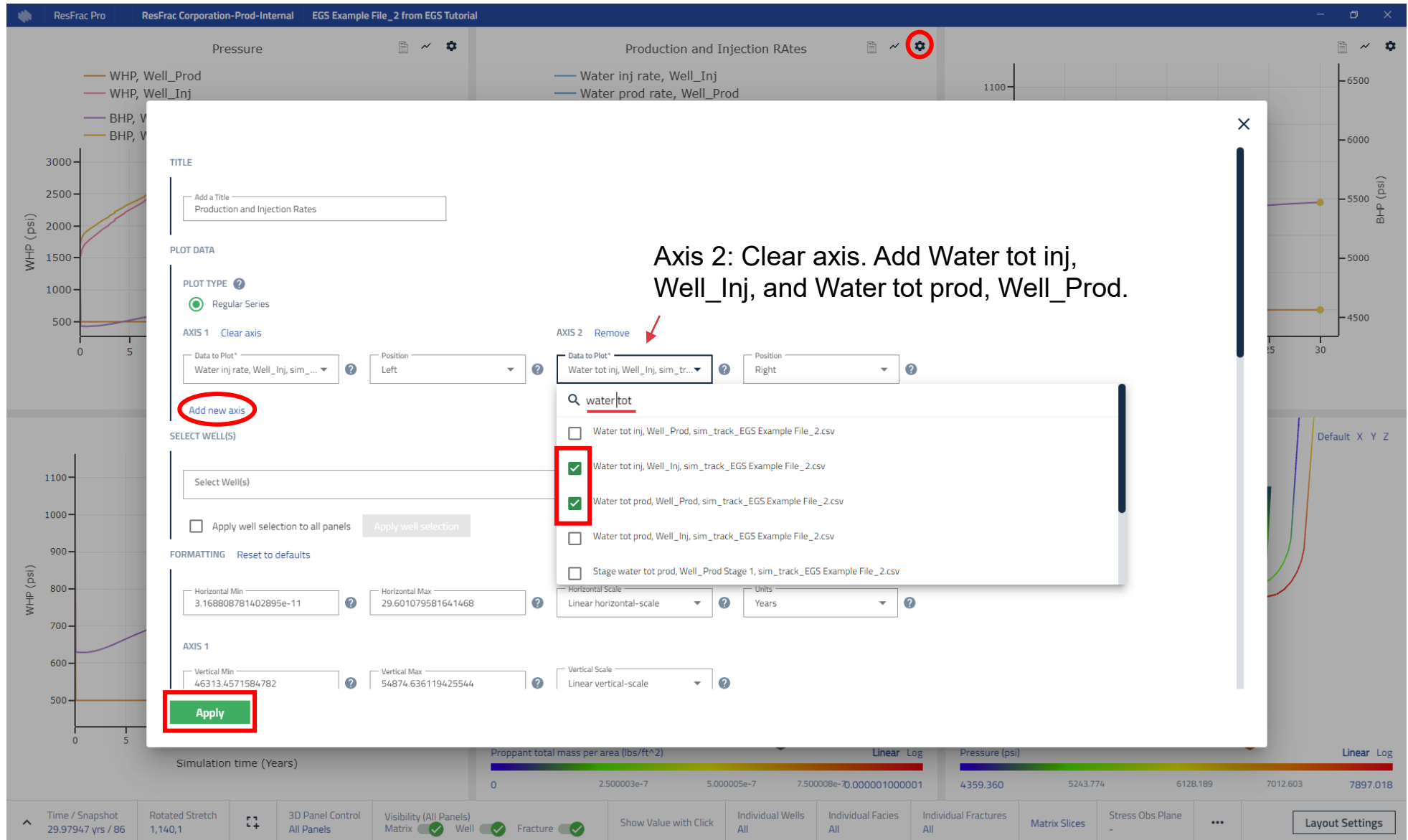


Select the settings (gear) icon for the second plot to customize.

On **Axis 2**, plot:

Water tot inj,
Well_Inj

Water tot prod,
Well_Prod

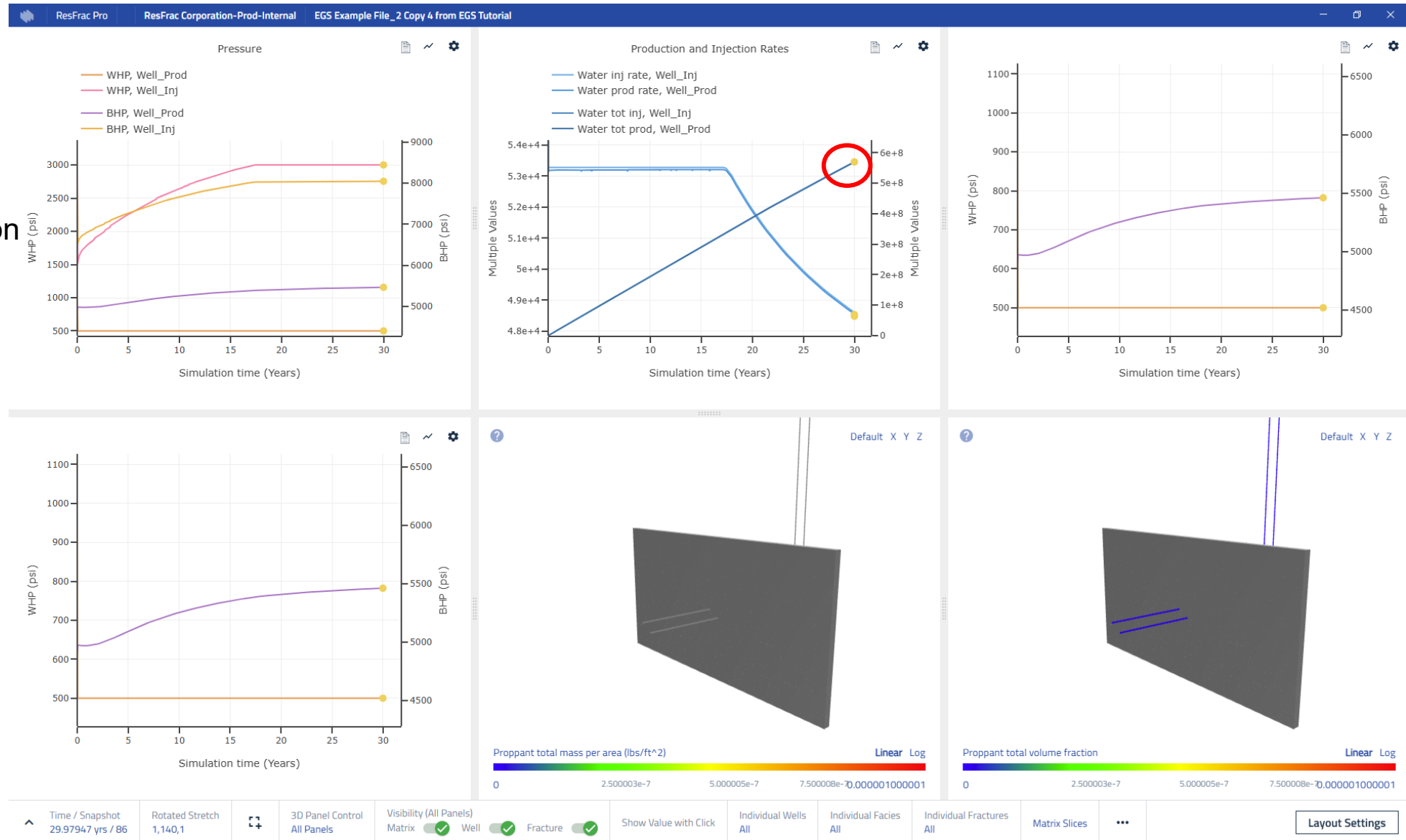


Viz Tool: Line Plots – Total Water Volumes (2 of 2)

Compare cumulative injection and production volumes to quantify water loss.

Observations:

- Cumulative water production and injection totals similarly show minimal water loss



Viz Tool: Line Plots – Temperature and Electricity (1 of 3)

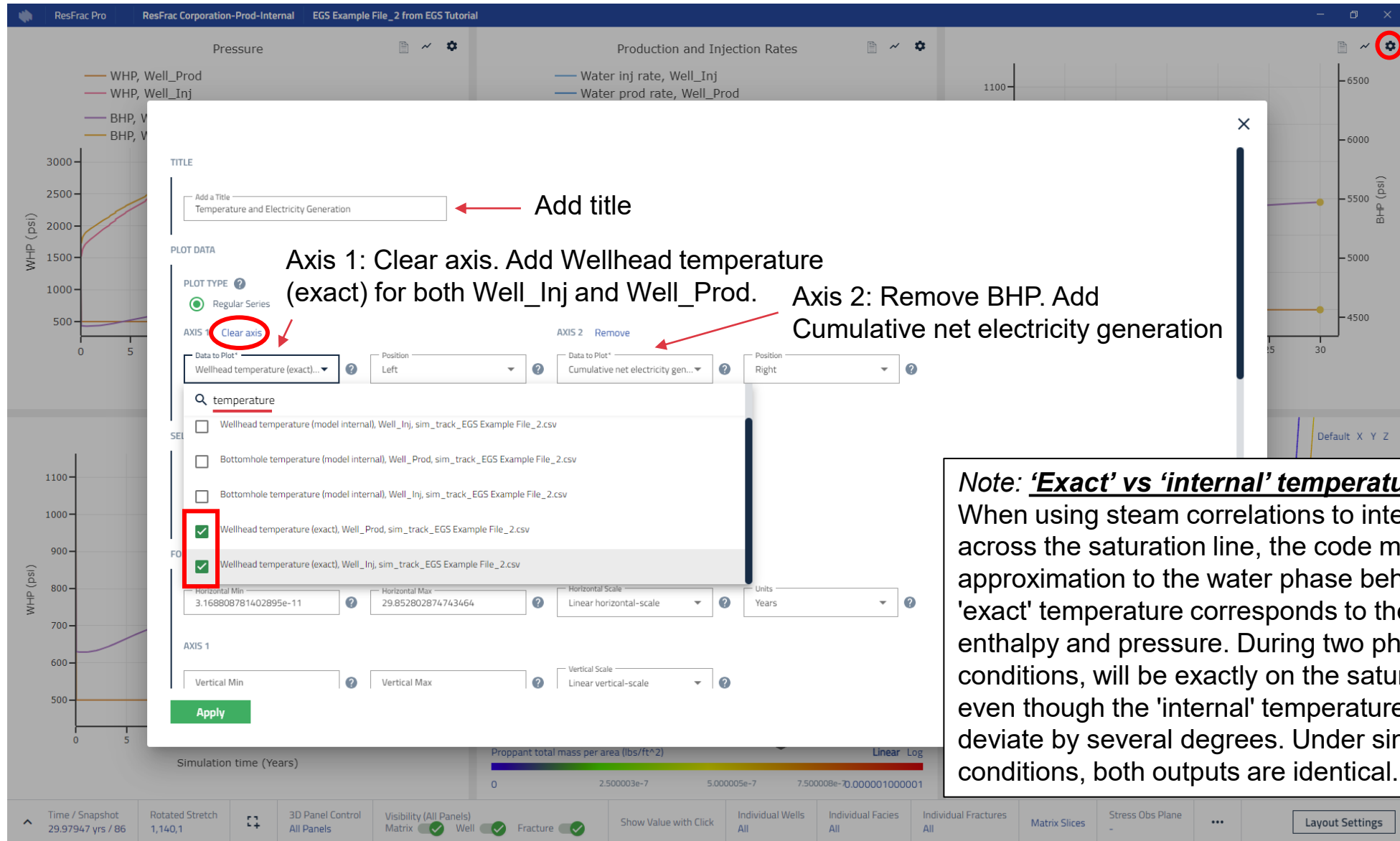
Select the settings (gear) icon for the third plot to customize.

On **Axis 1**, plot:

Wellhead temperature (exact),
Well_Prod

Wellhead temperature (exact),
Well_Inj

On **Axis 2**, plot:
Cumulative net electricity generation



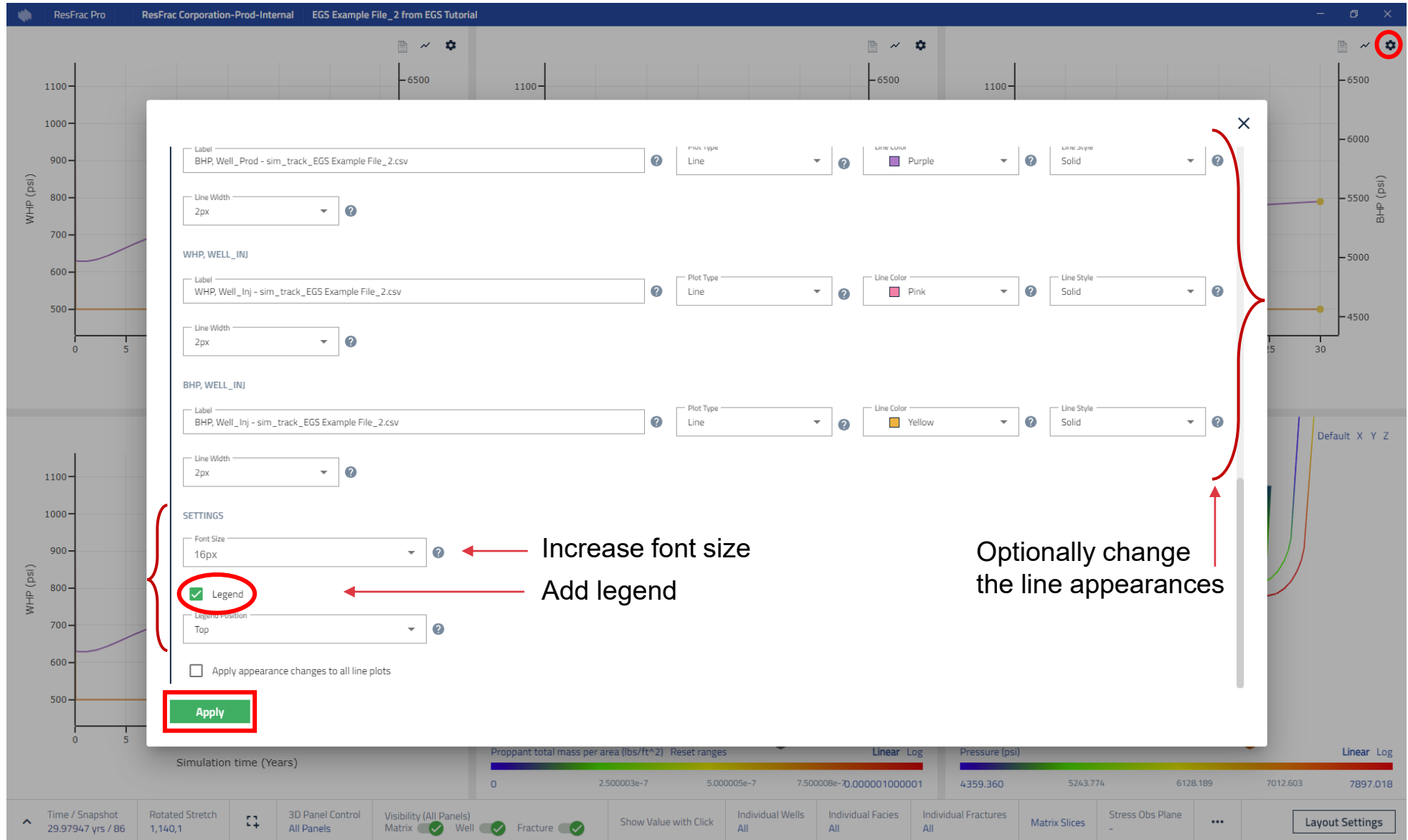
Viz Tool: Line Plots – Temperature and Electricity (2 of 3)

Select the settings (gear) icon for the third plot to customize.

Scroll down to the **Settings** sections:

Change font size

Turn on legend

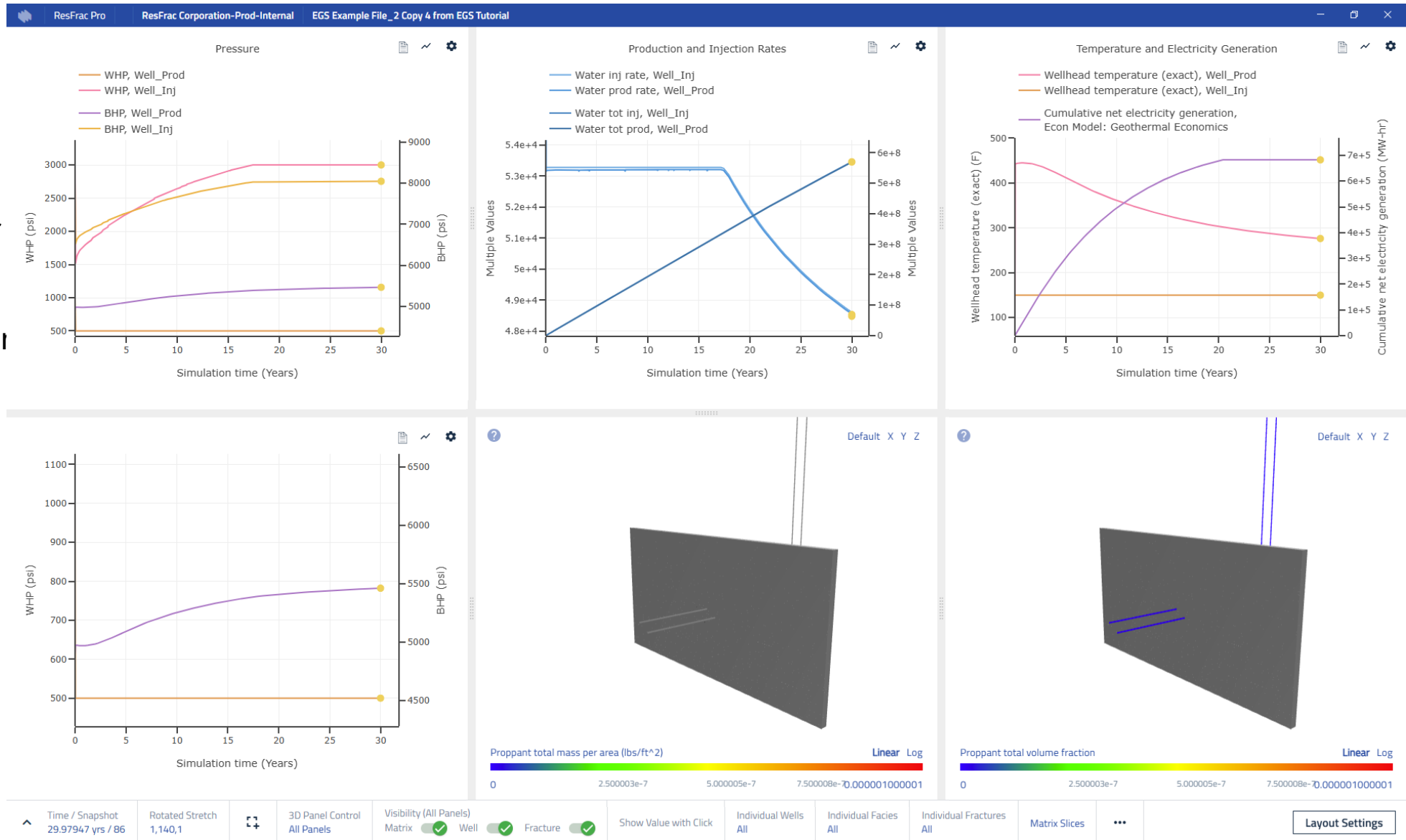


Viz Tool: Line Plots – Temperature and Electricity (3 of 3)

See how temperature declines in the production well, and note the diminishing electricity generation rate.

Observations:

- Lower cutoff temperature for electricity generation is 300°F (based on geothermal economics model).
- When temperature reaches 300°F, electricity generation stops.



300°F
cutoff
reached

Viz Tool: Line Plots – Economics (1 of 3)

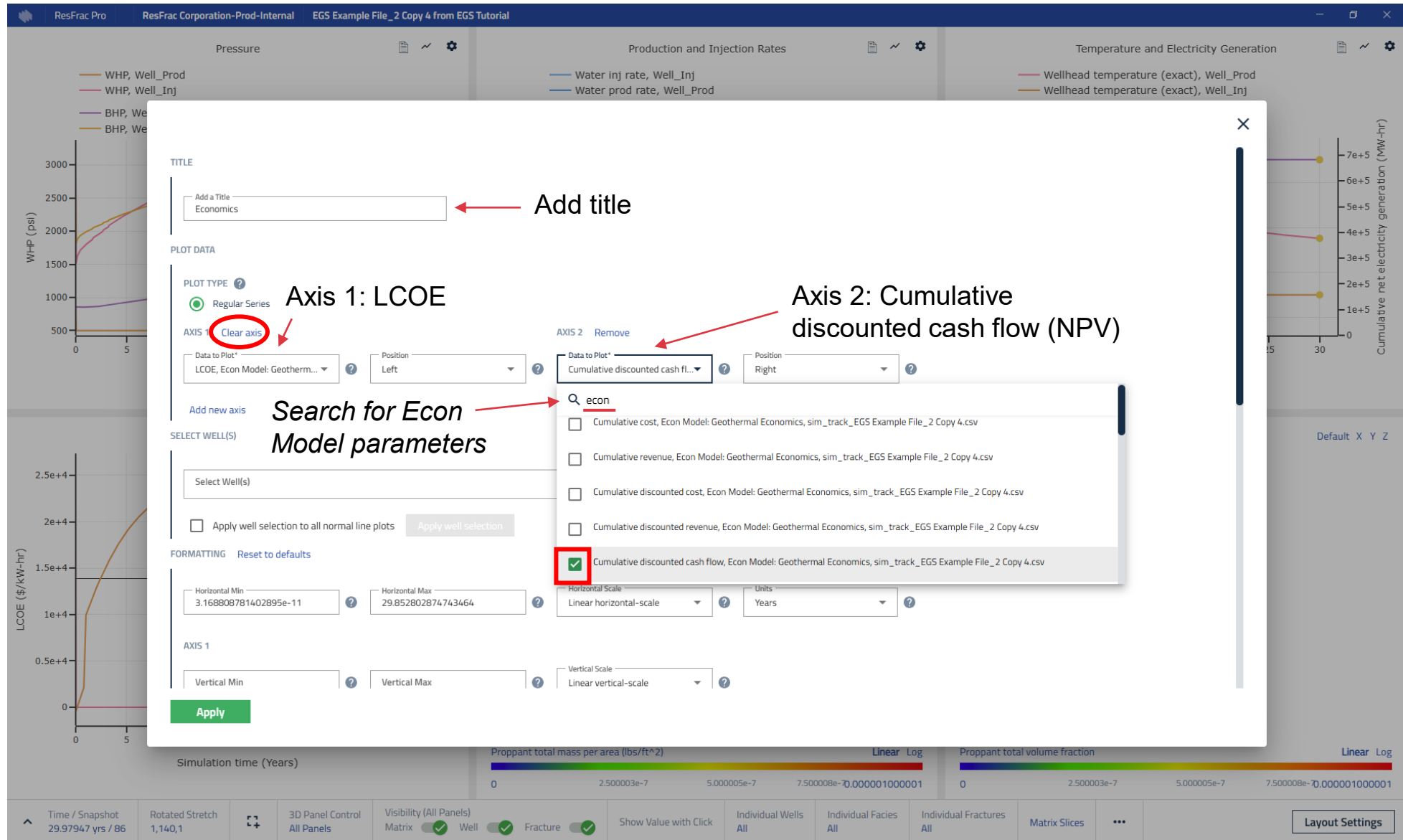
Select the settings (gear) icon for the fourth plot to customize.

On **Axis 1**, plot:

LCOE

On **Axis 2**, plot:

NPV



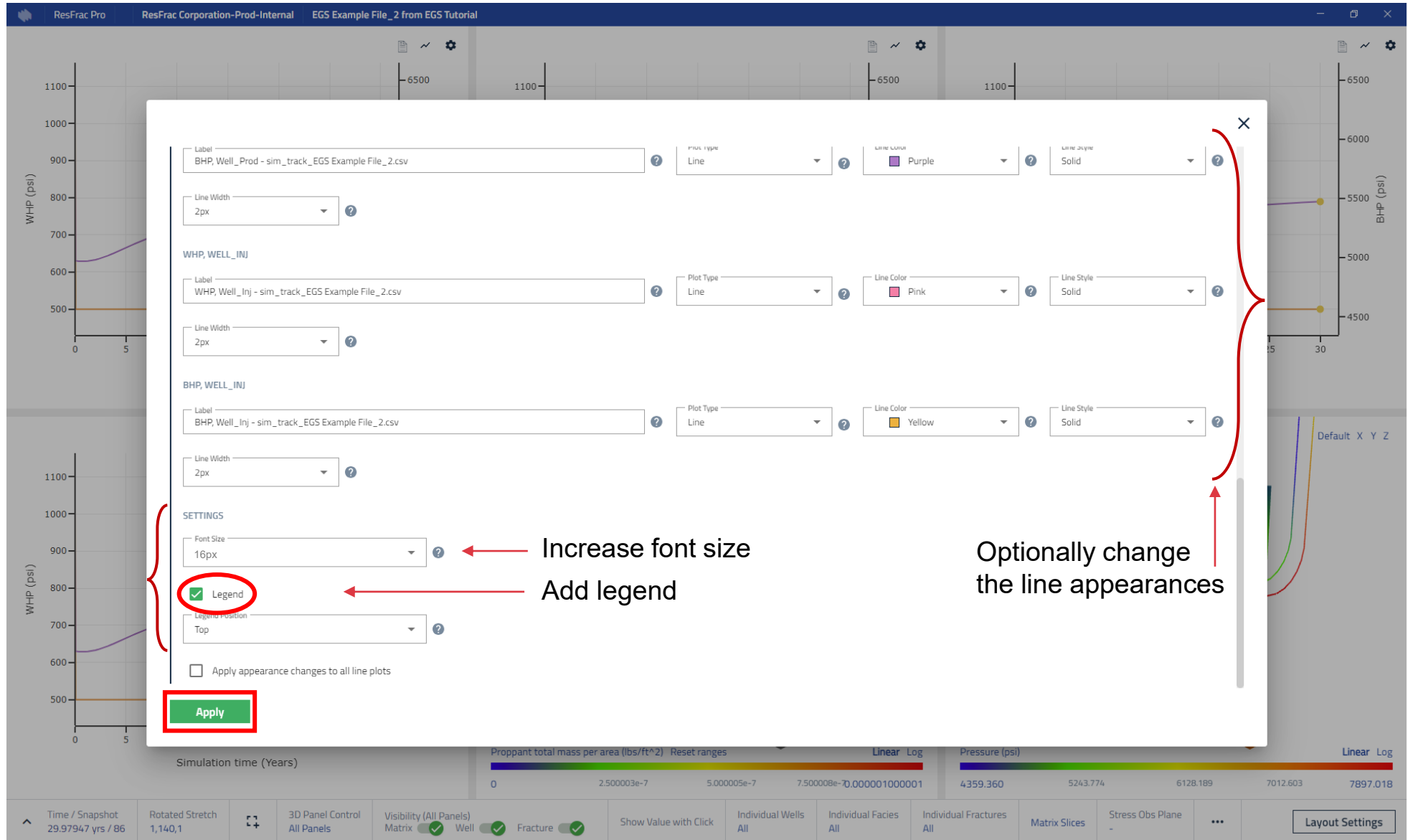
Viz Tool: Line Plots – Economics (2 of 3)

Select the settings (gear) icon for the fourth plot to customize.

Scroll down to the **Settings** sections:

Change font size

Turn on legend



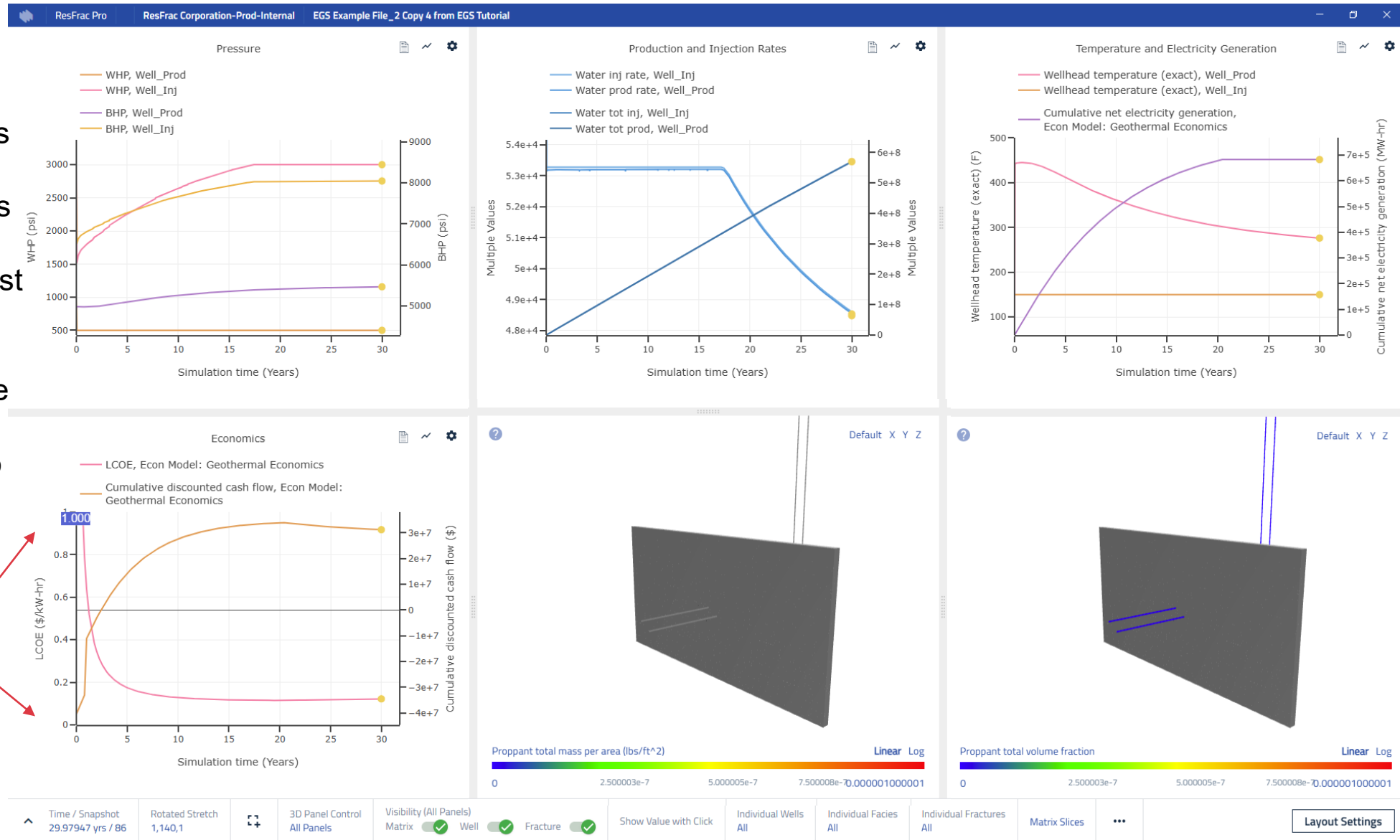
Viz Tool: Line Plots – Economics (3 of 3)

See how temperature declines in the production well, and note the diminishing electricity generation rate.

Observations:

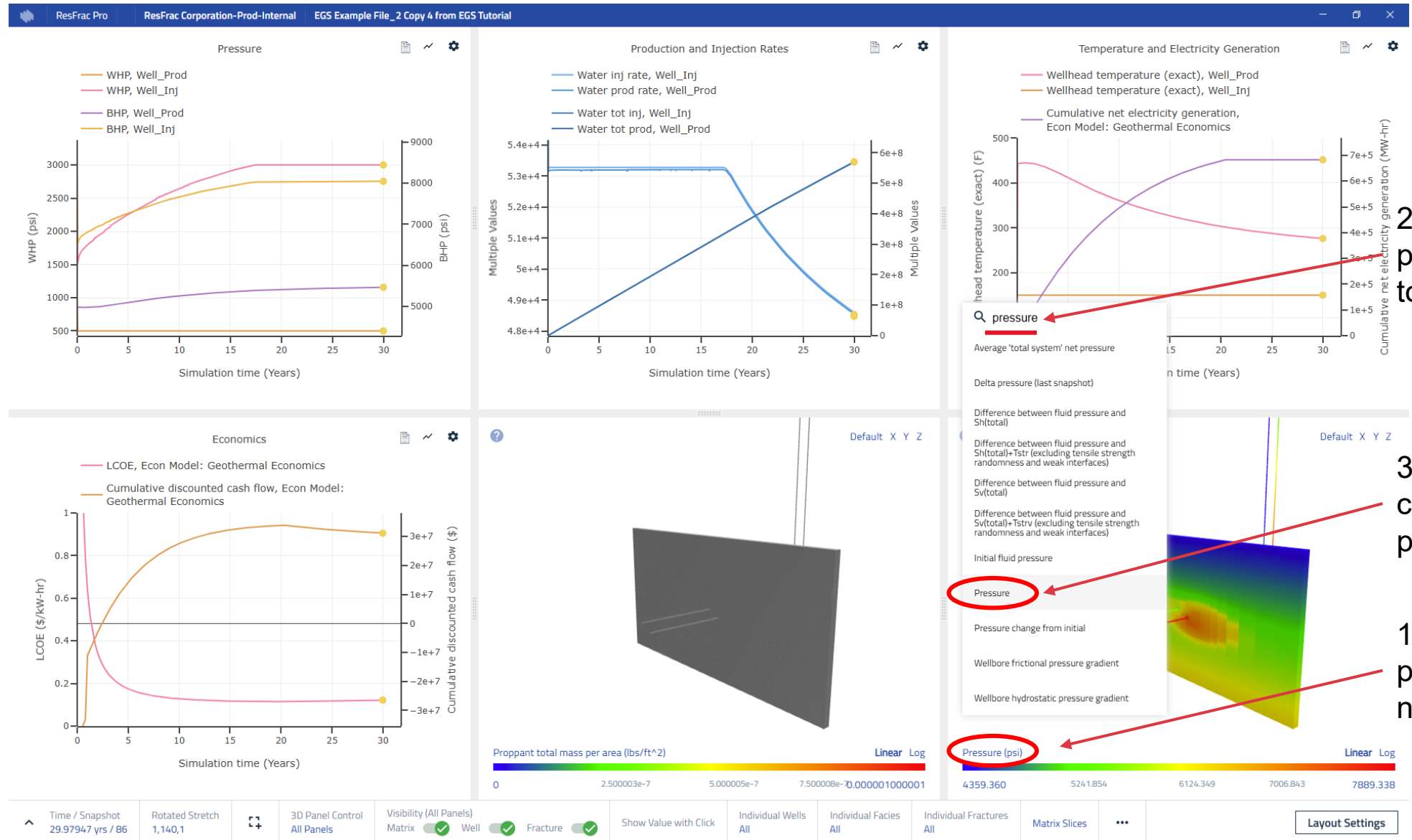
- LCOE is \$125 MW-hr, which is a bit high. <\$100/MW-hr is a reasonable target (see latest [Lazard LCOE data](#)).
- NVP is low. The system should be optimized to improve the economics.

Rescale the LCOE axis to go from 0 to 1



Viz Tool: 3D Plots, parameter selection

Select the bottom right parameter to change it to 'Pressure'.



2. Type parameter to search

3. Select correct parameter

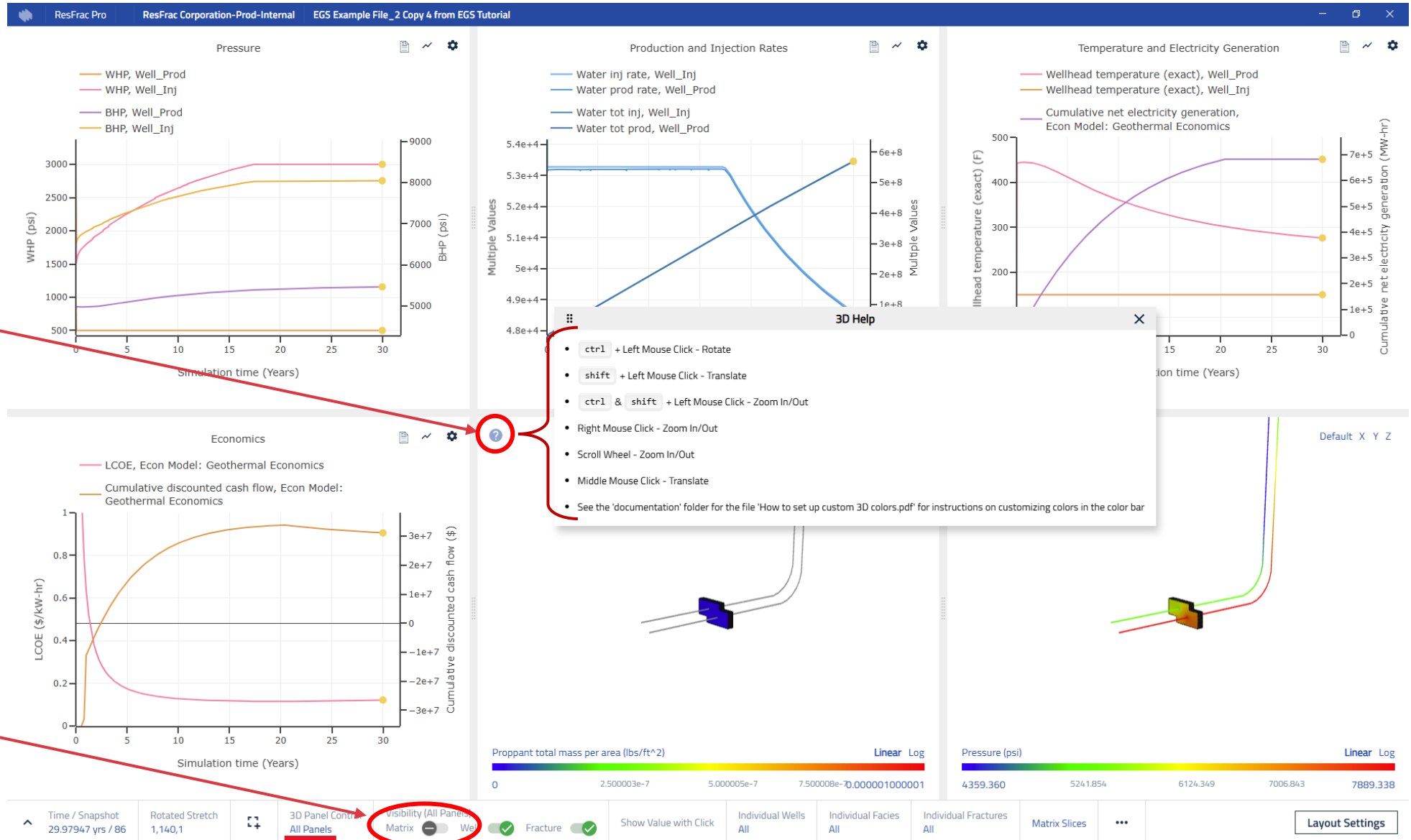
1. Click parameter name

Viz Tool: 3D Plots, navigation and visibility

3D Control tips are available in the viz tool via the (?) icon.

Review the 3D controls and practice zooming and navigating the 3D views. All panels in the same camera group are adjusted simultaneously

Turn off matrix visibility to view the fractures (for all panels)

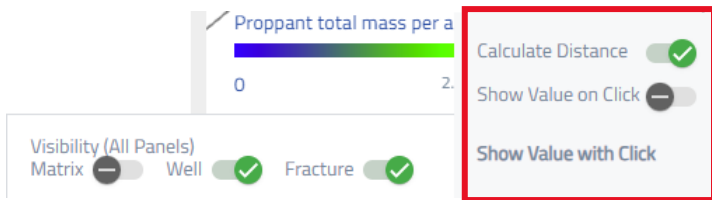


Viz Tool: 3D plots, fracture dimensions

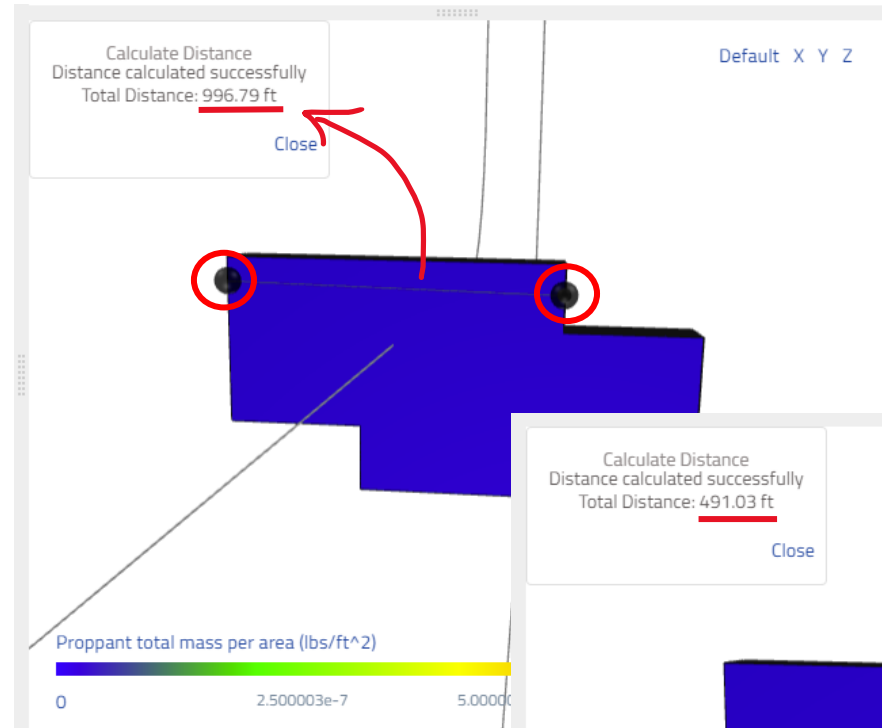
Under “Show Value with Click,” toggle the “Calculate Distance” tool to measure the length and height of the fractures.

Fracture length:
This matches the assigned value of 1000 ft

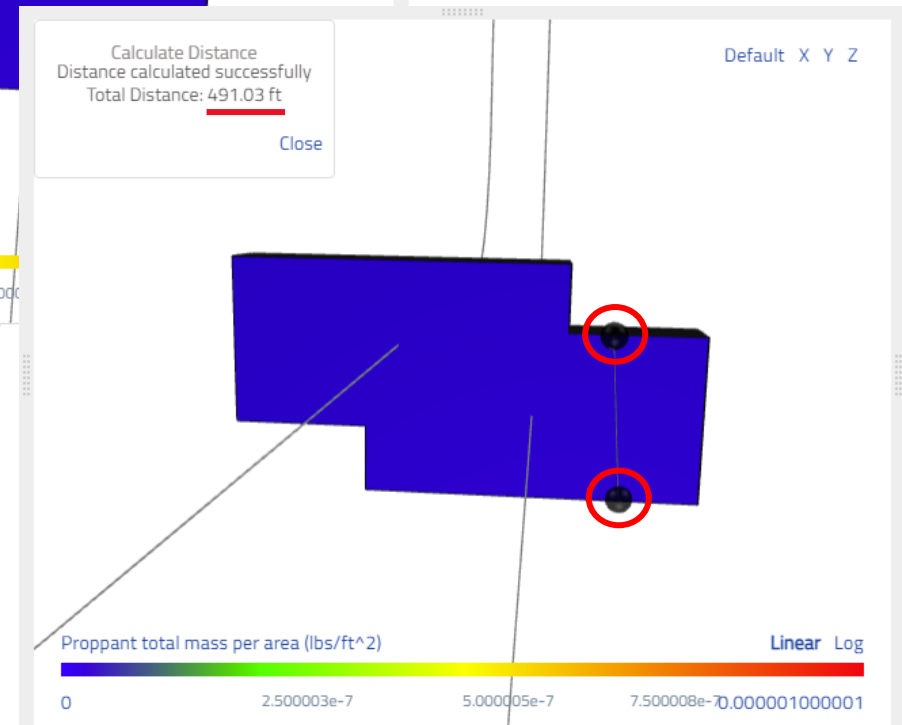
Select “Calculate Distance”.
Click on two points to measure the distance between them.



Note: you cannot calculate distance with rotated stretch turned on (next slide)



Fracture height:
This matches the assigned value of 500 ft

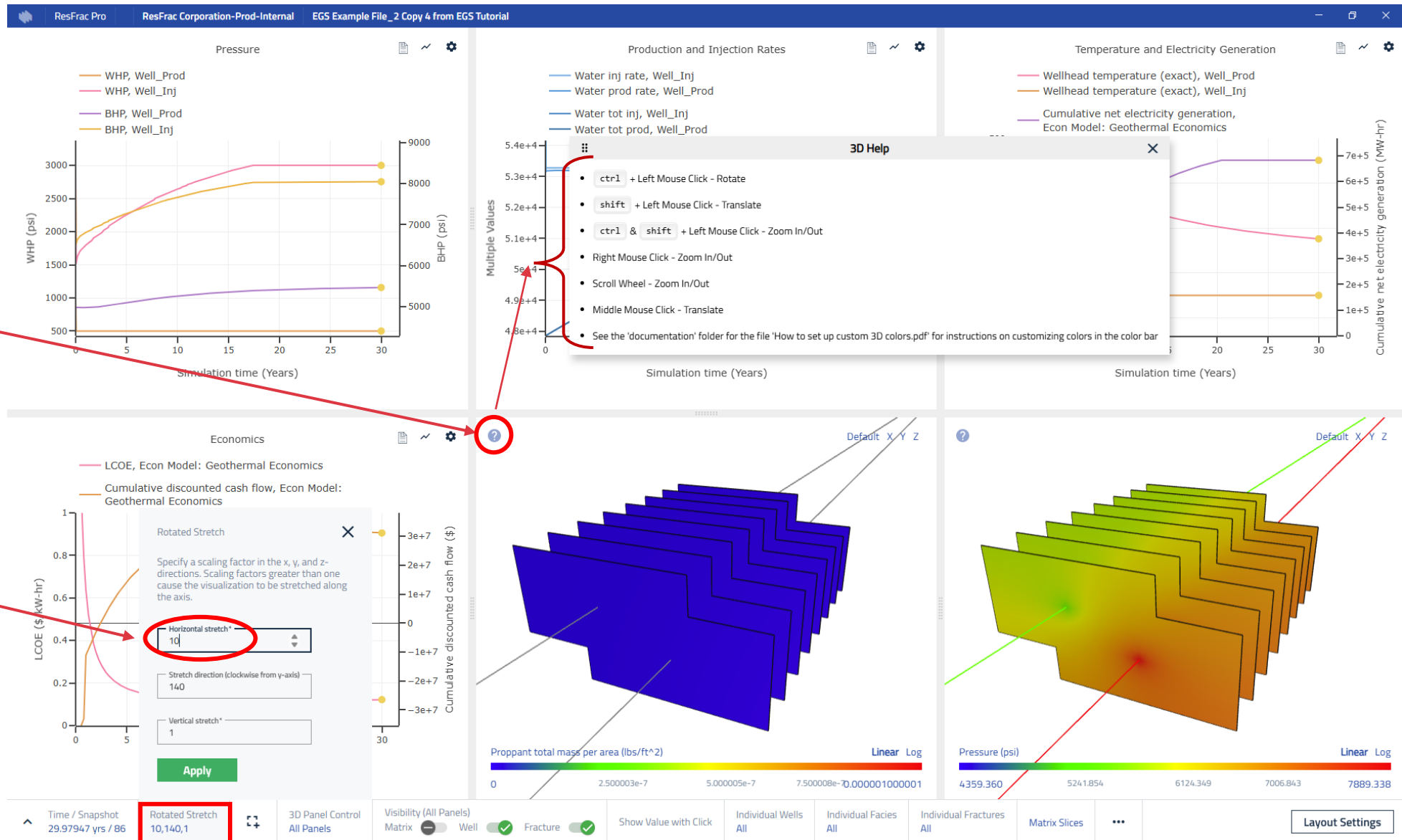


Viz Tool: 3D Plots, rotated stretch

To more easily view individual fractures, apply a 10x horizontal stretch.

This tip window can be kept open and moved around.

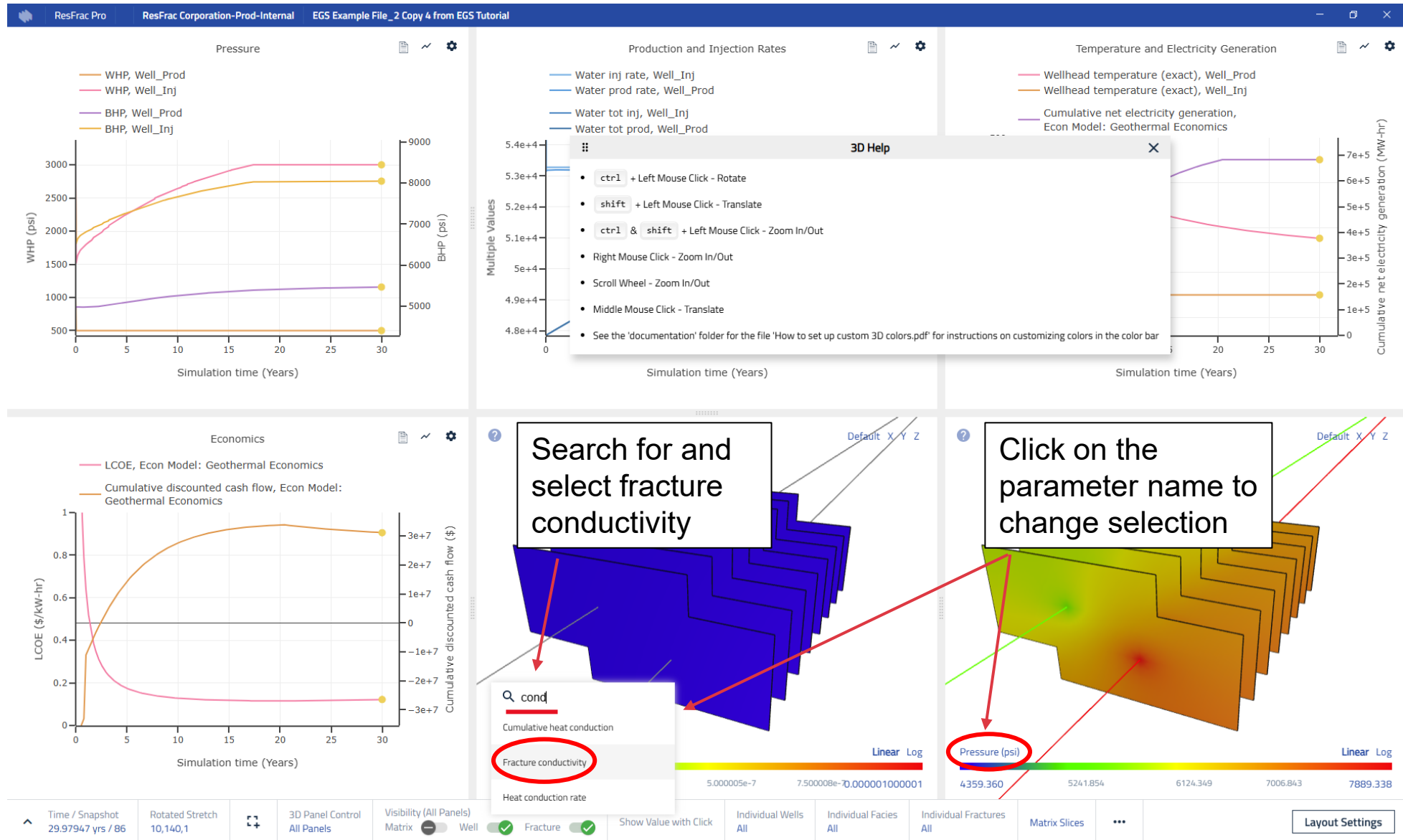
Apply a 10x horizontal stretch to better view individual fractures



Viz Tool: 3D Plots – Fracture Conductivity (1 of 2)

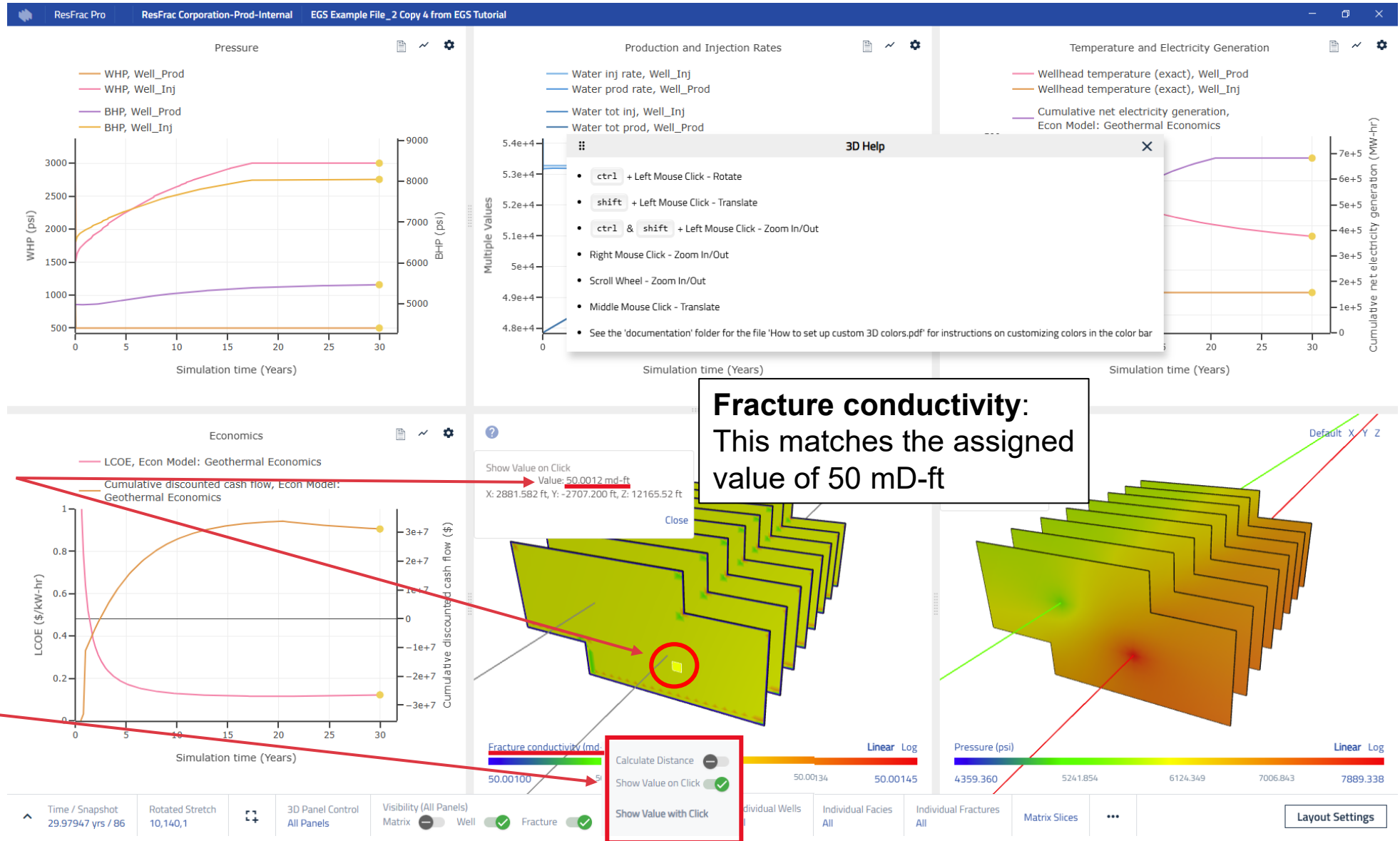
Change 3D view from 'Proppant mass per area' (since there is none) to 'Fracture conductivity'.

To reassign 3D panel parameters, click on the current parameter, and start typing the name of the parameter. Keep in mind, some may be abbreviated.



Viz Tool: 3D Plots – Fracture Conductivity (2 of 2)

Choose “Show value with click” to output the fracture conductivity in a specific element in the model.

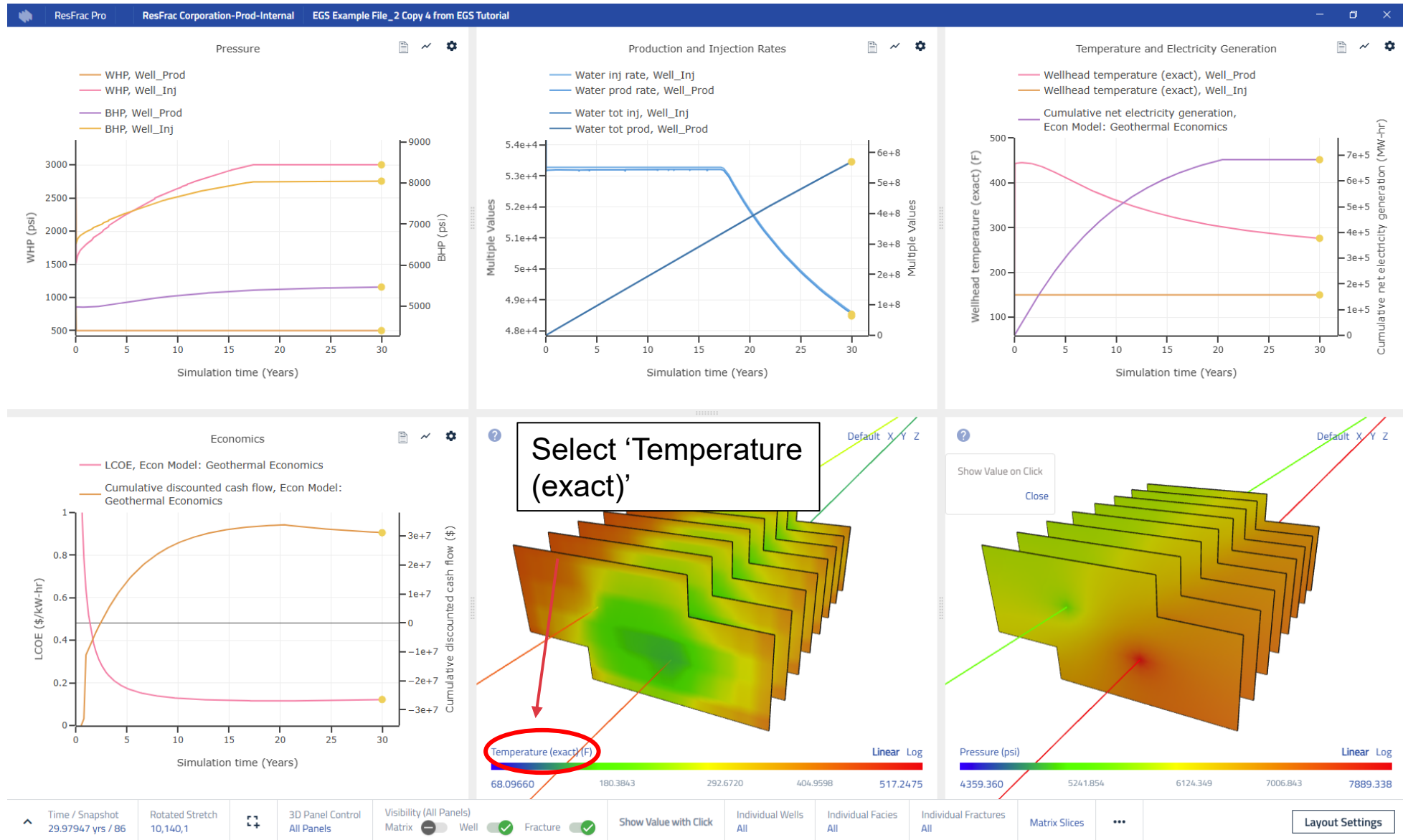


Select a location in the 3D view to output the fracture conductivity for a specific element

Select “Show value with click”

Viz Tool: 3D Plots – Temperature (1 of 2)

Change 3D view from 'Fracture conductivity' to 'Temperature (exact)'.

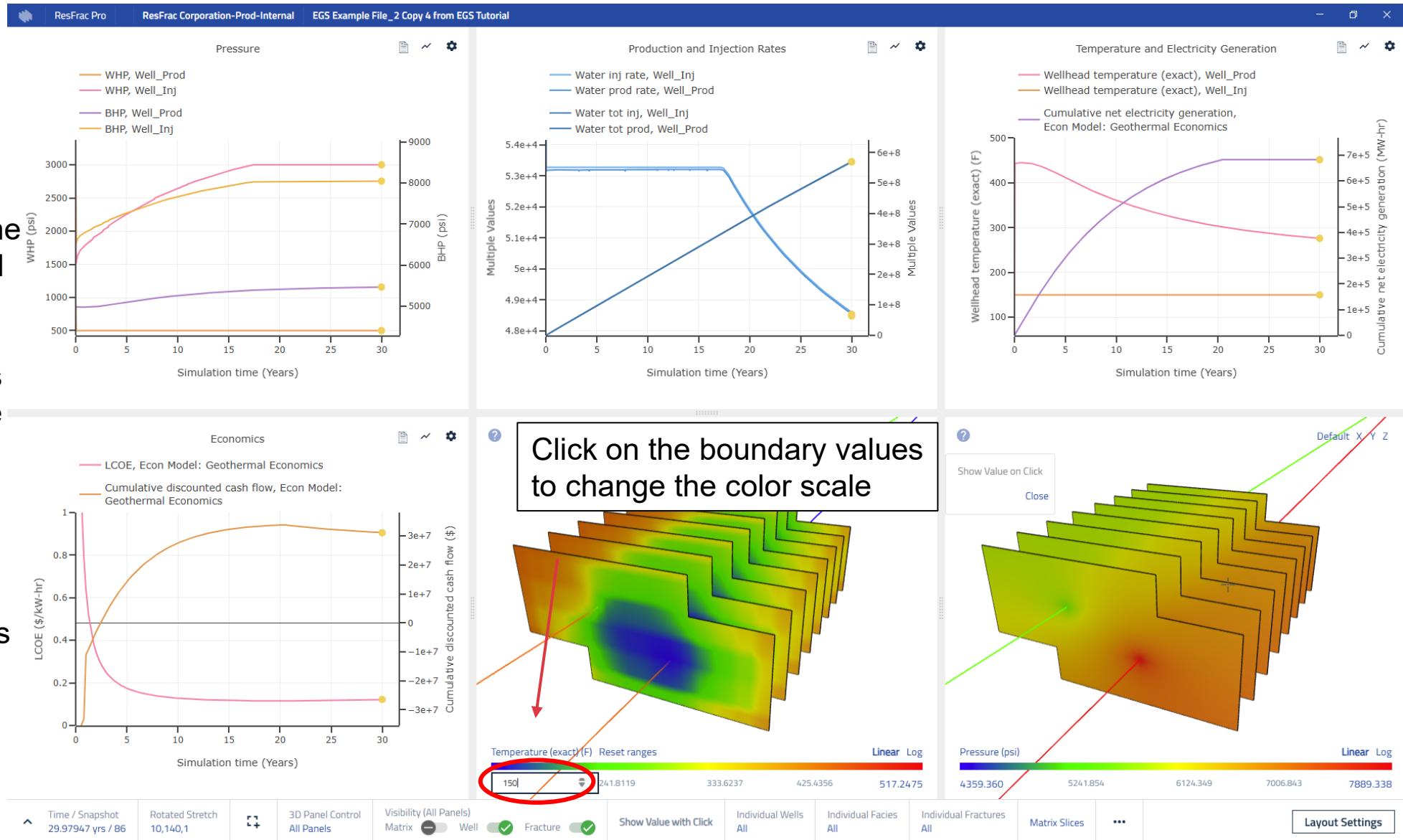


Viz Tool: 3D Plots – Temperature (1 of 2)

Change 3D view from 'Fracture conductivity' to 'Temperature (exact)'.

Observations:

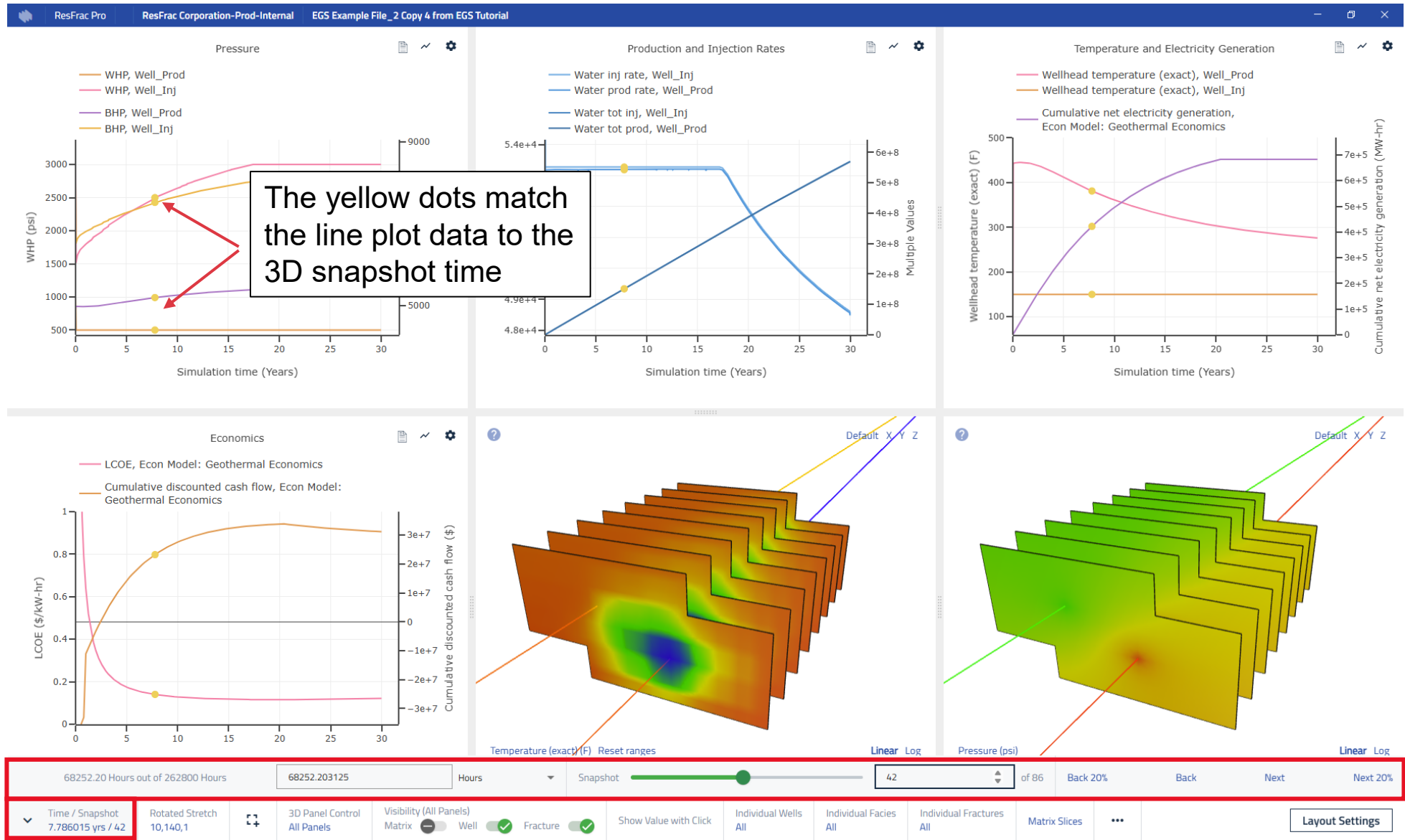
- Temperature distribution is the same across all 8 fractures
- Thermal breakthrough is observed at the production well
- Pressure differential between the injection and production wells



Viz Tool: 3D Plots, timesteps

Changing timesteps can be done using the bottom right menu.

Clicking the “Time / Snapshot” button opens menu to navigate 3D views through time. The default is at the end of sim.

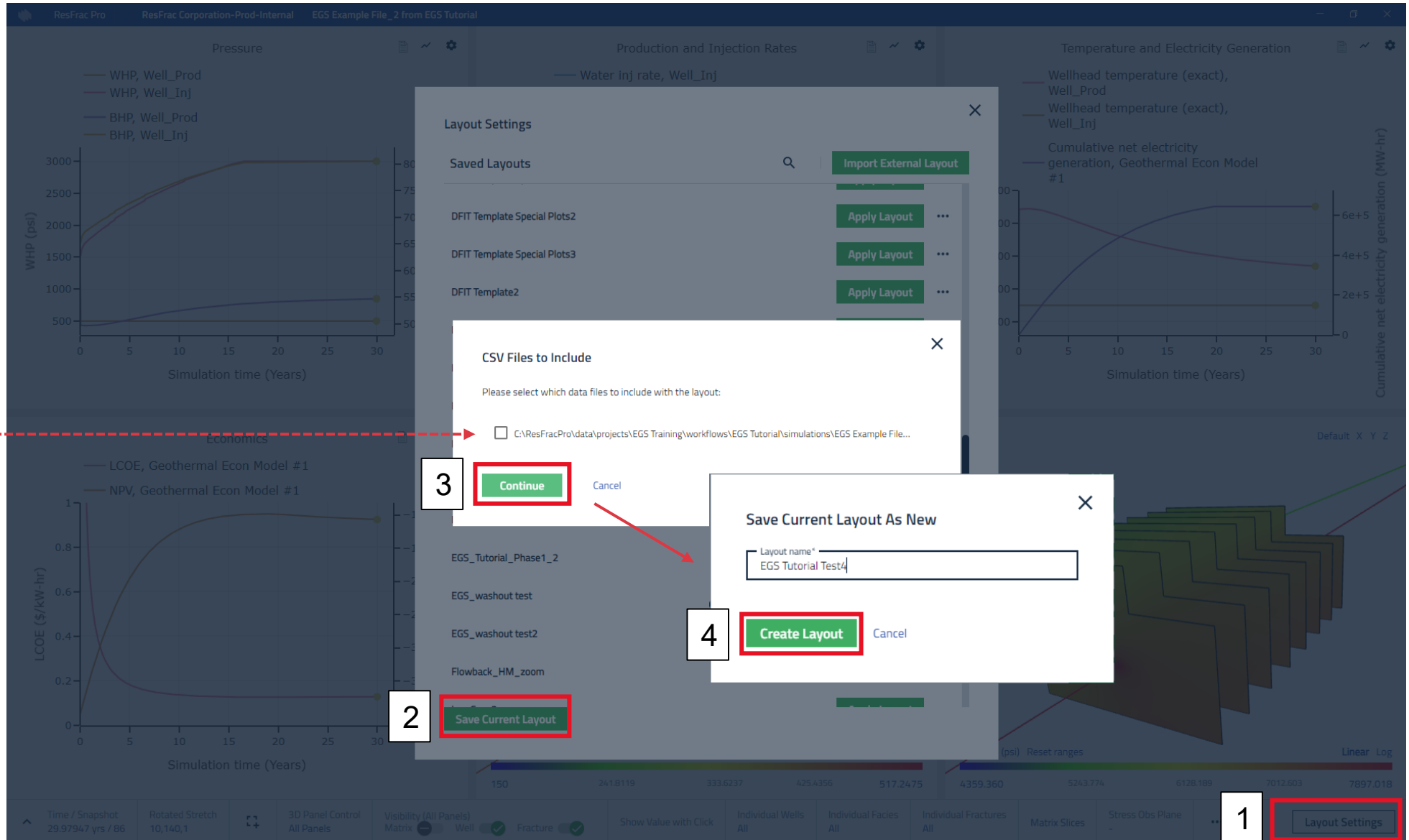


Viz Tool: 3D Plots, layout settings (1 of 2)

Save the layout you just created to easily revisit these plots. Layout Settings are in the bottom right corner.

Make sure that the timestep and the color scale are set to the desired value when saving layout.

Save CSV of sim_track file with your layout if you want to compare your results with another sim. Otherwise, leave deselected. Or save a version each way.

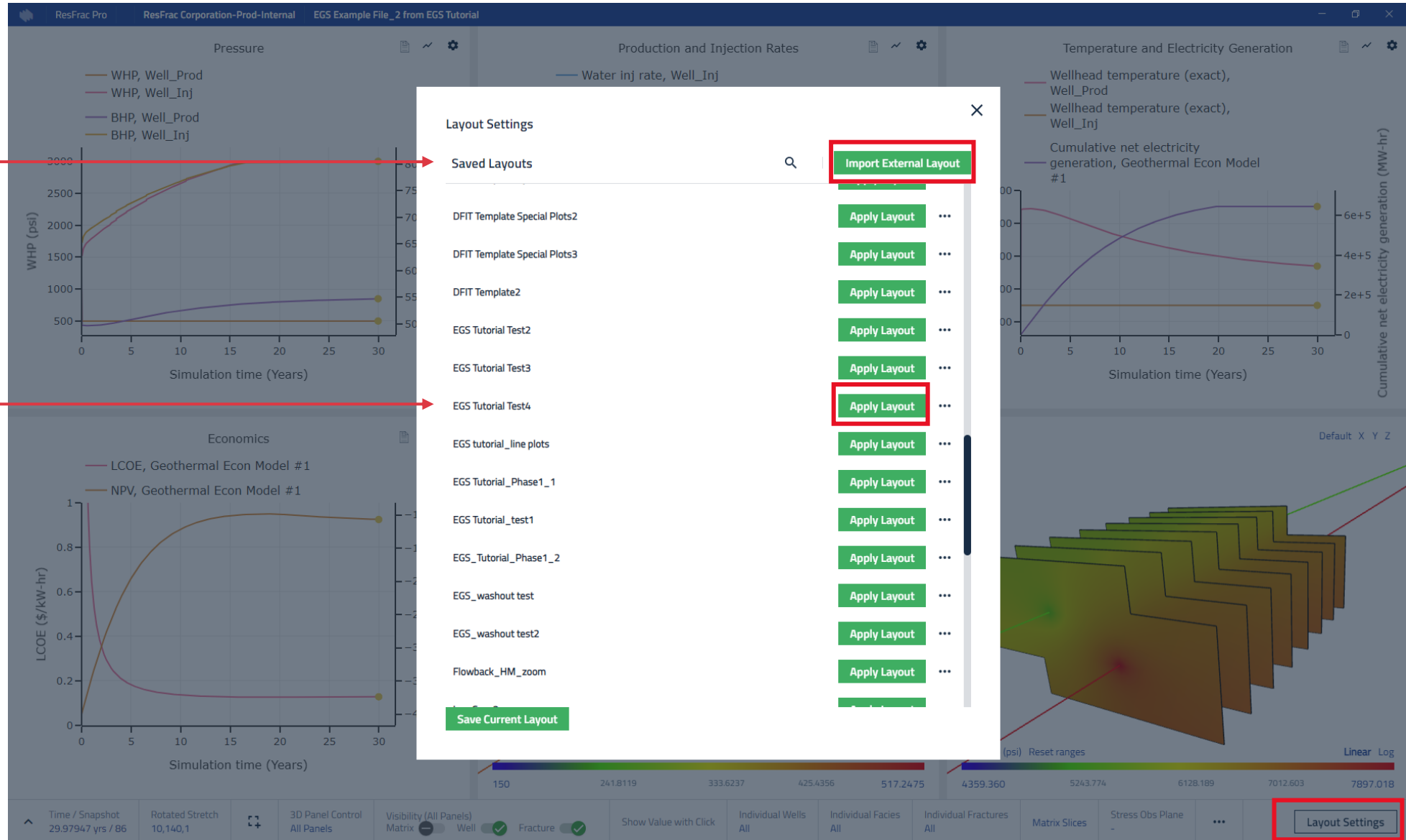


Viz Tool: 3D Plots, layout settings (2 of 2)

Revert to saved layout by selecting 'Apply Layout'.

Import shared layout

Revert to saved layout



Improving Simulation Results

The completion design in this model is underperforming. Try iterating on some parameters to improve the performance.

- **Parameters to test:**
 - Fracture size
 - Fracture conductivity
 - Injection pressures / rates
 - Well spacing & configuration

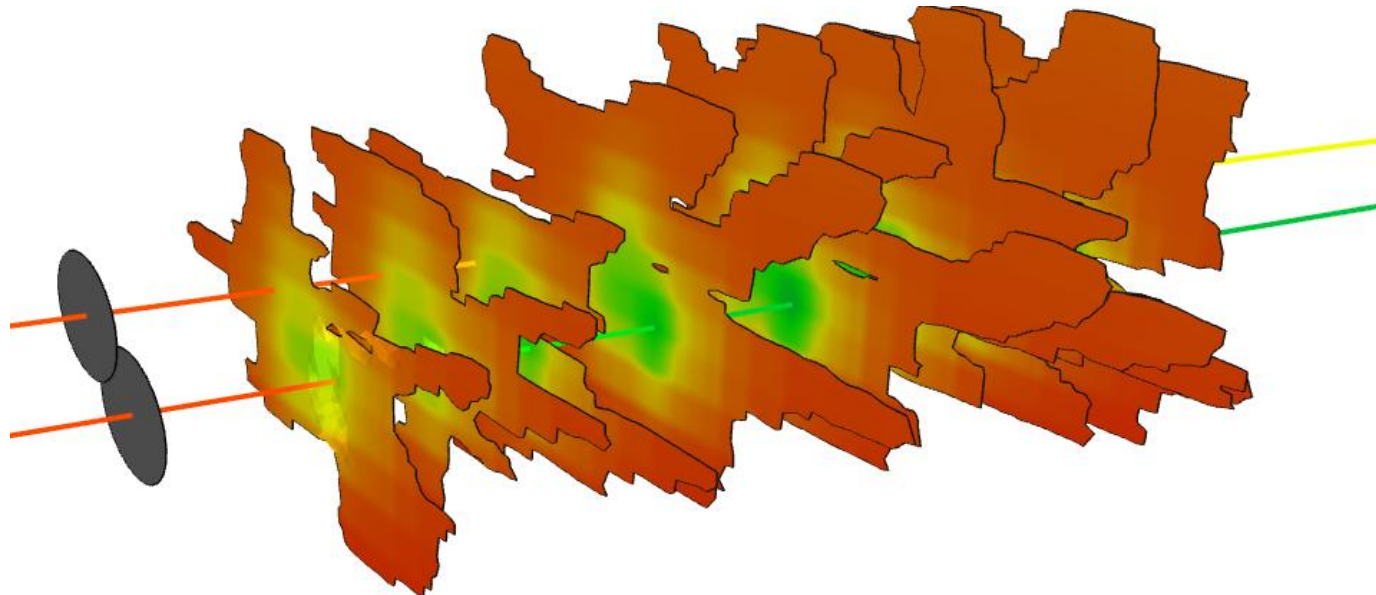


Tutorial Phase 2 – Hydraulic Fracturing

Phase 2 Overview

Problem description:

- Once the pre-existing fracture case has given you have a preliminary design target, you can replace the pre-existing fractures with hydraulic fractures
- This requires changing the well controls to include a stimulation period, and defining proppants, water solutes, and additional fracture options.
- The goal of this part of a project is to optimize the pump job design to reach your target fracture conductivity.
- We have created a stimulation preliminary design to review performance, and compare against the pre-existing fracture case. This is not a fully optimized model.



For insights on calibration parameters from the Utah FORGE project, refer to the following [paper](#).

Phase 2 – Steps to Setup Model with Hydraulic Fracturing

1. [Copy existing simulation](#)
2. [Static model panel - remove the pre-existing fractures](#)
3. [Fracture Options panel](#)
4. [Proppants panel](#)
5. [Water Solutes panel](#)
6. [Well Controls panel](#)
7. [Wells and perforations panel - add external fractures](#)
8. [Output Options panel](#)

If you have any issues with your sim setup, you may download the results for Phase I at this [link](#).

Copy existing simulation

Copy your existing pre-existing fractures simulation, name your new file, then open it in the Builder.

The screenshot displays the ResFrac Pro web interface. At the top, the navigation bar includes 'ResFrac Pro', 'ResFrac Corporation-Prod-Internal', and a 'Download Manager' button. Below this, a breadcrumb trail shows 'Home > EGS Training > EGS Tutorial'. The main content area is titled 'Sandbox Details' and includes a 'Workflow name' of 'EGS Tutorial', 'Simulations' count of '5', and a 'Creation timestamp' of 'Dec 2, 2025 at 11:20 am'. A 'Description' field is also present. Below the details, a table lists the simulations, with columns for 'SIMULATION NAME', 'STATUS', and 'LAST MODIFIED'. The table contains four entries: 'EGS Example File_3', 'EGS Example File_2', and 'EGS Example File'. A 'Copy Simulation' dialog box is open in the center, prompting the user to 'Specify the name for the new copy of the simulation. Name should use letters, numbers, spaces, underscores only and should be 30 or fewer characters in length.' The dialog box has a text input field containing 'EGS Example File_2 Copy 1' and an 'OK' button. To the right of the dialog box, a context menu is open, showing options: 'Simulation Details', 'Edit Simulation in Builder', 'Run Simulation', 'Copy Simulation', 'Copy Simulation to a Sandbox', and 'Check for New Results in Next Sync'. The 'Edit Simulation in Builder' option is highlighted with a red box. A red arrow points from the 'OK' button to the 'Edit Simulation in Builder' option. Another red arrow points from the 'Copy Simulation' option in the context menu to the 'Copy Simulation' button in the top right corner of the interface.

ResFrac Pro ResFrac Corporation-Prod-Internal Download Manager

Home > EGS Training > EGS Tutorial

Sandbox Details ?

Incremental Edit ...

Workflow name
EGS Tutorial

Simulations
5

Creation timestamp
Dec 2, 2025 at 11:20 am

Description

Location of data
Local : C:\ResFracPro\data

Simulations (5)

>	SIMULATION NAME	STATUS	LAST MODIFIED
>	EGS Example File_3	M	Mar 12, 2026 at 5:46 p
>	EGS Example File_2	F	Feb 23, 2026 at 3:43 p
>	EGS Example File	F	Mar 12, 2026 at 2:46 p

Import Sim Batch Run Simulations Multiplot

Simulation Details
Edit Simulation in Builder
Open Economics Navigator
Run Simulation
Copy Simulation
Copy Simulation to a Sandbox
Check for New Results in Next Sync

Copy Simulation

Specify the name for the new copy of the simulation. Name should use letters, numbers, spaces, underscores only and should be 30 or fewer characters in length.

Simulation Copy Name*
EGS Example File_2 Copy 1

OK

Simulation Details
Edit Simulation in Builder
Run Simulation
Copy Simulation

Static Model: Remove Pre-existing Fracture

Delete all rows from the 'Preexisting Fractures' and 'Autoplaced Preexisting Fractures' tables

Click (and drag) to highlight all rows, then right-click and select 'Remove Row'

AUTOPLACED PREEXISTING FRACTURES ? 📄

	Preexisting fracture template row index ?	Well name ?	
1	1	Well_Prod ▼	☰
		Well_Inj ▼	☰

Duplicate Row

Add Row Above

Add Row Below

Remove Row

PREEXISTING FRACTURES ? 📄

	Center x-coordinate [ft] ?	Center y-coordinate [ft] ?	Center z-coordinate [ft] ?	Fracture full-length [ft] ?	Fracture full-height [ft] ?	Orientation (clockwise from positive y-direction) [degrees] ?	EO (option
1				1000	500	50	

New Row

New number of rows for table*
0

Alternatively, select 'Resize Table', and enter the value '0'

Fracture Options: Overview

←

Welcome

Startup

Static Model and Initial Conditions

Curve Sets

Wells and Perforations

Meshing Options

Fluid Model Options

Fracture Options

Proppants

Water Solutes

Well Controls

Other Physics Options

Numerical Options

Output Options

Advanced Options

Fracture Options

Specify fracture physics options

Editor Search

Fracture options library

Relative fracture toughness per square root fracture size [1.0/ft^{1.5}]
0.101993

☐ Scale toughness by larger dimension

Effective fracture aperture conductivity factor
0.395473272625642

Vertical open and roughness fracture conductivity multiplier
0.598779772386477

Adjust submesh for multiphase flow distance [ft]
1

Adjust submesh for PDP flow distance [ft]
0.5

Water bank 'rel perm increase' scaling thickness [m]
0.5

Water bank 'rel perm decrease' scaling thickness [m]

Water bank immobile fraction
0

Library – save or import panel settings

Toughness scaling

Conductivity scaling

Submesh adjustments

Water banking

Submesh fractal D (fracture swarms)

Fracture initiation randomness

Collision parameters

Submesh fractal D
0

Fracture initiation randomness distance [ft]
8

Cased well and fracture connection distance [ft]
30

Conductivity of the 'connect frac through 'cased well fracture collision di:
10000

Propped wellbore-to-fracture connection conductivity multiplier
100

Fracture collision relative distance (different wells)
0.02

Depleted fracture collision distance (different wells) [ft]
30

Fracture collision depletion stress [psi]
150

HYDRAULIC FRACTURE PROPAGATION REGIME BY LAYER

	Layer name	Dimensionless toughness with XLink	Fluid efficiency with XLink
1	Formation	0.389193124765592	0.862708751265831

Fracture Options: frac geometry tuning parameters

If set, fracture toughness increases with size, making smaller fractures

Control viscous pressure drop in fracture. Increasing viscous pressure (by decreasing conductivity) creates more symmetrical fractures

The screenshot shows the 'Fracture Options' configuration window in ResFrac. On the left is a sidebar menu with options: Welcome, Startup, Static Model and Initial Conditions (checked), Curve Sets, Wells and Perforations (checked), Meshing Options, Fluid Model Options, Fracture Options (checked), Proppants, and Water Solutes. The main panel is titled 'Fracture Options' with the subtitle 'Specify fracture physics options'. It has tabs for 'Editor' and 'Search'. Below the tabs is a green button labeled 'Fracture options library' with a help icon. The configuration area contains three input fields, each with a puzzle piece icon and a help icon: 1. 'Relative fracture toughness per square root fracture size [1.0/ft^{0.5}]' with a value of 0. A red arrow points from the first text box to this field. 2. A checkbox for 'Scale toughness by larger dimension'. 3. 'Effective fracture aperture conductivity factor' with a value of 0.3. 4. 'Vertical open and roughness fracture conductivity multiplier' with a value of 0.6. A red bracket groups the last two fields, with a red arrow pointing from the second text box to this group.

Fracture Options
Specify fracture physics options

Editor Search

Fracture options library ?

Relative fracture toughness per square root fracture size [1.0/ft^{0.5}]
0

☐ Scale toughness by larger dimension

Effective fracture aperture conductivity factor
0.3

Vertical open and roughness fracture conductivity multiplier
0.6

Fracture Options: Other key parameters (1 of 2)

Always set to 0 to deactivate this feature – use PDP instead

Submesh fractal D

0



Introduce randomness in location where fractures initiate

Fracture initiation randomness distance [ft]

8



Allow flow behind casing if fractures are within 10 ft of perforation (creating a hydraulic connection)

Cased well and fracture connection distance [ft]

10



Conductivity of the 'connect frac through 'cased well fracture collision dis

10000



Propped wellbore-to-fracture connection conductivity multiplier

100



Determines when fractures (originating from different wells) connect. Multiply by fracture element length to get absolute distance. $0.2 \times 50 \text{ ft} = 10 \text{ ft}$

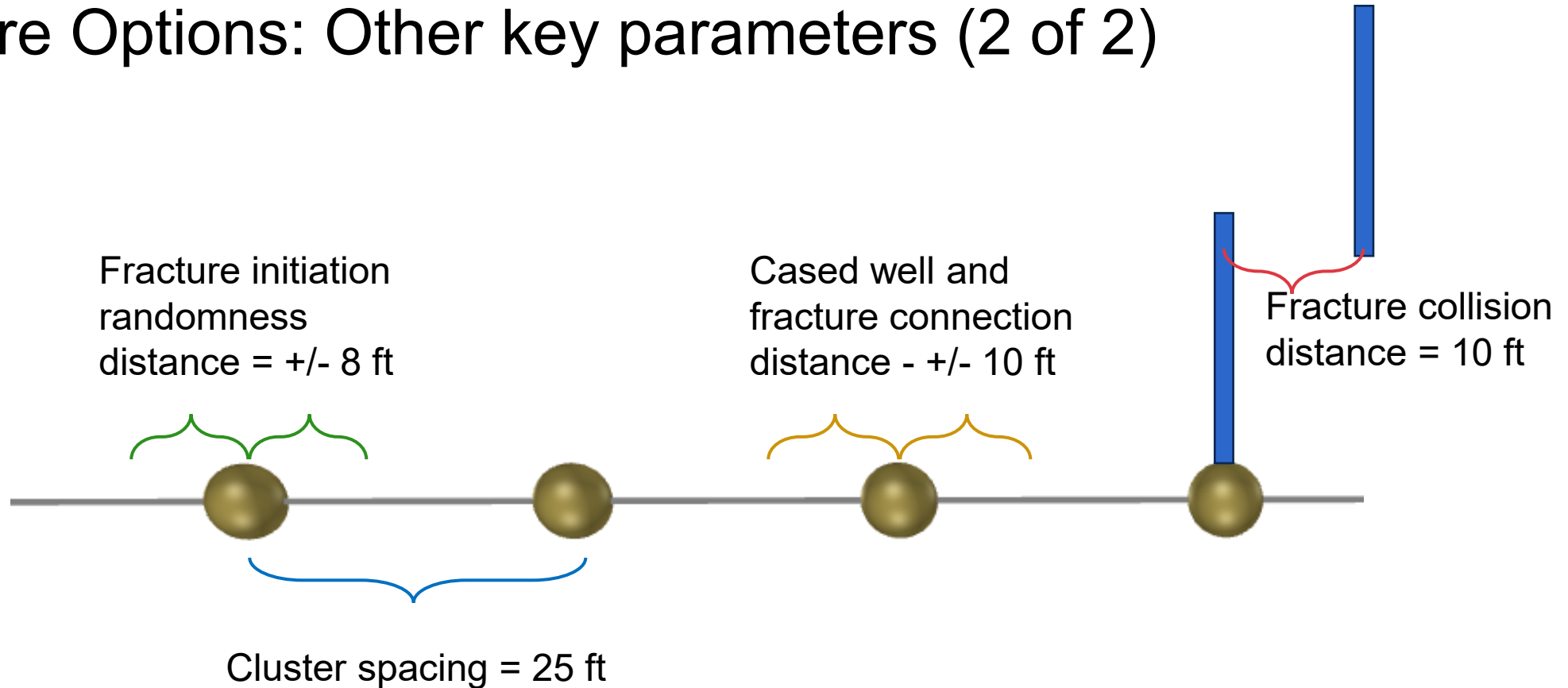
Fracture collision relative distance (different wells)

0.2



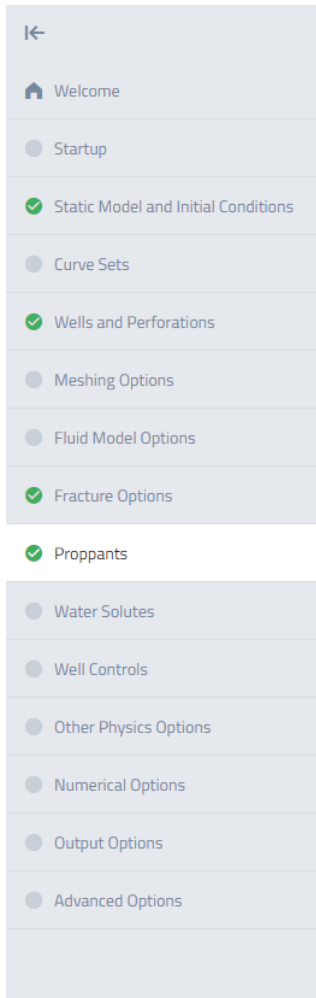
A ResFrac Mini-Guide on Fracture Connections is also available at this [link](#).

Fracture Options: Other key parameters (2 of 2)



If the perforations across the two wells are in line with each other, and 'fracture initiation randomness distance' is < 'cased well and fracture connection distance', then all frac hits with the well will hydraulically connect (through cross-flow behind the casing).

Proppants: Overview



Proppants

Specify parameters related to proppants

Editor Search

Proppant library

Proppant conductivity wizard

PROPPANTS

	Name	Diameter of grains [mesh]	Density of grains [lbs/ft^3]	Proppant pack compressibility [psi^-1]
1	40/70	55	165	0.0000758423302406488
2	100	100	165	0.0000758423302406488

New Row Resize Table

PROPPANT MIXTURES

	Name	Density [lbs/ft^3]	Mass fraction 40/70	Mass fraction 100
1	NoProppant	165	0	0
2	100mesh	165	0	1
3	40/70 mesh	165	1	0

New Row Resize Table

Library – Import proppant specs from our library, or save your own

Individual proppant specs

Proppant mixtures – this is what is used in Well Controls. Mixtures may consist of 1 or more proppants.

- Proppant immobilization and screenout behavior

Maximum immobilized proppant mass per area [lbs/ft^2] 0.15

Proppant screenout minimum ratio 1.25

TIME-DEPENDENT PROPPANT CONDUCTIVITY LOSS

	Proppant Name	Rate constant [days^-1]
1	40/70	
2	100	

☒ Time dependent conductivity loss smoothly approaches minimum con

Advanced options

- Proppant degradation

Proppants: Proppant meshes and mixtures

Key history match parameter to specify propped fracture conductivity and control obtained circulation flow rates

PROPPANTS ?

	Name ?	Diameter of grains [mesh] ?	Density of grains [lbs/ft^3] ?	Proppant pack compressibility [psi^-1] ?	k0 ?	f ?	Proppant pack gamma ('perm compressibility') [psi^-1] ?	Settling velocity adjustment factor ?	
1	40/70	55	165	0.0000758423302406488	0.02028	0	0.000257658998498709	1	
2	100	100	165	0.0000758423302406488	0.012436	0	0.000255613560270119	1	

The 40/70 mesh is approximated as a single proppant of intermediate size, and a single-component mixture. This is the typical approach.

PROPPANT MIXTURES ?

	Name ?	Density [lbs/ft^3] ?	Mass fraction 40/70 ?	Mass fraction 100 ?	
1	NoProppant	165	0	0	
2	100mesh	165	0	1	
3	40/70 mesh	165	1	0	

Alternatively, 40/70 could be specified by a range of individual proppant sizes that are then combined as a proppant mixture.

Proppants: Create new proppants

As an exercise, we'll turn the 40/70 mesh a mixture.

Right-click on the row number and duplicate the 40/70 entry (twice)

2x

PROPPANTS ? | | ⚠

	Name ?	Diameter of grains [mesh] ?	Density of grains [lbs/ft^3] ?
1	40/70	55	165
		100	165

PROPPANTS ? | | ⚠

Duplicate Row

- Add Row Above
- Add Row Below
- Remove Row

Split the 40/70 mesh into a 40, 55, and 70 mesh proppant. Change the diameter of the new proppants accordingly. (we'll keep k0 constant, and let diameter impact conductivity)

PROPPANTS ? | | ⚠

	Name ?	Diameter of grains [mesh] ?	Density of grains [lbs/ft^3] ?	Proppant pack compressibility [psi^-1] ?	k0 ?
1	40	40	165	0.0000758423302406488	0.024
2	55	55	165	0.0000758423302406488	0.024
3	70	70	165	0.0000758423302406488	0.024
4	100	100	165	0.0000758423302406488	0.015

Proppants: Create new proppant mixtures

Redistribute the components of the 40/70 mesh mixture to contain 40, 55, and 70 mesh.

PROPPANT MIXTURES ?

	Name ?	Density [lbs/ft^3] ?	Mass fraction 40 ?	Mass fraction 55 ?	Mass fraction 70 ?	Mass fraction 100 ?
1	NoProppant	165	0	0	0	0
2	100mesh	165	0	0	0	1
3	40/70 mesh	165	0.25	0.5	0.25	0

Proppants: Other proppant properties

Specify maximum immobilized proppant mass per area:

Maximum immobilized proppant mass per area [lbs/ft²] 

ResFrac does not currently support a temperature-dependent correlation for proppant degradation. However, time-dependent proppant conductivity loss could be used to account for degradation of proppant over time. In this simulation, we will skip this.

TIME-DEPENDENT PROPPANT CONDUCTIVITY LOSS

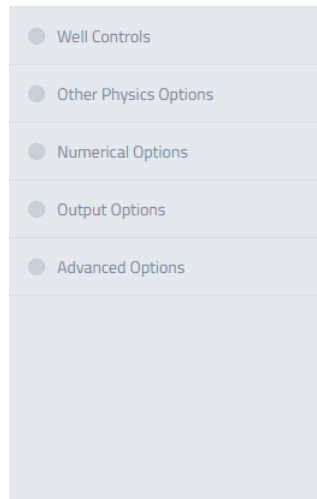
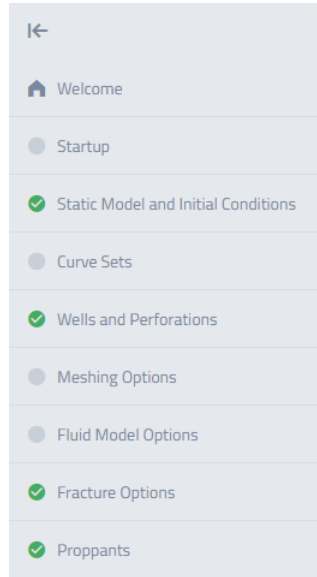
	Proppant Name 	Rate constant [days ⁻¹] 	Damage type 	Rate scaling with effective normal stress (optional) [psi] 	Minimum conductivity multiplier (optional) 
1	40		1		
2	55		1		
3	70		1		
4	100		1		

Apply a vertical proppant flow holdup factor (Advanced options) to account for roughness

Vertical proppant flow holdup factor 

Water Solutes: Overview

- Reactions and chemical proppant pack damage



Water Solutes

Specify parameters related to water solutes

Editor Search

Water solutes library

Water solutes wizard

WATER SOLUTES

	Name	Type	Molar mass	Viscosity multiplier per 0.001 mass fraction
1	Xlinkgel	Modified Power Law	1000000	882.72
2	Xlinkgel_degraded	Inert Solute	1000000	
3	Slickwater	Modified Power Law	1000000	30

New Row Resize Table

FLUID MIXTURES

Number of Items: 3

Previous 1 Next

> XLink

> Water

> Slickwater

Wellbore friction adjustment factor
1

Library – Import water solutes from our library, or save your own

Individual water solute specs

Fluid mixtures – this is what is used in Well Controls. Mixtures may consist of 1 or more solutes.

Expand fluid mixture

REACTIONS BETWEEN WATER SOLUTES [1/HOURS]

	Reactant	Product	First-order reaction constant [1/hours]
1	Xlinkgel	Xlinkgel_degraded	0.666666666666667

New Row Resize Table

FRACTURE PROPPANT PACK DAMAGE REACTIONS

	Primary water solute	(Optional) second water solute	Reaction rate constant [1/s]	Potency constant for the reaction
1				

New Row Resize Table

☐ Damage proportional to both oil and gas saturation

Slickwater

Name
Slickwater

MIXTURE PROPERTY SUMMARY

	Viscosity at room temperature and 170 s ⁻¹ [cp]	Viscosity at reservoir temperature and 170 s ⁻¹ [cp]	Density of fluid mixture at room temperature [g/cc]	Density at reservoir temperature [g/cc]
1	3.52211644565805	0.429173920097687	1.00070851633401	1.00097309345029

INJECTION FLUID MIXTURE COMPOSITION

User inputs applied here

	Water solute	Unit for input	Input quantity
1	Xlinkgel	Mass fraction	0
2	Xlinkgel_degraded	Mass fraction	0
3	Slickwater	Mass fraction	0.001

[illegible]

We will just use slickwater here. To clean up the panel, remove the cross-linked gel, its degradation product, fluid mixture, and reactions.

[illegible]

The water solute and the fluid mixture are both named “slickwater”. Keep in mind that these are different.

Water Solutes: Rename water solute

In the EGS template, both the water solute and the fluid mixture are named “slickwater”. To help differentiate the two, we will rename the water solute to “FR” for friction reducer. This is a common naming convention, and is used in the water solutes library.

WATER SOLUTES ?

	Name ?	Type ?	Molar mass ?	Viscosity multiplier per 0.001 mass fraction ?
1	FR	Modified Power Law ▼	1000000	30

New Row Resize Table

Water Solutes: Solute specification methods

There are four ways to specify the slickwater properties:

1. Use the default slickwater (now named FR) from the template.
2. Use the library to apply pre-saved values.
3. Use the wizard to calculate properties (often to match a target viscosity).
4. Enter custom values based on known properties of the intended fluid.

The screenshot shows the 'WATER SOLUTES' interface. At the top left, there are two green buttons: 'Water solutes library' and 'Water solutes wizard'. Below them are icons for a question mark, a bar chart, and a document. A table below these buttons lists solute properties. Callouts point to specific elements: 'Option 2. Library' points to the 'Water solutes library' button; 'Option 3. Wizard' points to the 'Water solutes wizard' button; 'Option 1. Default' points to the 'FR' entry in the 'Name' column of the table; and 'Option 4. Customize' points to the '30' value in the 'Viscosity multiplier per 0.001 mass fraction' column.

	Name ?	Type ?	Molar mass ?	Viscosity multiplier per 0.001 mass fraction ?	Power law exponent - n ?	Shear rate for transition to zero-shear rate plateau [s ⁻¹] ?	Viscosity multiplier per 0.001 mass fraction (in the well) ?	Friction adjustment factor ?	
1	FR	Modified Power Law ▼	1000000	30	0.6	1	1	0.19	≡

Water Solutes: Water solute wizard (1 of 3)

We will use Option 3, the water solutes wizard, to adjust the solute properties based on a target viscosity.

Water Solutes

Specify parameters related to water solutes

Editor

Search

Water solutes library

Water solutes wizard

Note: A pre-requisite for using the wizard is to have a fluid mixture containing a non-zero quantity of the solute. This mixture already exists from the template.

Name
Slickwater

MIXTURE PROPERTY SUMMARY

	Viscosity at room temperature and 170 s ⁻¹ [cp]	Viscosity at reservoir temperature and 170 s ⁻¹ [cp]	Density of fluid mixture at room temperature [g/cc]	Density at reservoir temperature [g/cc]
1	3.52211644565805	0.429173920097687	1.00070851633401	1.00097309345029

INJECTION FLUID MIXTURE COMPOSITION

	Water solute	Unit for input	Input quantity
1	FR	Mass fraction	0.001

Water Solutes: Water solute wizard (2 of 3)

We will use Option 3, the water solutes wizard, to adjust the solute properties based on a target viscosity.

Water Solutes

Specify parameters related to water solutes

Editor

Search

Water solutes library

Water solutes wizard

The wizard changes the properties of the water solute (FR) that makes up this fluid mixture, in order to match the slickwater mixture properties specified in this wizard.

Water solutes wizard

This wizard sets the modified power law input parameters for water solutes. Prior to using this wizard, you should have already specified a nonzero concentration for exactly one water solute. This wizard can only be used on a fluid mixture that has exactly one water solute with nonzero concentration, it would be ambiguous how much effect each solute should have on the viscosity (which is why this is not possible if there are multiple solutes). Once you've done that, this wizard helps you choose the value for 'viscosity multiplier' if none have already been specified. If you specify that the fluid is a cross-linked gel, this wizard sets up a 'degraded' gel and a

Is this fluid a cross-linked gel? If you specify 'yes', then this wizard will automatically create a 'broken gel' and a 'water solute reacti

Cross-linked gel?
 No

What is the name of the fluid mixture for which you would like the wizard to set up the viscosity parameters?

Fluid mixture name
 Slickwater

Do you know the fluid viscosity at a particular shear rate?

Know viscosity?
 Yes

Next

Water solutes wizard

Specify the fluid mixture viscosity at a particular shear rate.

Specify the fluid viscosity at reservoir conditions and the specified shear rate
 0.5

Specify the fluid viscosity at room temperature and the specified shear rate

The shear rate at which the fluid viscosity above is specified [s^{-1}]
 170

Previous

Apply

Water Solutes: Water solute wizard (3 of 3)

Observe: the viscosity multiplier updated, and the viscosity of the slickwater now matches what was entered into the wizard (0.5 cP at reservoir temperature and 170 s⁻¹).

WATER SOLUTES ?

	Name ?	Type ?	Molar mass ?	Viscosity multiplier per 0.001 mass fraction ?
1	FR	Modified Power Law ▼	1000000	35.115894452468

New Row Resize Table

The wizard revised the viscosity multiplier to achieve the slickwater viscosity target

▼ Slickwater

Name ?

Viscosity now matches what was entered into the wizard

MIXTURE PROPERTY SUMMARY ?

	Viscosity at room temperature and 170 s ⁻¹ [cp] ?	Viscosity at reservoir temperature and 170 s ⁻¹ [cp] ?	Density of fluid mixture at room temperature [g/cc] ?	Density at reservoir temperature [g/cc] ?
1	4.10336728389315	0.5	1.00070851633401	1.00097309345029

INJECTION FLUID MIXTURE COMPOSITION ?

	Water solute ?	Unit for input ?	Input quantity ?
1	FR	Mass fraction ▼	0.001

The wizard considers the quantity of the solute when calculating the viscosity multiplier

Water solutes: initial wellbore fluid mixtures

Initialize the wellbore so that it's already filled with one of the defined fluid mixtures. Since we'll be using slickwater for our stimulation, it makes sense to initialize the wellbore with slickwater.

INITIAL WELLBORE FLUID MIXTURES ? 📄 ⚠️

	Well name ?	Initial wellbore fluid mixtures ?
1	Well_MB1	Default ▼
2	Well_TF1	Default ▼

Warning: Initial wellbore fluid mixtures

Consider using 'Initial wellbore fluid mixtures' to specify the initial fluid composition in the wells. Specifically, you may want to initialize the well full of low viscosity friction reducer to avoid a pressure spike at the beginning of injection.

INITIAL WELLBORE FLUID MIXTURES ? 📄

	Well name ?	Initial wellbore fluid mixtures ?
1	Well_MB1	Slickwater ▼
2	Well_TF1	Slickwater ▼

Filtercake permeability wizard

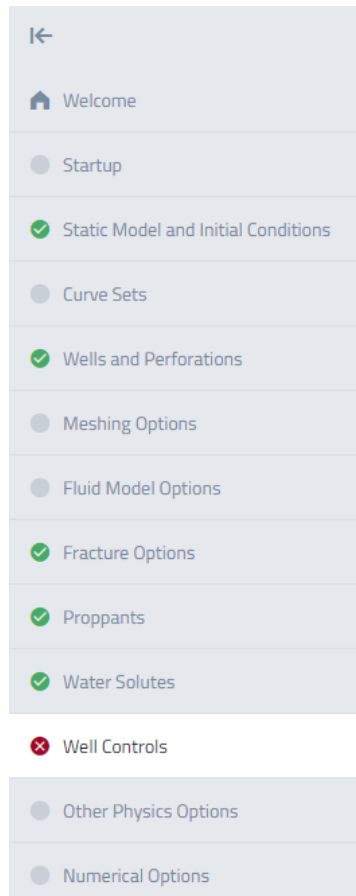
Filtercake permeability [md]
0.0000101324996582814

Default
HVFR 20cP
Fresh water
Slickwater

Well Controls: Overview (again)

Well Controls define the injection, production, and shut-in sequences.

When you arrive at this panel, there will be an Error because we've added new proppants. We must fix this in the General Constraint.



Well Controls
Specify injection and production schedules

Editor Search

Well controls library ?

Maximum simulation time [hours]
262800

Injection sequence wizard ?

Production sequence wizard ?

WELLBORE BOUNDARY CONDITION CONTROLS ?

Well_Prod ? Well_Inj ?

Number of Blocks: 1

Previous 1 Next

> 1. Production Sequence Start time: 0 Days D

Advanced options ^

⋮

WELL FLOW SCALERS ?

	Well name ?	MD [ft] ?	Flow multiplier ?	Start time [days] ?	End time [days] ?	Coefficient of variation penalty scaler ?	
1	Well_Prod ▼	15110.6	28	0			
2	Well_Inj ▼	15110.6	28	0			

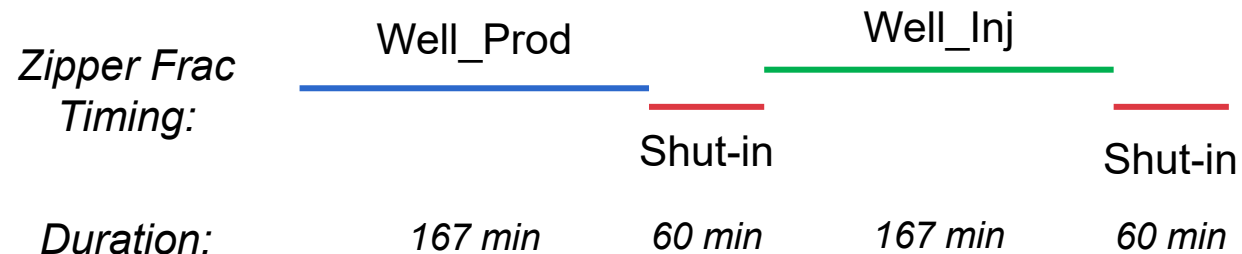
- Import or export well control blocks
- Simulation end time
- Wizards to assist in creating injection and production blocks
- Well Control blocks
 - Each well has a tab
 - For each well, create injection, production, shut-in, and/or general sequence blocks to define the
 - No blocks are currently populated
- Well flow scalers (in Advanced options)

Well Controls: Planned Pump Schedule (1 of 2)

We'll perform a zipper frac, starting with Well_Prod. Each stimulation takes 167 minutes, with a 60-min shut-in between each. Long-term circulation starts on day 10.

User Inputs					
Duration [Minutes]	Stage	Fluid type	Slurry injection rate [bpm]	Proppant/Pad	Proppant mass per volume [ppg]
10	1	Slickwater	10	NoProppant	0
2	1	Slickwater	10	NoProppant	0
11	1	Slickwater	80	NoProppant	0
14	1	Slickwater	80	100mesh	0.25
14	1	Slickwater	80	100mesh	0.5
14	1	Slickwater	80	100mesh	1
13	1	Slickwater	80	100mesh	1.25
13	1	Slickwater	80	100mesh	1.5
12	1	Slickwater	80	100mesh	1.75
10	1	Slickwater	80	NoProppant	0
13	1	Slickwater	80	40/70 mesh	0.75
13	1	Slickwater	80	40/70 mesh	1
11	1	Slickwater	80	40/70 mesh	1.25
11	1	Slickwater	80	40/70 mesh	1.4
6	1	Slickwater	80	NoProppant	0

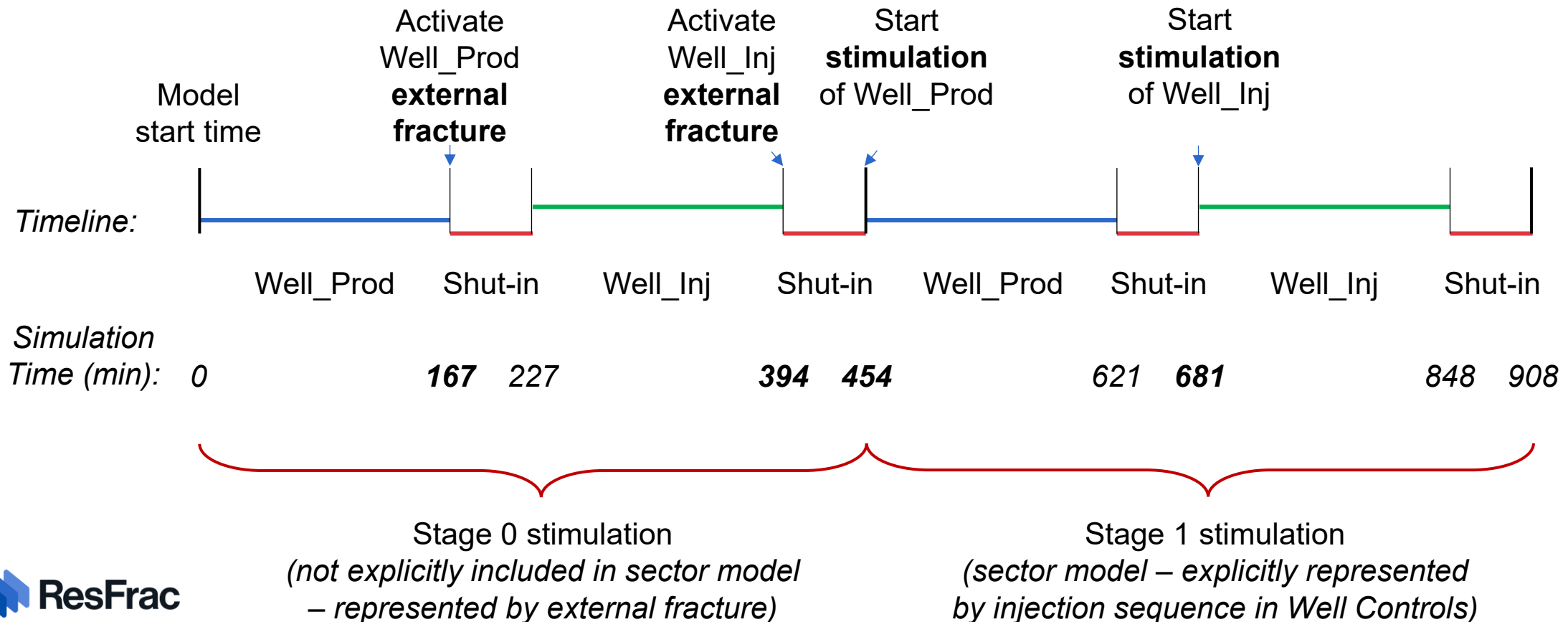
Total time = 167 minutes



Well Controls: Planned Pump Schedule (2 of 2)

We're simulating a single stage. To account for stress shadow from previous stages, we include 'external fractures' (Wells and Perfs panel, see next slide).

The best practice for setting up a model with an external fracture is to initiate the model one stage *before* the sector model is stimulated, as shown below.



Wells and perfs: add external fractures

External fractures are used to “mimic” stress shadowing from the previous stages. Activate these at the shut-in time of the previous stage (167 and 394 min, respectively).

Create a new row for each well

Specify external fracture location

- Convention is to place an external fracture at $0.5 \times \{\text{cluster spacing}\}$ outside the matrix
- Assign *either* fracture distance from the edge of the matrix, *or* (x,y,z) coordinates of the fracture.

	Well name ?	Approx distance from edge of matrix region [ft] ?	Center x-coordinate [ft] ?	Center y-coordinate [ft] ?	Center z-coordinate [ft] ?
1	Well_Prod	12.5			
2	Well_Inj	12.5			
	[BLANK]				

New Row

Settings do not need to be exact, but something ‘representative’ helps to preserve realism. Optionally, this can be done iteratively by running the sim once to select representative fracture properties for future runs. (see [External Fractures Mini-Guide](#) to learn how)

	Total volume [bbl] ?	Net pressure [psi] ?	Half-length [ft] ?	Half-height [ft] ?	Closure time [hours] ?	Residual fraction ?	Activation time [hours] ?
1		250	300	200	0.5	0.2	2.7
2		250	300	200	0.5	0.2	6.4

New Row Resize Table

Assign *either* net pressure or fracture volume. This should be the stress shadow at the end of the previous stage’s stimulation.

Anticipated propped fracture size (or slightly smaller to avoid excessive overlap).

Time fractures close after activation, and residual net P

Activation time – shut-in time for the previous stage (see Well Controls)

192

Well Controls: Create new injection block for Well_Prod

WELLBORE BOUNDARY CONDITION CONTROLS ? ! !

Well_Prod ? ! !

Well_Inj ? ! !

Ensure the Well_Prod tab is selected.

Number of Blocks: 2

Add Block ...

'Add Block'

Previous

1

Next

> 1. Production Sequence

Start time: 0 Days

Duration: (Blank) Days

Number of controls: 1

≡ ...

▼ 2. Shut-in

Start time: (Blank) Hours

Duration: (Blank) Hours

Number of controls: 1

≡ ...

Collapse the block to drag it to the top of the Well Control blocks list

Type

NoFluidOrHeatFlow

Search

NoFluidOrHeatFlow ✓

InjectionSequence

ProductionSequence

General

Then change the block type from Shut-in to InjectionSequence.

Well Controls: specify pump schedule

Copy schedule from spreadsheet.

Expand injection sequence

These dictate how proppant and fluid injection quantities are defined. These change the column names in the Control Records table below.

Pump schedule in the spreadsheet can be copied and pasted here (ctrl+v). Note: the well is shut-in for first 454 min (to represent previous stage).

1. Injection Sequence

Start time: 0 Minutes Duration: 636 Minutes Number of controls: 17 Proppant stage 1: 2236.9 lbs/ft Fluid stage 1: 60.185 bbl/ft

Type: InjectionSequence

INJECTION SEQUENCE SUMMARY

	Proppant input variable	Fluid input variable	Maximum injection pressure [psi]	Temperature [F]	Time units	Duration to truncate sequence [Minutes]
1	MassPerSlurryVolume	SlurryRate	13000	72	Minutes	

INJECTION SEQUENCE BOUNDARY CONDITION CONTROL RECORDS

	Start time [Minutes]	Duration [Minutes]	Stage	Fluid type	Slurry injection rate [bpm]	Proppant/Pad	Proppant mass per volume [ppg]	Proppant
1	0	454	Isolate wellbore	Slickwater	0	NoProppant	0	
2	454	10	1	Slickwater	10	NoProppant	0	
3	464	2	1	Slickwater	10	NoProppant	0	
4	466	11	1	Slickwater	80	NoProppant	0	
5	477	14	1	Slickwater	80	100mesh	0.25	
6	491	14	1	Slickwater	80	100mesh	0.5	
7	505	14	1	Slickwater	80	100mesh	1	
8	519	13	1	Slickwater	80	100mesh	1.25	
9	532	13	1	Slickwater	80	100mesh	1.5	

Pressure constraints and injection temperature (ambient)

A high max pressure ensures rate-controlled stimulation

Duration of injection step, and stage being stimulated

Proppant and slurry types + quantities

Well Controls: preview pump schedule (1 of 3)

Select graph symbol to preview the injection sequence.

1. Injection Sequence

Start time: 0 Minutes

Duration: 6

Type
InjectionSequence

INJECTION SEQUENCE SUMMARY

	Proppant input variable	Fluid input variable	Ma
1	MassPerSlurryVolume	SlurryRate	

INJECTION SEQUENCE BOUNDARY CONDITION CONTROL RECORDS

	Start time [Minutes]	Duration [Minutes]	
1	0	454	
2	454	10	
3	464	2	
4	466	11	
5	477	14	
6	491	14	
7	505	14	
8	519	13	
9	532	13	
17	621	15	

17

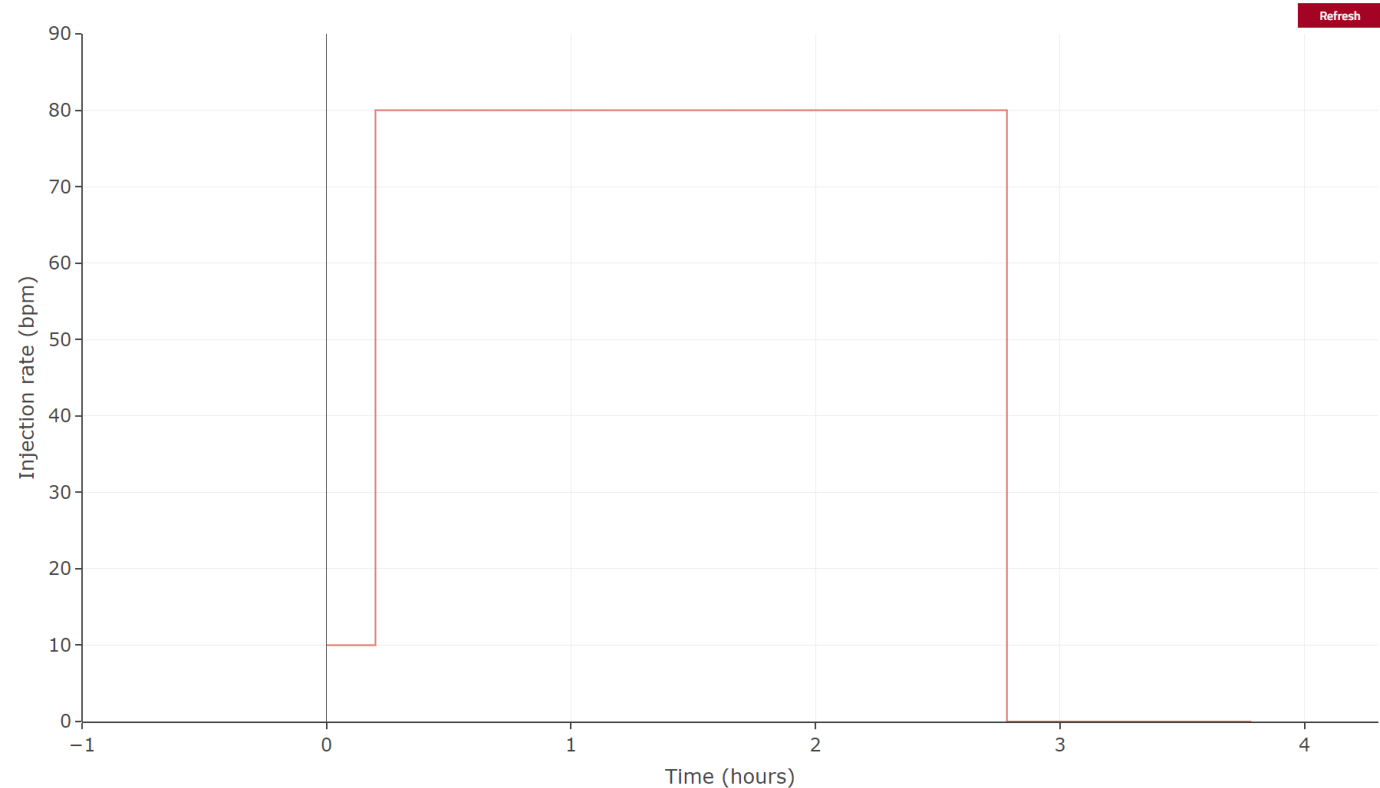
621

15

1

Slickwater

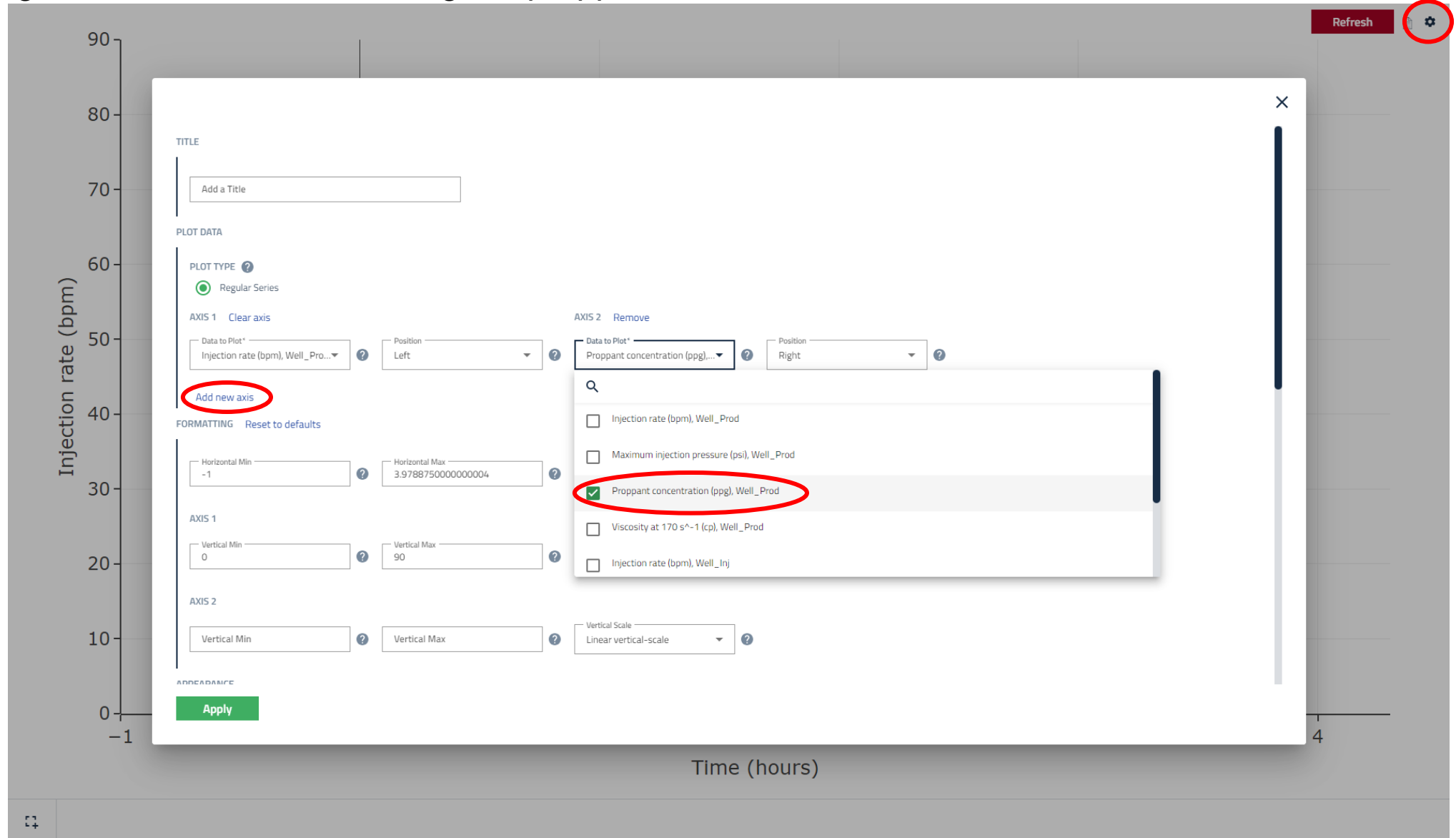
0



Note: last step has a rate of 0 bpm. This allows the simulator to calculate ISIP.

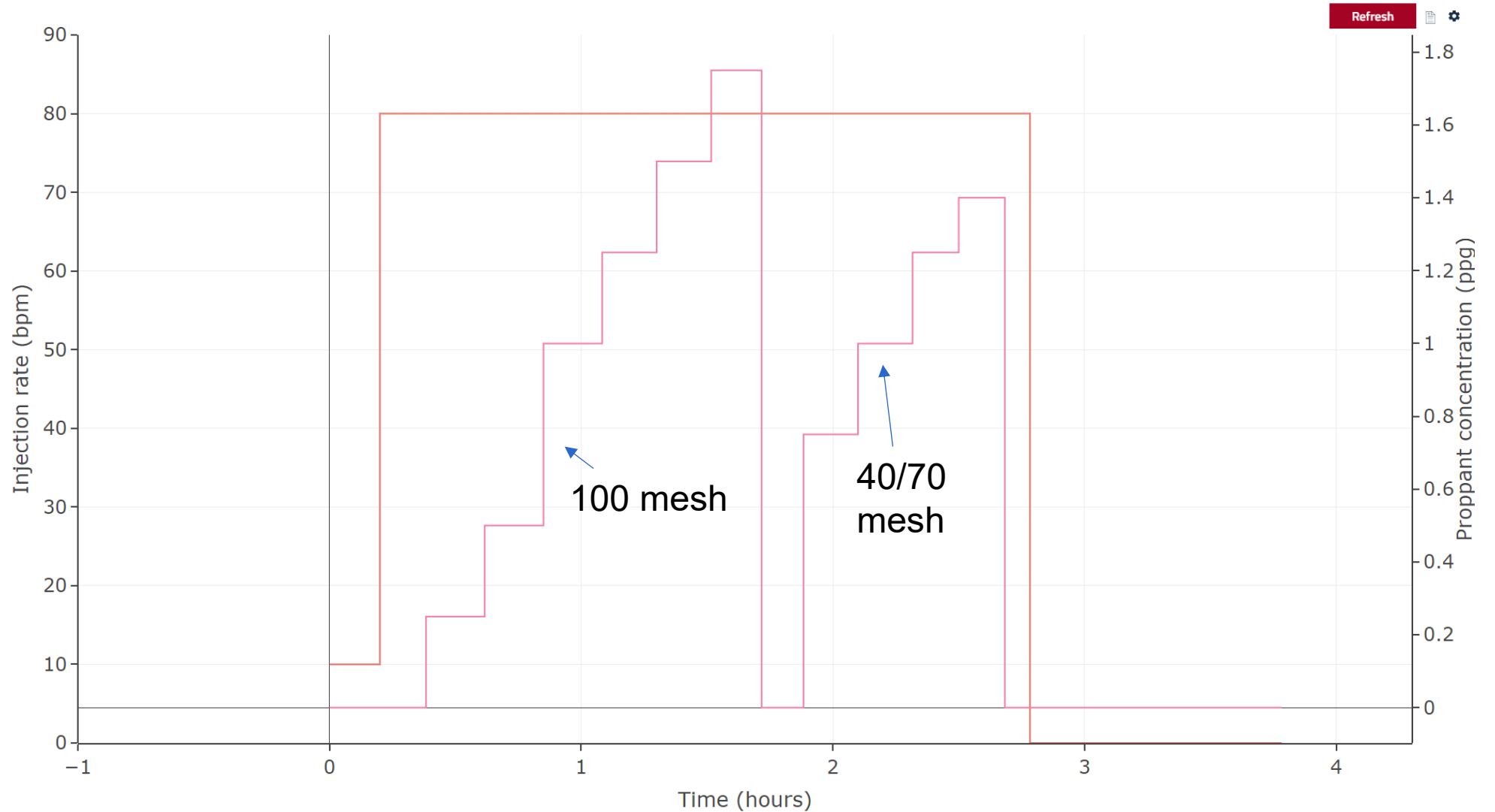
Well Controls: preview pump schedule (2 of 3)

In the settings, add another axis showing the proppant concentration.



Well Controls: preview pump schedule (3 of 3)

In the settings, add another axis showing the proppant concentration.



Well Controls: Create new Shut-in block for Well_Prod

WELLBORE BOUNDARY CONDITION CONTROLS ? ! !

Well_Prod ? ! !

Well_Inj ? ! !

Ensure the Well_Prod tab is selected.

Number of Blocks: 3

Add Block ...

'Add Block'

Previous

1

Next

> 1. Injection Sequence

Start time: 0
Minutes

Duration: 636
Minutes

Number of
controls: 17

Proppant stage 1:
2236.9 lbs/ft

Fluid stage 1:
60.185 bbl/ft

≡

...

> 2. Production Sequence

Start time: 0.44167 Days

Duration: (Blank) Days

Number of controls: 1

≡

...

▼ 3. Shut-in

Start time: (Blank) Minutes

Duration: 13764 Minutes

Number of controls: 1

≡

...

Collapse the new block to drag it between the injection and production sequences

Type
NoFluidOrHeatFlow

?

Keep the block type as Shut-in

Time units

Minutes

?

Isolate wellbore option saves on computation time, and cleans out the well

Isolate wellbore for 13,764 min so we can start production at exactly day 10
(13,764 + 636 = 14,400 min = 10 day)

Shut-in type
IsolateWell

SHUT-IN SUMMARY ?

	Stage ?	Duration [Minutes] ?	Start time [Minutes] ?
1	Isolate wellbore	13764	636

Well Controls: Copy well blocks to Well_Inj

We will use the same injection sequence to stimulate the injection well. Duplicate the Well_Prod well blocks.

WELLBORE BOUNDARY CONDITION CONTROLS ? ⚠ ⚠

Well_Prod ? ⚠ ⚠

Well_Inj ? ⚠ ⚠

Number of Blocks: 3

Add Block ...

Previous

1

Next

> 1. Injection Sequence	Start time: 0 Minutes	Duration: 182 Minutes	Number of controls: 16	Proppant stage 1: 2236.9 lbs/ft	Fluid stage 1: 60.185 bbl/ft	
> 2. Shut-in	Start time: 0.12639 Days	Duration: 9.8736 Days	Number of controls: 1			
> 3. Production Sequence	Start time: 10 Days	Duration: (Blank) Days	Number of controls: 1			

Duplicate Block

Remove Block

Duplicate Injection sequence and Shut-in blocks

Duplicate Block ?

Which well would you like to duplicate the block to?

Well_Inj

Select

Copy blocks to Well_Inj

Well Controls: Reorder well blocks in Well_Inj

Duplicated well blocks append by default to the end of the well block list. Reorder to match Well_Prod.

WELLBORE BOUNDARY CONDITION CONTROLS ? ! !

Well_Prod ? ! !

Well_Inj ? ! !

Switch to the Well_Inj tab

Number of Blocks: 3

Add Block ...

Previous

1

Next

>

1. General Constraint

Start time: 0 Days

Duration: (Blank) Days

Number of controls: 1

≡

...

>

2. Injection Sequen...

Start time: (Blank) Minutes

Duration: 182 Minutes

Number of controls: 16

Proppant stage 1: 2236.9 lbs/ft

Fluid stage 1: 60.185 bbl/ft

≡

...

>

3. Shut-in

Start time: (Blank) Days

Duration: 9.8736 Days

Number of controls: 1

≡

...

Move both new blocks above the General Constraint

Two new well blocks have been copied over to Well_Inj

New order

- > 1. Injection Sequence
- > 2. Shut-in
- > 3. General Constraint

Well Controls: Revise Well_Inj injection sequence

Increase the shut-in at the start of the injection sequence (by $167 + 60 = 227$ min) to account for the Well_Prod stimulation.

A shut-in period within an injection sequence block is defined by:

1. Selecting 'Isolate wellbore' as the stage
2. Setting injection rate to 0

1. Injection Sequence

Start time: 0 Minutes

Duration: 863 Minutes

Number of controls: 17

Proppant stage 1: 2236.9 lbs/ft

Fluid stage 1: 60.185 bbl/ft

Type

InjectionSequence

INJECTION SEQUENCE SUMMARY

	Proppant input variable	Fluid input variable	Maximum injection pressure [psi]	Temperature [F]	Time units	Duration to truncate sequence [Minutes]
1	MassPerSlurryVolume	SlurryRate	13000	72	Minutes	

INJECTION SEQUENCE BOUNDARY CONDITION CONTROL RECORDS

	Start time [Minutes]	Duration [Minutes]	Stage	Fluid type	Slurry injection rate [bpm]	Proppant/Pad	Proppant mass per volume [ppg]	Proppant
1	0	681	Isolate wellbore	Slickwater	0	NoProppant	0	
2	681	10	1	Slickwater	10	NoProppant	0	
3	691	2	1	Slickwater	10	NoProppant	0	
4	693	11	1	Slickwater	80	NoProppant	0	
5	704	14	1	Slickwater	80	100mesh	0.25	
6	718	14	1	Slickwater	80	100mesh	0.5	
7	732	14	1	Slickwater	80	100mesh	1	
8	746	13	1	Slickwater	80	100mesh	1.25	
9	759	13	1	Slickwater	80	100mesh	1.5	

Well Controls: Revise Well_Inj shut-in block

Because we've increased the duration of the injection sequence, we need to shorten the shut-in duration too.

WELLBORE BOUNDARY CONDITION CONTROLS ? ! !

Well_Prod ? ! !

Well_Inj ? ! !

Number of Blocks: 3

Add Block ...

Previous

1

Next

> 1. Injection Sequence

Start time: 0
Minutes

Duration: 863
Minutes

Number of
controls: 17

Proppant stage 1:
2236.9 lbs/ft

Fluid stage 1:
60.185 bbl/ft

≡ ...

▼ 2. Shut-in

Start time: 863 Minutes

Duration: 13537 Minutes

Number of controls: 1

≡ ...

Type
NoFluidOrHeatFlow

?

Time units
Minutes

?

Shut-in type
IsolateWell

?

SHUT-IN SUMMARY ?

	Stage ?	Duration [Minutes] ?	Start time [Minutes] ?
1	Isolate wellbore	13537	863

Isolate wellbore for
13,537 min so we
can start production
at exactly day 10
(13,537 + 863 =
14,400 min = 10 day)

Well Controls: Correct Error Messages

Because we've made new proppants, it impacted the General Constraint.

WELLBORE BOUNDARY CONDITION CONTROLS ? ! !

Well_Prod ? ! ! **Well_Inj ? ! !**

Number of Blocks: 3

Previous 1 Next

> 1. Injection Sequence | Start time: 0 Minutes | Duration: 409 Minutes

> 2. Shut-in | Start time: 0.28403 Days | Duration: 9.7161 Days | Number of controls: 1

3. General Constraint | Start time: 10 Days | Duration: (Blank) Days | Number of controls: 1

⋮

GENERAL WELLBORE BOUNDARY CONDITION CONTROL RECORDS ? ?

	Component ? ?	Proppant mass per volume 40 [ppg] ?	Proppant mass per volume 55 [ppg] ?	Proppant mass per volume 70 [ppg] ?	Proppant mass per volume 100 [ppg] ?	Water solute mass fraction FR ?	Optional secondary maximum production rate [bbl/day] ?
1	0			0	0	0	

New Row Resize Table

Error: Wellbore boundary condition controls

The parameter 'proppant mass per volume in constant pressure boundary condition for well "Well_Inj"' cannot be defined as nan (not a number).

OK

Most Well Control sequences only deal with proppant mixtures. However, because General Constraints are designed to be more flexible, the quantity of each individual proppant must be specified. Enter 0 for all.

Well Controls: well flow scalers

Change the start time of the Well flow scalers to apply *after* hydraulic fracturing. During stimulation, injection occurs one stage at a time, so the flow does not need to be scaled up. Conversely, during long-term circulation flow occurs in all stages at once, and that is when well flow scalers need to be applied to represent flow across the full well lateral.

WELL FLOW SCALERS ?

	Well name ?	MD [ft] ?	Flow multiplier ?	Start time [days] ?	End time [days] ?	Coefficient of variation penalty scaler ?	
1	Well_Prod ▼	15110.6	28	10			≡
2	Well_Inj ▼	15110.6	28	10			≡

Start time of 10 days corresponds to when long-term circulation starts in the model.

Output Options: Overview (again)

←

Welcome

Startup

Static Model and Initial Conditions

Curve Sets

Wells and Perforations

Meshing Options

Fluid Model Options

Fracture Options

Proppants

Water Solutes

Well Controls

Other Physics Options

Numerical Options

Output Options

Advanced Options

Output Options

Specify options related to simulator outputs

EditorSearch

Output options library?

Overall output frequency scaler?

Lite matrix export

Only output raw results on flagged snapshots

Only output raw results on the final timestep

Output per well raw results files

STRESS OBSERVATION POINTS AND PLANES?

	nx?	ny?	nz?
1			

STRESS OBS POINTS AT WELL MD?

	Well name?	Measured depth [ft]?
1		

Save or import output options from a library

Change amount of output files

Stress obs points & planes – in matrix and along well

Econ models

Temporal averaging for production rates [hours]?

Only sxx stress in obs points

Output obs point strains

Output displacements to tracking file

Extra stress observation plane output

Rotate stress observation planes with

PRODUCTION VOLUME MULTIPLIERS?

	Well name?	Production volume multipliers?
1	Well_Prod	
2	Well_Inj	

ADDITIONAL LINE PLOTS FOR HISTORY MATCHING?

Number of items: 0

Previous1Next

Economic models library?

ECONOMIC MODELS?

Number of items: 0

Previous1Next

ECONOMICS MODEL ADDITIONAL SPENDING?

	Time [days]?
1	

Area per DSU [ft^2]?

VOLUME TO FIRST RESPONSE TRACKERS?

	Injection well?
1	

FRAC HIT TRACKERS?

	Injection well?
1	

PROPERTY OUTPUTTING RECTANGLES?

	Name?	X-center [ft]?
1		

Perf efficiency area erosion cutoff?

Perf efficiency fluid flow cutoff [bbt]?

Advanced options

205

Output options: Stress observation plane (1 of 2)

Including a horizontal stress observation plane allows the mechanical stress to be viewed in the viz tool. This can be used to depict the stress shadow, or matching fiber optic data.

We'll center the plane approximately around the center of the matrix.

CENTER OF MATRIX REGION [FT]

Matrix center in x direction [ft]
2467.50936807094

Matrix center in y direction [ft]
-2940.66315415691

Matrix center in z direction [ft]
11899.9631169039

Matrix center can be found in the Meshing Options panel

The matrix length is 200 ft by 9000 ft. We'll make a plane with the same SHmax extents, but slightly longer in the Shmin direction (to better capture stress shadowing). To do that, set the min and max values to be +/- 200 ft to the x center point, and +/- 4500 ft to the y center point.

Extents of the stress observation plane

STRESS OBSERVATION POINTS AND PLANES

	nx	ny	nz	minx [ft]	maxx [ft]
1	100	100	1	2267.5	2667.5

New Row Resize Table

Number of data points (observations) to record.

Additional columns

miny [ft]	maxy [ft]	minz [ft]	maxz [ft]
-7440.7	1440.7	11900	11900

Output options: Stress observation plane (2 of 2)

STRESS OBSERVATION POINTS AND PLANES ?

	nx ?	ny ?	nz ?	minx [ft] ?	maxx [ft] ?
1	100	100	1	2367.5	2567.5

New Row Resize Table

STRESS OBS POINTS AT WELL MD ?

	Well name ?	Measured depth [ft] ?
1		

New Row Resize Table

Temporal averaging for production rates [hours] ?

☐ Only sxx stress in obs points ?

☒ Output obs point strains ?

☐ Output displacements to tracking file ?

☒ Extra stress observation plane outputting ?

☒ Rotate stress observation planes with stresses ?

miny [ft] ?	maxy [ft] ?	minz [ft] ?	maxz [ft] ?
-5190.7	-690.7	11900	11900

The stress observation plane will rotate around its center point: (2467.5, -2940.7)

Because the SHmax direction is not 0, we need to rotate the stress observation plane to align with the stress orientation.

A ResFrac Mini-Guide on Stress Observation Points and Planes is also available at this [link](#).

Output Options: Geothermal economics module - Update

Some modifications need to be made to account for the additional hydraulic fracturing phase.

GEOTHERMAL ECONOMIC MODEL INPUTS ?

	Price of electricity [\$/kW-hr] ?	(Optional) Cost of electricity for pumping power [\$/kW-hr] ?	Time when surface plant cost is applied [days] ?	Surface plant cost [\$] ?	Surface plant cost per gross capacity (electric) [\$/kWe] ?	Additional surface plant cost per net capacity (electric) [\$/kWe] ?
1	0.15	0.15	10		2500	

Installed gross plant capacity (electric) [MWe] ?

Time to start calculating peak output for surface plant cost [day...]

40

NET-OUT INSTANTANEOUS INJECTION AND PRODUCTION START AND END TIMES BY WELL ?

	Well name ?	(Optional) Start time of period one to apply cost for net instant... ?	(Optional) End time of period one to apply cost for net instantan... ?
1	Well_Prod	10	
2	Well_Inj	10	

- Shift start times by 10 days to account for fracturing period

- During the pre-existing fracture case, since proppant and fluid injection were not included in the model, \$3 million were added to the 'fixed fracturing cost per well' to account for those costs. In this sim we are explicitly modeling stimulation, so we'll separate those costs out based on the Well Control inputs and specify the cost per lb and bbl.

Fixed fracturing cost per well [dollars] 2000000

(Optional) Completion cost per stage [dollars] ?

☒ Apply fracturing cost at the start of injection

Fracturing proppant cost [dollars/lb] 0.1

Injection water cost [dollars/bbl] 5

Output options: add VFR and frac hit trackers

Turn on Volume to first response (VFR) and Frac hit trackers.

VOLUME TO FIRST RESPONSE TRACKERS ? 📄

	Injection well ?	Observation well ?	
1	Well_Prod ▼	Well_Inj ▼	⋮
2	Well_Inj ▼	Well_Prod ▼	⋮

New Row Resize Table

FRAC HIT TRACKERS ? 📄

	Injection well ?	Observation well ?	
1	Well_Prod ▼	Well_Inj ▼	⋮
2	Well_Inj ▼	Well_Prod ▼	⋮

New Row Resize Table

Since we're stimulating both wells, we'll treat them as both 'injection' and 'observation' wells

A ResFrac Mini-Guide on Volume to First Response and Frac Hit Trackers is also available at this [link](#).

Output options: add extra fracture info

Advanced options ^

⋮ *scroll*

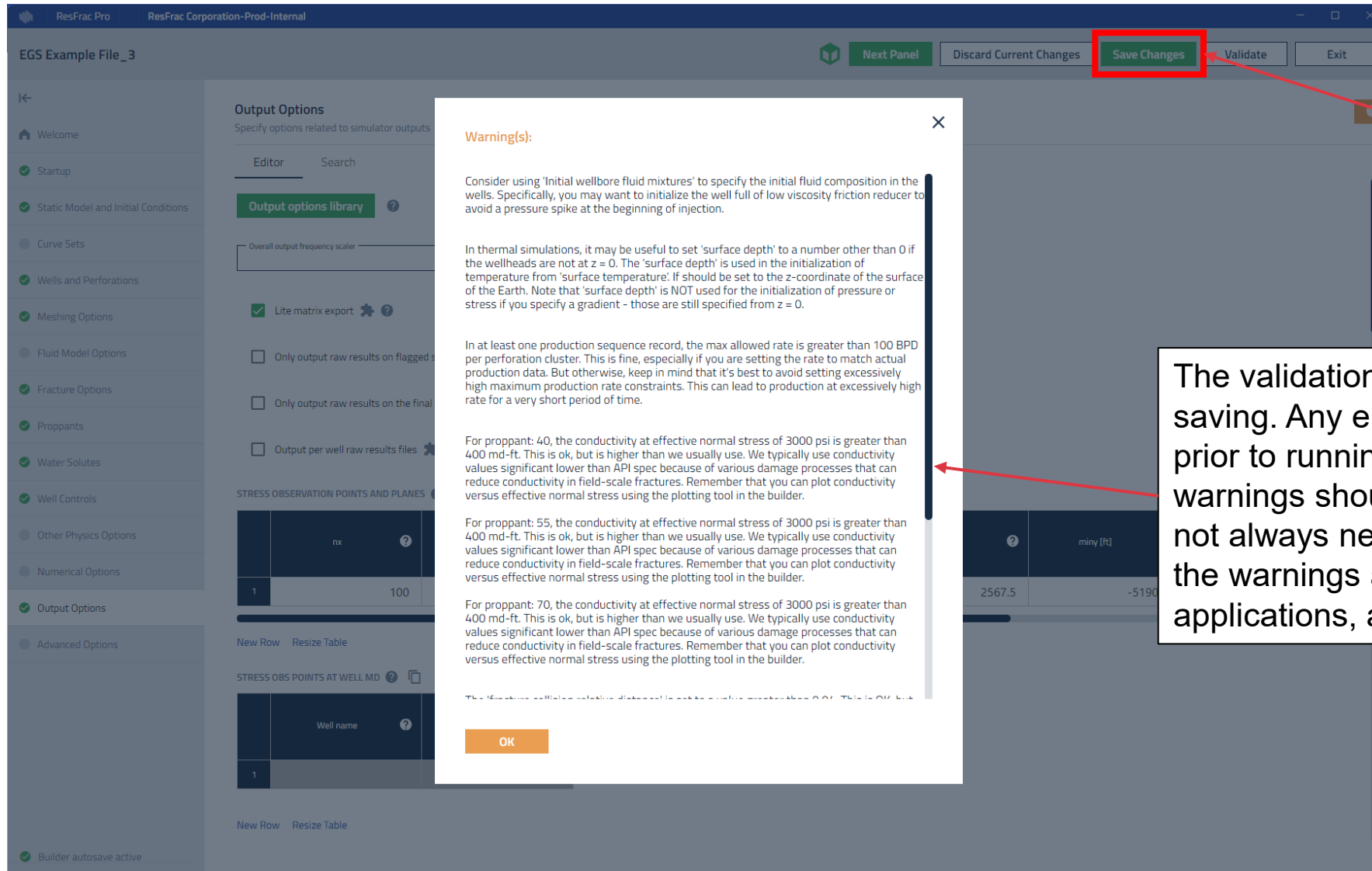


Extra fracture info in tracking file



Should already be checked in the EGS template

Save and Exit Builder



Click Save Changes, which will validate and save your model.

The validation window will appear after saving. Any errors must be addressed prior to running the sim. Meanwhile, warnings should be reviewed, but may not always need addressing. Many of the warnings are targeted to O&G applications, and these may be ignored.

Run Simulation (slide 1 of 2)

Click on the simulation name, or the ellipses on the right, and select “Run Simulation” from the list of actions.

The screenshot shows the ResFrac Pro web interface. At the top, the breadcrumb navigation is 'Home > EGS Training > EGS Tutorial'. The 'Sandbox Details' section shows the workflow name 'EGS Tutorial', 6 simulations, and a creation timestamp of 'Dec 2, 2025 at 11:20 am'. Below this is a table of 5 simulations. The first simulation, 'EGS Example File_3', is highlighted. A context menu is open for this simulation, with 'Run Simulation' selected and highlighted by a red box. The menu also includes options like 'Simulation Details', 'Edit Simulation in Builder', 'Copy Simulation', and 'Open Simulation Folder in File Explorer'.

>	SIMULATION NAME	STATUS	DATE CREATED ↓	LAST MODIFIED	...
>	EGS Example File_3	Not Yet Submitted	Feb 23, 2026 at 4:16 pm	Feb 23, 2026 at 4:16 pm	...
>	EGS Example File_2	Finished running	Feb 4, 2026 at 12:10 pm	Feb 23, 2026 at 4:16 pm	...
>	EGS Example File	Finished running	Dec 15, 2025 at 3:20 pm	Jan 28, 2026 at 12:10 pm	...
>	Preexisting fractures	Not Yet Submitted	Dec 2, 2025 at 12:56 pm	Dec 2, 2025 at 11:58 am	...
>	Base_from template	Not Yet Submitted	Dec 2, 2025 at 11:58 am	Dec 2, 2025 at 11:58 am	...

You have reached the end of the list

Run Simulation (slide 2 of 2)

Click “Run Simulation” to submit the job.

Run Simulation

Simulation Name*

EGS Example File_3

Description

Created as a copy of simulation EGS Example File_2 at 16:16:10 2026-02-23
1) corrected the production WHP minimum to 500 psi vs 200 psi (to maintain single-phase flow in the wellbore)
2) increased the fracture size.

Created as a copy of simulation 08_FullFact_7 at 12:10:18 2026-02-04
Imported from simulations.csv file

Simulator Version *

2026-02-10 10:58:19 -0800 49f9c10

Job Priority *

Normal

Vm Size

Regular (1x new CPUs, 1.2x cost per hour, approx 20 percent reduction in runtime)

Run Simulation

Cancel

- Then wait for simulation to run.
This sim should take <1 hr.

Generally, select latest available simulator version

Job priority has no impact

Choose Vm size depending on how fast you want the sim to run. On Regular, this sim should run in <1 hr.

Results Phase 2 – Hydraulic Fracturing

Visualizing Simulation Results - Overview

Objective: Use the 3D viz tool to visualize the EGS tutorial simulation and analyze the results.
Compare Phase I and Phase II results.

- Line plot 1
 - WHP
 - BHP
- Line Plot 2
 - Water Inj Rate
 - Water Prod Rate
- Line Plot 3
 - Wellhead Temperature
 - Cumulative Net Electricity
- Line Plot 4
 - LCOE
 - NPV
- 3D Images to plot
 - Pressure & temperature distribution
 - Fracture height, length, and conductivity
 - Proppant concentration & screenout
 - Stress shadowing

For an introduction on using the viz tool, watch [Module 4: Visualization Tool](#) on the ResFrac Online Resources page.

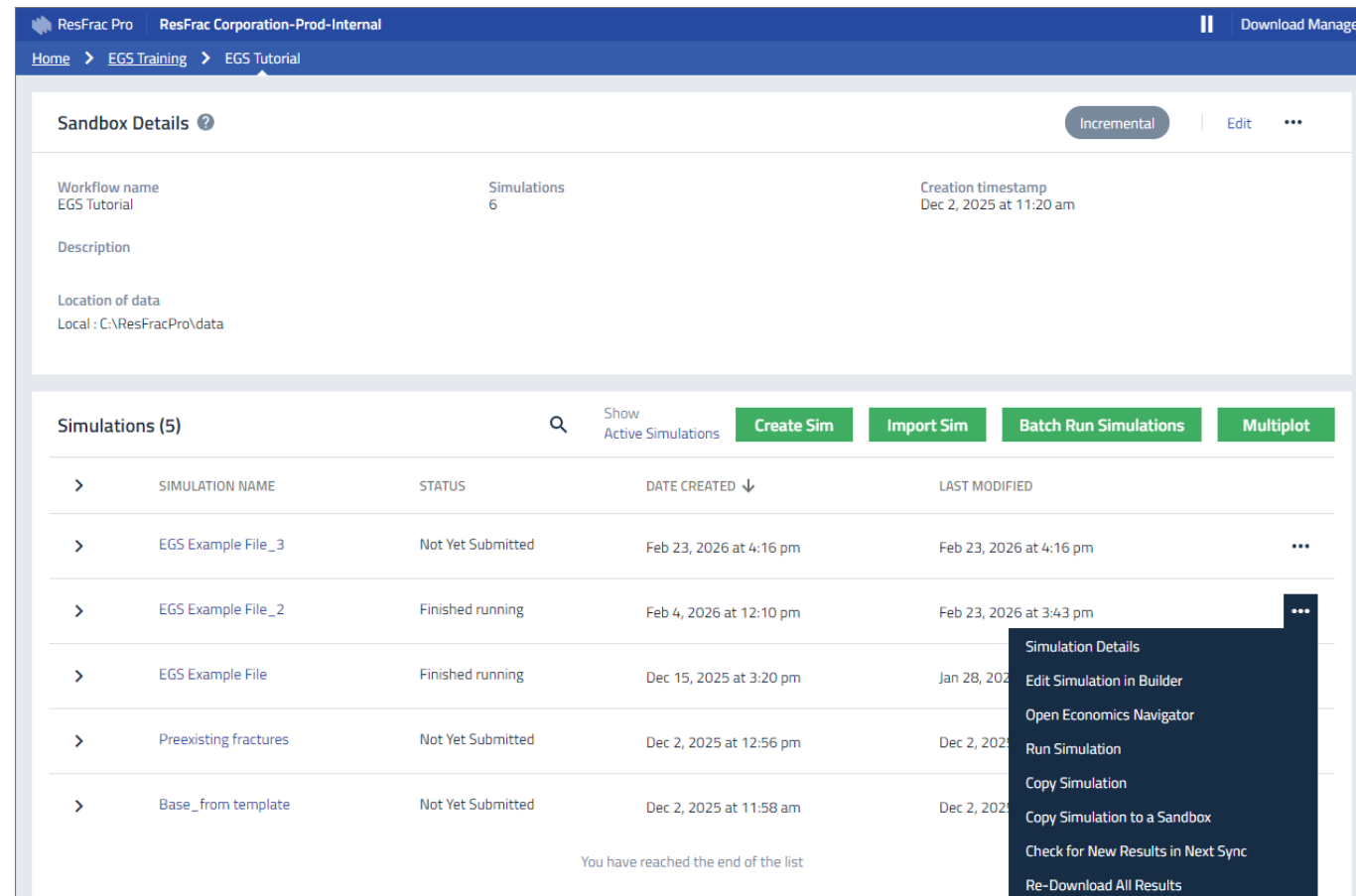
If you have any issues with your sim setup, you may download the result for Phase II at this [link](#).

Visualize Simulation Results

Click on the simulation name, or the ellipses on the right, and select “Visualize Results *with Layout*” from the list of actions.

Choose the Layout that you saved during Phase I as a starting point.

Pull up both the Phase I and II sim results to compare.



ResFrac Pro ResFrac Corporation-Prod-Internal

Home > EGS Training > EGS Tutorial

Sandbox Details ?

Incremental | Edit ...

Workflow name: EGS Tutorial
Simulations: 6
Creation timestamp: Dec 2, 2025 at 11:20 am

Description:

Location of data: Local : C:\ResFracPro\data

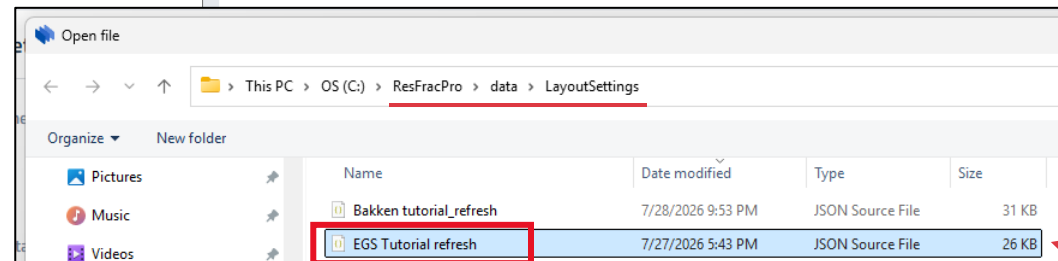
Simulations (5)

Show Active Simulations Create Sim Import Sim Batch Run Simulations Multiplot

>	SIMULATION NAME	STATUS	DATE CREATED ↓	LAST MODIFIED	
>	EGS Example File_3	Not Yet Submitted	Feb 23, 2026 at 4:16 pm	Feb 23, 2026 at 4:16 pm	...
>	EGS Example File_2	Finished running	Feb 4, 2026 at 12:10 pm	Feb 23, 2026 at 3:43 pm	...
>	EGS Example File	Finished running	Dec 15, 2025 at 3:20 pm	Jan 28, 2026	...
>	Preexisting fractures	Not Yet Submitted	Dec 2, 2025 at 12:56 pm	Dec 2, 2025	...
>	Base_from template	Not Yet Submitted	Dec 2, 2025 at 11:58 am	Dec 2, 2025	...

You have reached the end of the list

- Simulation Details
- Edit Simulation in Builder
- Open Economics Navigator
- Run Simulation
- Copy Simulation
- Copy Simulation to a Sandbox
- Check for New Results in Next Sync
- Re-Download All Results
- Export Simulation Folder
- Open Simulation Folder in File Explorer
- Open Comments File
- Open Text Settings File
- Open Text Input File
- Download Restart Files
- Import Additional Files
- Visualize Simulation Results
- Visualize Results with Layout



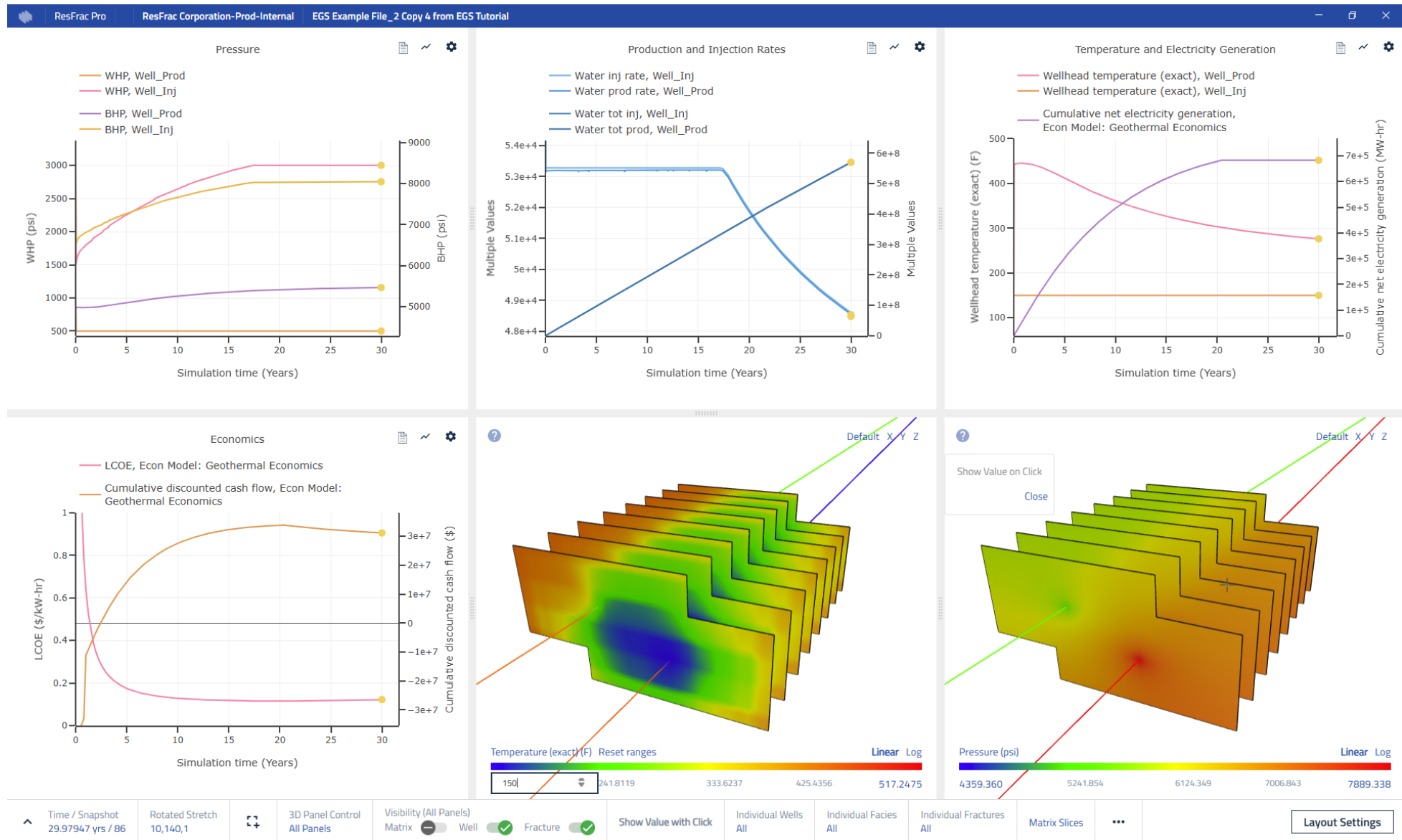
Open file

This PC > OS (C:) > ResFracPro > data > LayoutSettings

Organize New folder

Name	Date modified	Type	Size
Bakken tutorial_refresh	7/28/2026 9:53 PM	JSON Source File	31 KB
EGS Tutorial refresh	7/27/2026 5:43 PM	JSON Source File	26 KB

Viz Tool: Phase I Results (for comparison)



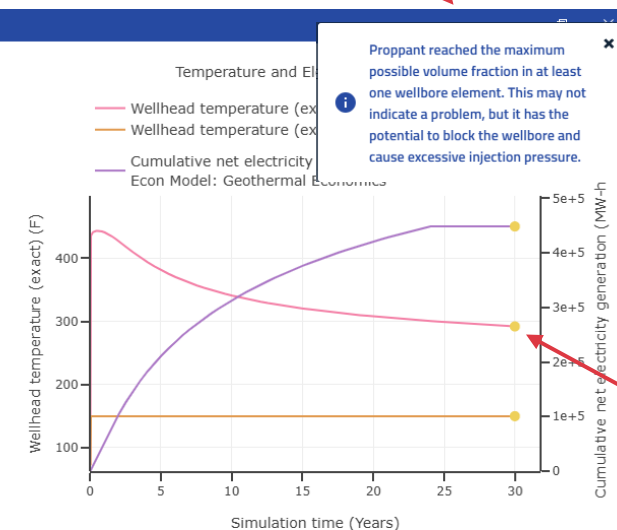
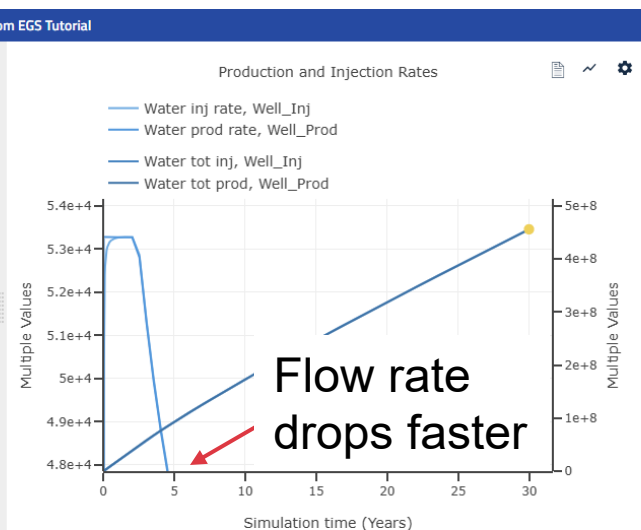
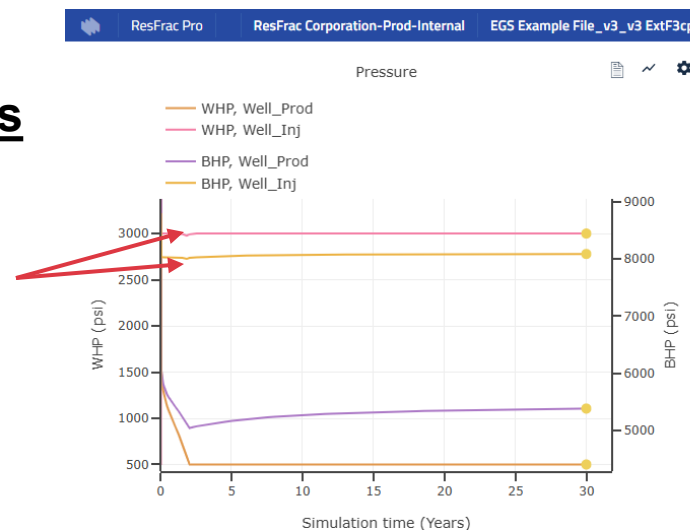
Viz Tool: Phase II Results (Saved Layout View)

Our previously saved plot views show up, with the same axis scales.

Toaster message warns of possible screenout

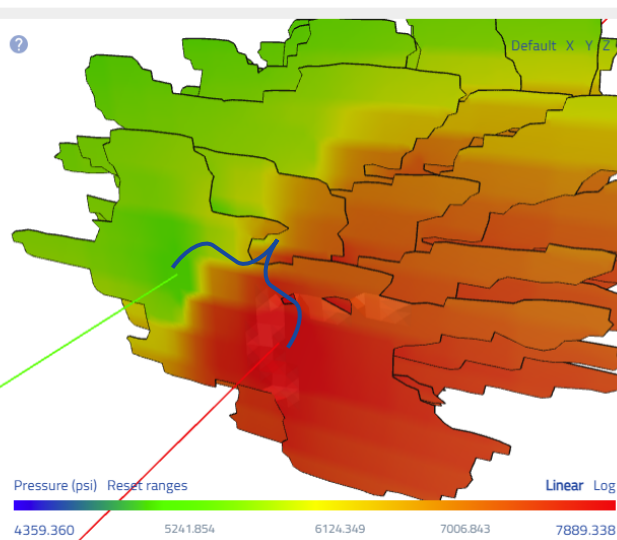
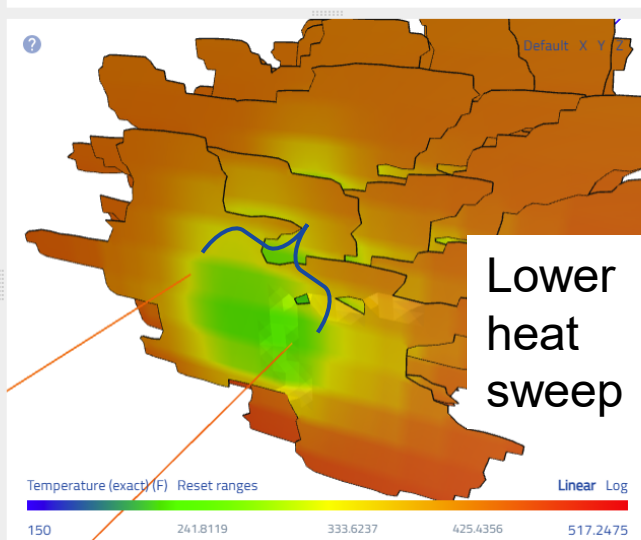
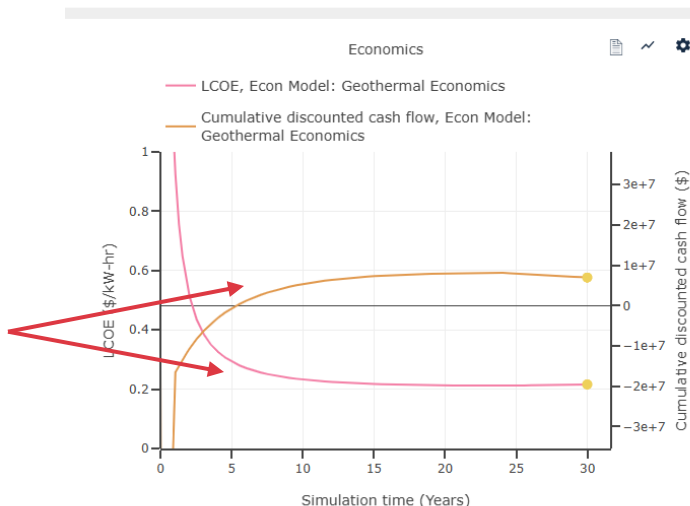
Observations

Max inj pressure reached early



Temp declines slower

Less favorable economics



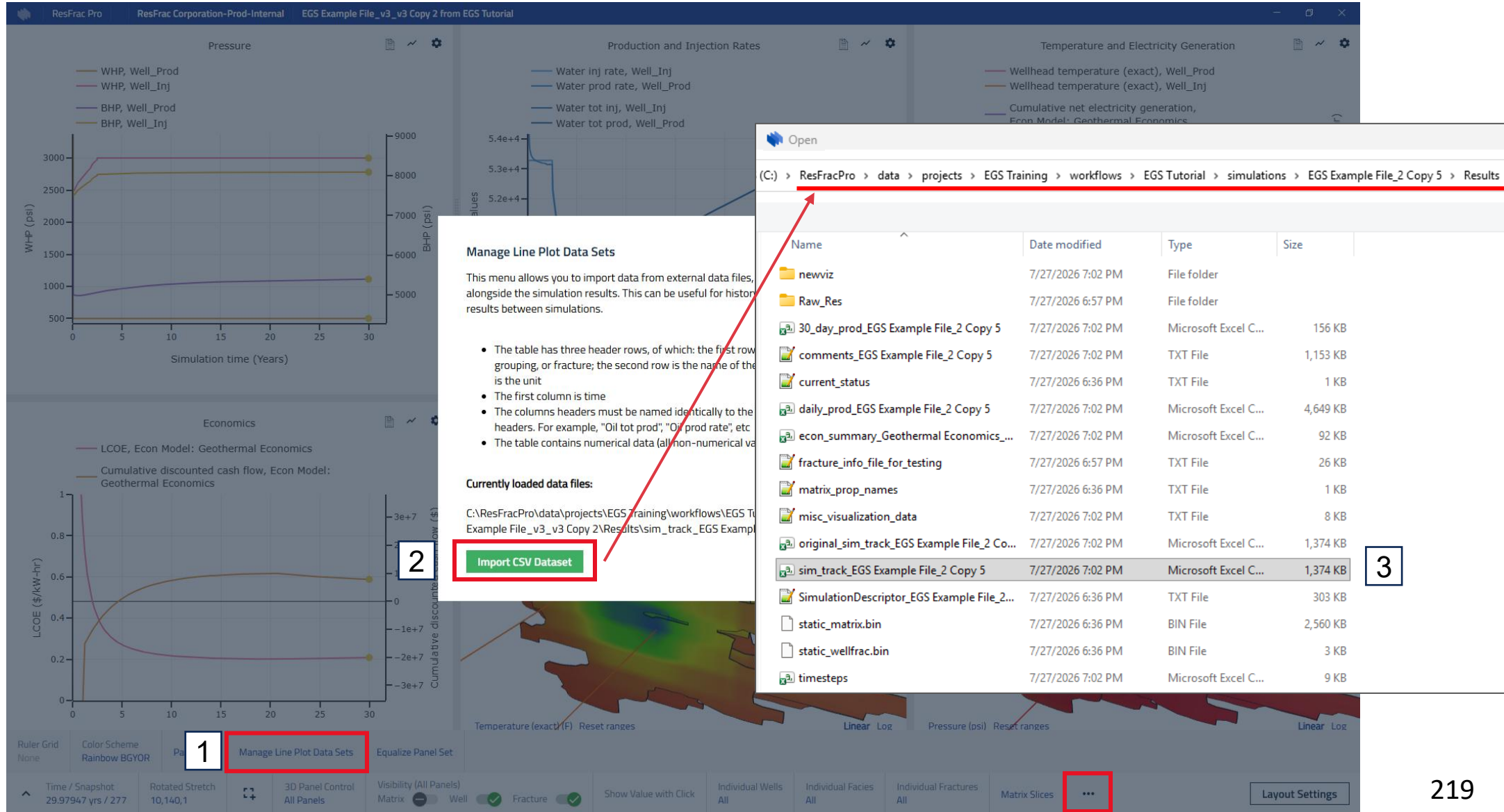
Greater delta pressure

Viz Tool: Import External Dataset – Compare Sims (1 of 4)

Let's compare between the Phase I and Phase II results directly.

1. Select 'Manage Line Plot Data Sets'
2. 'Import CSV Dataset'
3. Navigate to the sim_track file of the sim you'd like to import

*If importing external data, match sim_track format



The screenshot displays the ResFrac software interface with three main panels: Pressure, Production and Injection Rates, and Temperature and Electricity Generation. A 'Manage Line Plot Data Sets' dialog box is open in the center, and a file explorer window is open on the right. The file explorer shows the path (C:) > ResFracPro > data > projects > EGS Training > workflows > EGS Tutorial > simulations > EGS Example File_2 Copy 5 > Results. The file explorer lists various files, including 'sim_track_EGS Example File_2 Copy 5' which is highlighted. The 'Manage Line Plot Data Sets' dialog box contains instructions on how to import data from external files and lists currently loaded data files. The 'Import CSV Dataset' button is highlighted in the dialog box. The 'Manage Line Plot Data Sets' button in the bottom toolbar is also highlighted.

Manage Line Plot Data Sets

This menu allows you to import data from external data files, alongside the simulation results. This can be useful for historical results between simulations.

- The table has three header rows, of which: the first row grouping, or fracture; the second row is the name of the is the unit
- The first column is time
- The columns headers must be named identically to the headers. For example, "Oil tot prod"; "Oil prod rate"; etc
- The table contains numerical data (all non-numerical va

Currently loaded data files:

C:\ResFracPro\data\projects\EGS Training\workflows\EGS Tutorial\simulations\EGS Example File_2 Copy 5\Results\sim_track_EGS Example File_2 Copy 5

Import CSV Dataset

File Explorer:

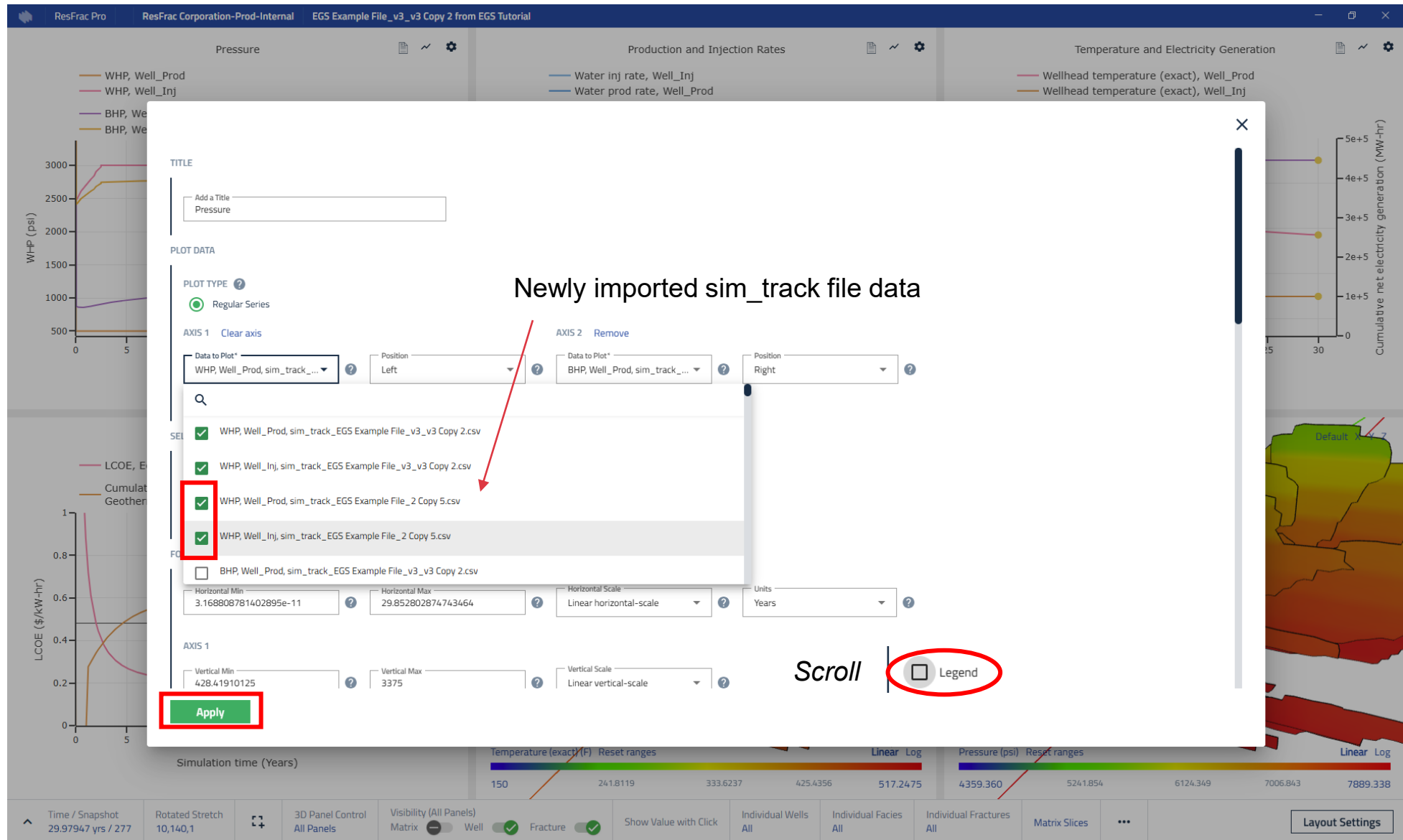
Name	Date modified	Type	Size
newviz	7/27/2026 7:02 PM	File folder	
Raw_Res	7/27/2026 6:57 PM	File folder	
30_day_prod_EGS Example File_2 Copy 5	7/27/2026 7:02 PM	Microsoft Excel C...	156 KB
comments_EGS Example File_2 Copy 5	7/27/2026 7:02 PM	TXT File	1,153 KB
current_status	7/27/2026 6:36 PM	TXT File	1 KB
daily_prod_EGS Example File_2 Copy 5	7/27/2026 7:02 PM	Microsoft Excel C...	4,649 KB
econ_summary_Geothermal Economics...	7/27/2026 7:02 PM	Microsoft Excel C...	92 KB
fracture_info_file_for_testing	7/27/2026 6:57 PM	TXT File	26 KB
matrix_prop_names	7/27/2026 6:36 PM	TXT File	1 KB
misc_visualization_data	7/27/2026 7:02 PM	TXT File	8 KB
original_sim_track_EGS Example File_2 Co...	7/27/2026 7:02 PM	Microsoft Excel C...	1,374 KB
sim_track_EGS Example File_2 Copy 5	7/27/2026 7:02 PM	Microsoft Excel C...	1,374 KB
SimulationDescriptor_EGS Example File_2...	7/27/2026 6:36 PM	TXT File	303 KB
static_matrix.bin	7/27/2026 6:36 PM	BIN File	2,560 KB
static_wellfrac.bin	7/27/2026 6:36 PM	BIN File	3 KB
timesteps	7/27/2026 7:02 PM	Microsoft Excel C...	9 KB

Viz Tool: Import External Dataset – Compare Sims (2 of 4)

Let's compare between the Phase I and Phase II results directly.

For each axis, select the same parameters loaded from the new sim_track file.

Turn the legends 'off' to save on space.

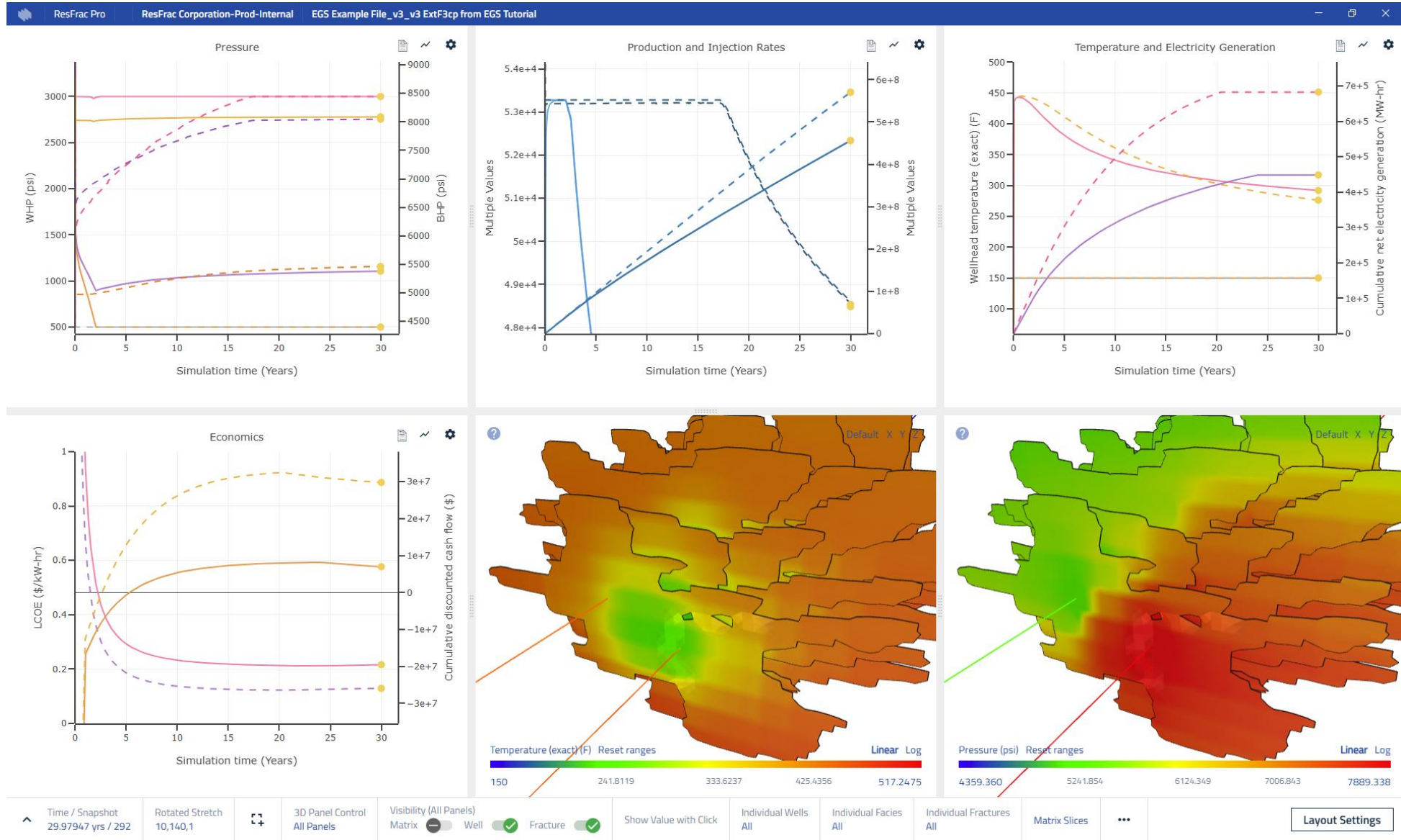


Viz Tool: Import External Dataset – Compare Sims (3 of 4)

Let's compare between the Phase I and Phase II results directly.

The external csv data (Phase I) is automatically dashed.

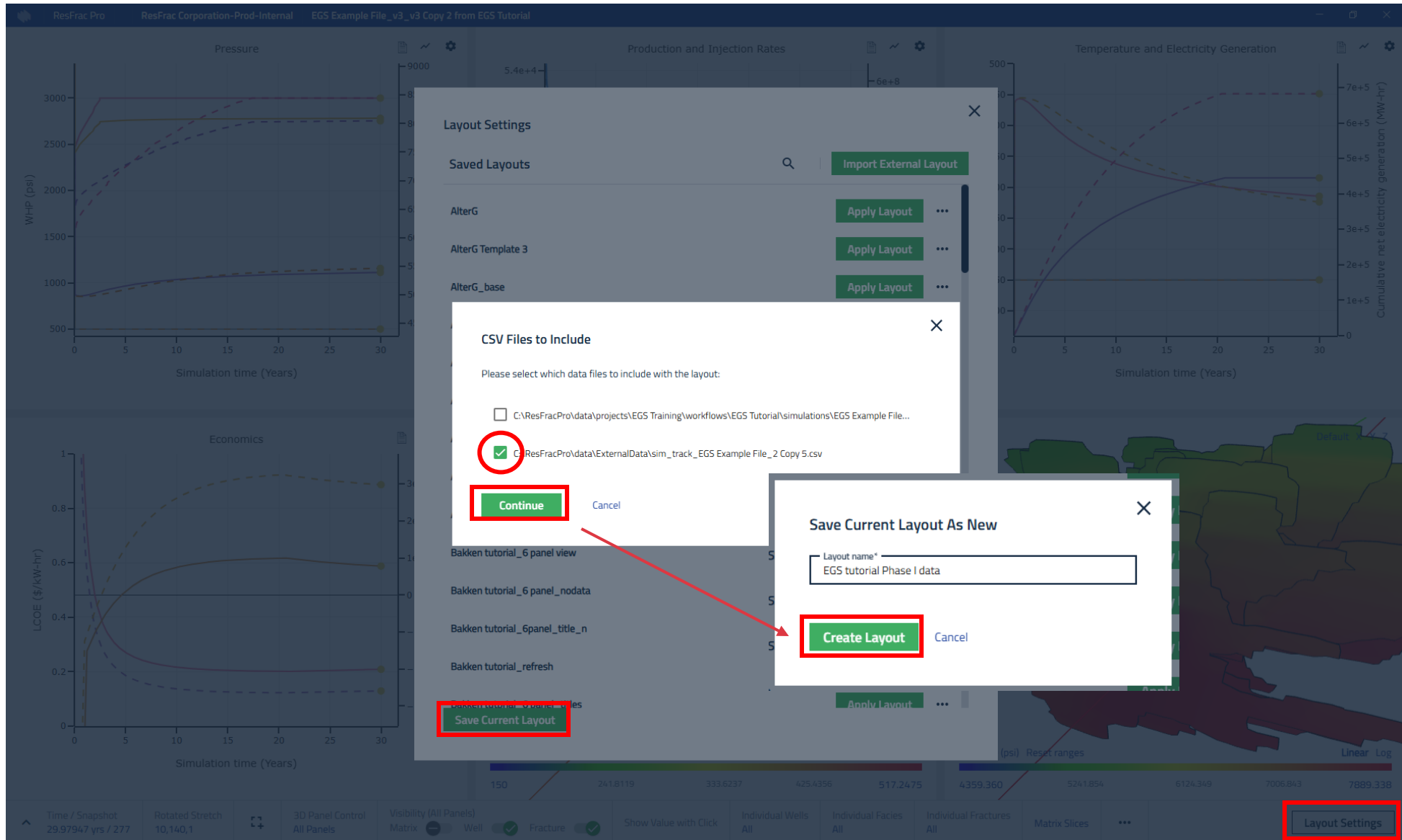
The design of the HF system (Phase II) could be improved.



Viz Tool: Import External Dataset – Compare Sims (4 of 4)

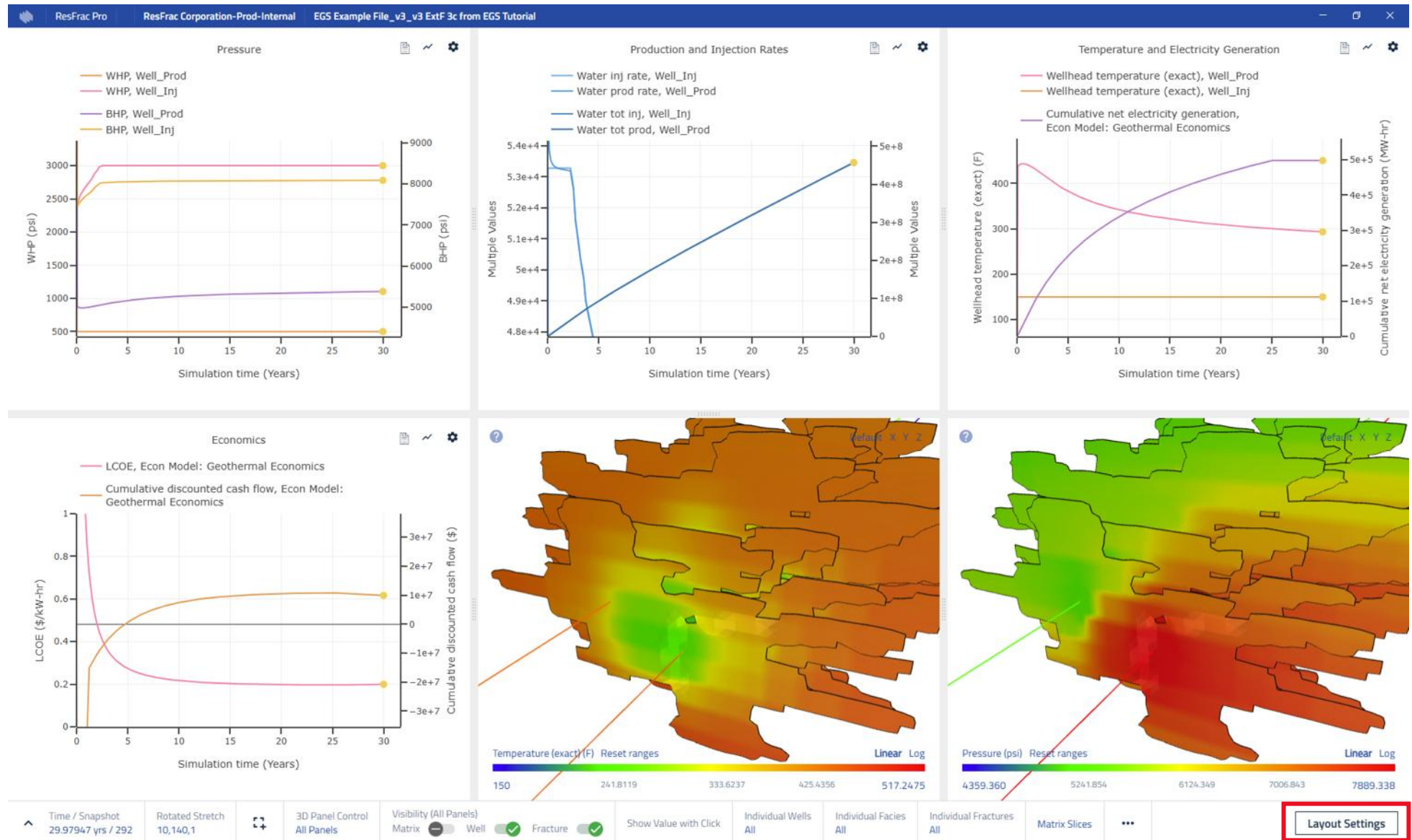
Save the layout with external data. Then the Phase I data will automatically load when opening the layout.

1. Select 'Layout Settings'
2. 'Save Current Layout'
3. Select the Phase I sim_track file with the layout so it will auto-load as an external dataset



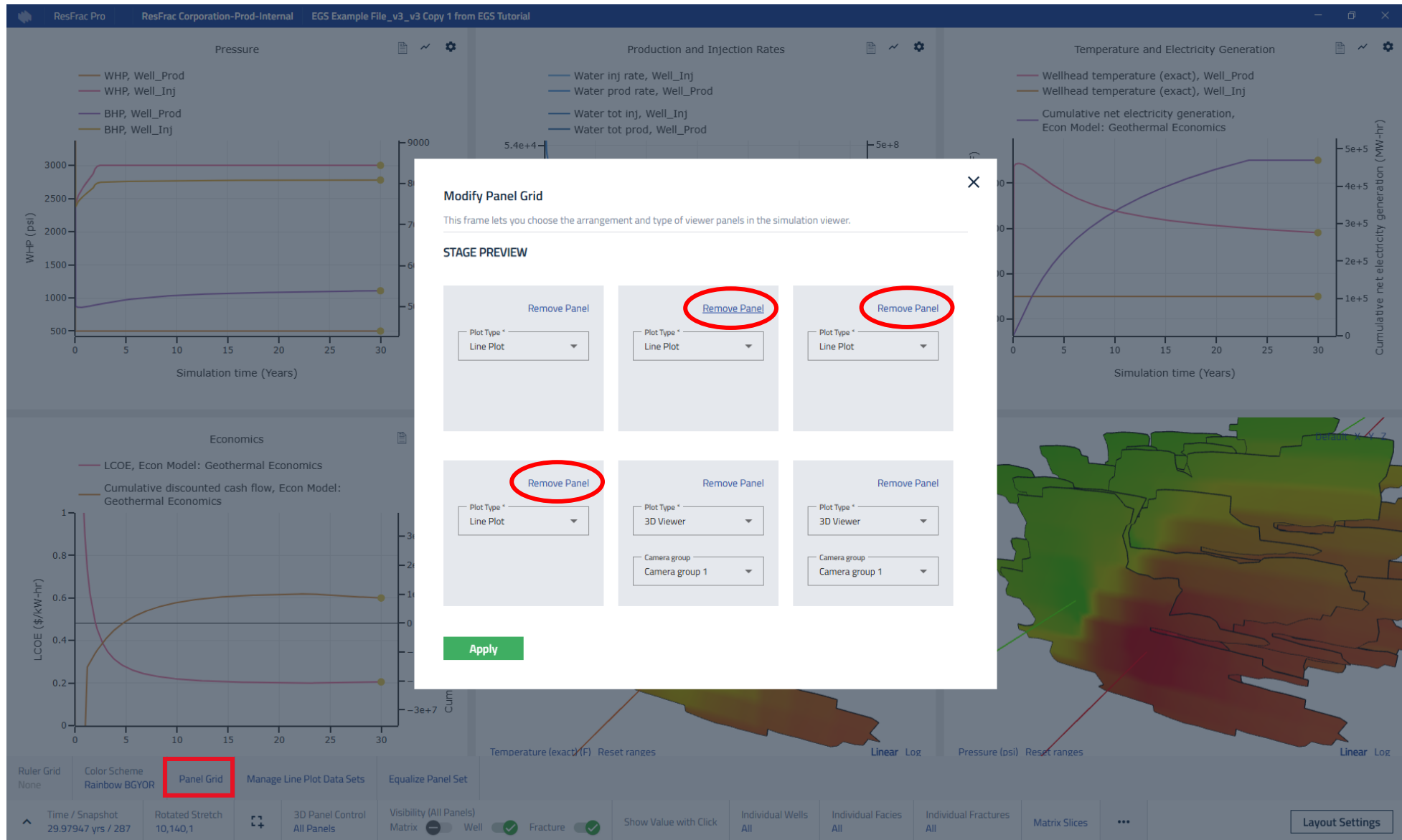
Viz Tool: Phase II Results – Return to the Saved Layout View

Now to remove the Phase I data, just re-load the original layout.



Viz Tool: Panel Grid

Remove line plots 2-4, keeping only the pressure line plot and the two 3D views.

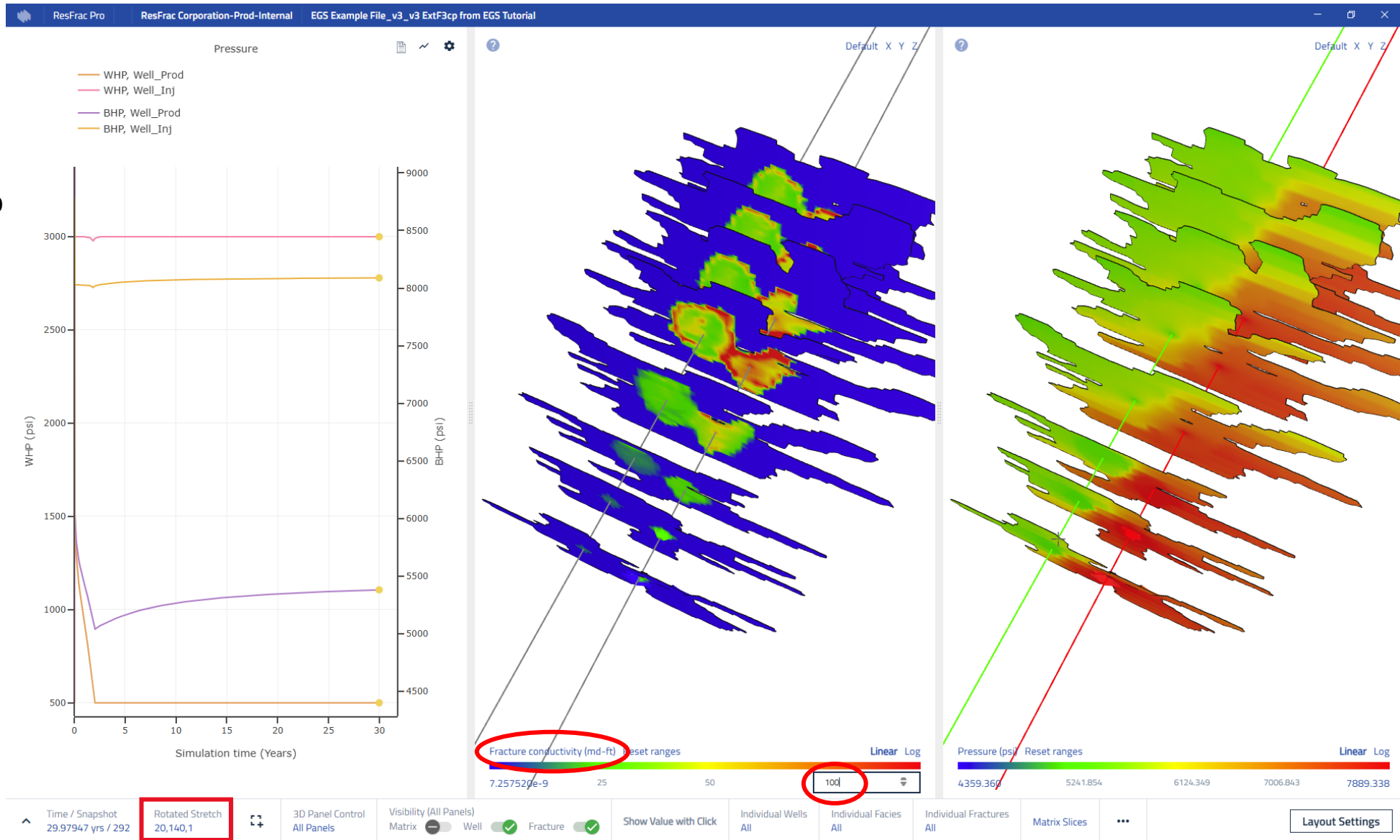


Viz Tool: 3D Plots – Fracture Conductivity (1 of 4)

Convert the first 3D plot parameter to 'Fracture Conductivity', and change the max value to 100 mD.

View fracture conductivity. Scale from 0 to 100 mD to compare with the 50 mD in Phase I.

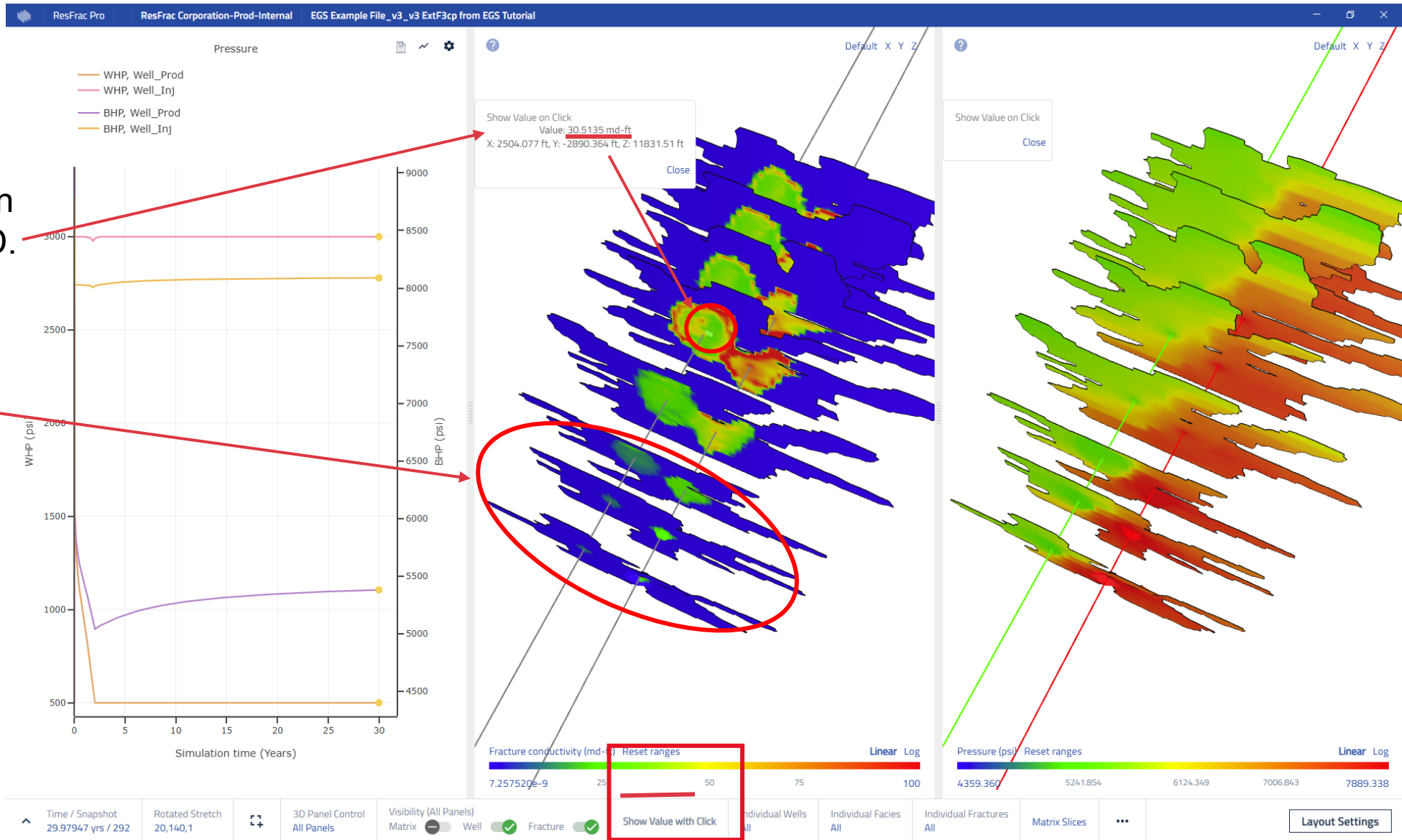
Increase the horizontal stretch to 20 and rotate to view fractures.



Viz Tool: 3D Plots – Fracture Conductivity (2 of 4)

Much of the fracture area hovers between 25 and 100 mD.

However, the toe fracs show diminished fracture conductivity (due to poor proppant placement).

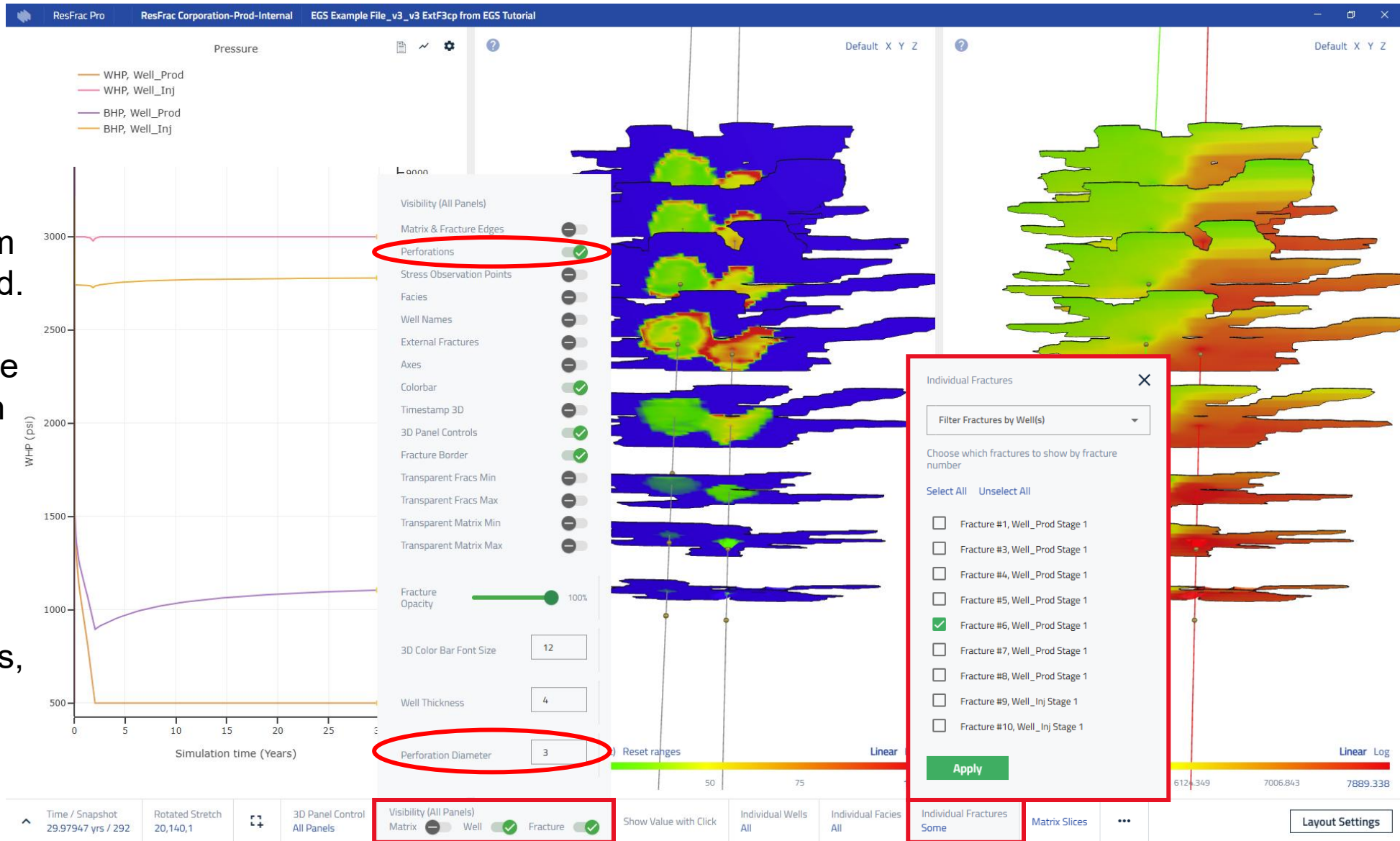


Viz Tool: 3D Plots – Fracture Conductivity (3 of 4)

Turn on perforations and filter by fracture - choose a representative fracture to view.

Fractures are numbered based on the perforation from which it initiated.

If a new fracture merges with an existing one, it may not create a new named fracture (thus, there are 8 Well_Prod fracs, but only 2 Well_Inj fracs).

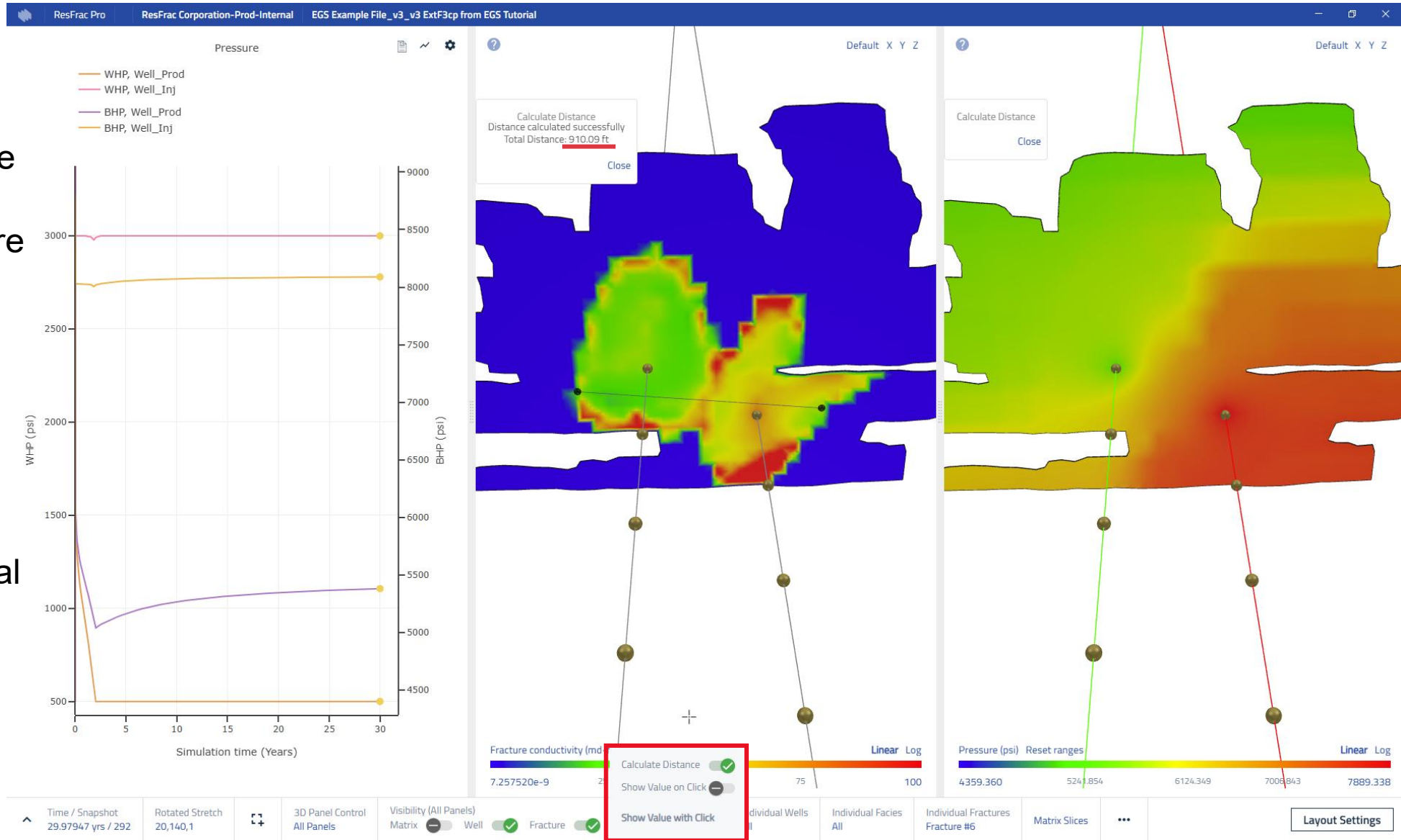


Viz Tool: 3D Plots – Fracture Conductivity (4 of 4)

Measure conductive fracture length.

Use 'Calculate Distance' to see how large the propped fracture is.

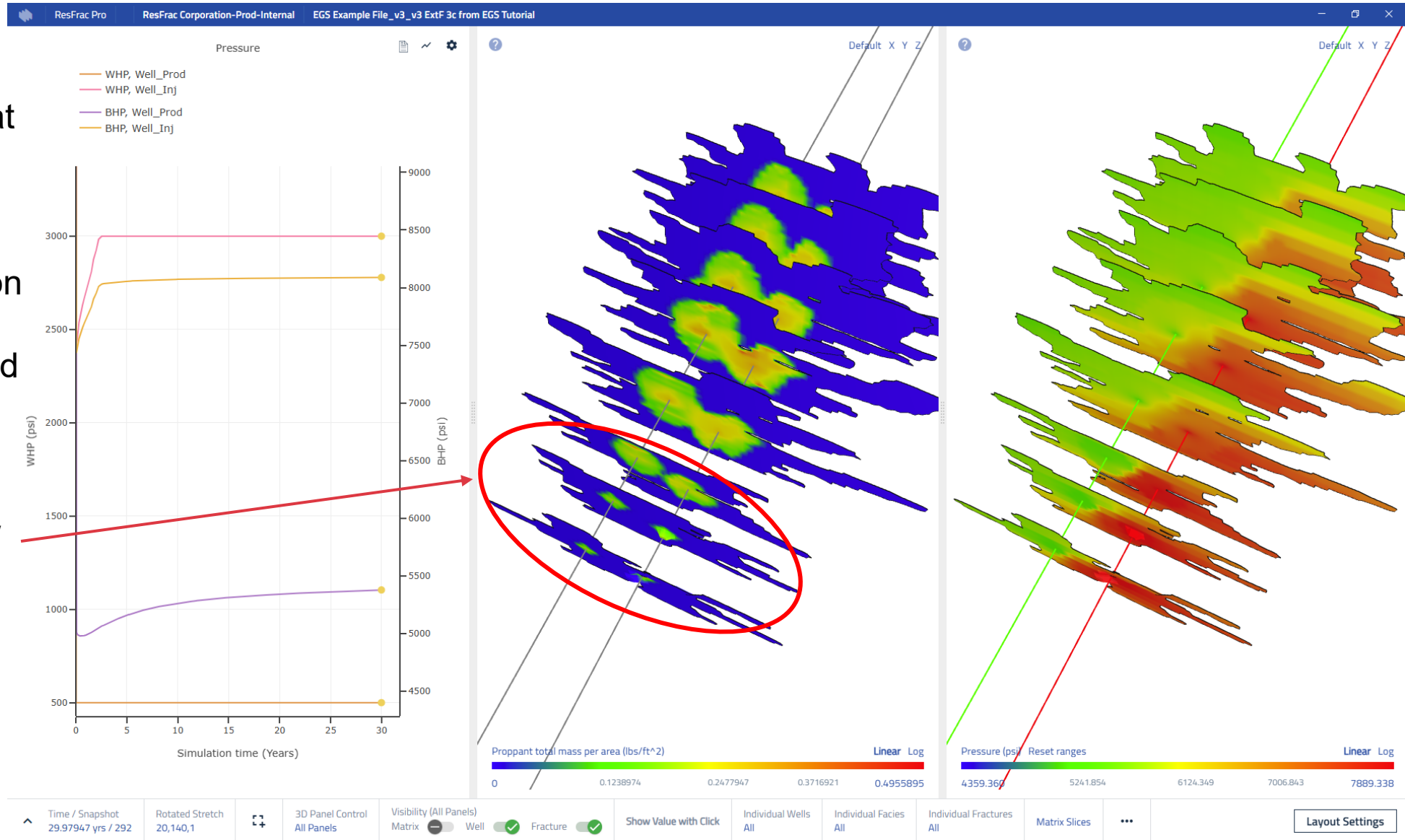
Here, the conductive (propped) fracture length is ~900 ft. In Phase I the total fracture length was 1400 ft.



Viz Tool: 3D Plots – Proppant Placement

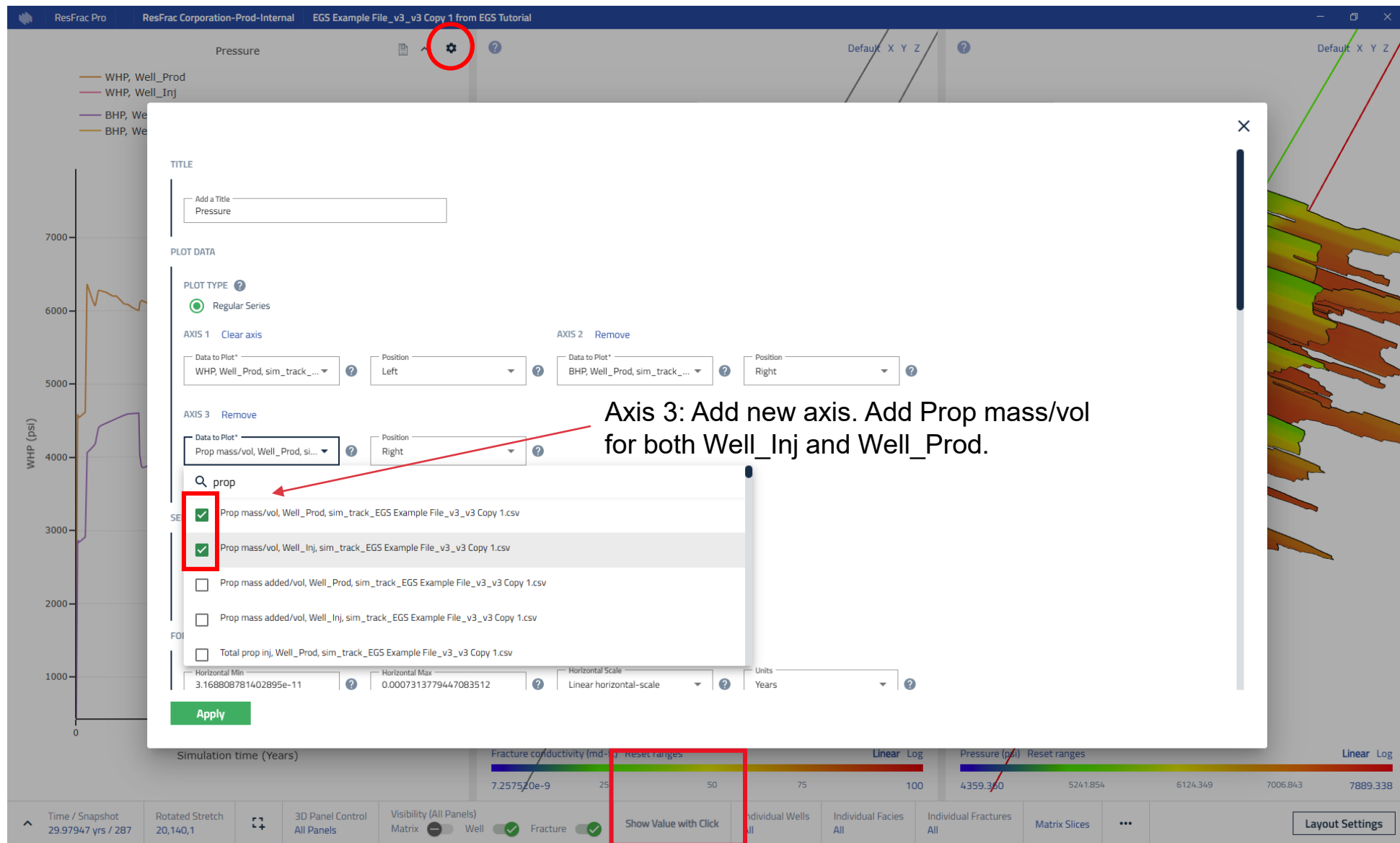
If you do look at the proppant total mass, you'll find a close correlation between conductivity and proppant concentration.

Toe fracs show poor proppant placement



Viz Tool: 3D Plots – Identifying Screenout (1 of 3)

Add proppant injection to the line plot

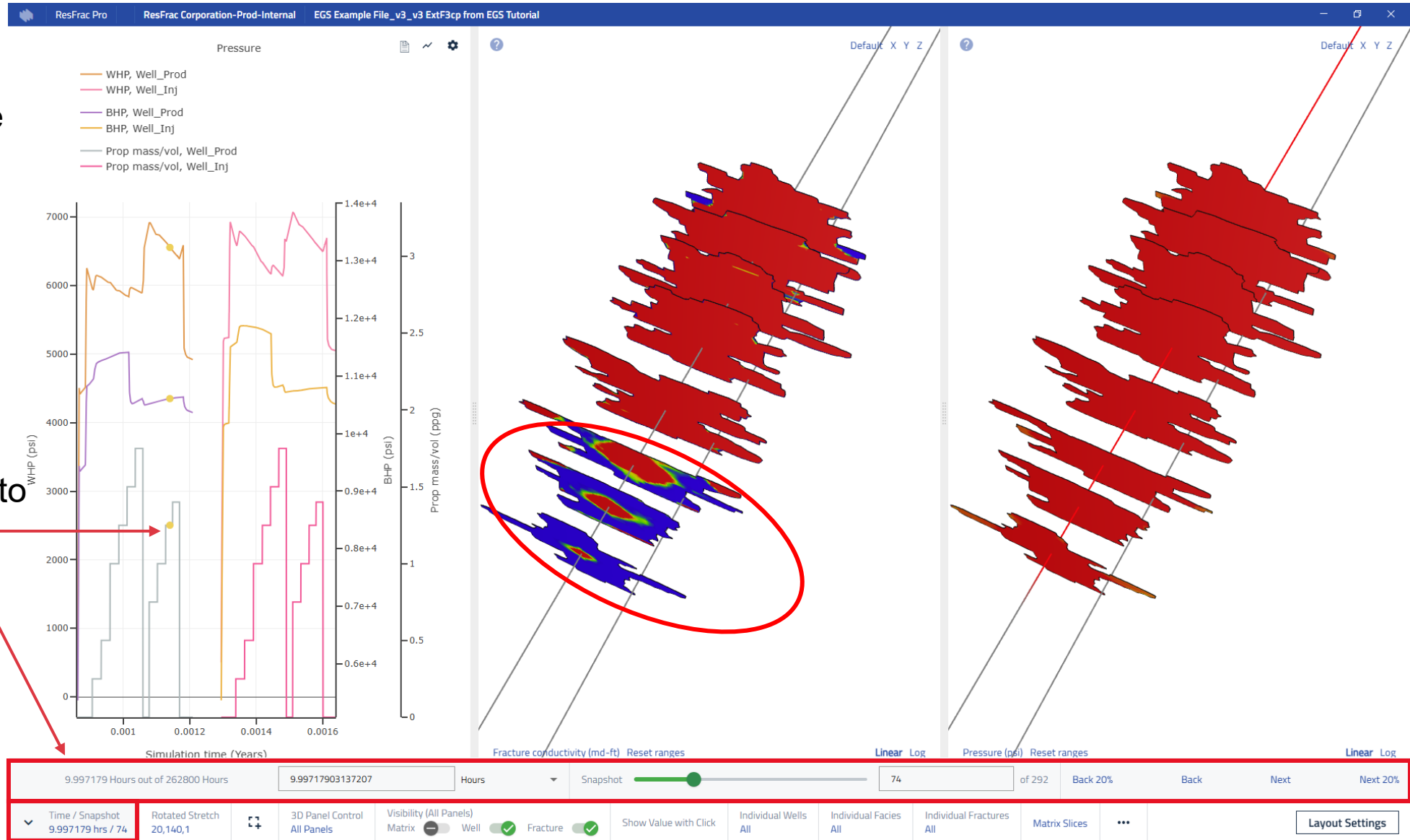


Viz Tool: 3D Plots – Identifying Screenout (2 of 3)

Zoom in on the stimulation period of the line plot. Stagger the axes so each plot is visible.

Change the snapshot time to be during simulation.

Toe fracs still show low conductivity.

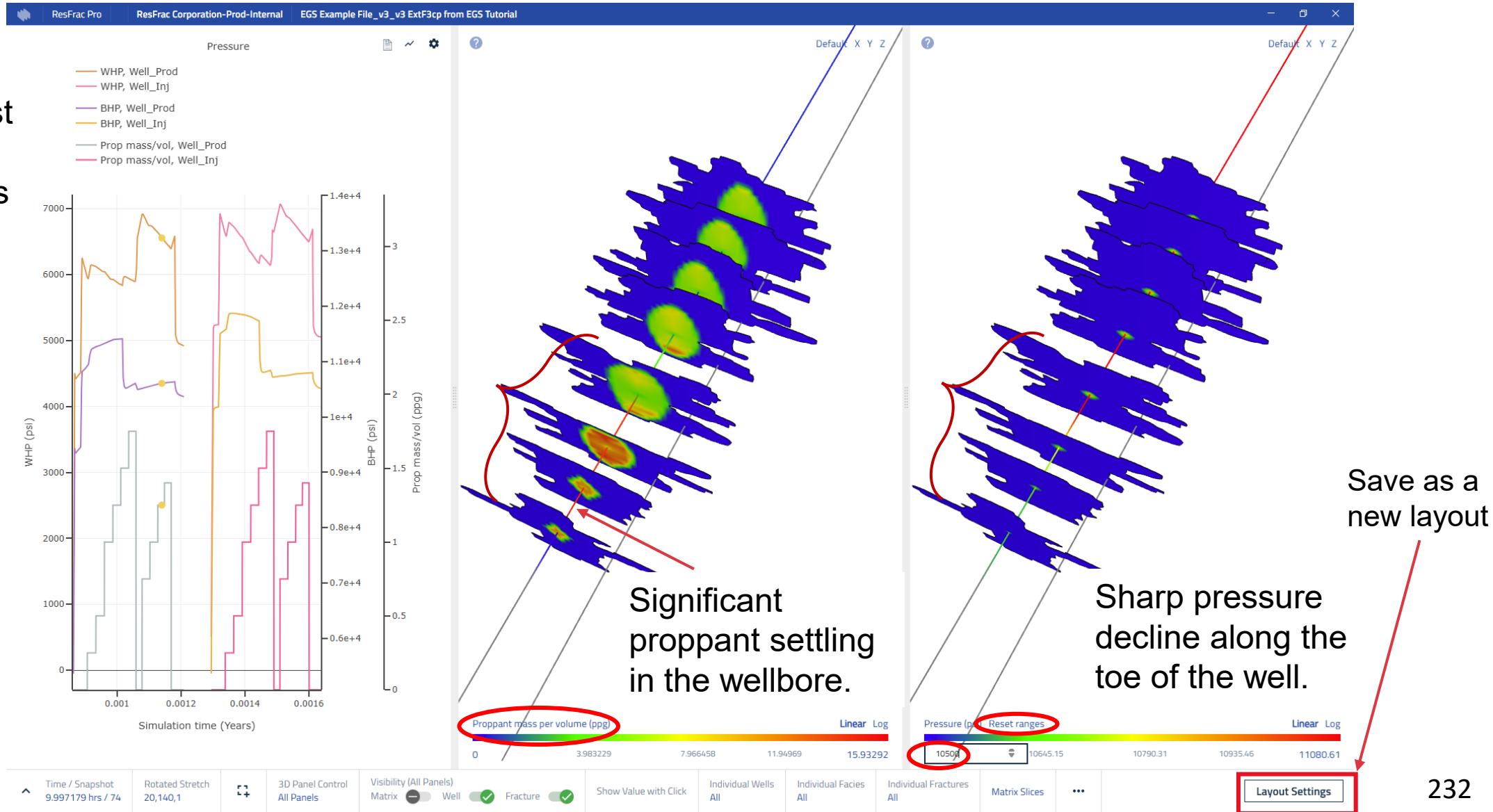


Viz Tool: 3D Plots – Identifying Screenout (3 of 3)

Change the first image to 'Proppant mass per vol'.

Rescale the pressure plot (set min = 10,500 psi)

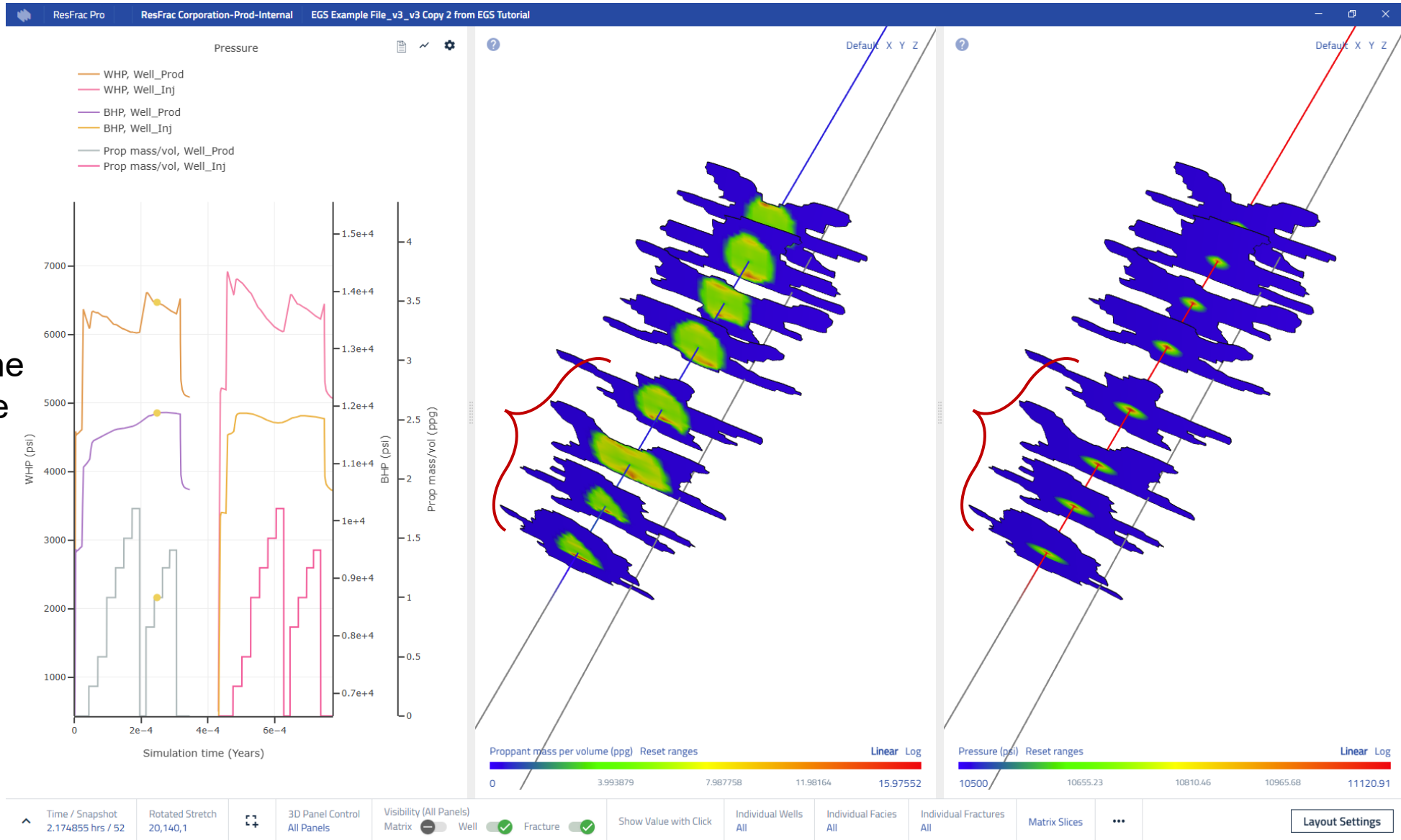
These signals indicate screenout.



Correcting Screenout

Here is a version of the simulation with the slickwater viscosity set at 1.5 cP instead of 0.5 cP.

Observations:
Increasing the fluid viscosity removed significant settling and pressure decline in the toe of the well.

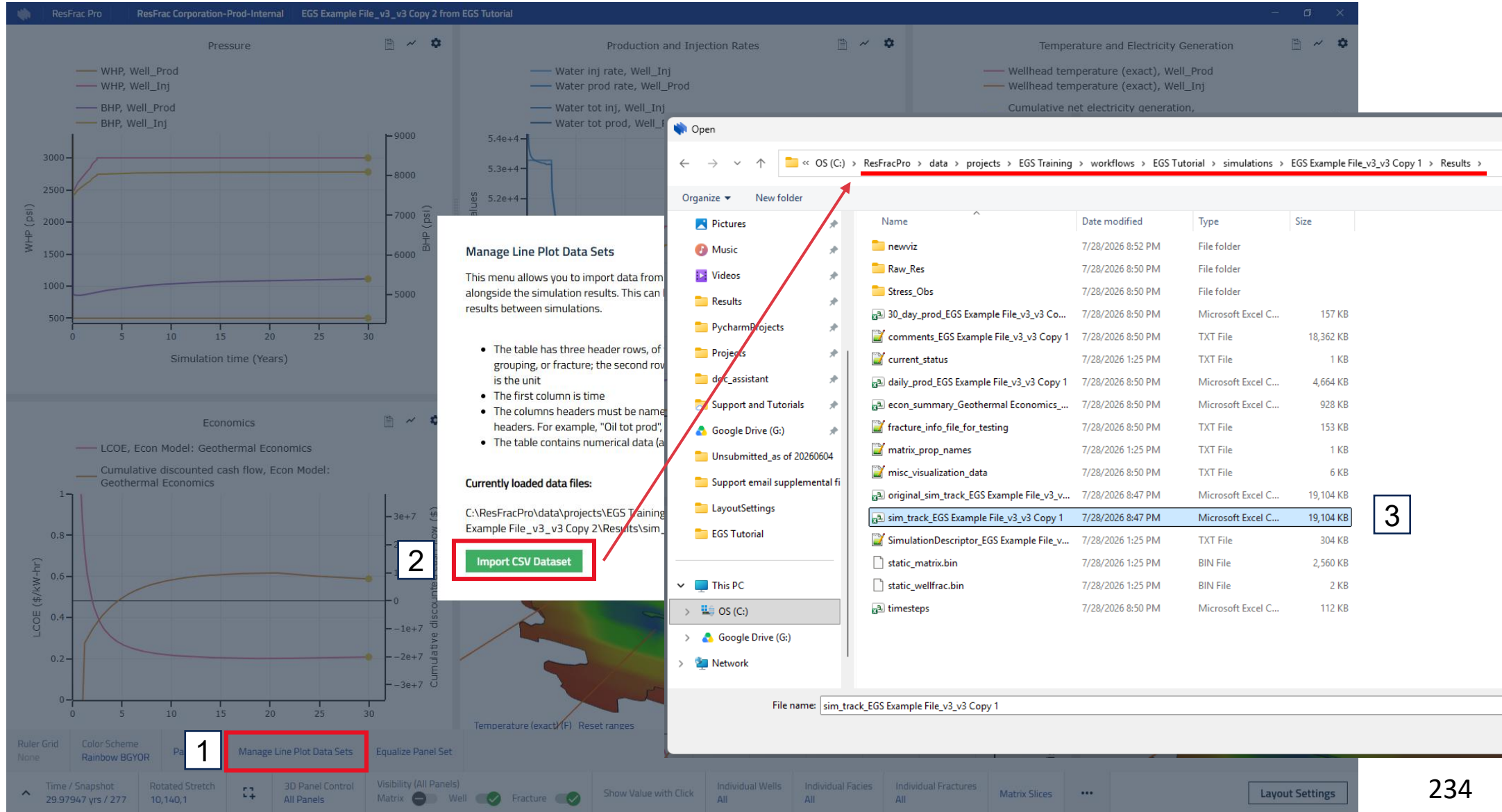


Viz Tool: Import External Dataset – Compare Sims (1 of 3)

Here's how you would compare between the high viscosity case (current) and the low viscosity case (original).

1. Select 'Manage Line Plot Data Sets'
2. 'Import CSV Dataset'
3. Navigate to the sim_track file of the sim you'd like to import

*If importing external data, match sim_track format



The screenshot displays the ResFrac software interface with three main panels: Pressure, Production and Injection Rates, and Temperature and Electricity Generation. A 'Manage Line Plot Data Sets' dialog box is open, showing instructions for importing data and a list of currently loaded data files. A file explorer window is also open, showing the file structure and a list of files. A red arrow points from the 'Import CSV Dataset' button in the dialog box to the 'sim_track_EGS Example File_v3_v3 Copy 1' file in the file explorer.

Manage Line Plot Data Sets

This menu allows you to import data from alongside the simulation results. This can be used to compare results between simulations.

- The table has three header rows, of grouping, or fracture; the second row is the unit
- The first column is time
- The columns headers must be named headers. For example, "Oil tot prod";
- The table contains numerical data (a

Currently loaded data files:

C:\ResFracPro\data\projects\EGS Training
Example File_v3_v3 Copy 2\Results\sim_

Import CSV Dataset

File Explorer:

File name: sim_track_EGS Example File_v3_v3 Copy 1

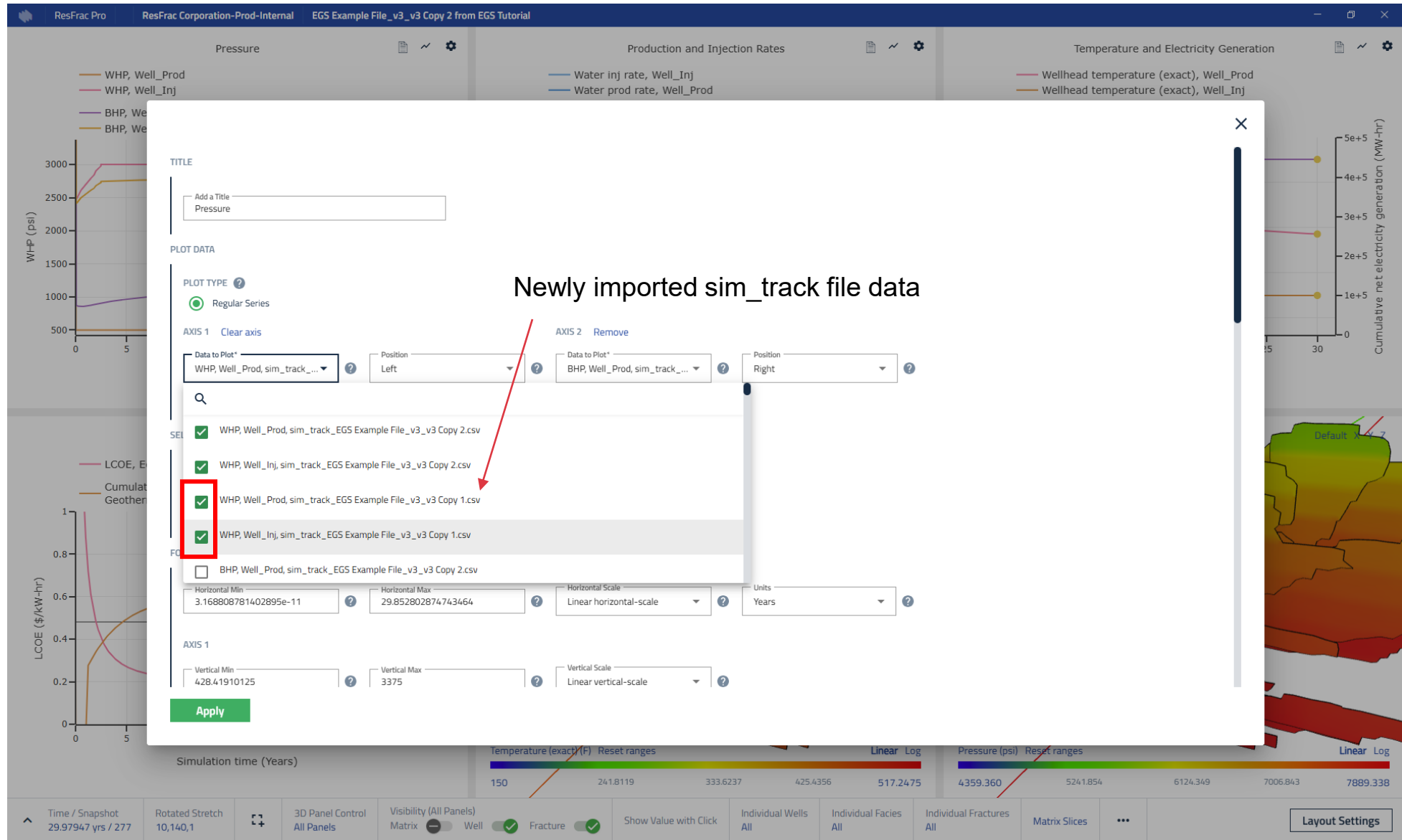
Name	Date modified	Type	Size
newviz	7/28/2026 8:52 PM	File folder	
Raw_Res	7/28/2026 8:50 PM	File folder	
Stress_Obs	7/28/2026 8:50 PM	File folder	
30_day_prod_EGS Example File_v3_v3 Co...	7/28/2026 8:50 PM	Microsoft Excel C...	157 KB
comments_EGS Example File_v3_v3 Copy 1	7/28/2026 8:50 PM	TXT File	18,362 KB
current_status	7/28/2026 1:25 PM	TXT File	1 KB
daily_prod_EGS Example File_v3_v3 Copy 1	7/28/2026 8:50 PM	Microsoft Excel C...	4,664 KB
econ_summary_Geothermal Economics...	7/28/2026 8:50 PM	Microsoft Excel C...	928 KB
fracture_info_file_for_testing	7/28/2026 8:50 PM	TXT File	153 KB
matrix_prop_names	7/28/2026 1:25 PM	TXT File	1 KB
misc_visualization_data	7/28/2026 8:50 PM	TXT File	6 KB
original_sim_track_EGS Example File_v3_v...	7/28/2026 8:47 PM	Microsoft Excel C...	19,104 KB
sim_track_EGS Example File_v3_v3 Copy 1	7/28/2026 8:47 PM	Microsoft Excel C...	19,104 KB
SimulationDescriptor_EGS Example File_v...	7/28/2026 1:25 PM	TXT File	304 KB
static_matrix.bin	7/28/2026 1:25 PM	BIN File	2,560 KB
static_wellfrac.bin	7/28/2026 1:25 PM	BIN File	2 KB
timesteps	7/28/2026 8:50 PM	Microsoft Excel C...	112 KB

Viz Tool: Import External Dataset – Compare Sims (2 of 3)

Let's compare between the high viscosity case (current) and the low viscosity case (original).

For each axis, select the same parameters loaded from the new sim_track file.

Turn the legends 'off' to save on space.

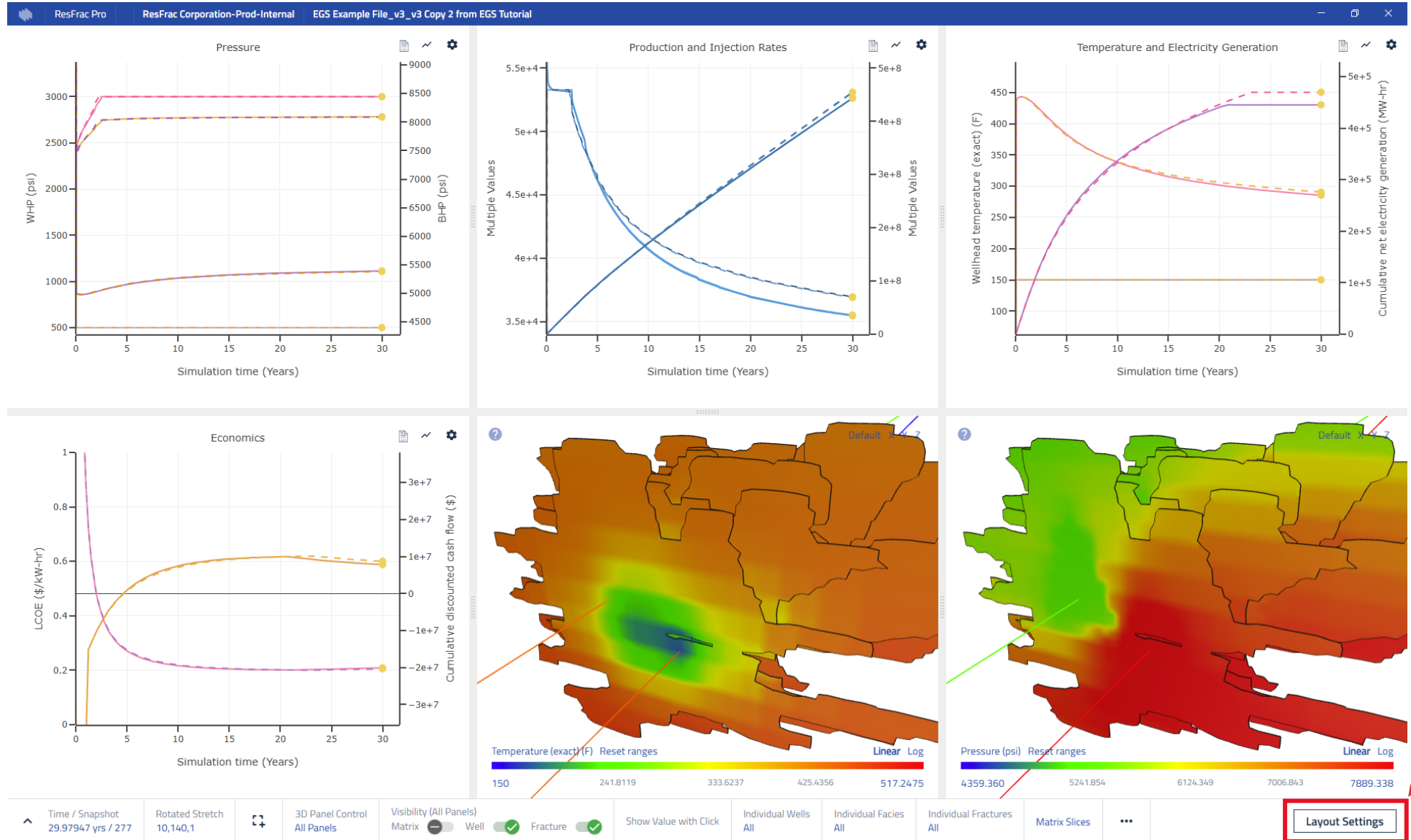


Viz Tool: Import External Dataset – Compare Sims (3 of 3)

Let's compare the high viscosity case (current) to the low viscosity case (original) using the 6-panel layout.

The external csv (original) data is automatically dashed.

Despite removing screenout, overall impact is minimal because frac #3 is creating a short-circuit.



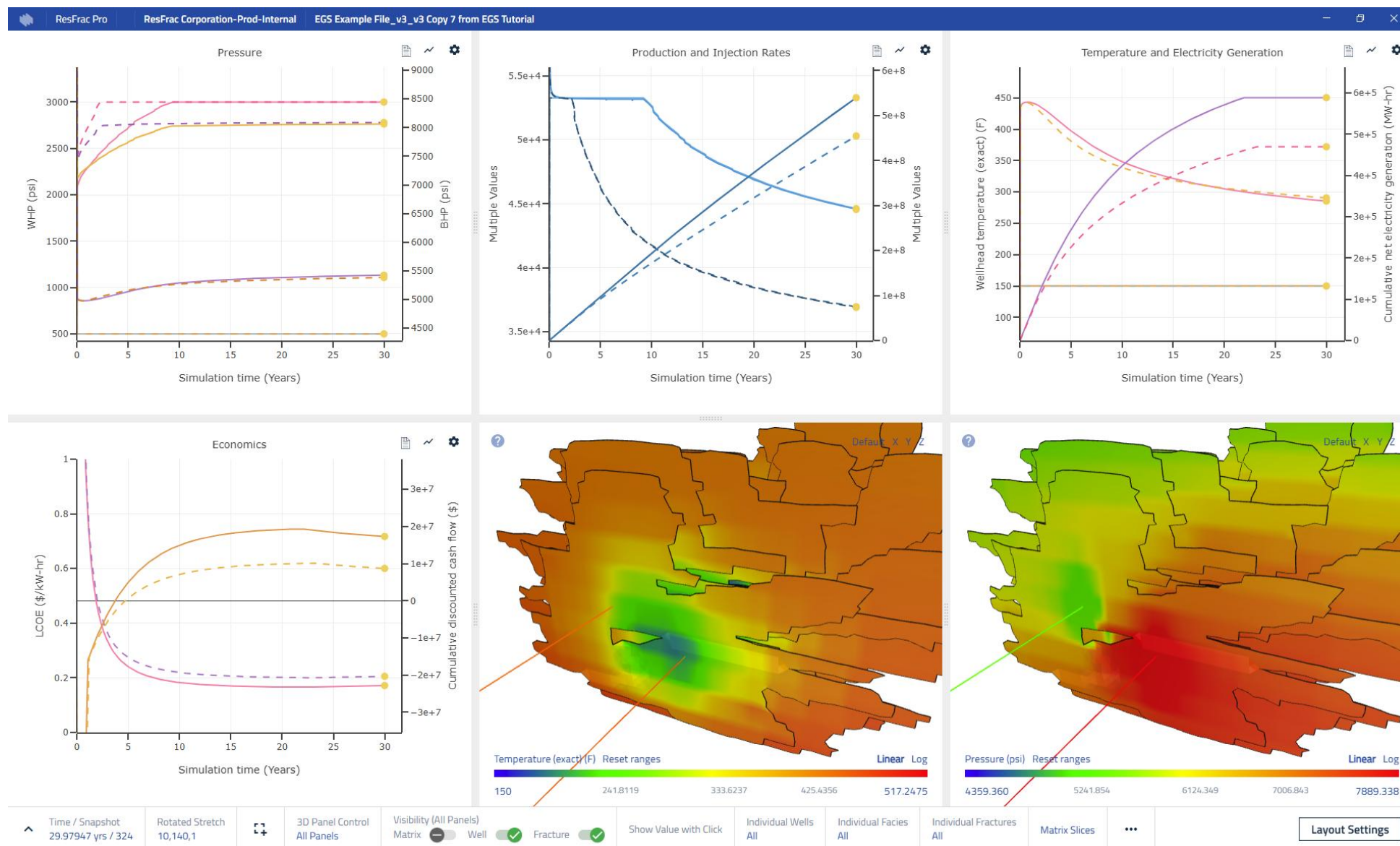
Open 6 panel layout

Viz Tool: Import External Dataset – Compare Job Size

This time, let's compare a sim with a 15% larger job size to our original sim.

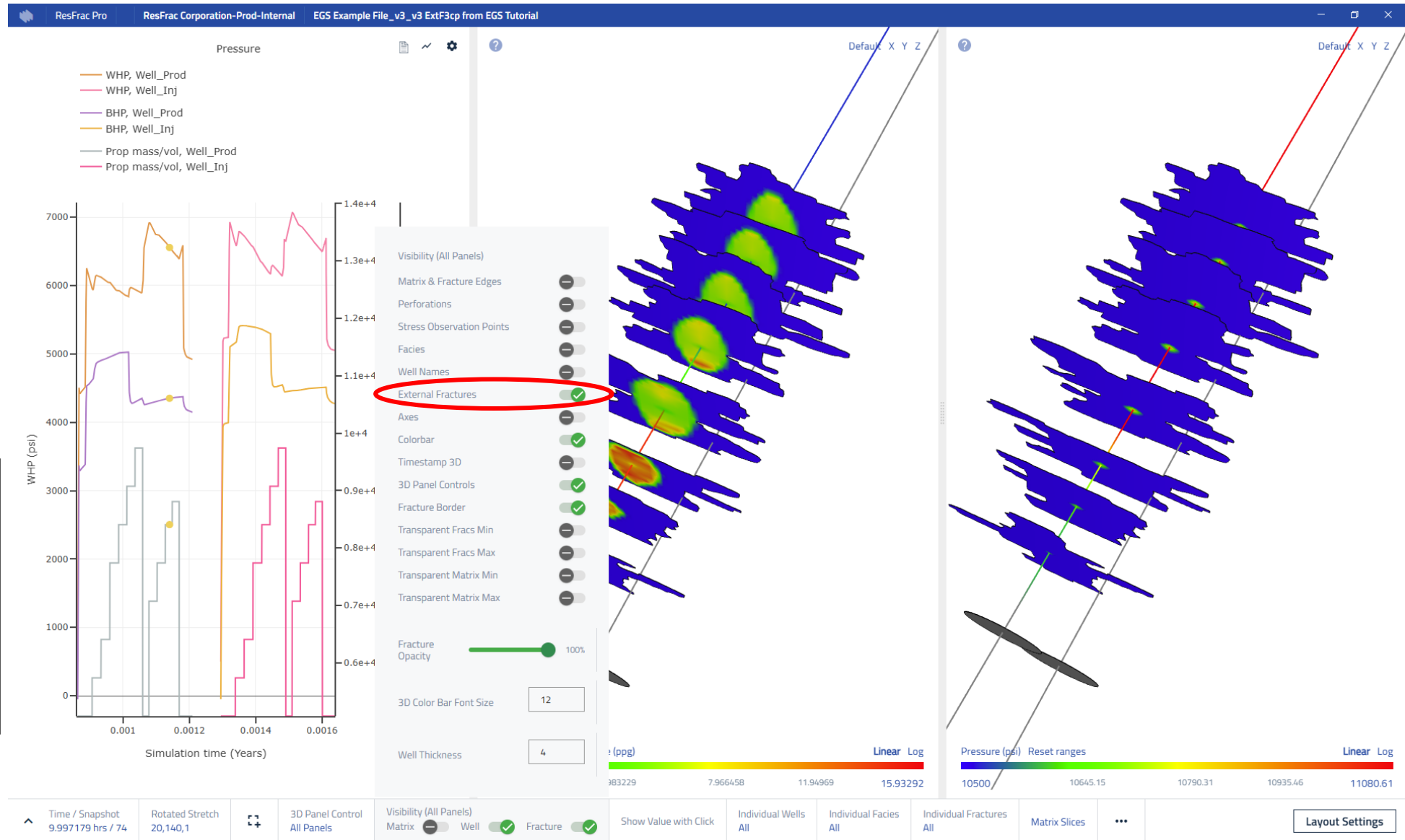
The external csv (original) data is automatically dashed.

Pressure limit is reached later, leading to greater production, net electricity, and NPV.



Viz Tool: Stress Observation Planes (1 of 5)

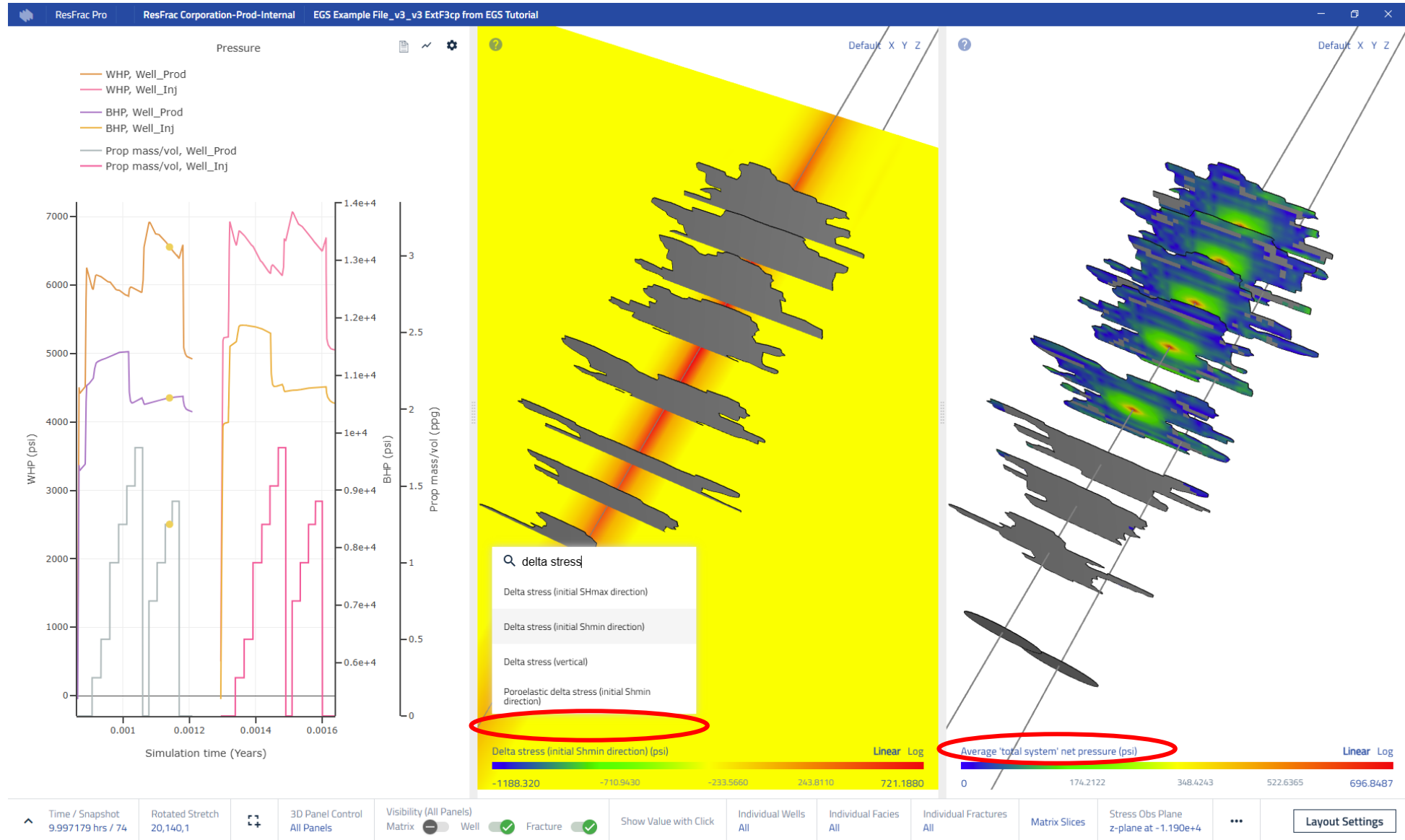
Turn on external fractures so we can observe the stress shadow imposed on the sector.



A ResFrac Mini-Guide on Stress Observation Points and Planes is also available at this [link](#).

Viz Tool: Stress Observation Planes (2 of 5)

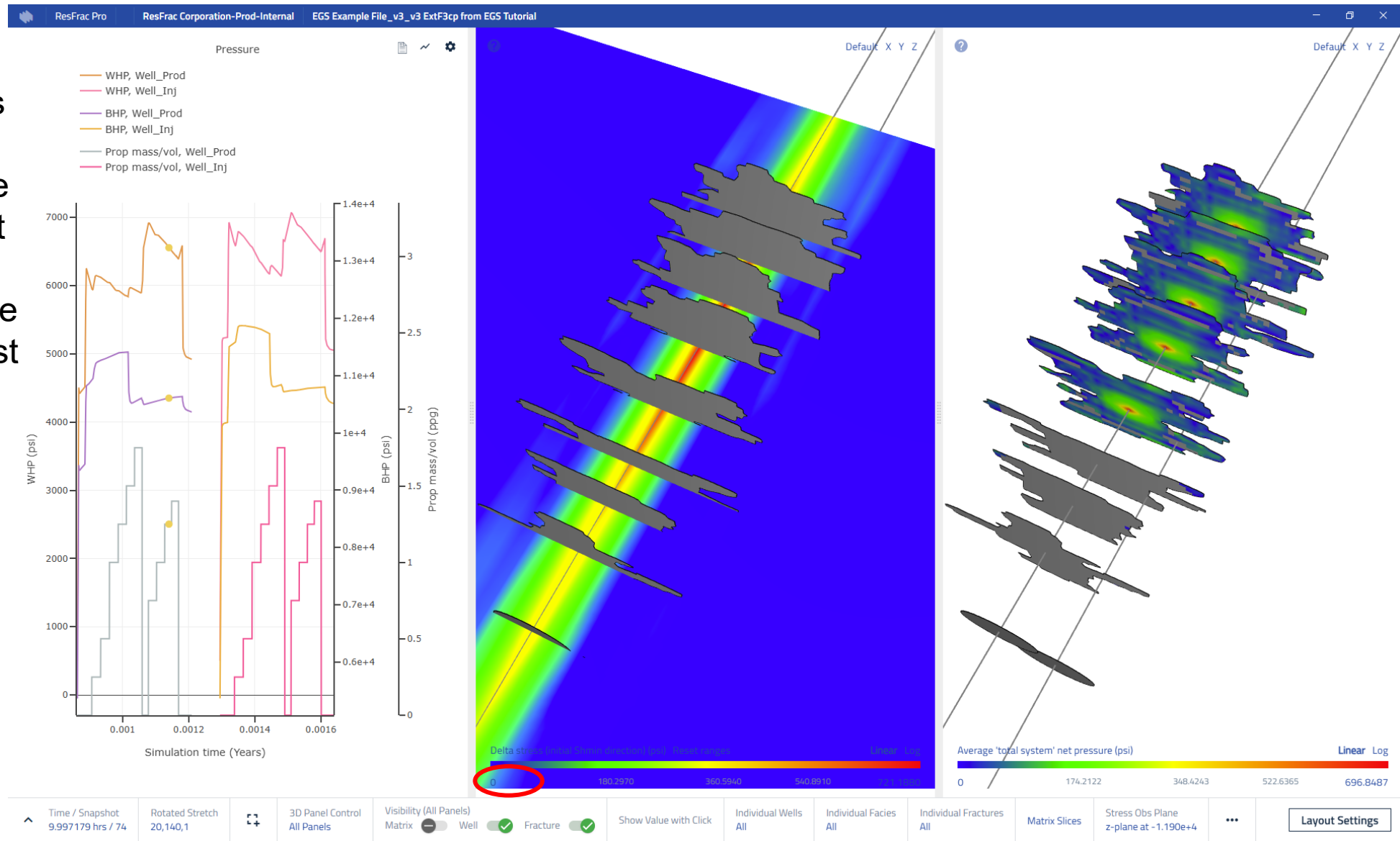
View 'Delta stress (initial Shmin direction)' to view the stress shadow from the fractures opening.



Viz Tool: Stress Observation Planes (3 of 5)

Set the minimum delta stress value to 0 psi.

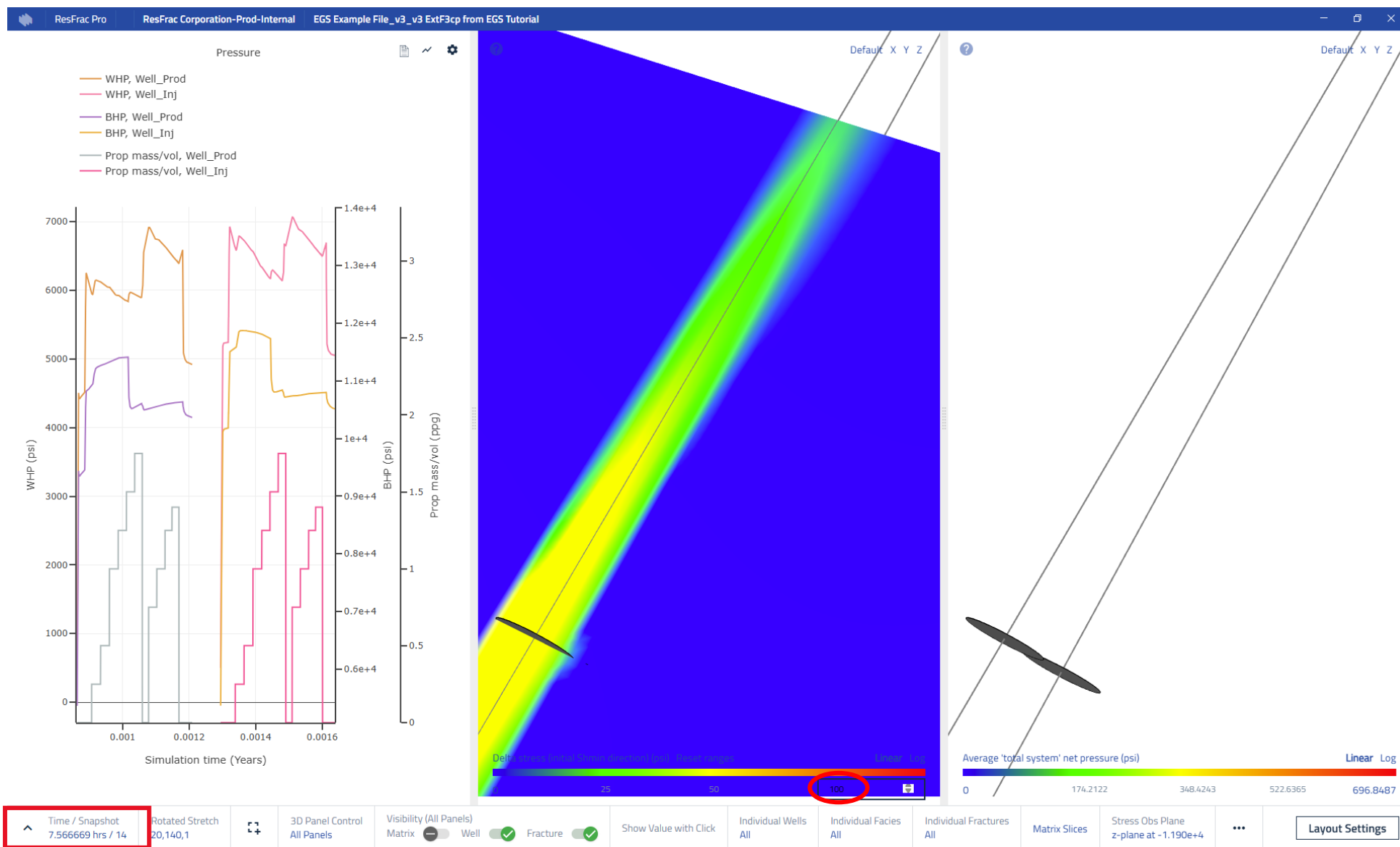
Observations:
Greatest stress shadowing occurs near the wellbore and at the upper fractures, where there is greatest net pressure.



Viz Tool: Stress Observation Planes (4 of 5)

Change time to right before stimulation, to see the residual stress shadow exhibited by the external fractures.

Observations:
Peak delta stress is about 50 psi – which matches the residual net pressure defined in the external fractures table.



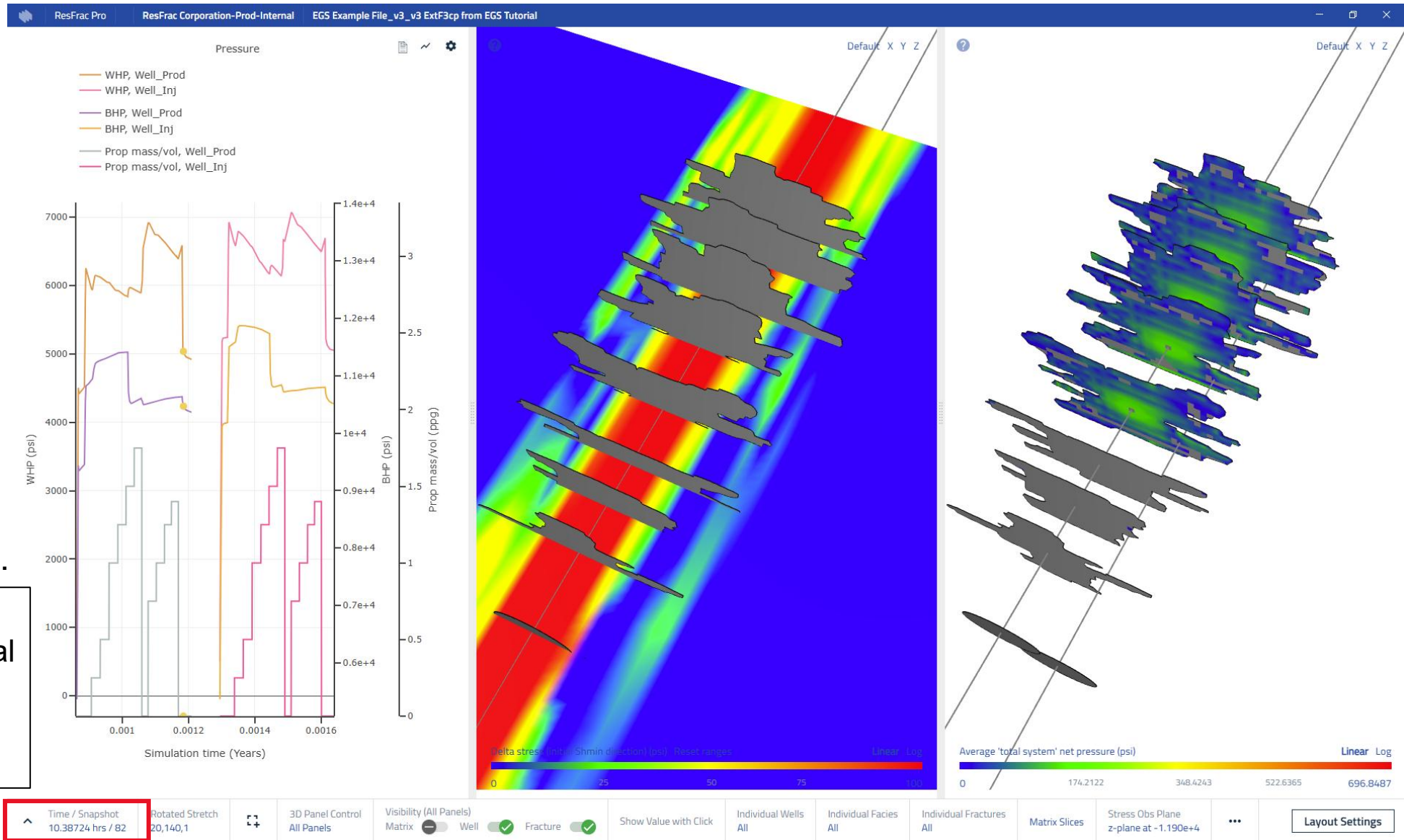
Viz Tool: Stress Observation Planes (5 of 5)

Change time to right end of Well_Prod stimulation to see peak stress shadow.

Observations:

This plane allows you to estimate net pressure, time to closure, and residual stress shadow. This data can be used to populate the External Fractures table.

A ResFrac Mini-Guide on External Fractures is also available at this [link](#).



Click “square icon” to make a movie or save a screenshot

Making a movie can be a good way to monitor changes in the 3D view over time.

The screenshot displays the ResFrac software interface. On the left, a 2D plot shows simulation time (Years) on the x-axis (0.001 to 0.0016) and a y-axis with values 0, 1000, and 2000. On the right, a 3D visualization shows a stress field with a color scale from 0 to 50. Below the 3D view, a 3D panel control menu is visible, containing options for 'Make a Movie' and 'Take a screenshot'. A red box highlights these two options. Arrows point from these options to two separate dialog boxes: 'Take a screenshot' and 'Make Movie'.

Take a screenshot

Screenshot file location* [Browse](#)

☐ Include ResFrac Logo

☐ Include Simulator Version

[Make screenshot](#) [Cancel](#)

Make Movie

Movie file location* [Browse](#)

First Snapshot* 1 Last Snapshot* 292 Number of snapshots included* 292

Movie length (seconds)* 20 Time scaling* Constant time per snapshot

☐ Include ResFrac Logo

☐ Include Simulator Version

☒ Show simulation time

[Make movie](#) [Cancel](#)

Click square icon to open panel

Viz Tool: Additional Outputs – VFR and frac hit trackers (1 of 2)

You can show Volume to First Response (VFR) and frac hits on the injection plot.

“Add new Axis”

On Axis 4, add: Frac hit counter

“Add new Axis”

On Axis 5, plot: VFR

A ResFrac Mini-Guide on Volume to First Response and Frac Hit Trackers is also available at this [link](#).

The screenshot shows the 'Viz Tool' interface with the following configuration:

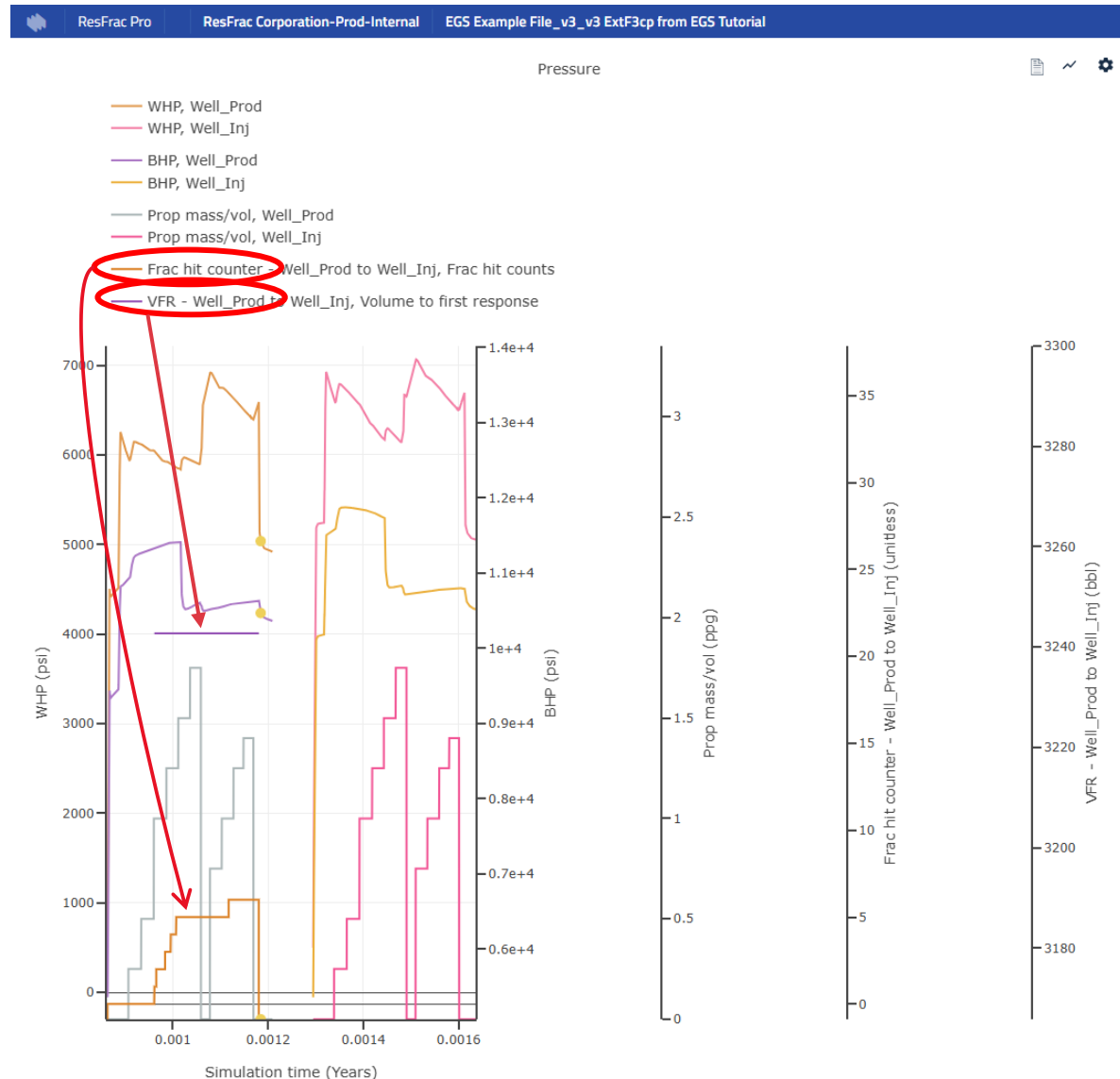
- TITLE:** Add a Title (Pressure)
- PLOT DATA:**
 - PLOT TYPE:** Regular Series
 - AXIS 1:** Clear axis. Data to Plot*: WHP, Well_Prod, sim_track_...; Position: Left
 - AXIS 2:** Remove. Data to Plot*: BHP, Well_Prod, sim_track_...; Position: Right
 - AXIS 3:** Remove. Data to Plot*: Prop mass/vol, Well_Prod, si...; Position: Right
 - AXIS 4:** Remove. Data to Plot*: Frac hit counter - Well_Prod t...; Position: Right
 - AXIS 5:** Remove. Data to Plot*: VFR - Well_Prod to Well_Inj, ...; Position: Right
- SELECT:** A dropdown menu is open, showing a list of data series. The selected series is 'VFR - Well_Prod to Well_Inj, Volume to first response, sim_track_EGS Example File_v3_v3 ExtF 3c.csv'.

Viz Tool: Additional Outputs – VFR and frac hit trackers (2 of 2)

You can show Volume to First Response (VFR) and frac hits on the injection plot.

This shows 6 total frac hits in the adjacent well, with the first frac hit occurring after 3,240 bbl were injected.

A ResFrac Mini-Guide on Volume to First Response and Frac Hit Trackers is also available at this [link](#).



Viz Tool: Additional Outputs – Extra fracture info (1 of 2)

You can also show extra fracture information, which splits results up by each fracture or perforation.

Here we can use the injection plot as a base.

“Remove” Axis 2-5

On Axis 2, add any frac info of interest. In this case, we selected the height and length of the fracture.

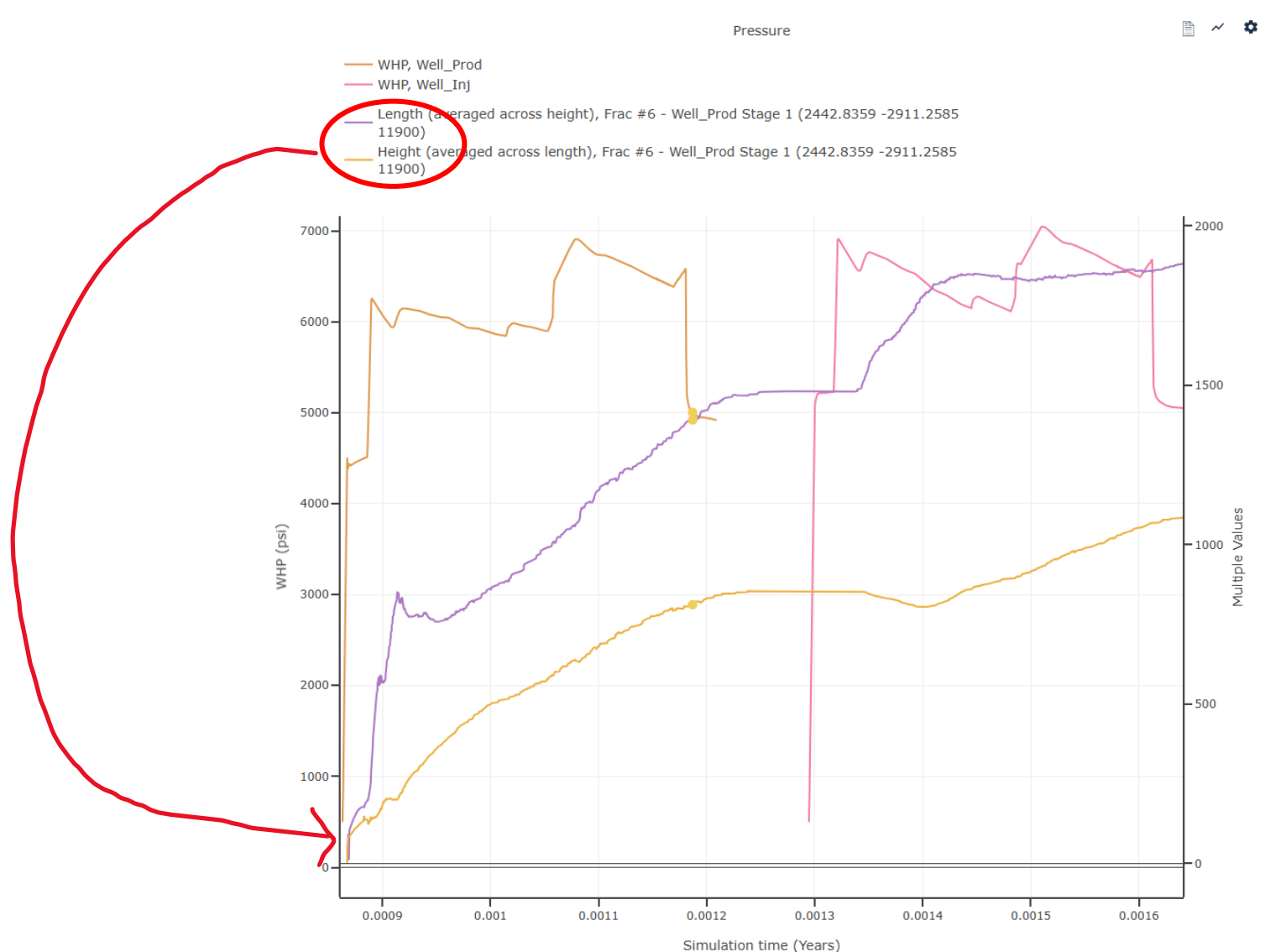
The screenshot shows the 'Viz Tool' interface with the following sections:

- TITLE:** A text box containing 'Pressure'.
- PLOT DATA:**
 - PLOT TYPE:** 'Regular Series' is selected.
 - AXIS 1:** 'Clear axis' button. 'Data to Plot*' is 'WHP, Well_Prod, sim_track_...'. 'Position' is 'Left'.
 - AXIS 2:** 'Remove' button. 'Data to Plot*' is 'Length (averaged across heig...'. 'Position' is 'Right'.
- SELECT WELL(S):** A text box for selecting wells. Below it, a checkbox 'Apply well selection to all normal line plots' is unchecked, and an 'Apply well selection' button is present.
- FORMATTING:** 'Reset to defaults' button. 'Horizontal Min' is '0.0008597562203722785', 'Horizontal Max' is '0.0015867064567856013'. 'Vertical Min' is '-297.726322819149', 'Vertical Max' is '7214.368714680852'. 'Vertical Scale' is 'Linear vertical-scale'. 'Horizontal Scale' is 'Linear horizontal-scale'. 'Units' is 'Years'.
- AXIS 1:** A section for axis configuration.
- AXIS 2:** A section for axis configuration.

A red bracket on the left side of the 'PLOT DATA' section indicates the 'Remove' button for Axis 2. A red arrow points from the 'Search for a given frac number, e.g. "Frac #1" to see available plots.' text to the search bar in the 'AXIS 2' section, which contains 'frac #6'. Below the search bar, a list of data series is shown, with 'Length (averaged across height), Frac #6 - Well_Prod Stage 1 (2442.8359 - 2911.2585 11900), si File_v3_v3 ExtF3cp.csv' and 'Height (averaged across length), Frac #6 - Well_Prod Stage 1 (2442.8359 - 2911.2585 11900), si File_v3_v3 ExtF3cp.csv' selected. A red box highlights the 'Apply' button at the bottom of the interface.

Viz Tool: Additional Outputs – Extra fracture info (2 of 2)

Here we see the fracture growing during stimulation. Frac by frac production parameters could also be shown.



Improving Simulation Results

The completion design in this model is underperforming. Try iterating on some parameters to improve the performance.

- **Parameters to test:**

- Higher frac fluid viscosity – to improve proppant placement
- Job size – to improve fracture conductivity and size
- Cluster distribution and perforation phasing – to improve flow uniformity
- Well spacing & configuration

Advanced ResFrac Geothermal Topics

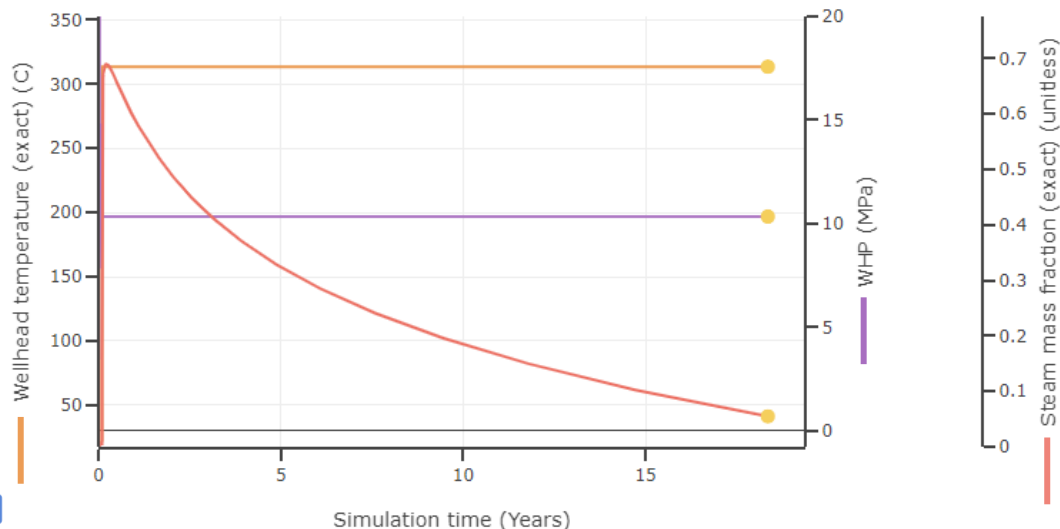
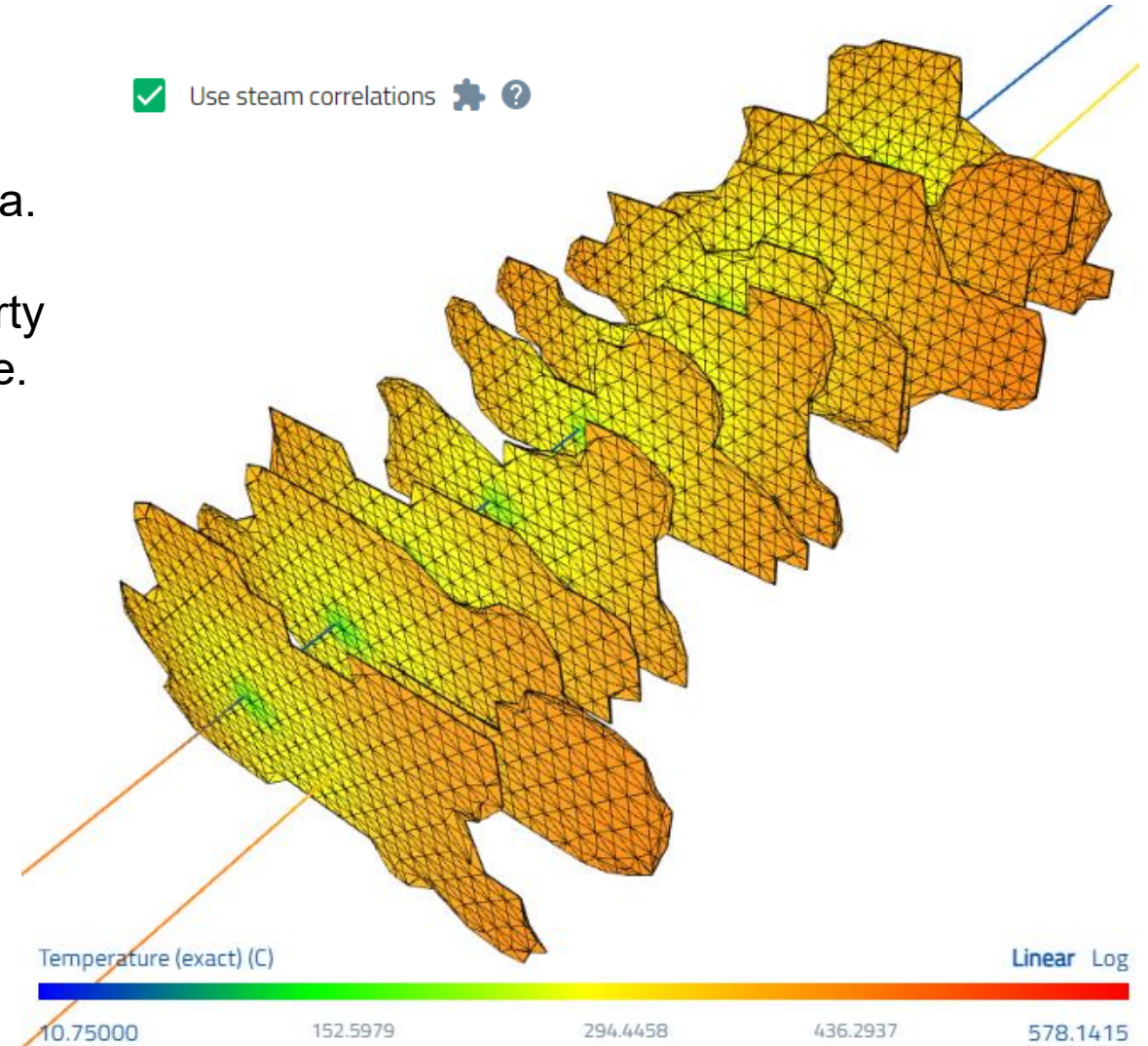
Content

- ResFrac geothermal features:
 - Superhot geothermal
 - Geothermal economics module
 - Pre-existing features
 - Thermo-elasticity
 - Templates
- Tips, tricks and troubleshooting
- Geothermal templates
- Pre-existing fractures
- Tracers
- Dual porosity model
- Thermo-elasticity
- Importing data
- Automated workflows

ResFrac can simulate superhot geothermal conditions

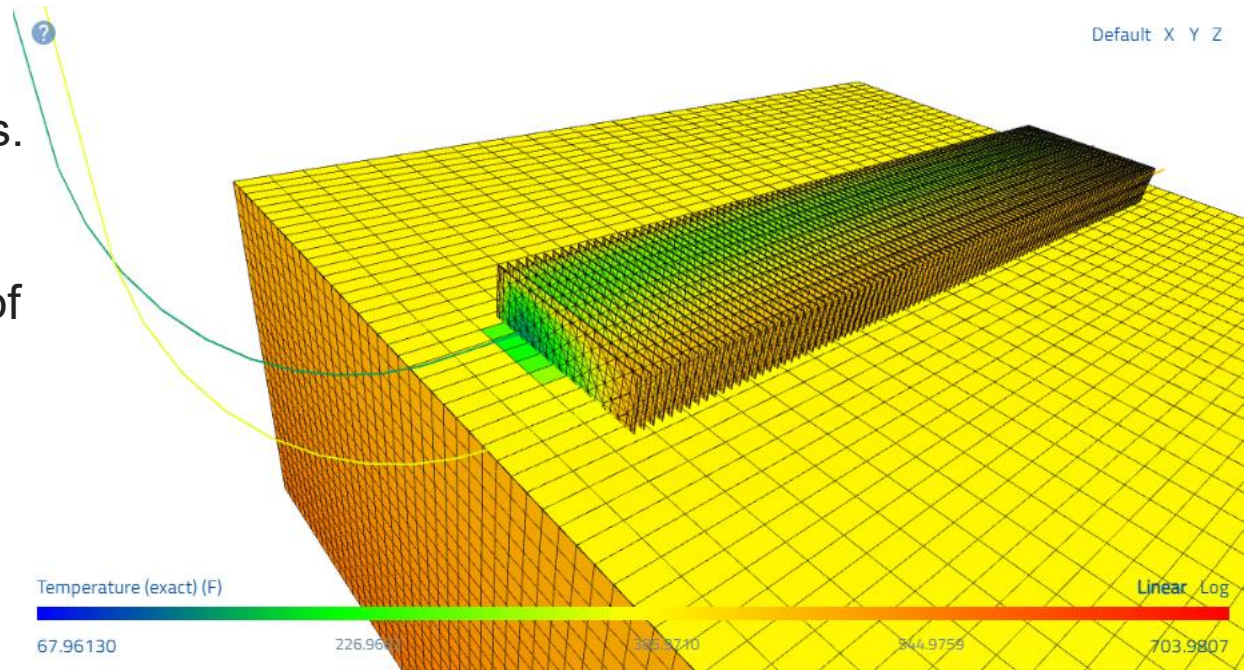
- ResFrac has built-in water property tables (i.e., density, viscosity, enthalpy) for liquid water, steam, two-phase, and supercritical conditions.
- Water properties are valid up to 800°C and 100 MPa.
- Relevant output results include temperature, pressure, steam mass fraction and enthalpy. Property values are available in matrix, fracture, and wellbore.
- Computational time may increase, especially when fluid undergoes phase transitions

✓ Use steam correlations



Pre-existing fractures can simulate natural fractures or synthetic hydraulic fractures

- Pre-existing fractures represent synthetic hydraulically created fractures or pre-existing faults. They can have any orientation and dip angle.
- Pre-existing fractures are computationally fast, which allows to simulate the full reservoir instead of only a section of the reservoir
- Specify pre-existing fracture location, geometry, aperture parameter and/or fracture conductivity under Advanced Options in Static Model and Initial Conditions panel



PREEXISTING FRACTURES ? ? ?

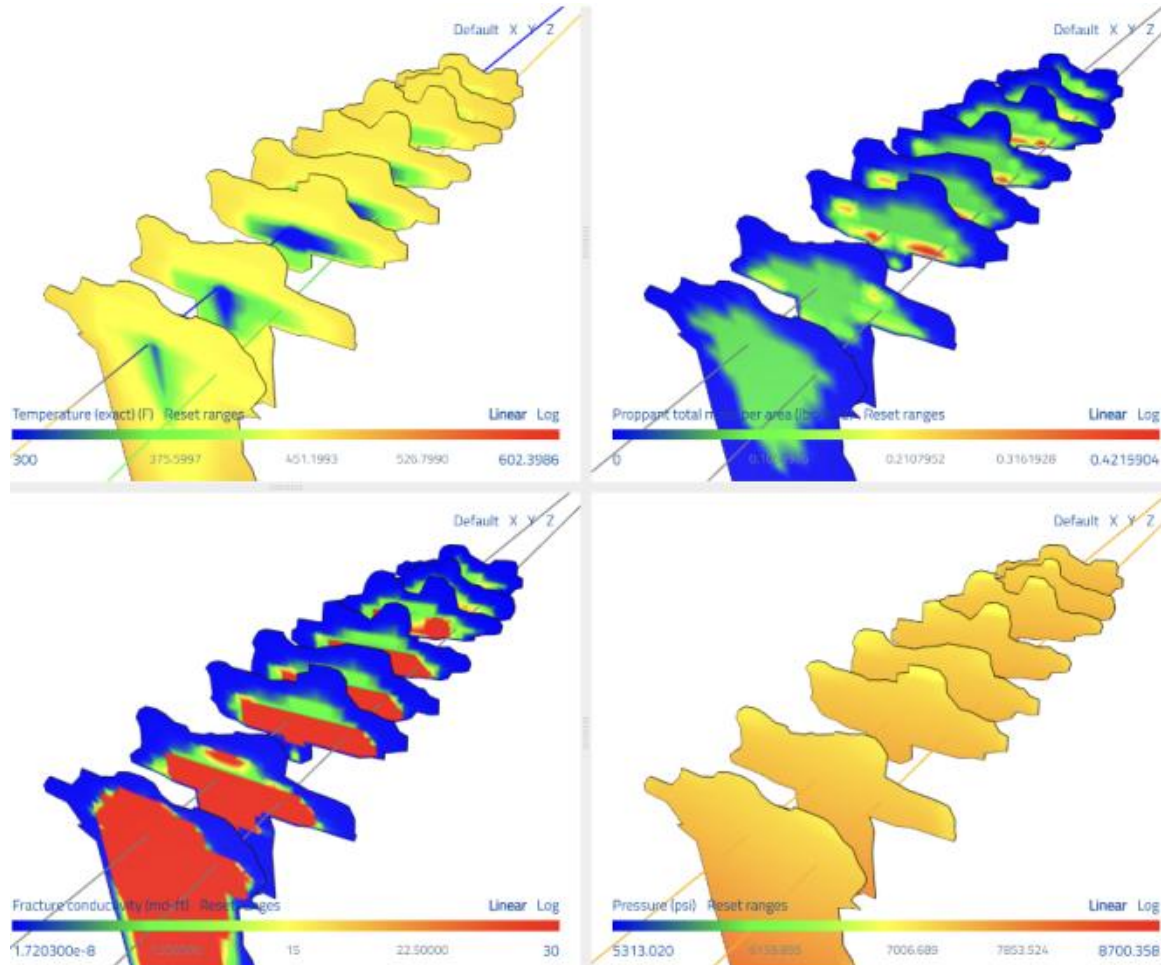
	Center x-coordinate [ft] ?	Center y-coordinate [ft] ?	Center z-coordinate [ft] ?	Fracture full-length [ft] ?	Fracture full-height [ft] ?	Orientation (clockwise from positive y-direction) [degrees] ?	E0 (optional) [ft] ?	Eres (optional) [ft] ?	90% closure stress (optional) [psi] ?	Unpropped conductivity (optional) [md-ft] ?
1	0	6975	13579.1	1000	500	90	0.0006	0	10000000000	
2	0	6925	13579.1	1000	500	90	0.0006	0	10000000000	
3	0	6875	13579.1	1000	500	90	0.0006	0	10000000000	
4	0	6825	13579.1	1000	500	90	0.0006	0	10000000000	
5	0	6775	13579.1	1000	500	90	0.0006	0	10000000000	
6	0	6725	13579.1	1000	500	90	0.0006	0	10000000000	
7	0	6675	13579.1	1000	500	90	0.0006	0	10000000000	
8	0	6625	13579.1	1000	500	90	0.0006	0	10000000000	
9	0	6575	13579.1	1000	500	90	0.0006	0	10000000000	

New Row Resize Table



Cold water injection introduces thermo-elastic stresses causing fracture opening and downward fracture propagation

Thermo-elastic fracture opening due to cold water injection has potential to cause premature breakthrough because of the positive feedback loop. However, it can also cause buoyancy-driven convection and downward crack extension over time, enhancing heat-sweep efficiency.



Thermo-elasticity activated in ResFrac by turning on thermo-elastic stress changes in the matrix and assigning a value for linear expansion coefficient. Thermo-elastic simulations generally increase computational time.

- ☒ Thermoelastic stress changes in the matrix
- ☒ Poroelastic stress changes in the matrix
- ☒ Rotate simulation mesh to align with stresses

Coefficient of linear expansion [1/C]

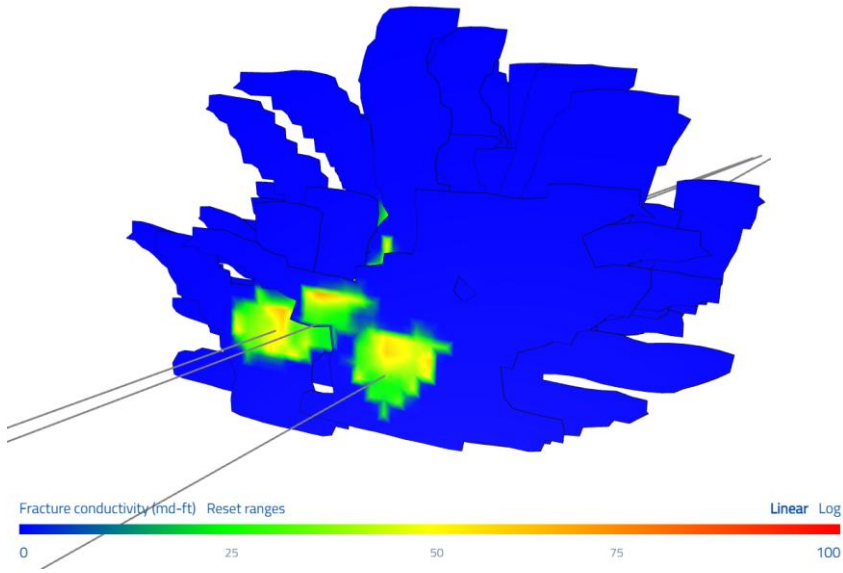
0.00001



Built-in ResFrac templates available to help you with setting-up geothermal models

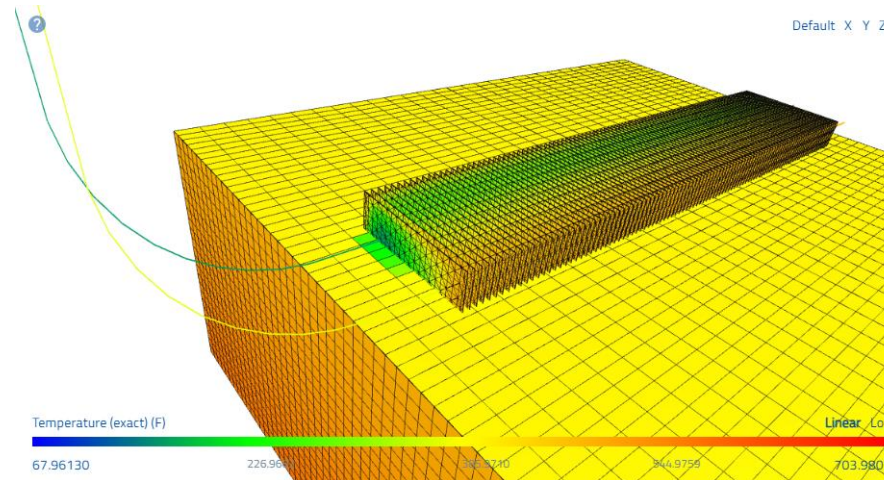
EGS template

3-well EGS model calibrated with publicly-available FORGE and Fervo data. Sector model simulating 1 stage for each well, scaled up to a full reservoir with well flow



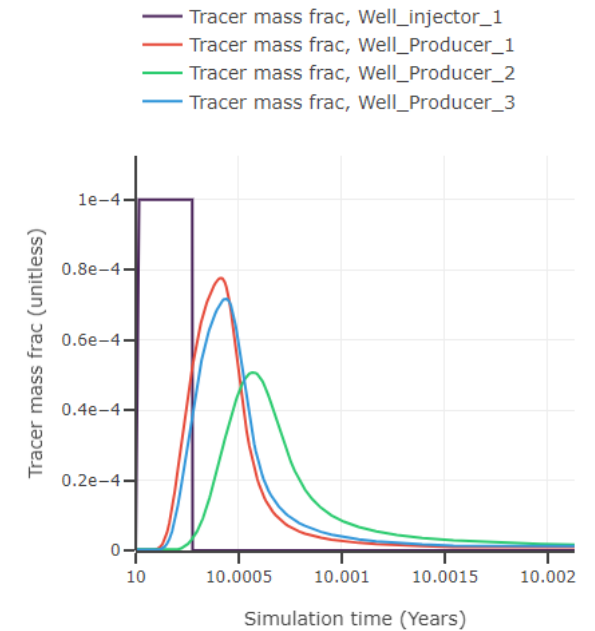
Pre-existing fractures

Doublet with horizontal laterals and 100 pre-existing fractures representing synthetic hydraulic fracture network. Fracture aperture constant at 0.00006 ft, corresponding to fracture conductivity of 100 md-ft.



Slug tracer test

Dual porosity model with 1 injector and 3 producers. Tracer injected for 0.1 day and recovery monitored at the producers



If simulation fails, first thing to check is info in job manager and comments file

Simulation status info in Job Manager:

 Wagner Test Model v3

Terminated early

May 15, 2025 at 6:02 pm

May 15, 2025 at 7:14 pm



Simulation terminated prematurely due to an error. Refer to the comments file for more details. Simulation wallclock time is: 31.5398 min. WARNING: Vertical frac propagation was prevented by the top or bottom of the matrix domain. Unless this was set up intentionally to limit height growth, you should consider increasing the height of the matrix domain. Timestep 408, dt = 33.48 s, cumulative time = 3.89605 hours. Simulation wallclock time is: 29.3937 min. Current memory usage of 13.6 percent (max ever: 13.6). WARNING: Vertical frac propagation was prevented by the top or bottom of the matrix domain. Unless this was set up intentionally to limit height growth, you should consider increasing the height of the matrix domain. Results are fully downloaded.

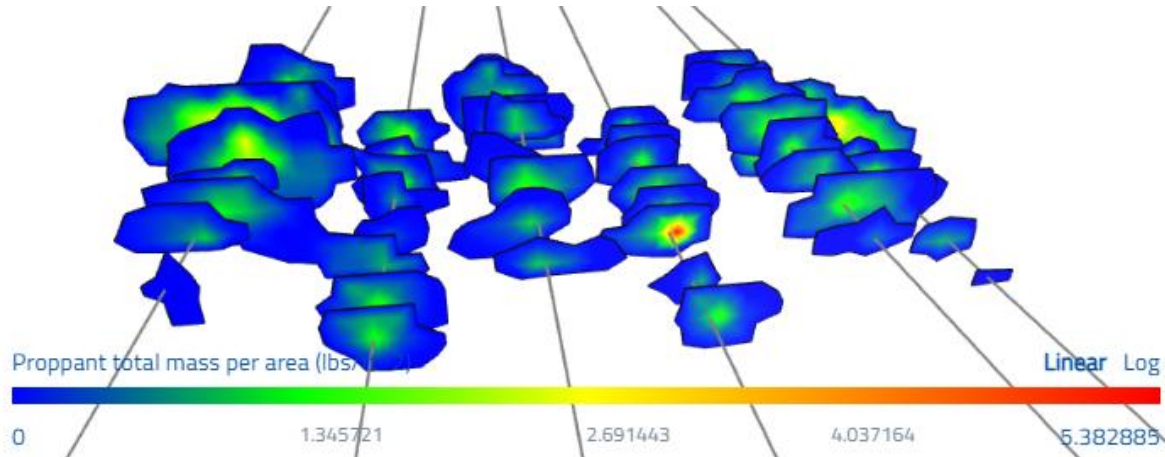
Comments file:

```
7 Convergence in 4 iterations.
8 setting porothermoelasticlinearsolversettingstype #0
9 Before poro solve
0 The iterative solver for the explicitporothermoelastic system has converged according to the petsc residual in 11 iterations.
1 The iterative solver for the explicitporothermoelastic system has converged.
2 PC hypr type: boomeramg
3 porothermo system (true) ||r||/||b||= 3.917076e-08.
4 porothermo current rtol (i.e. max(||r||/||b||) allowed)= 1.000000e-06
5 porothermo convergence: ||r|| <= rtol*||b||
6 porothermo convergence: ||r|| <= rtol
7 Checking that the solution is different from the null vector (in case the RHS is nonzero)
8 Porothermoelastic solution found
9 Timestep duration: 8.333333333333333e-05 hours. Cumulative time elapsed: 3.924715907034404 hours.
0 Problem with calculating proppant turning function. This problem may be resolved by running with 'numerics version number' set to 119 or higher, or by running with 'testingflag105' set to 'true' in the manual entry panel. This is a code bug. Simulation will abort.
1 Simulation did not finish successfully. Problem during printing of tracking file.
2 Simulation did not finish successfully. Problem with postprocessing.
3 Simulation did not finish successfully due to internal error.
```

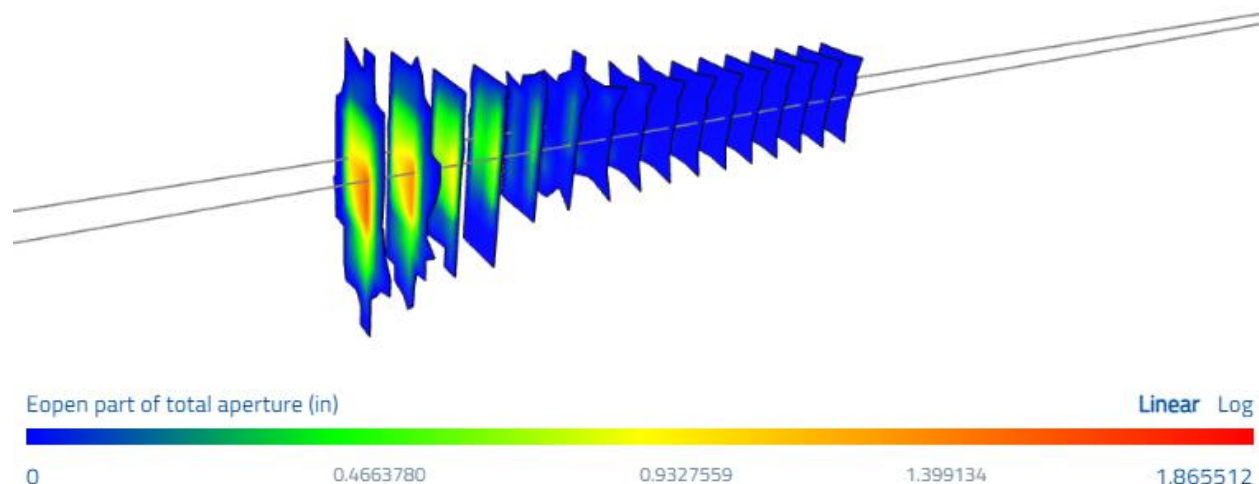
Check 3D visualization plots if simulation fails during runtime

- Proppant screenout? Is proppant volume fraction above 0.66?
- Wellbore connectivity?
- Pressure and temperature field as expected?
- Uniform fracture conductivity?

Poor connectivity between wells

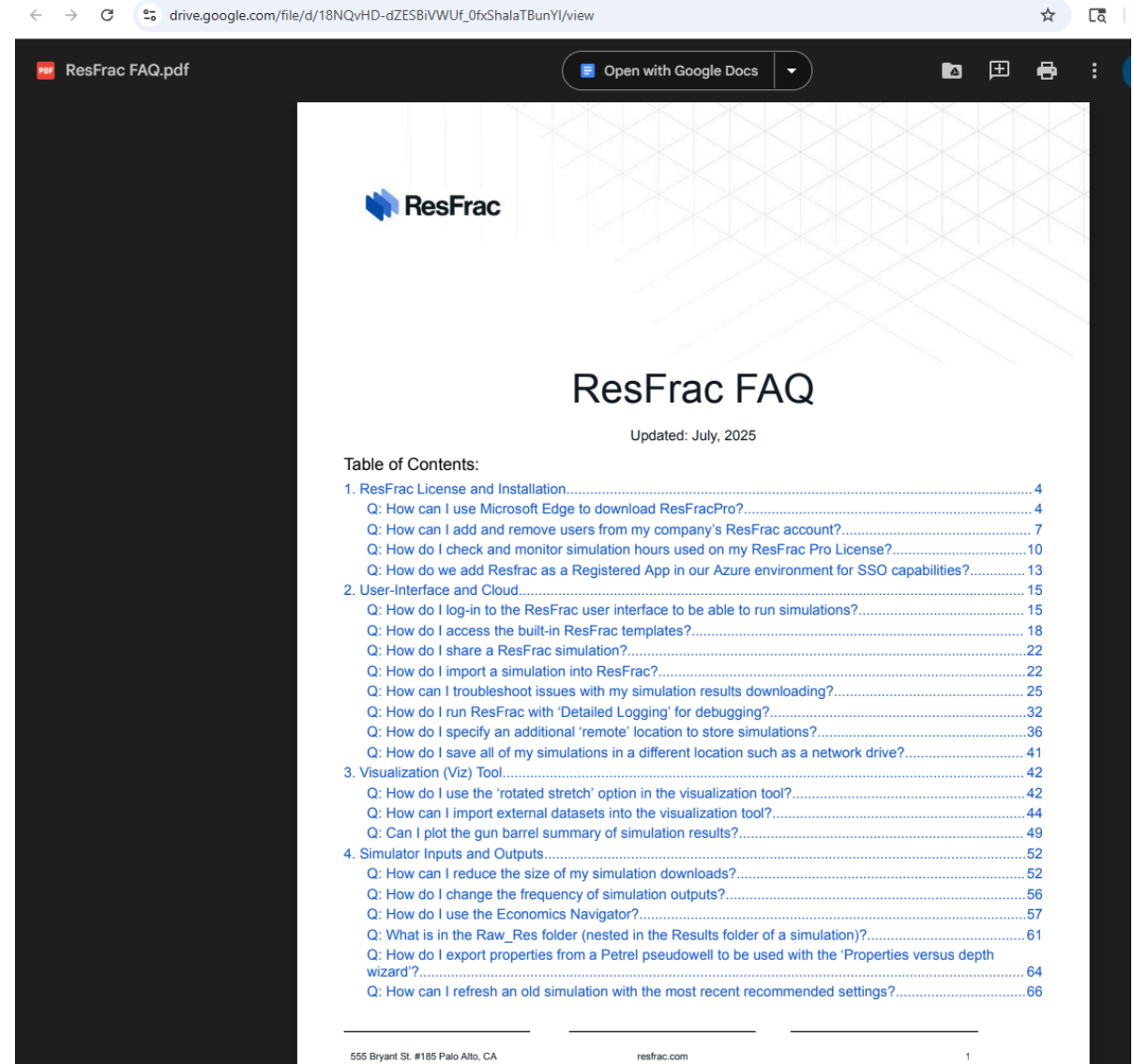


Some fractures are mechanically open, taking majority of the flow



Various resources available to help with addressing common issues and questions

- [FAQ](#)
- [A-to-Z Guide](#)
- [Mini-Guides](#)
- [ResFrac Technical Writeup](#)
- Template documentation: available in the ResFracPro folder > resources > documentation > Workflow templates
- Ask [ResChat](#), our AI chatbot with access to the full suite of ResFrac help content.
- Share simulations with support@resfrac.com



Use Winmerge to compare simulation settings files

Winmerge interface showing a comparison of two simulation settings files. The left pane displays the file `C:\...les\workflows\EGS Training Course July 22nd\simulations\EGS Example Model\settings_EGS Example Model.txt`, and the right pane displays `C:\...orkflows\EGS Training Course July 22nd\simulations\Simple 2 Well EGS v12\settings_Simple 2 Well EGS v12.txt`.

The files contain configuration entries for simulation parameters. The following entries are highlighted in yellow in both panes:

- `// Name in builder interface: "Calculate electricity output with respect to reference temperature"`
- `// Description: If set to false, then the 'power plant efficiency' in the geothermal`
- `// ResFrac internal variable name`
- `Variable name: calcelectricityoutputwithrespecttoreferencetemperatureforenthalpyoutput`
- `Length: 1`
- `Value(s): false` (left) / `true` (right)
- `// End entry`

The status bar at the bottom indicates **83 Differences Found**.

Tricks

- Start with small, simplified model: only 1 stage, without thermo-elasticity, uniform rock properties, etc.
- Start with available templates and modify for your conditions
- Verify:
 - Flow rates are as expected
 - Fracture conductivity in single- to double-digit md-ft
 - Matrix cools down around injection points
 - Are you producing liquid, two-phase, steam?
- Meshing tricks:
 - Number of fracture elements has number 1 impact on computational time
 - Wellbore length should be less than cluster spacing
 - Decrease mesh size by using non-uniform mesh distributions
 - Recommended number of matrix elements: Up to 200,000
 - Recommended number of fracture elements: Up to 5,000

Geothermal ResFrac templates

- EGS model based on FORGE data:

https://resfracsoma.blob.core.windows.net/collateral/templates/EGS_Template.zip

- Pre-existing fractures:

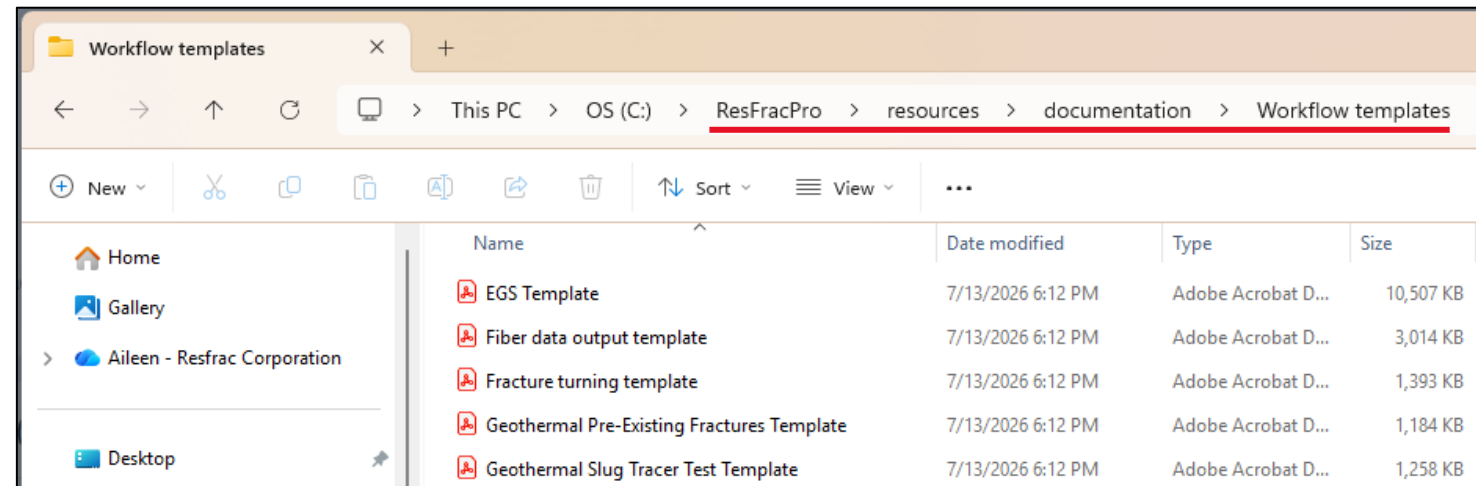
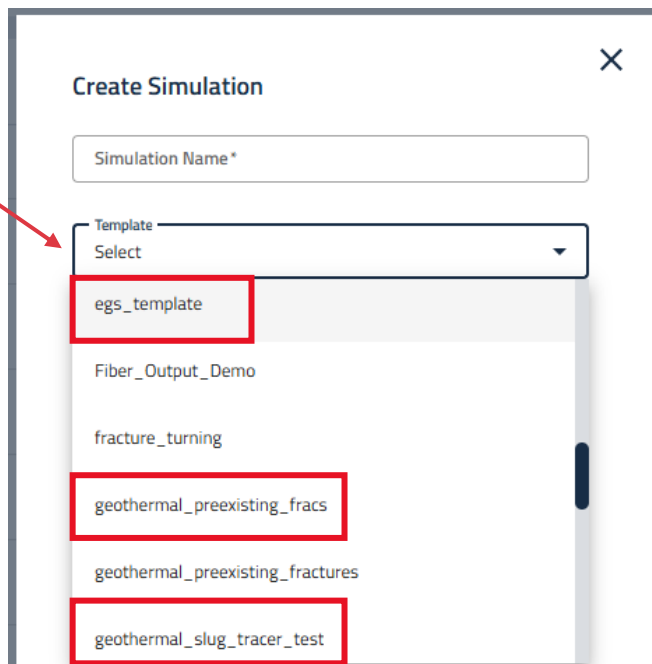
https://resfracsoma.blob.core.windows.net/collateral/templates/geothermal_preexisting_fracs.zip

- Slug tracer test:

https://resfracsoma.blob.core.windows.net/collateral/templates/geothermal_slug_tracer_test.zip

Links to run
versions of
the templates

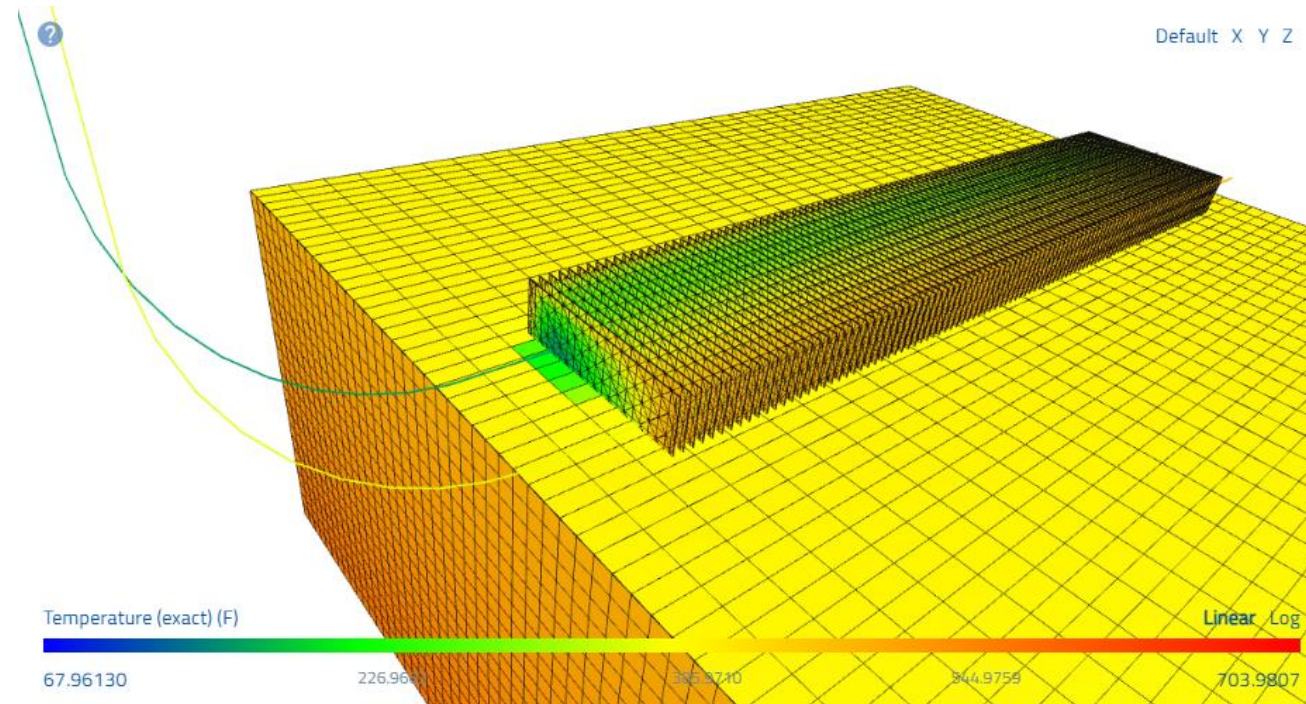
How to find
templates in
the UI



Where to find template
documentation

Pre-existing fractures template

- The template simulates a geothermal EGS reservoir with 100 pre-existing fractures.
- The stimulation phase (i.e., fracture creation and growth) is not modeled; instead, the model assumes 100 rectangular, vertical fractures are present from time 0, connecting the injection well to the production well.
- Because the computationally-intense stimulation step is skipped, the model allows for rapid calculations including simulating all fracture clusters along a lateral for full reservoir simulations.



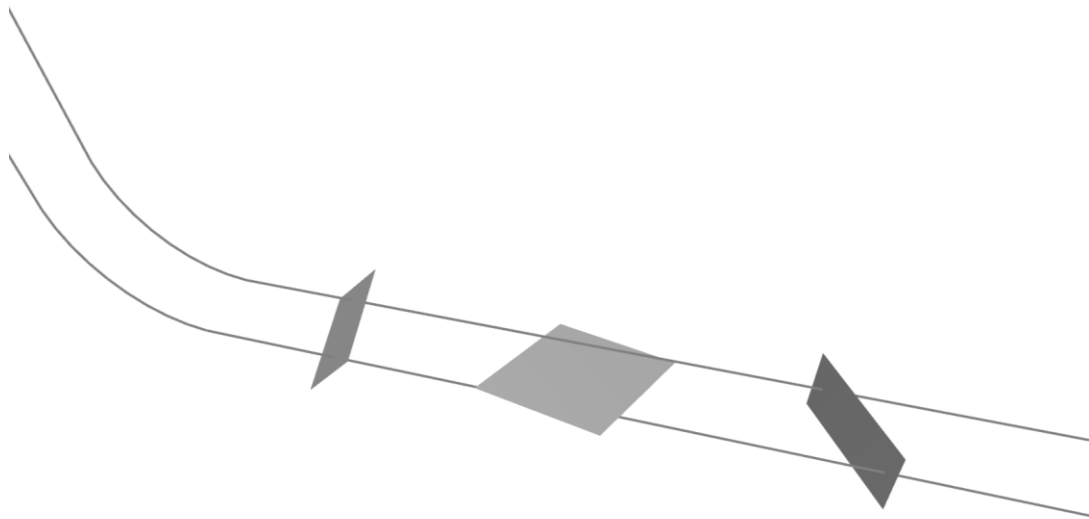
Potential EGS simulation studies with pre-existing fractures

- Using pre-existing (i.e., pre-defined) fractures can be computationally fast, which allows to simulate the full reservoir instead of only a section of the reservoir. Simulating the full lateral length allows to investigate, for example:
 - ✓ Impact of frictional pressure drop in the laterals on flow and thermal performance of fractures at the toe vs. the heel
 - ✓ Impact of non-uniformity of flow on thermal performance. For example, how is the production temperature profile impacted if the reservoir has a few fractures with very high conductivity
 - ✓ Impact of large pre-existing features (e.g., a fault) intersecting the reservoir on overall reservoir performance.
- Other studies that can be conducted with pre-existing fractures include:
 - ✓ Investigating the impact of cluster spacing on thermal performance
 - ✓ Investigating required fracture area to limited thermal decline after x years by y %.
- Pre-existing fractures cannot be used and modeling the stimulation phase would be required to answer questions such as:
 - ✓ What are the required pumping volumes, rates and pressure?
 - ✓ How effective is my proppant placement?
 - ✓ What is expected fracture conductivity?

One approach can be to apply a sector model to simulate one or a few stages per lateral for designing a stimulation treatment plan, which can then inform fracture properties (i.e., geometry, aperture/conductivity) of a full reservoir model with pre-existing fractures.

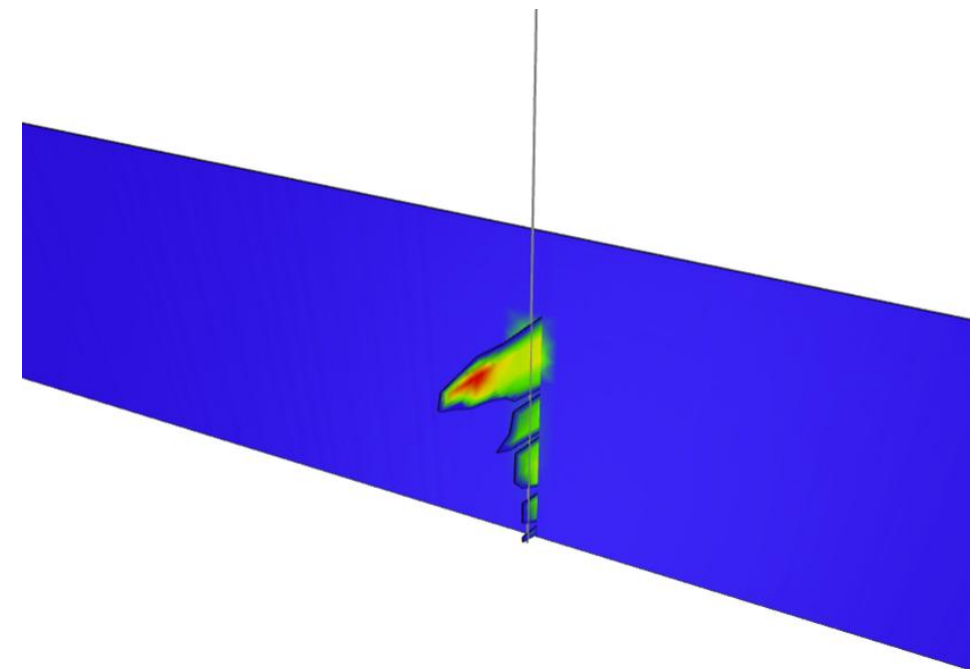
Pre-existing fractures can also represent natural fractures or faults

Angled or dipping natural fractures



A ResFrac Mini-Guide on Preexisting Fractures is also available at this [link](#).

Faults
(hydraulic fracturing in conventionals)



Proppant total mass per area (lbs/ft²)

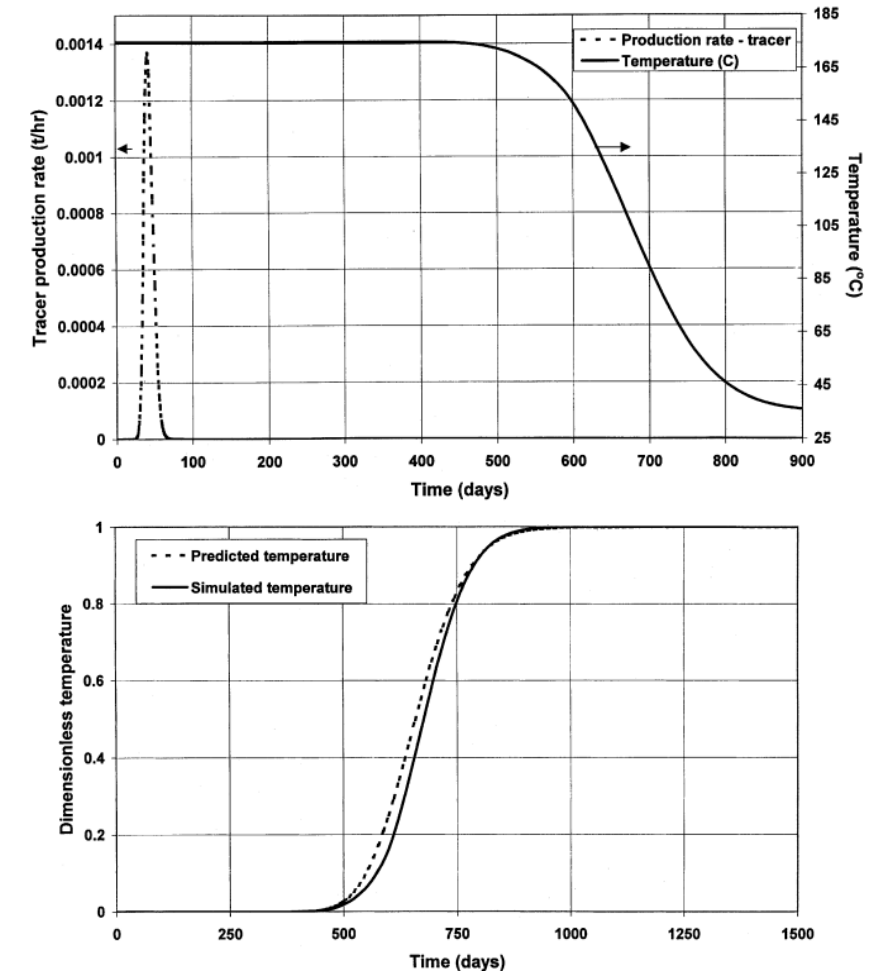


Slug geothermal tracer test

- In a tracer test, a small amount of detectable substance (the tracer) is injected in an injection well(s) and the recovery is monitored in a production well(s). In geothermal systems, the tracer typically injected as a small pulse (“slug”) and monitored over an extended time.
- Tracer tests are performed to characterize a variety of subsurface parameters such as inter-well connectivity, flow paths, swept volume, swept area, porosity, mineralogy and reservoir temperature.
- Tracer types:
 - Inert or conservative tracer tests do not react chemically or physically with the formation fluids or rocks. These are the simplest tracers and can currently be simulated in ResFrac.
 - Reactive tracers interact with the reservoir chemically or thermally:
 - Chemical reactive tracers react with rock minerals of in-situ fluids and can estimate reactive surface area of mineral dissolution rates.
 - Thermal tracers break down at predictable rates at different temperatures and can help estimate effective heat transfer area and temperature distribution.

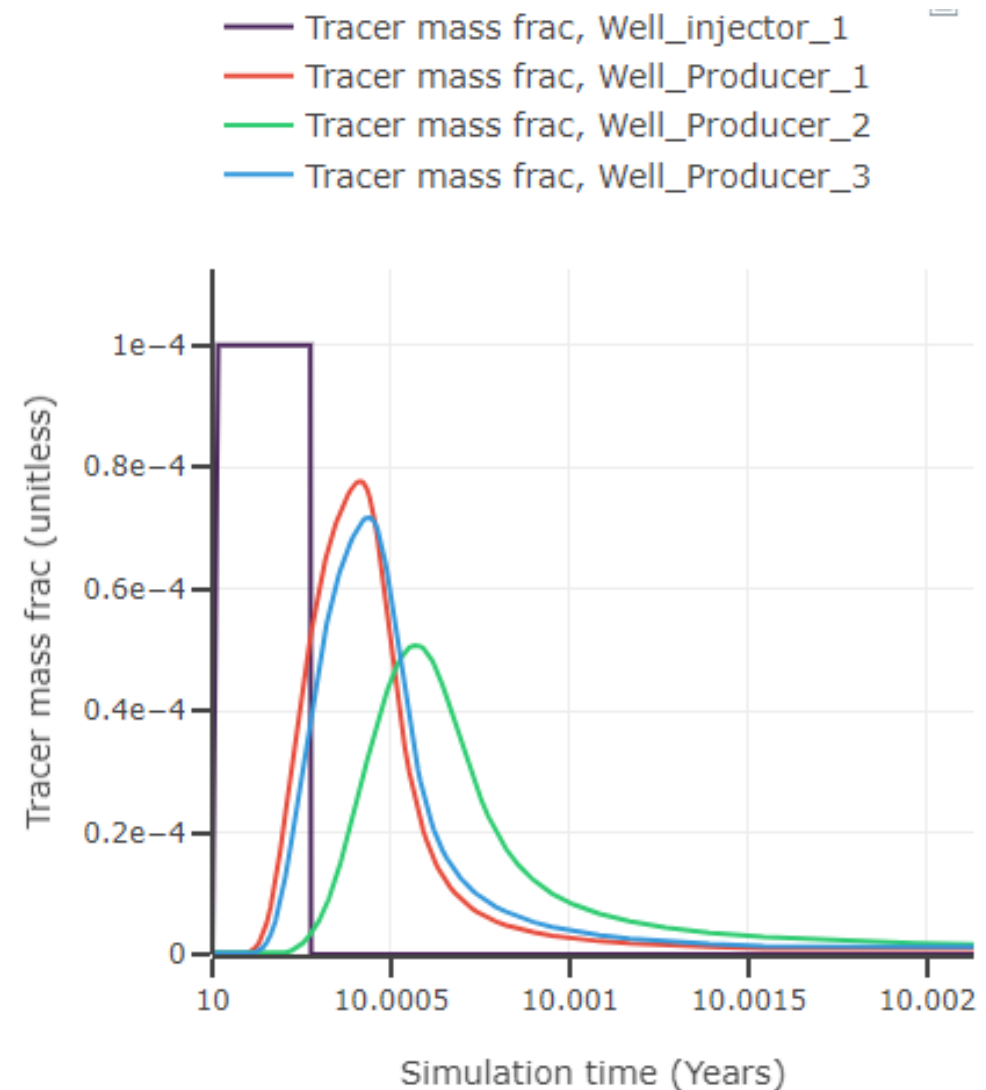
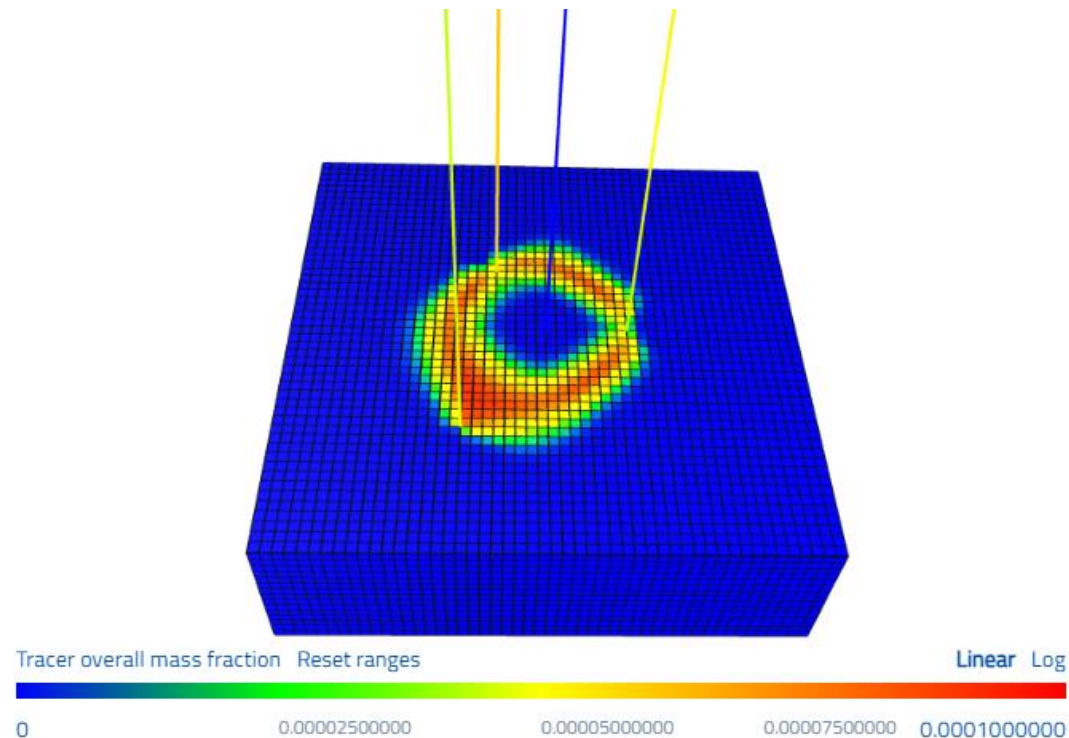
Shook (2001) demonstrates a powerful example application of a tracer test for an idealized, two-well geothermal system.

Using a tracer test performed around day 50, reservoir thermal decline (starting around day 500) was predicted within a few percent from the tracer test response.



Slug geothermal tracer test template results

- Tracer recovery at each producer plotted in the figure on the right, indicating rapid arrival of tracer (within a few hours) at each well, particularly producers 1 and 3, which are closest to the injector.
- Ring-shaped tracer pathway within the matrix shown in the figure below.



Dual porosity model: ResFrac can run “traditional” dual porosity simulations

Choose a dual porosity option in the start-up panel:

Dual porosity option ?

☐ None

☐ PSS

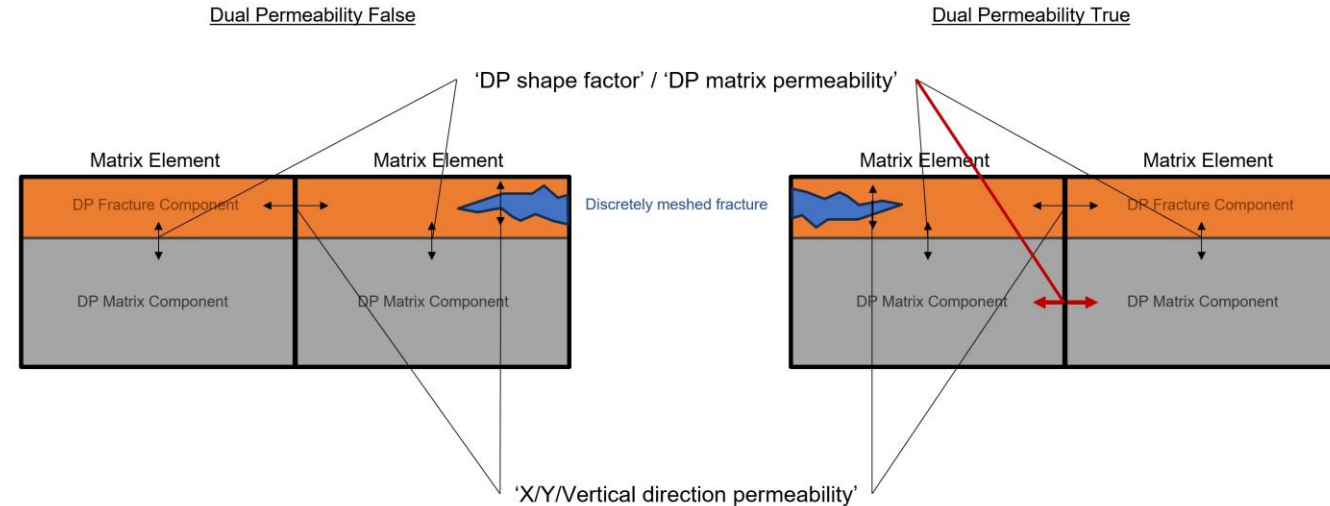
☒ Transient

☐ Dual permeability ?

☐ Transient dual porosity applies to thermal ?

Specify dual porosity parameters in the static model

Static model parameters controlling flow in a Dual Porosity/Dual Permeability model



GEOLOGICAL UNITS (FACIES LIST) ?

	Initial water saturation ?	Fracture gradient [MPa/km] ?	Dual porosity ?	DP fracture poro compressibility [MPa ⁻¹] ?	DP fracture porosity ?	DP shape factor [1/m ²] ?	DP matrix permeability [m ²] ?	Rock solid matrix density [kg/m ³] ?	Rock heat capacity [J/kg·K] ?
1	1	17.8702698908711	☐					2800	
2	1	17.8702698908711	☒	0.00145	0.0001	12	1e-15	2800	
3	1	17.8702698908711	☐					2800	

You can account for thermo-elasticity to investigate long-term fracture opening and downward fracture growth

Activate thermo-elastic stress changes in the matrix in the start-up panel

☒ Thermoelastic stress changes in the matrix  

☒ Poroelastic stress changes in the matrix  

☒ Rotate simulation mesh to align with stresses  

Specify thermal expansion coefficient in the static model

GEOLOGICAL UNITS (FACIES LIST)    

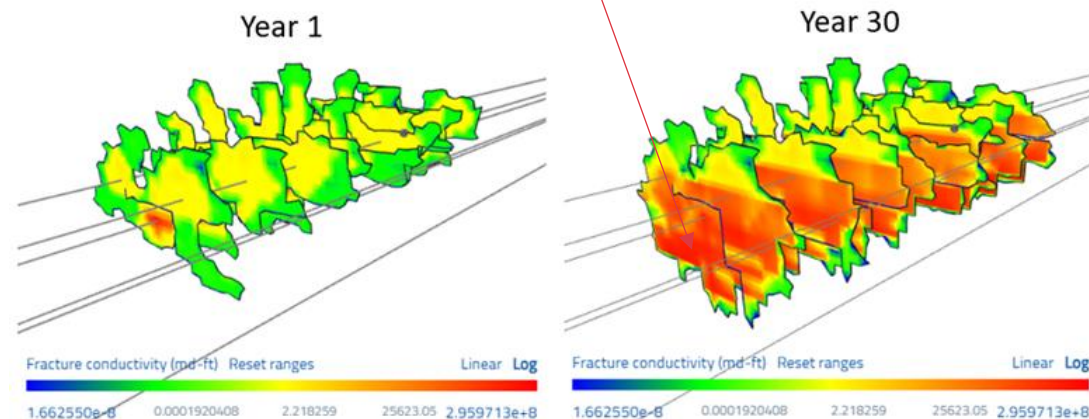
	Rock heat capacity [BTU/(lb-R)] 	Thermal conductivity [BTU/(hr-ft-R)] 	Coefficient of linear expansion [1/F] 	delta(pore)
1	0.239005736	1.44544012784629	0.000007	

In Fracture Options panel, activate stress shadow boundary condition

Symmetric fracture stress shadow boundary condition start time [days]

16 

Result: Fracture opening and downward fracture growth



Automated workflows: sensitivity analysis, history matching, optimization

ResFrac Pro | ResFrac Corporation-Prod-Internal

Home > Training Course Examples > EGS Training Course July 22nd

Sandbox Details ?

Workflow name
EGS Training Course July 22nd

Simulations
11

Description

Location of data
Local : C:\ResFracProdInternal\data

Simulations (11)

Show Active Simulations

Create Sim Import Sim

>	SIMULATION NAME	STATUS	DATE CREATED ↓	
>	EGS Example Model v6	Running	Jul 8, 2025 at 4:01 pm	
>	EGS Example Model v4	Finished running	Jul 8, 2025 at 2:45 pm	
>	EGS Example Model v3	Cancelled	Jul 8, 2025 at 2:38 pm	
>	EGS Example Model v2	Cancelled	Jul 8, 2025 at 2:32 pm	
>	EGS Example Model	Finished running	Jul 8, 2025 at 12:17 pm	Jul 8, 2025 at 1:56 pm ...
>	Simple 2 Well EGS v12	Finished running	Jul 8, 2025 at 9:23 am	Jul 8, 2025 at 11:38 am ...
>	Simple 2 Well EGS v11	Finished running	Jul 7, 2025 at 7:35 pm	Jul 7, 2025 at 9:48 pm ...

Simulation Details

- Edit Simulation in Builder
- Open Economics Navigator
- Run Simulation
- Copy Simulation
- Copy Simulation to a Sandbox
- Check for New Results in Next Sync
- Re-Download All Results
- Export Simulation Folder
- Open Simulation Folder in File Explorer
- Open Comments File
- Open Text Settings File
- Open Text Input File
- Download Restart Files
- Import Additional Files
- Visualize Simulation Results
- Visualize Results with Layout
- Set Up Sensitivity Analysis**
- Set Up History Matching**
- Set Up Optimization**
- Go To Workflows Based on This Sim
- Share Simulation
- Move to Trash

Thank you



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