

# Well Leakage Risk Assessment for Reducing Methane Leaks

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Net-Zero Geosystems & Astrimar

Methane Emissions in  
the North Sea Symposium  
13 & 14 November 2025 | Utrecht

## Where are we going?

Quantify methane leakages through simulations

## Why?

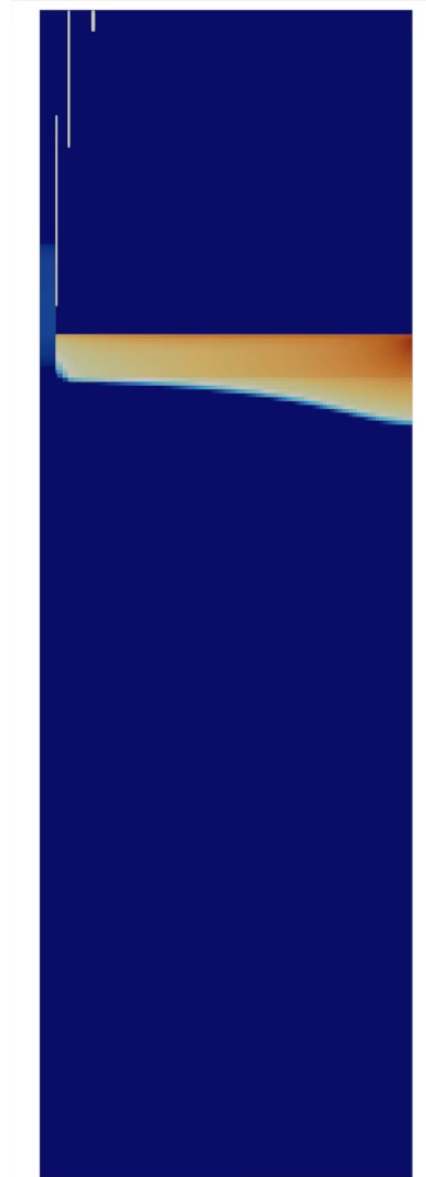
- Quantify leakages to prevent them
- Quantify leakages to comply with regulation

(20) 'quantification' means activities to determine the quantity of methane emissions by means of direct measurements or, where direct measurements are not feasible, based on other methods such as simulation tools, and other detailed engineering calculations or a combination of such methods;

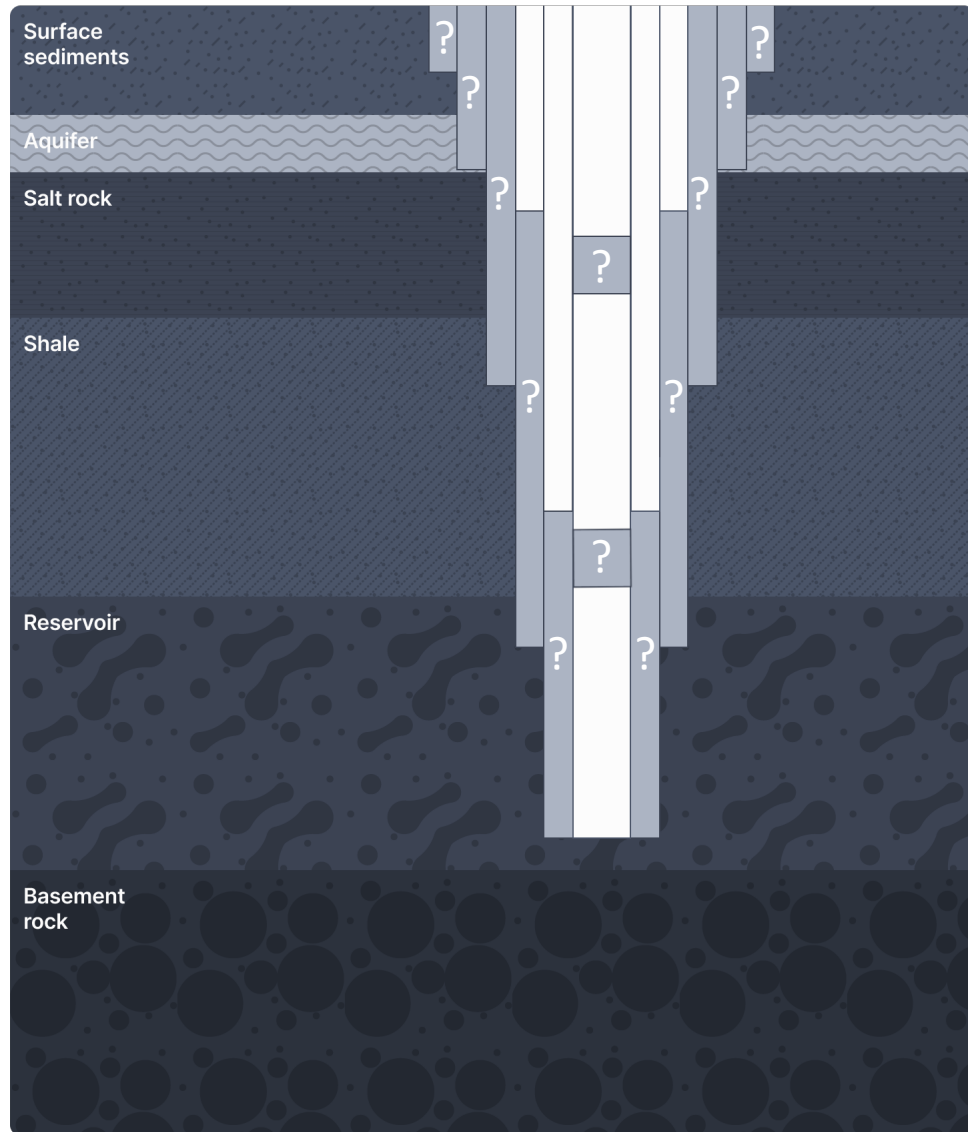
## How?

By developing a well leakage quantification methodology through a collaboration between

- Astrimar - World-class reliability engineering consultancy → **Qualitative**
- Net-Zero Geosystems - Advanced numerical simulation technology company → **Quantitative**

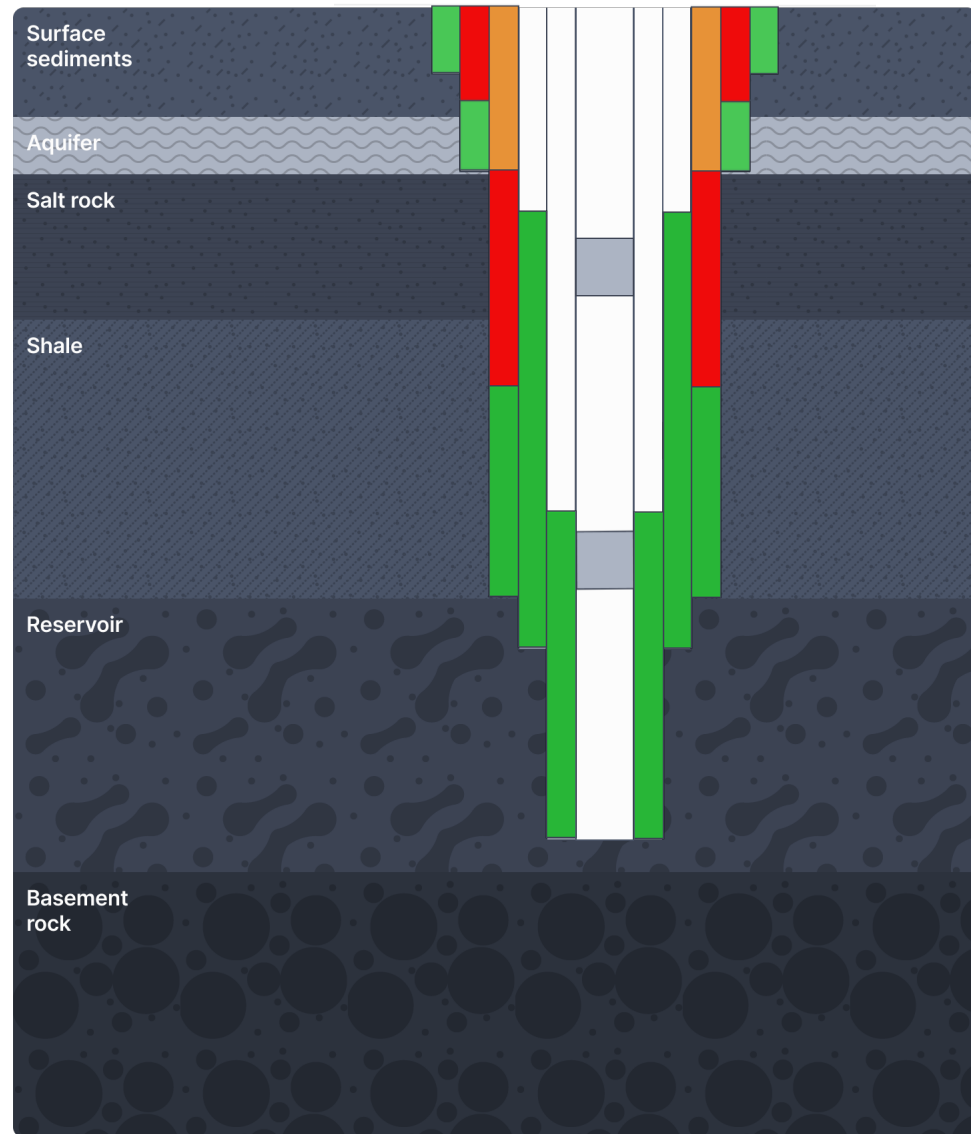


## Overview of the Methodology



Step 1  
Data Collection

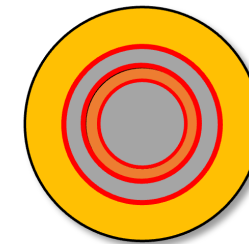
## Overview of the Methodology



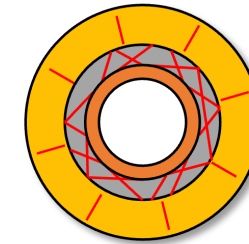
Step 1  
Data Collection

Step 2  
Integrity Simulations

Casing Cement Rock



Debonding

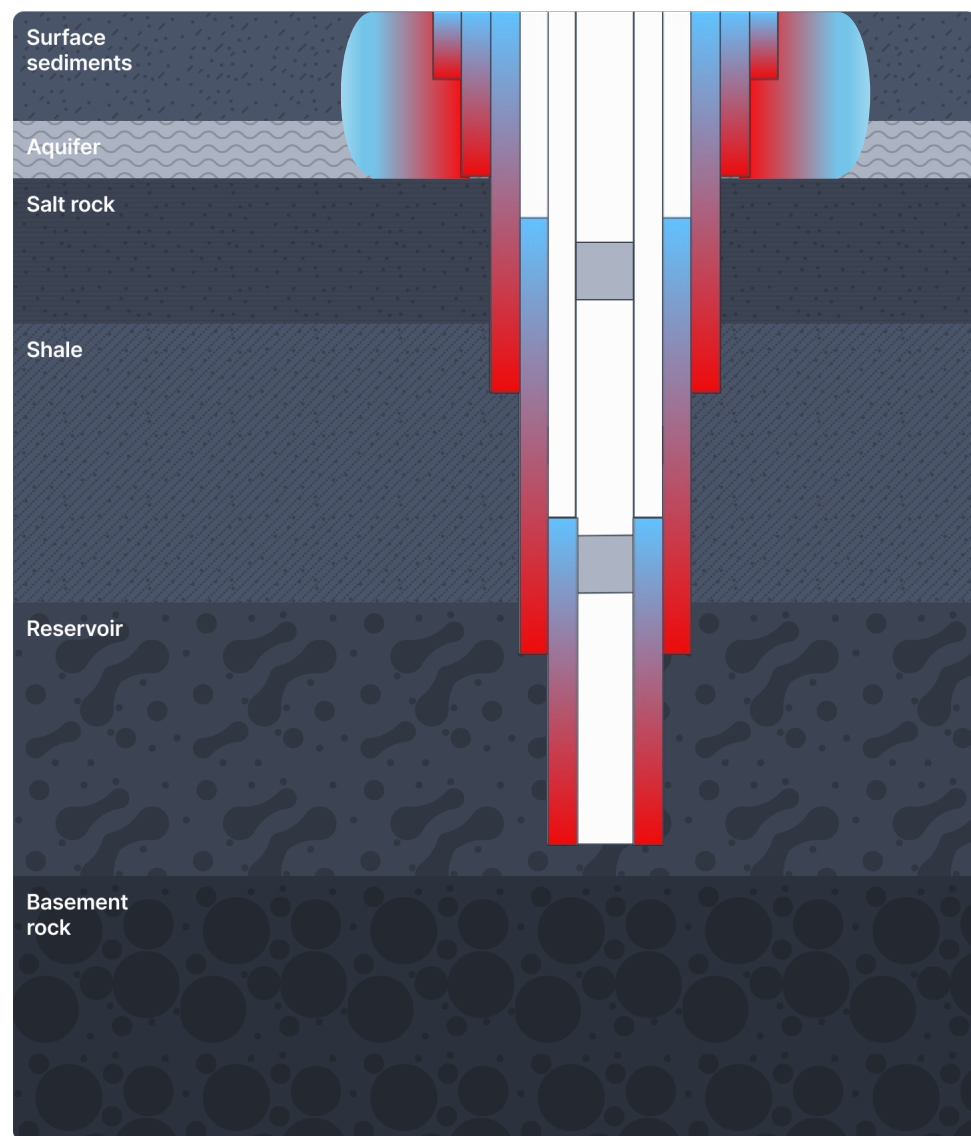


Fracturing



Collapse & burst

## Overview of the Methodology



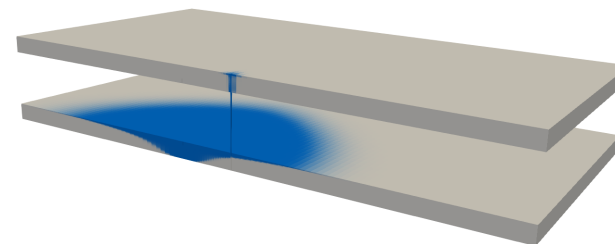
Step 1  
Data Collection

Step 2  
Integrity Simulations

Step 3  
Barrier Review Workshop

Step 4  
Leakage Simulations

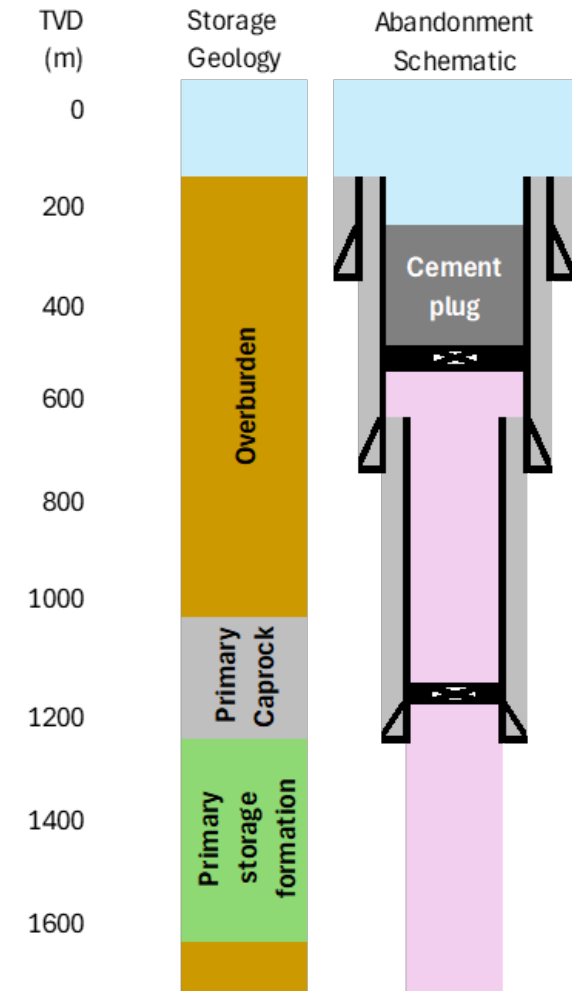
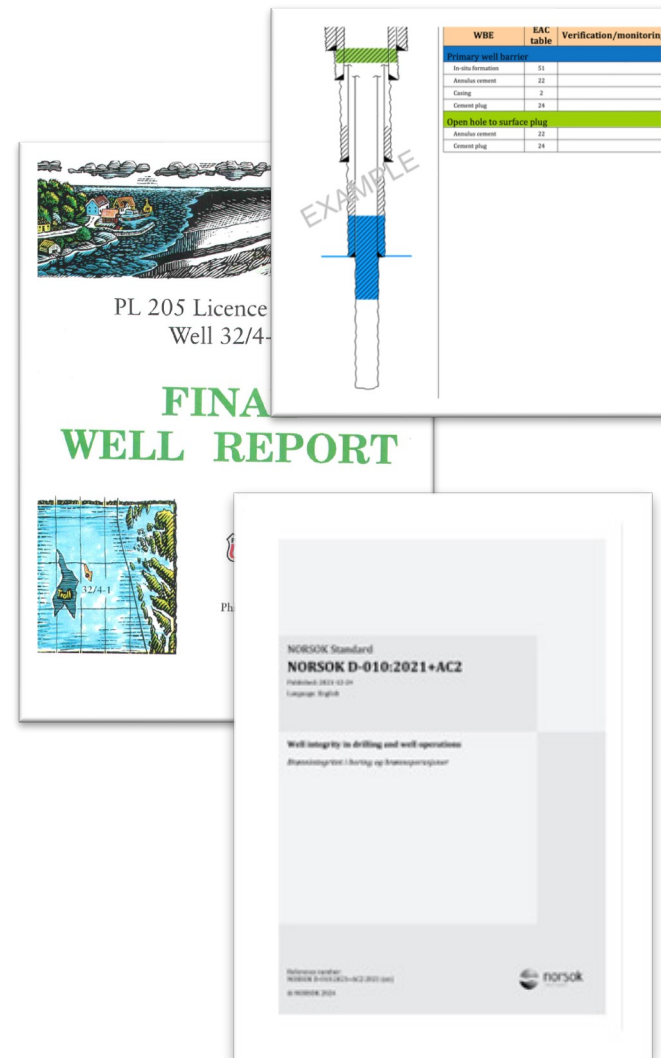
Step 5  
Risk- Based Decision  
Making



# Step 1: Data Collection and Review of P&A Design

## Request and review:

- Available data sources including
  - Up-to-date well schematics
  - Well reports (drilling, casing and cementing)
  - Well history and interventions
  - Reported integrity issues
  - Geomechanical & petrophysical data
- Industry standards and regional regulations



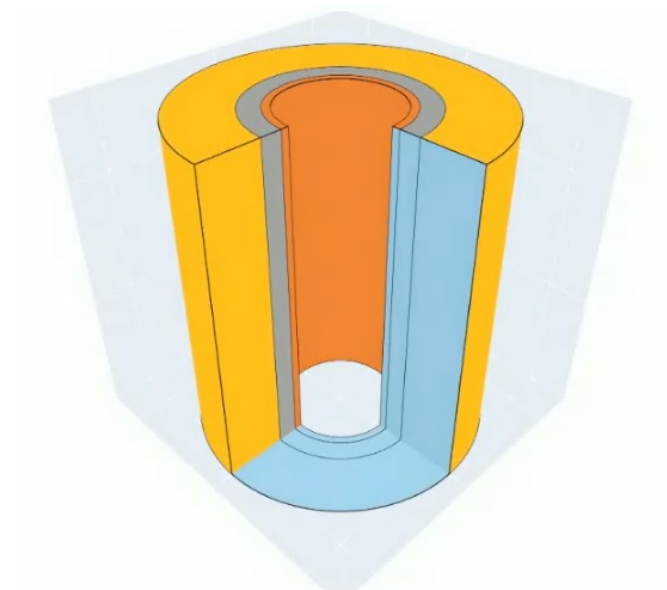
## Step 2: Integrity Simulations

Well integrity simulations provide information on leakage paths which are not available in well reports & data

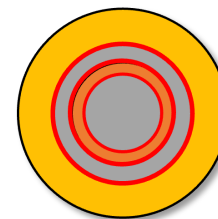
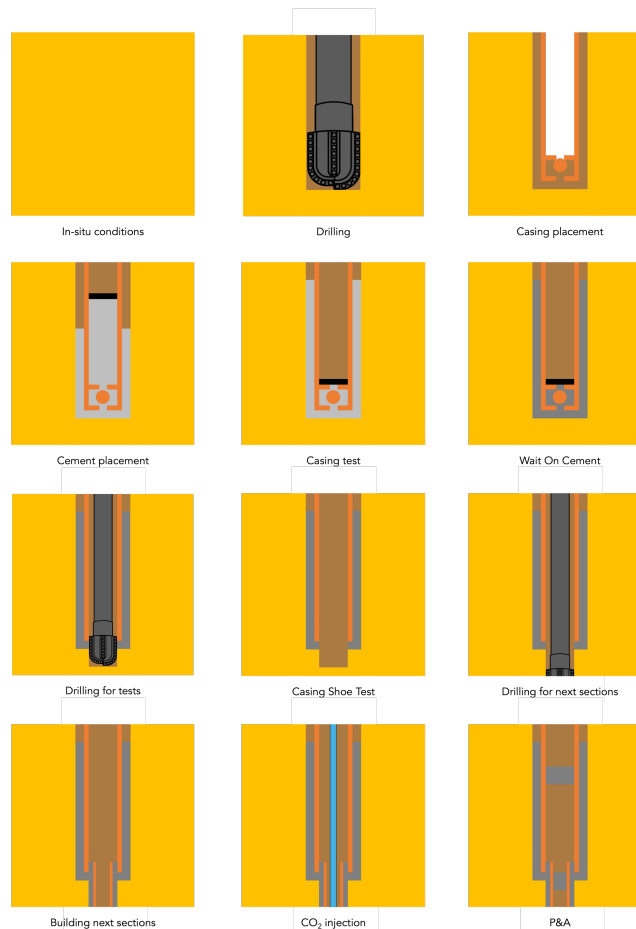
### Well integrity simulations

### Reproduce all stages of the life of the well

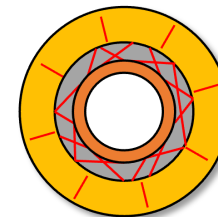
### Predict failure and leak paths



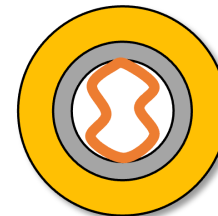
Casing
  Cement
  Formation



Debonding

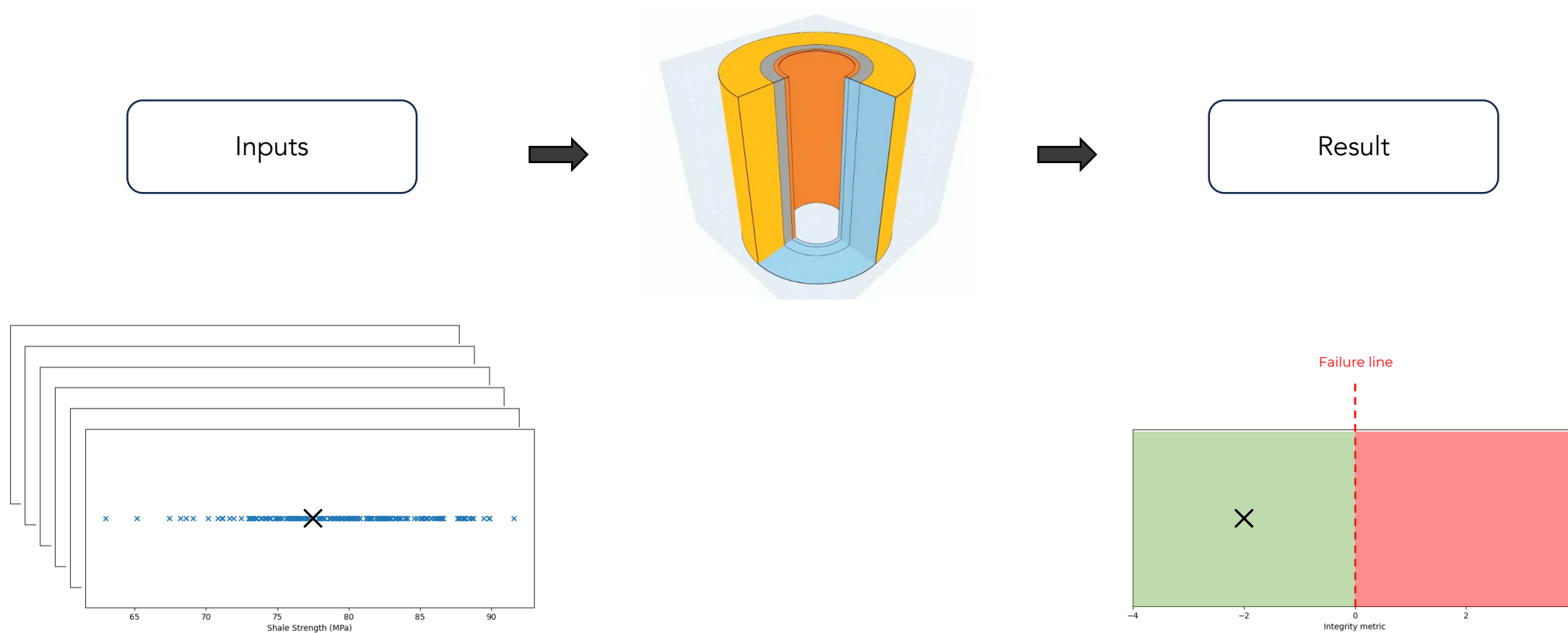


Fracturing



Collapse & burst

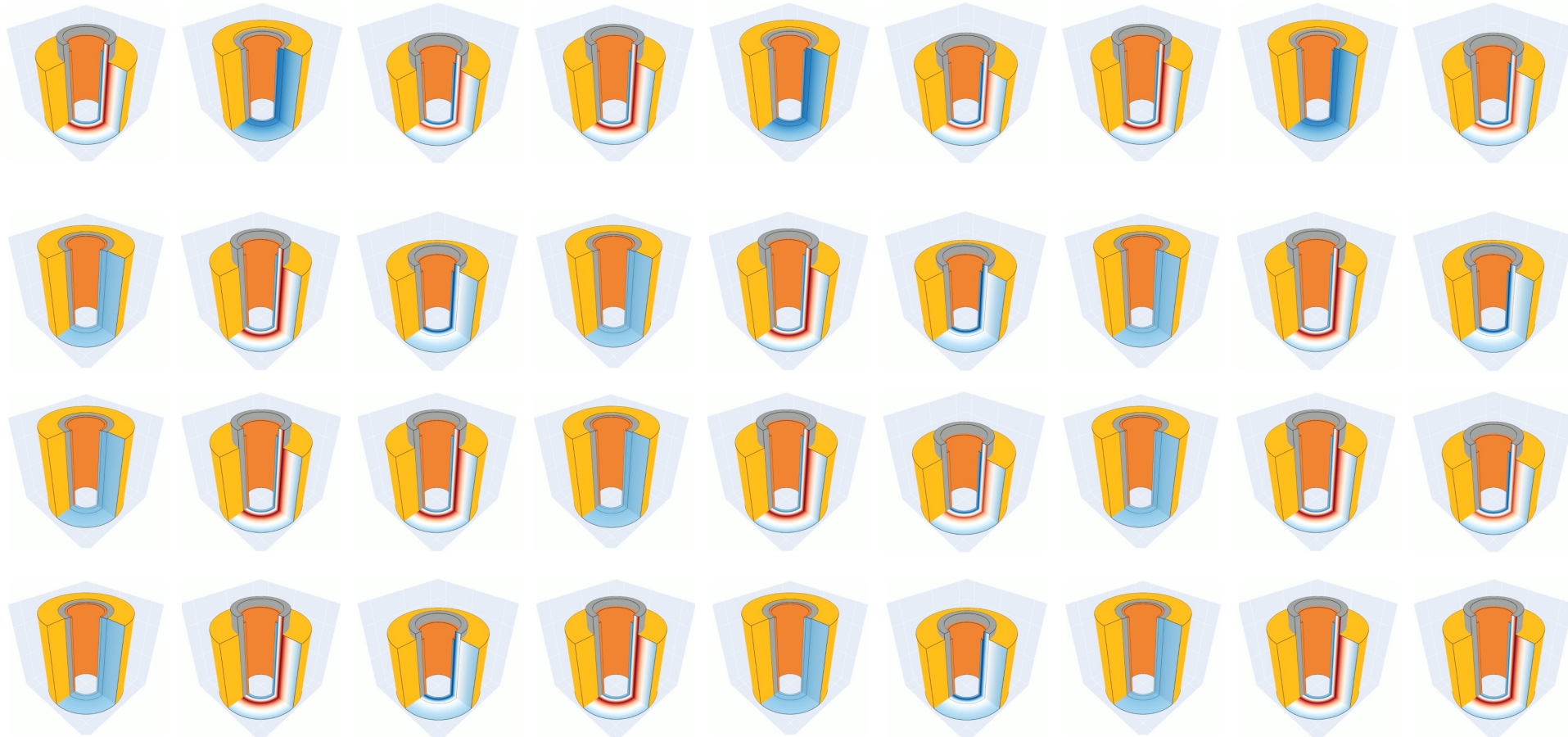
# Uncertainty





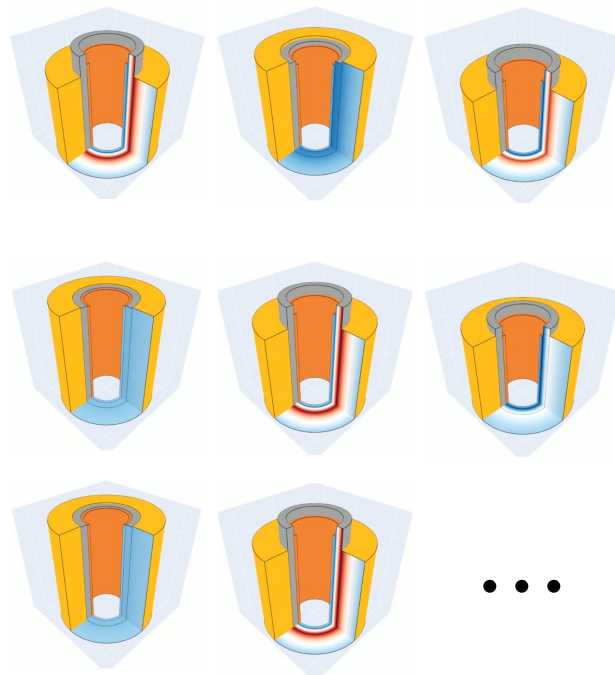
# The Monte Carlo method for Integrity Simulations

Performing simulations for as many scenarios as we can

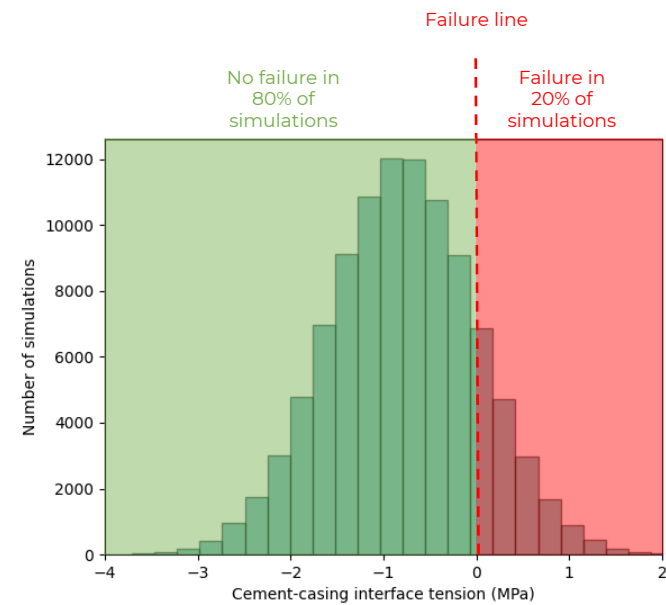


# The Monte Carlo method for Integrity Simulations

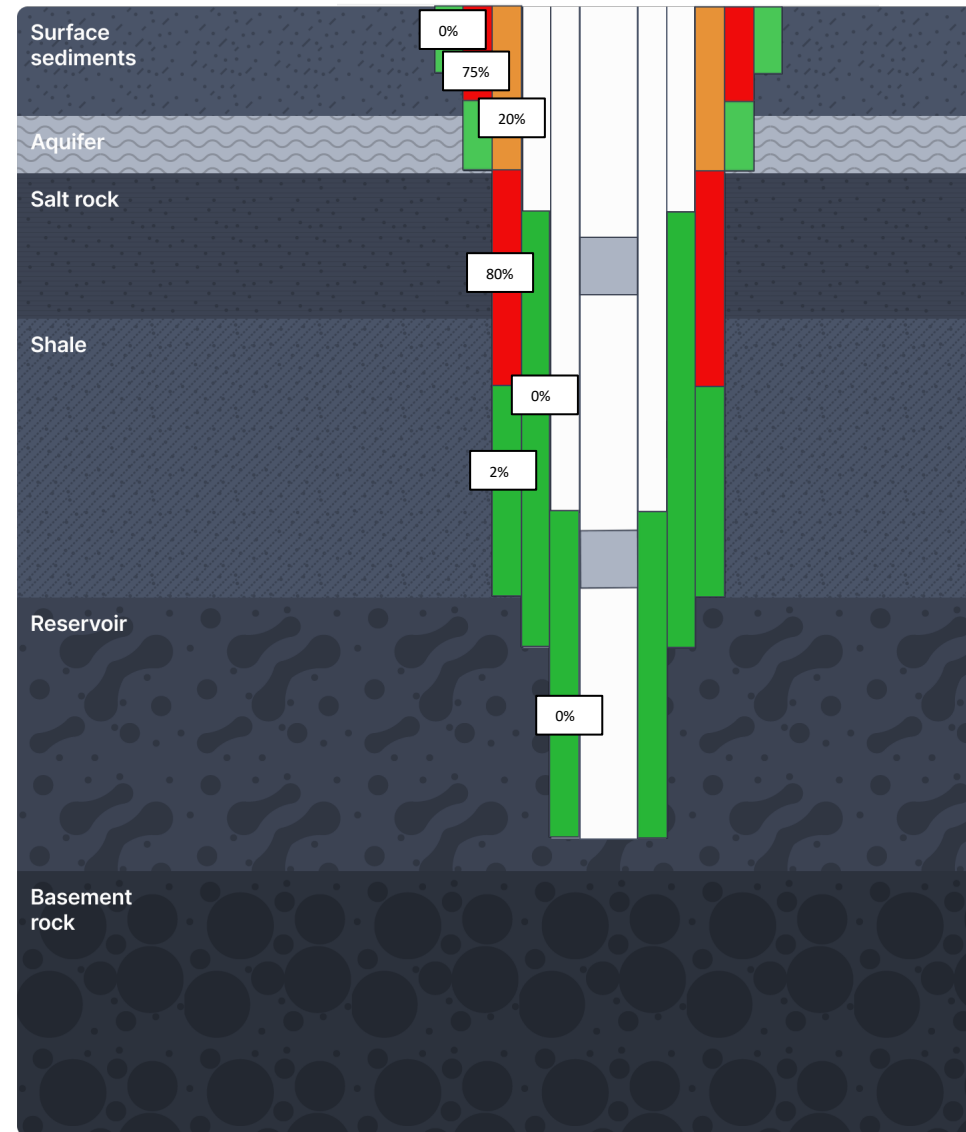
Performing simulations for many scenarios



Obtaining a probability of failure



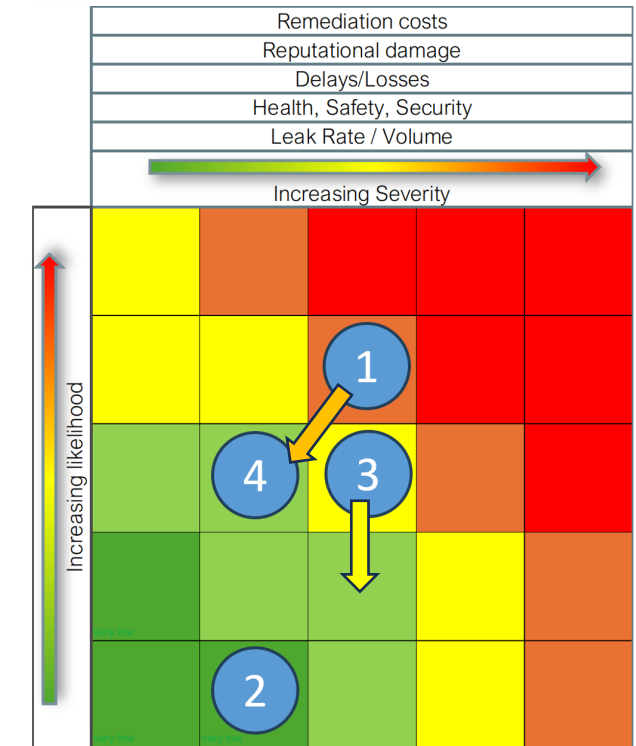
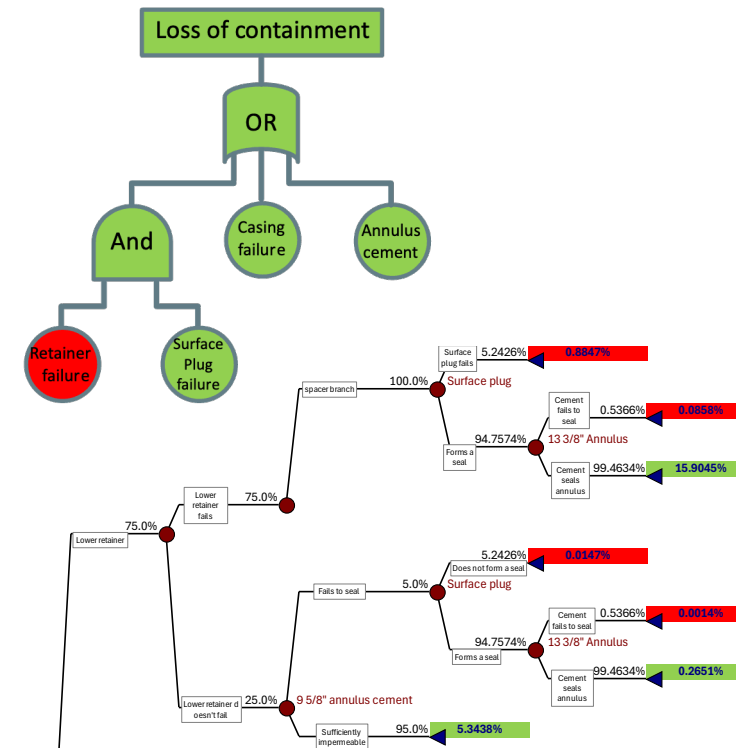
# The Monte Carlo method for Integrity Simulations



## Step 3: Barrier Review Workshop

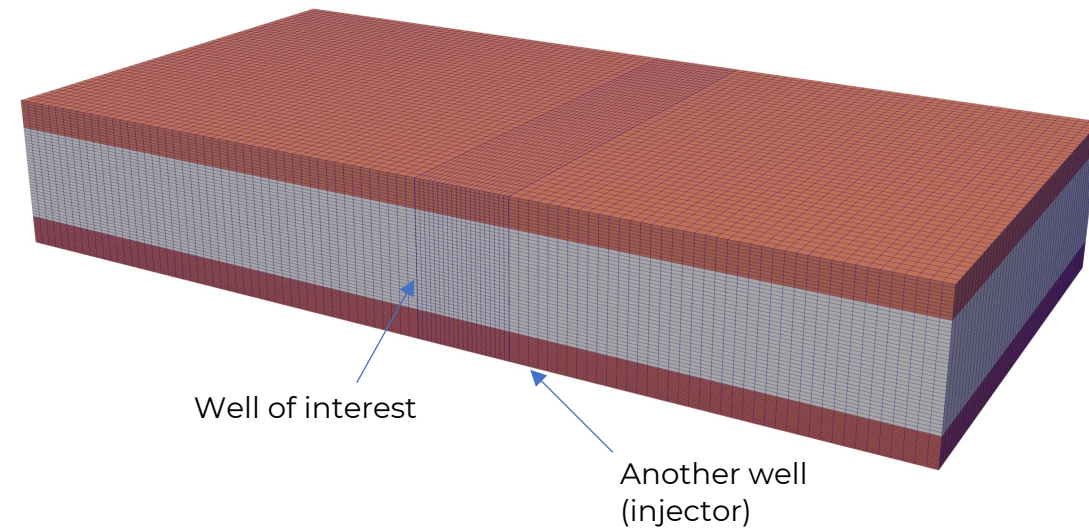
- Review results from the integrity simulations with the operator
- Gather opinions from well engineers, decommissioning managers, geologists, fluid and cement experts etc.
- Identify additional failure modes and mechanisms e.g.
  - Corrosion, creep, mud channels, cement placement issues, SCC
  - Calculate likelihoods (RBD, FTA, ETA)
- Reach a consensus on the inputs to be used for the leakage modelling

Components		Failure Mode Identification					Risk Assessment		
Item / Component	Technical Requirement / Function	Failure Mode	Failure Mechanism	Failure Cause	Failure Effect (local)	Failure Effect (system)	Likelihood	Consequence Severity	Risk Criticality
9 5/8" Casing	To provide a seal	Failure to provide a seal at casing interface	Material corrodes	Casing not protected by cement - exposed to CO2/carbonic acid	Pinhole leak	Loss of permanent well barrier envelope	Very low	Medium	Low
9 5/8" Annulus Cement	To provide a seal	Failure to provide a seal in Annulus	Permeability increases - carbonation	Annulus cement exposed to CO2	Cement permeability increases	Loss of permanent well barrier envelope	Medium	High	High



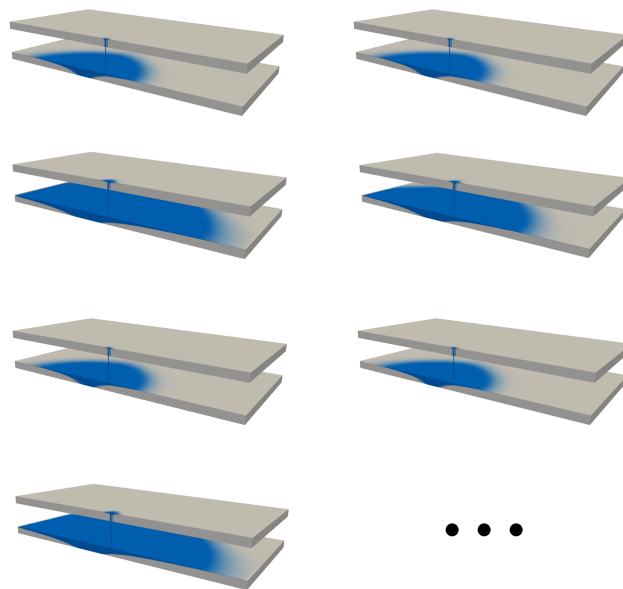
## Step 4: Leakage Simulations

- Simulation include
  - Legacy wells and injector wells
  - Casings, cements, plugs, packers
  - Reservoirs, caprocks, aquifers
  - Faults
  - Vertical, inclined or horizontal wells
- Physics
  - Multiphase flow (brine, oil, gas)
  - Capillary pressure & relative permeability

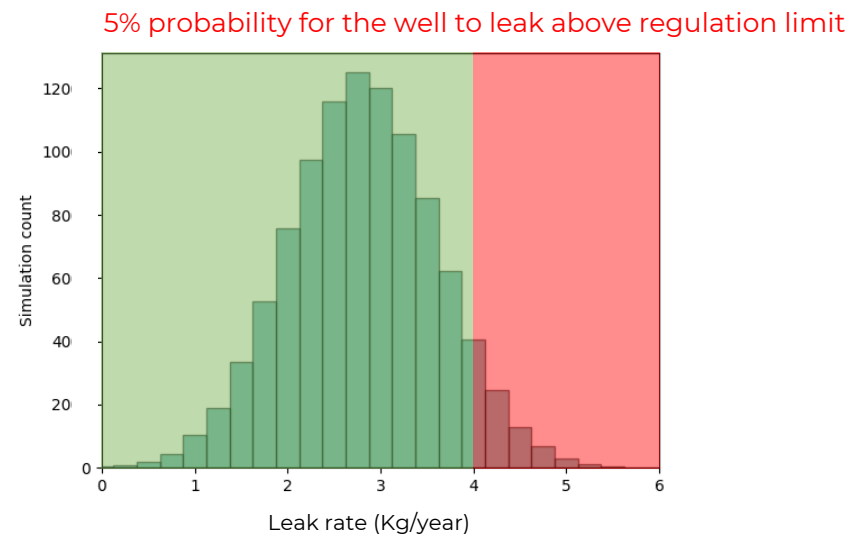


## Step 4: Leakage Simulations

Performing simulations for many scenarios

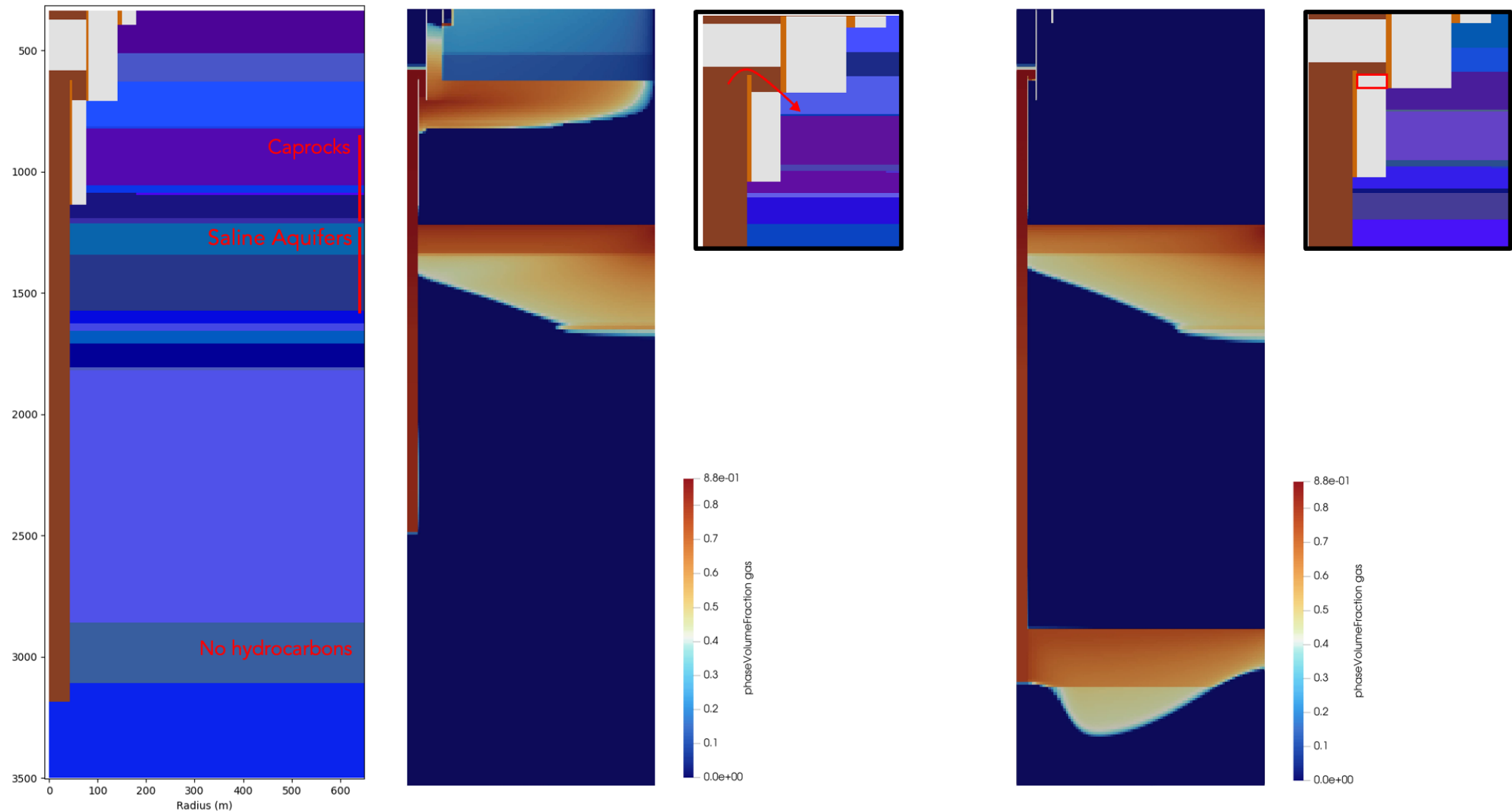


Obtaining a probability of leakage



## Step 4: Leakage Simulations

### Leakage simulation example





# Step 5: Risk Assessment & Decision Making

Risk assessment can support decision-making and include ALARP demonstration. Risks to

## Reservoir Risks

- Reservoir status
- Reservoir repressurisation and rate
- Displaced fluids (Oil, gas, brines)

## Well Risks

- Legacy well status
- Well condition/ degradation
- Well intervention options
- Loss of containment

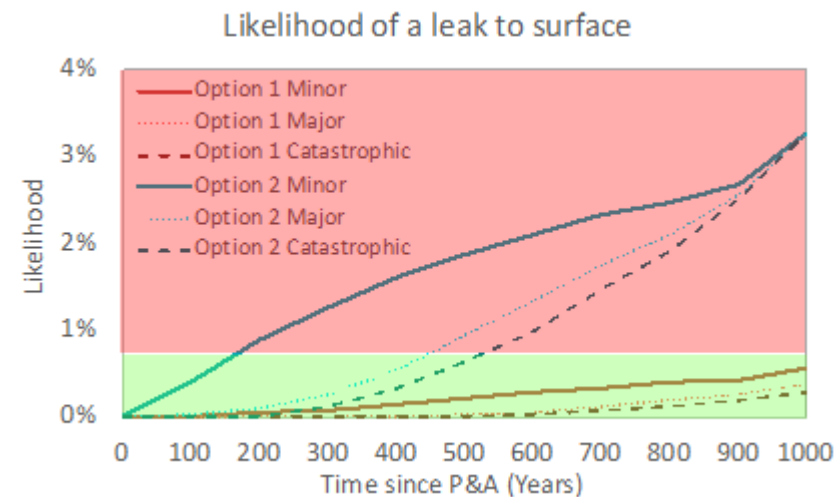
## Asset Risks

- Facilities status
- Facilities condition/degradation
- Facilities maintenance/ intervention

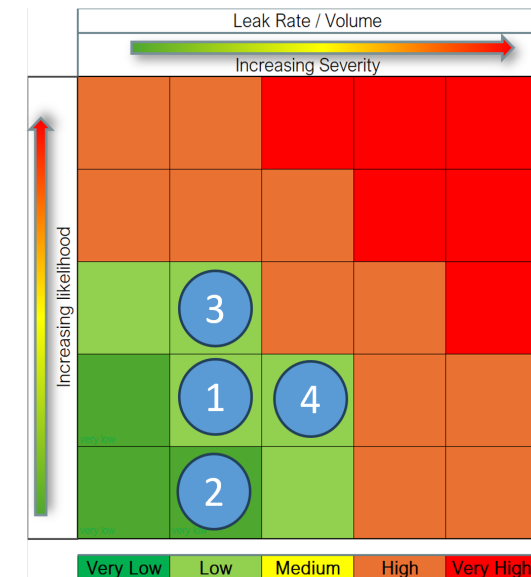
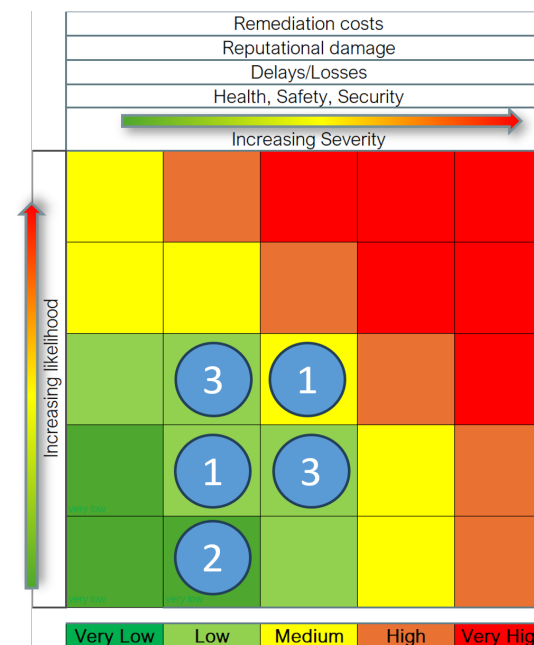
## Financial Risks

- Rig / manning cost
- Re-activation and modification cost
- Monitoring cost
- Abandonment / remediation cost

## Likelihood Assessment (For Leaks)



## Updated Risk Assessment





Thank you