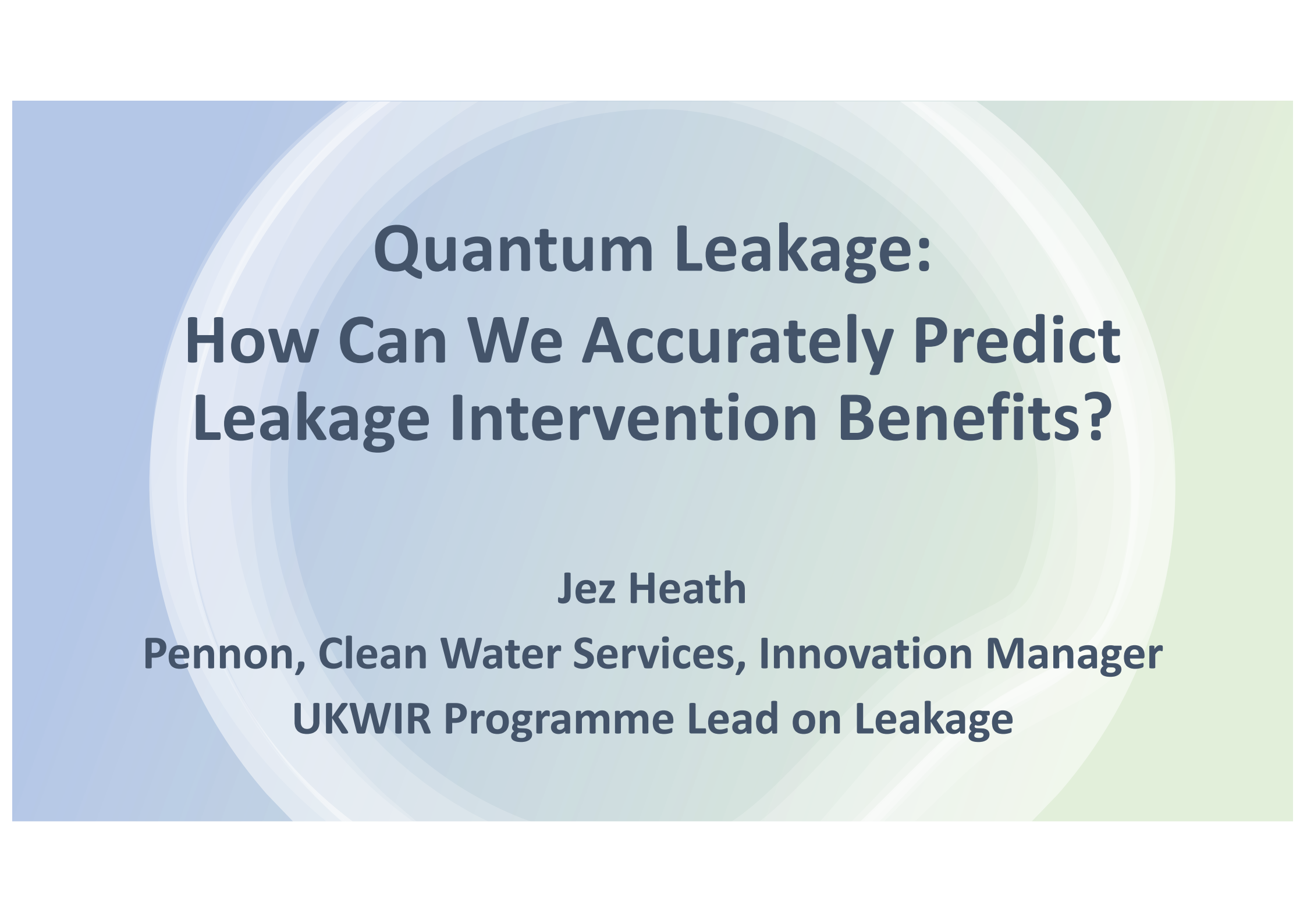




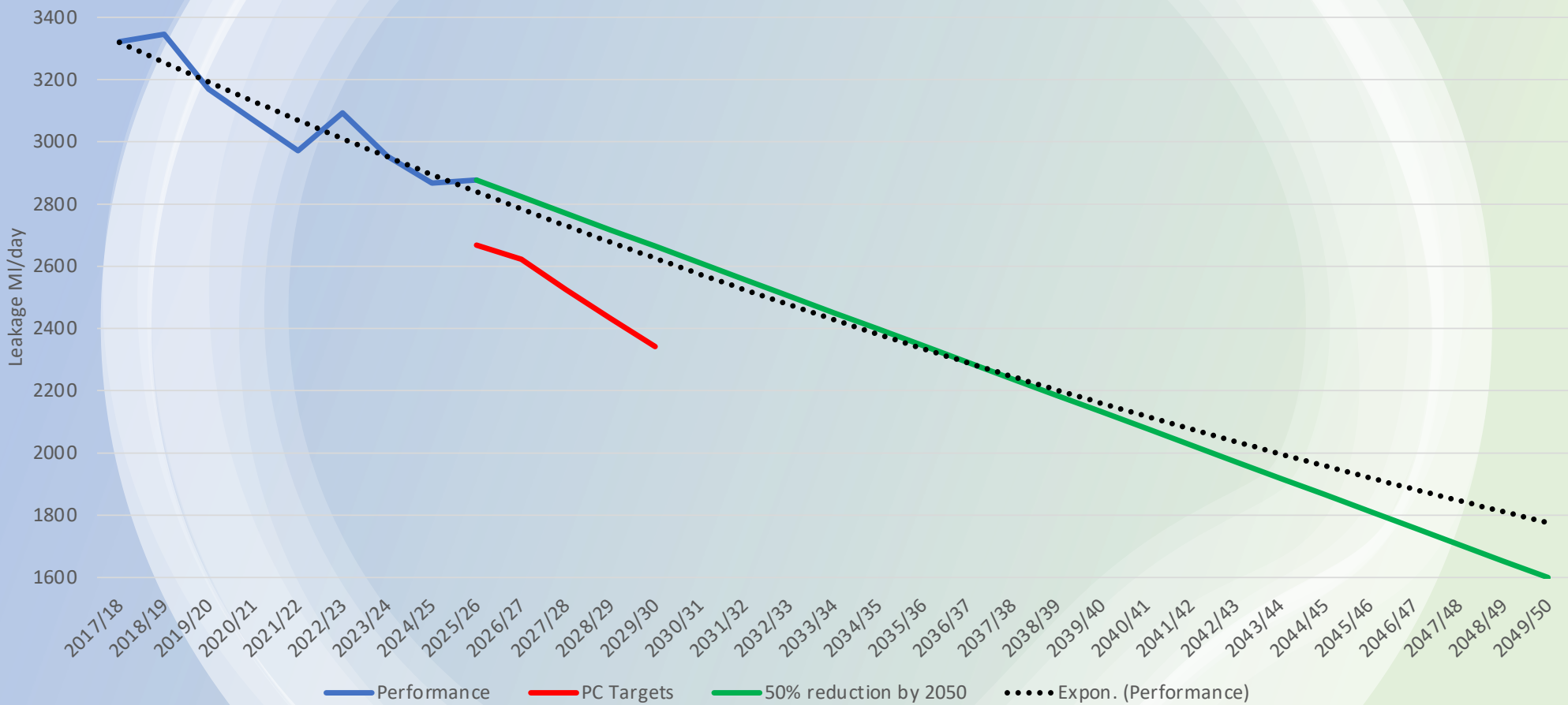
Quantum Leakage: How Can We Accurately Predict Leakage Intervention Benefits?

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UKWIR Programme Lead on Leakage**

Understanding leakage

England & Wales leakage reduction to 2050



Understanding leakage

- The UK water companies are struggling to meet the challenging reduction targets
- With mains replacement as a long-term solution and most companies Prevent approaches well developed, we will need to concentrate on Aware, Locate & Mend
- However, most of our understanding on the impact of measures in these areas is empirically derived. Faster location certainly reduces leakage, but by how much?
- For example, if I was able to reduce leak location times for slowly developing leaks by one day, what measurable actual impact would that have on leakage?
- We need to develop an approach that allows us to link our empirical approaches with the actual characteristics of leaks.
- A successful model would allow us to better develop leakage strategies and understand the costs and potential benefits of interventions

Quantum Mechanics

Quantum mechanics attempts to define the fundamental particles of matter.

Standard Model of Elementary Particles					
three generations of matter (fermions)			interactions / force carriers (bosons)		
	I	II	III		
mass	$\approx 2.16 \text{ MeV}/c^2$	$\approx 1.273 \text{ GeV}/c^2$	$\approx 172.57 \text{ GeV}/c^2$	0	$\approx 125.2 \text{ GeV}/c^2$
charge	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0	0
spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	0
QUARKS	u up	c charm	t top	g gluon	H higgs
	$\approx 4.7 \text{ MeV}/c^2$	$\approx 93.5 \text{ MeV}/c^2$	$\approx 4,183 \text{ GeV}/c^2$	0	
	$-\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	0	
	d down	s strange	b bottom	γ photon	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
LEPTONS	$\approx 0.511 \text{ MeV}/c^2$	$\approx 105.66 \text{ MeV}/c^2$	$\approx 1.77693 \text{ GeV}/c^2$	$\approx 91.188 \text{ GeV}/c^2$	
	-1	-1	-1	0	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
	e electron	μ muon	τ tau	Z Z boson	
	$< 0.8 \text{ eV}/c^2$	$< 0.17 \text{ MeV}/c^2$	$< 18.2 \text{ MeV}/c^2$	$\approx 80.3692 \text{ GeV}/c^2$	
	0	0	0	± 1	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	

- Quantum simply means something that can be counted or measured in discrete units
- Physicist are attempting to unify the forces we understand empirically (like gravity) with the elementary particles
- Maybe this approach could also be applied to our understanding of leakage.

How would this work

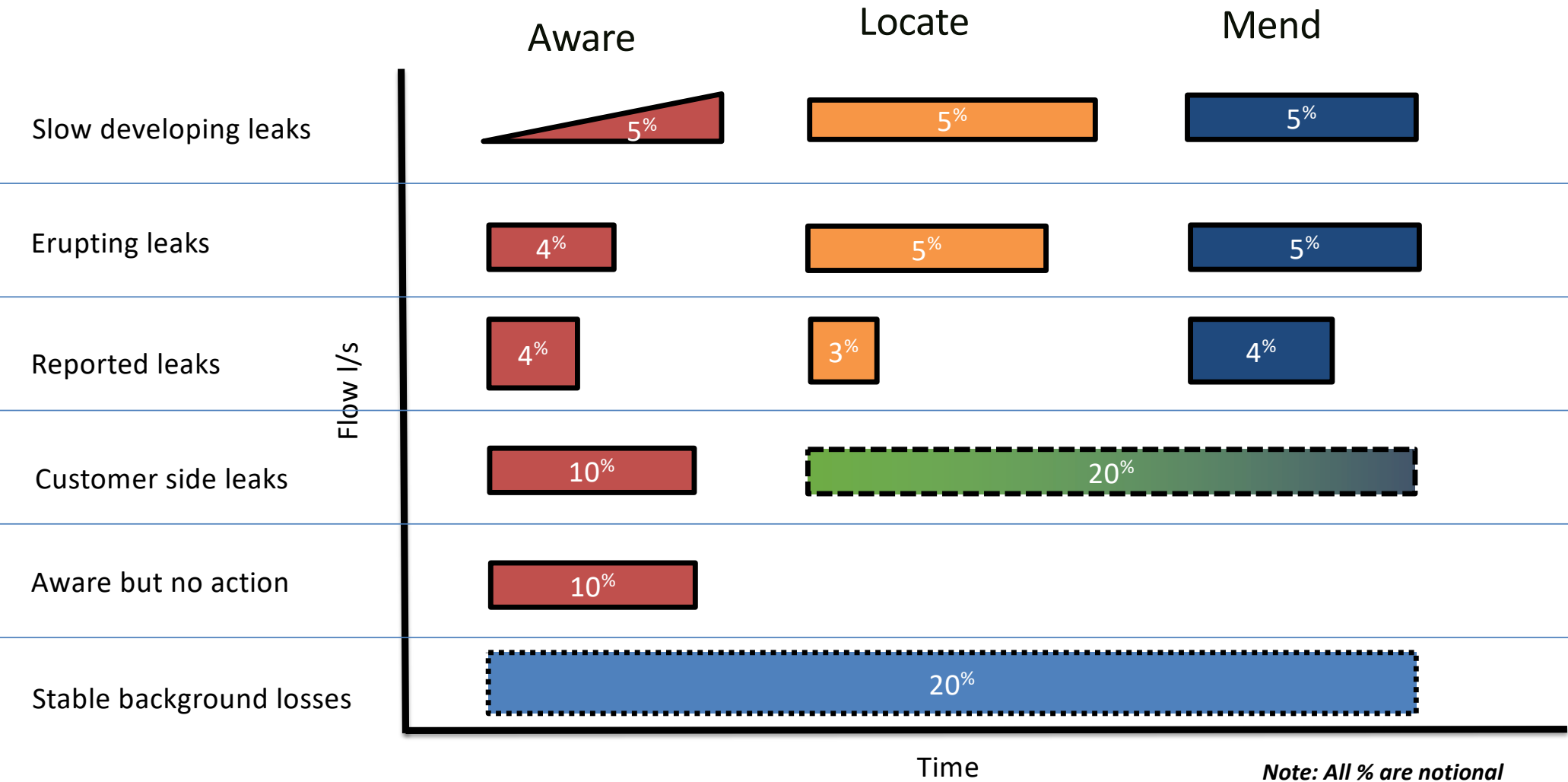
- The fundamental property of every leak is the volume lost, which is a function of the flow rate and the time for which it runs.
- As our ability to change the flow rate is limited, our main impact on the volume lost is the time taken to repair it, once a leak has occurred.
- Rather than consider the leak runtime as a whole, this can be broken down into awareness, locate and mend times, which will have different characteristics and intervention methods.
- In addition, the type of leak (background, customer side, reported, erupting or slow developing) will have different characteristics and intervention methods.
- This approach allows us to start building an initial model of quantum leakage.
- QL could potentially be applied over varying timescales (years or months) and areas.
- Key concept is that the sum of the model components should equal our real losses

Quantum Leakage

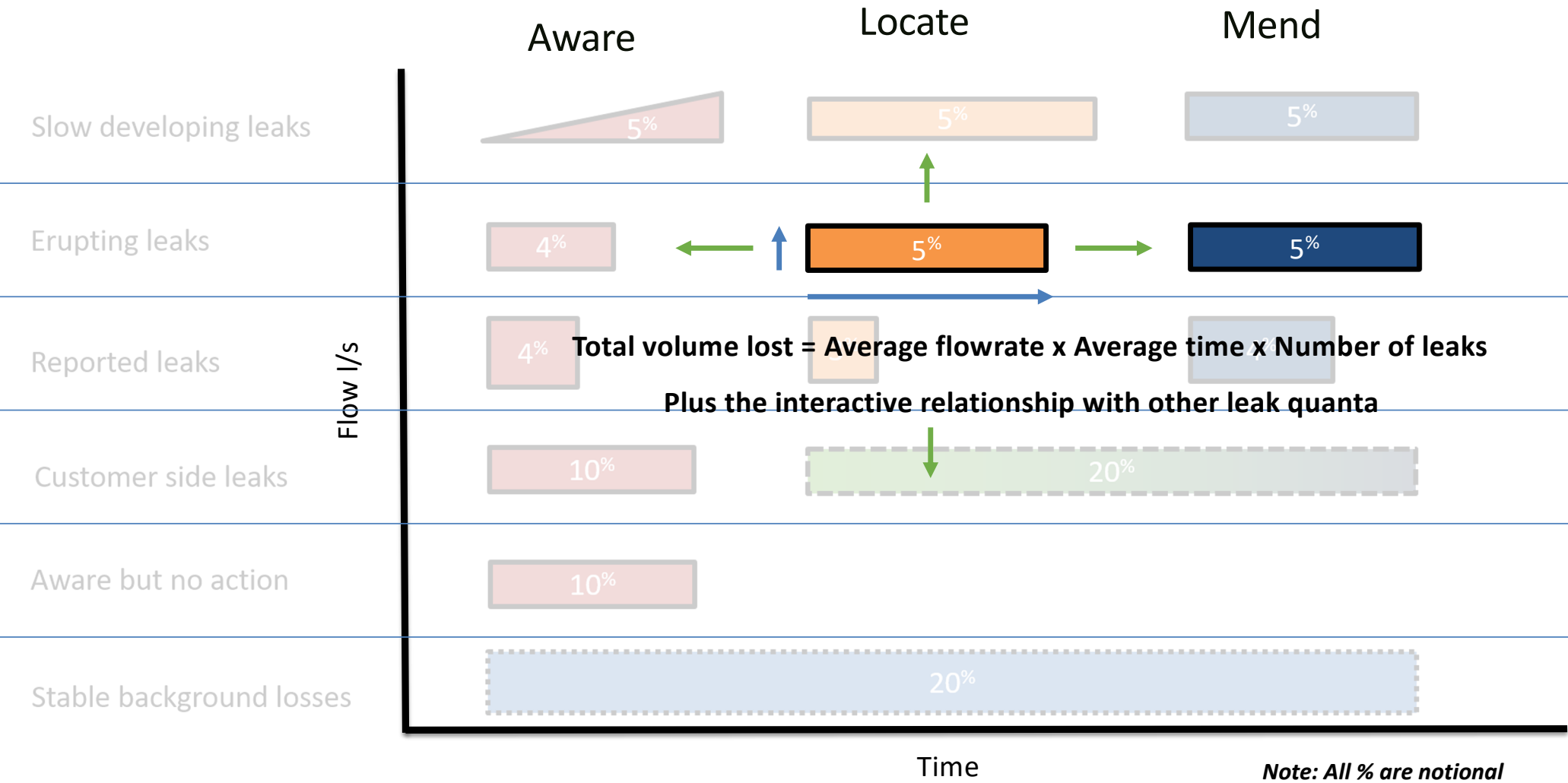
- Important to understand that this is not a leakage calculation approach but instead assists our development and implementation of leakage strategy and benefits.
- All of the QL allocations will be based on estimated numbers and averaged flows. As our knowledge increases, we will be able to better quantify these areas.
- It is entirely possible that we are missing significant areas in the model. We may need to identify the gaps and then find the “Higgs Bosons” of leakage.
- It is likely that QL models for varying timescales and areas will look different.
- At present QL is entirely conceptual. I have received support from the Leakage Managers group who view this as a potentially useful tool and from some consultants who are already working in this area.

Quantum Leakage

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Quantum Leakage



Quantum Leakage as a tactical and purchasing tool

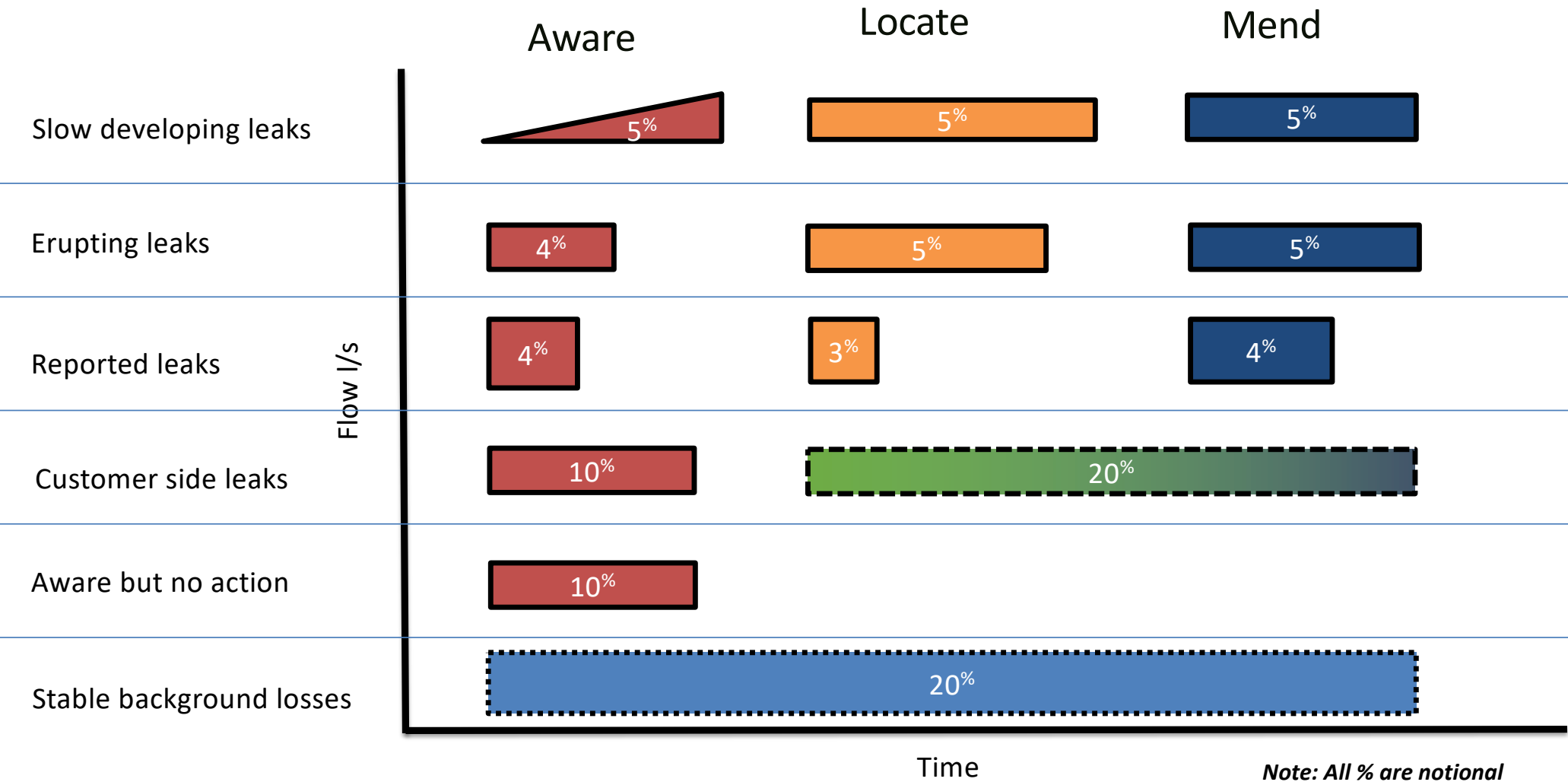
- Using QL, we can anticipate the likely change to our total leakage by changing one or a few leak quanta.
- Q. What is the impact on leakage of increasing ALC in an area by 20% for six months?
- Empirically, we know that this will mean we detect more leaks. But what is the anticipated impact on our leakage level?
- Using QL, we can identify the specify leak quanta impacted by this measure (Aware: Customer side leaks, Locate: Erupting leaks, Locate: slow developing leaks).
- We can also identify the related leak quanta impacted.
- By starting with the total volume lost for the area over six months, we can calculate the likely impact on total leakage of implementing this change.

Quantum Leakage as a strategy tool

- QL can also be used at company or national level to identify leakage reduction strategies.
- Q. What is required for England & Wales to halve leakage from the starting level of 3200 Mld to 1600 Mld by 2050?
- Run a number of scenarios to indicate how QL would assist in identifying the issues with achieving this and the areas of opportunity.

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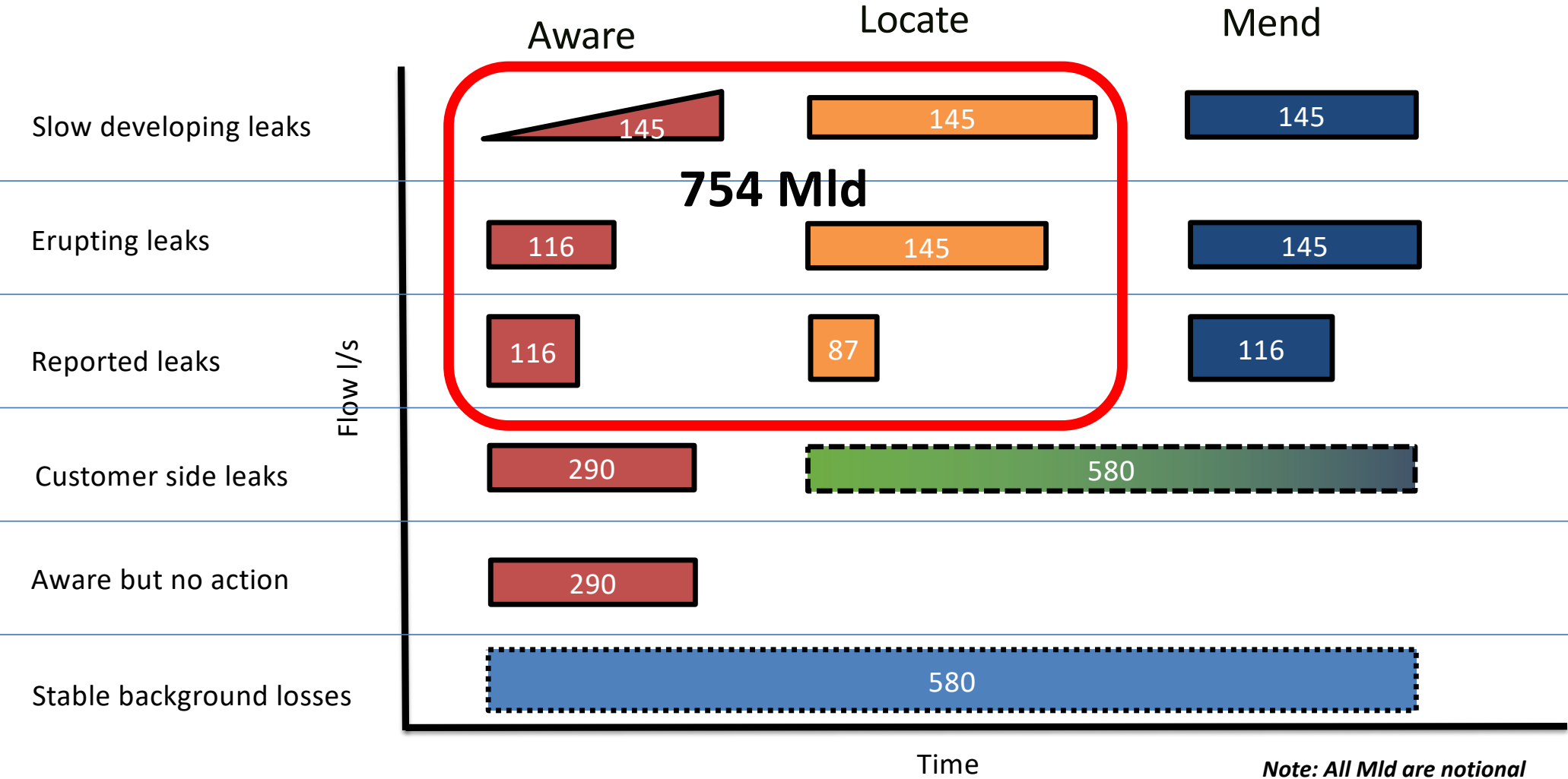


Quantum Leakage

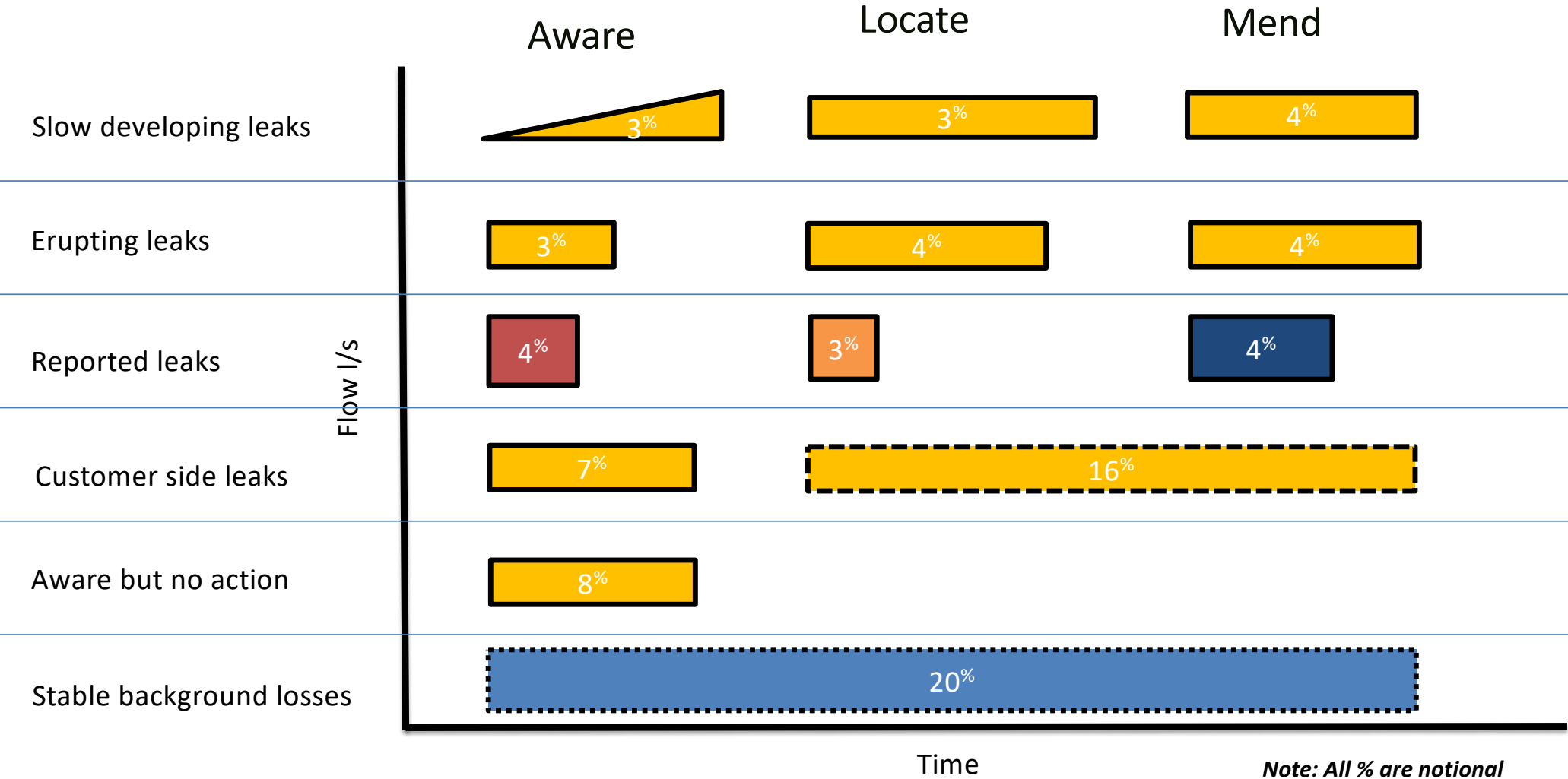
Current

2899 Mld

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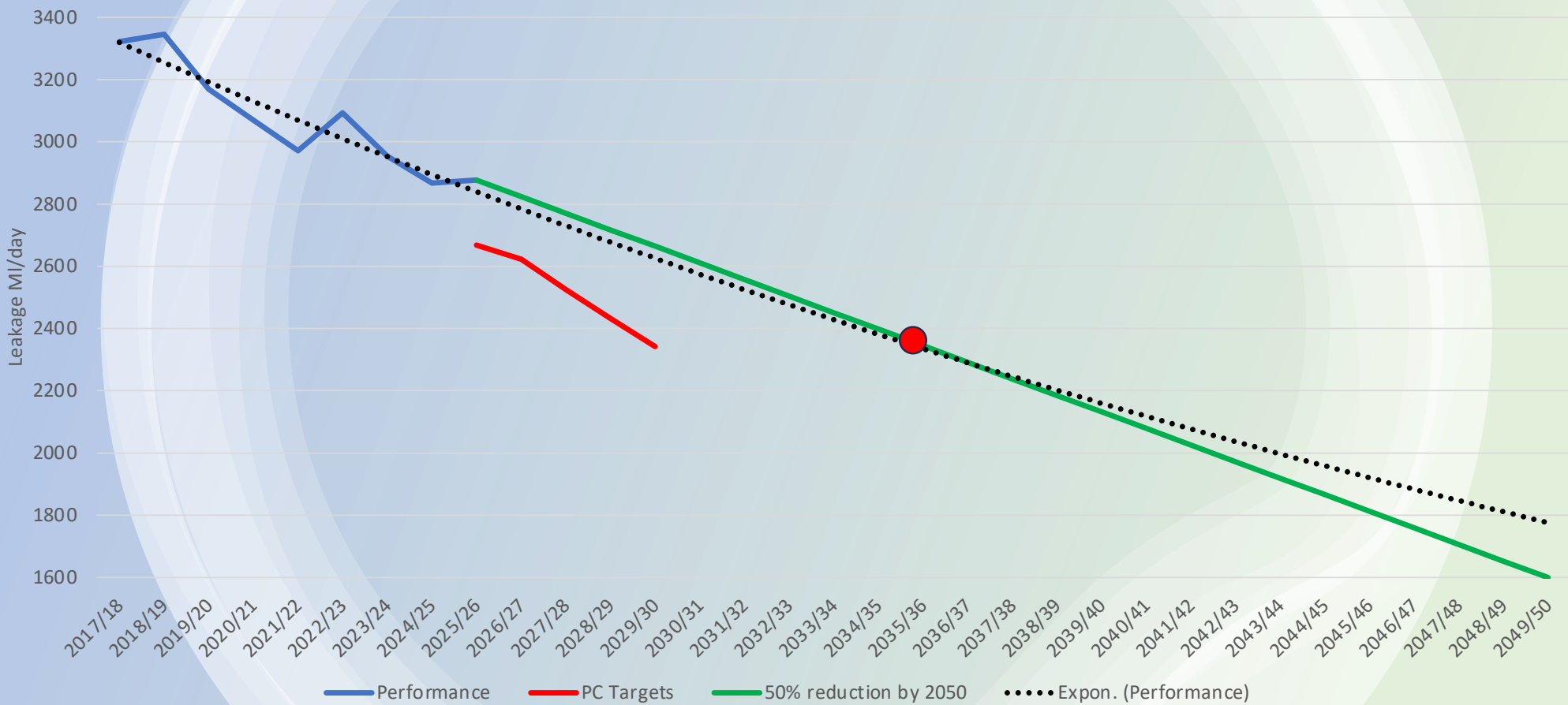


Quantum Leakage Future 2035



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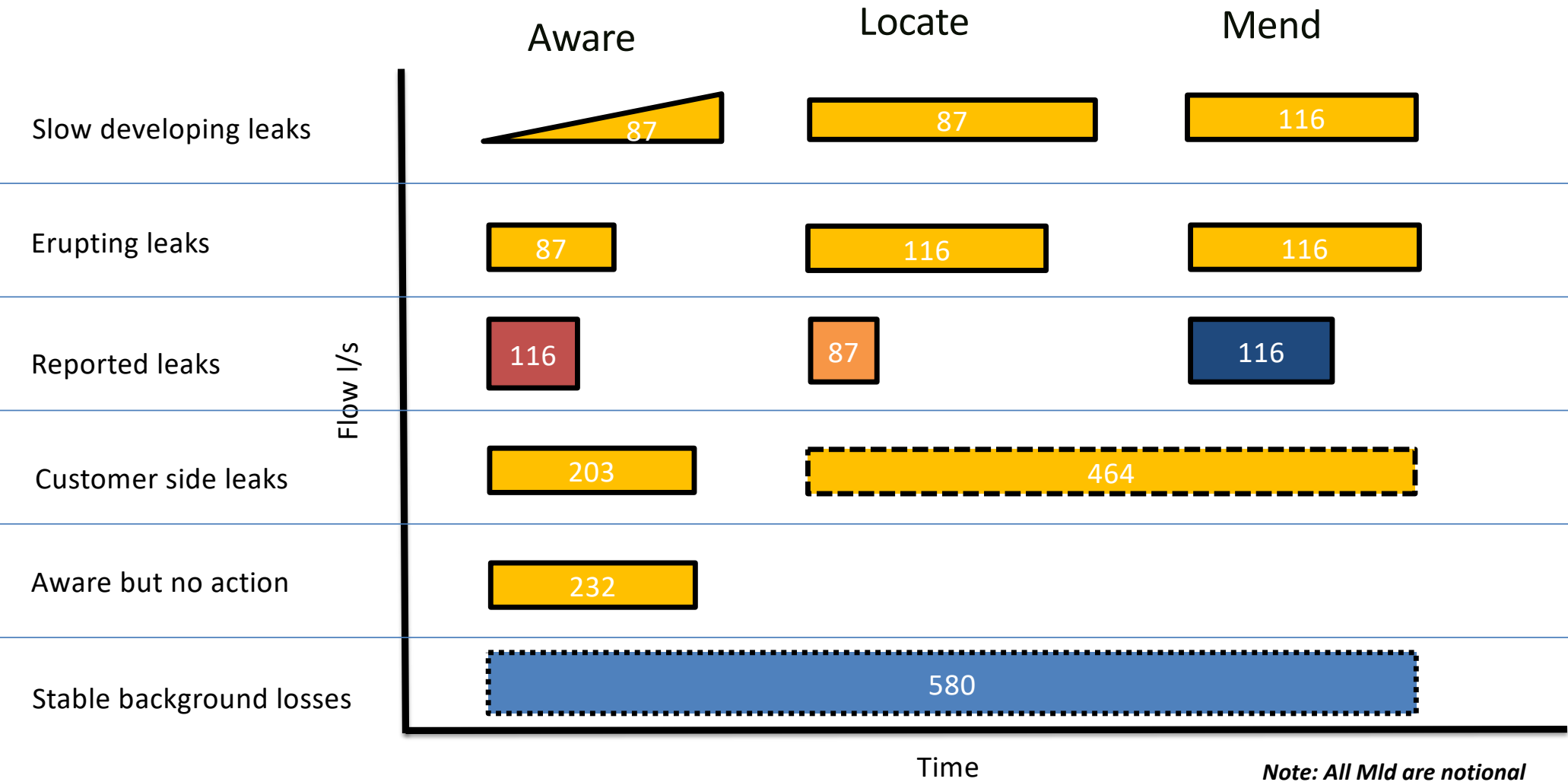
Quantum Leakage

Future 2035 2377 Mld

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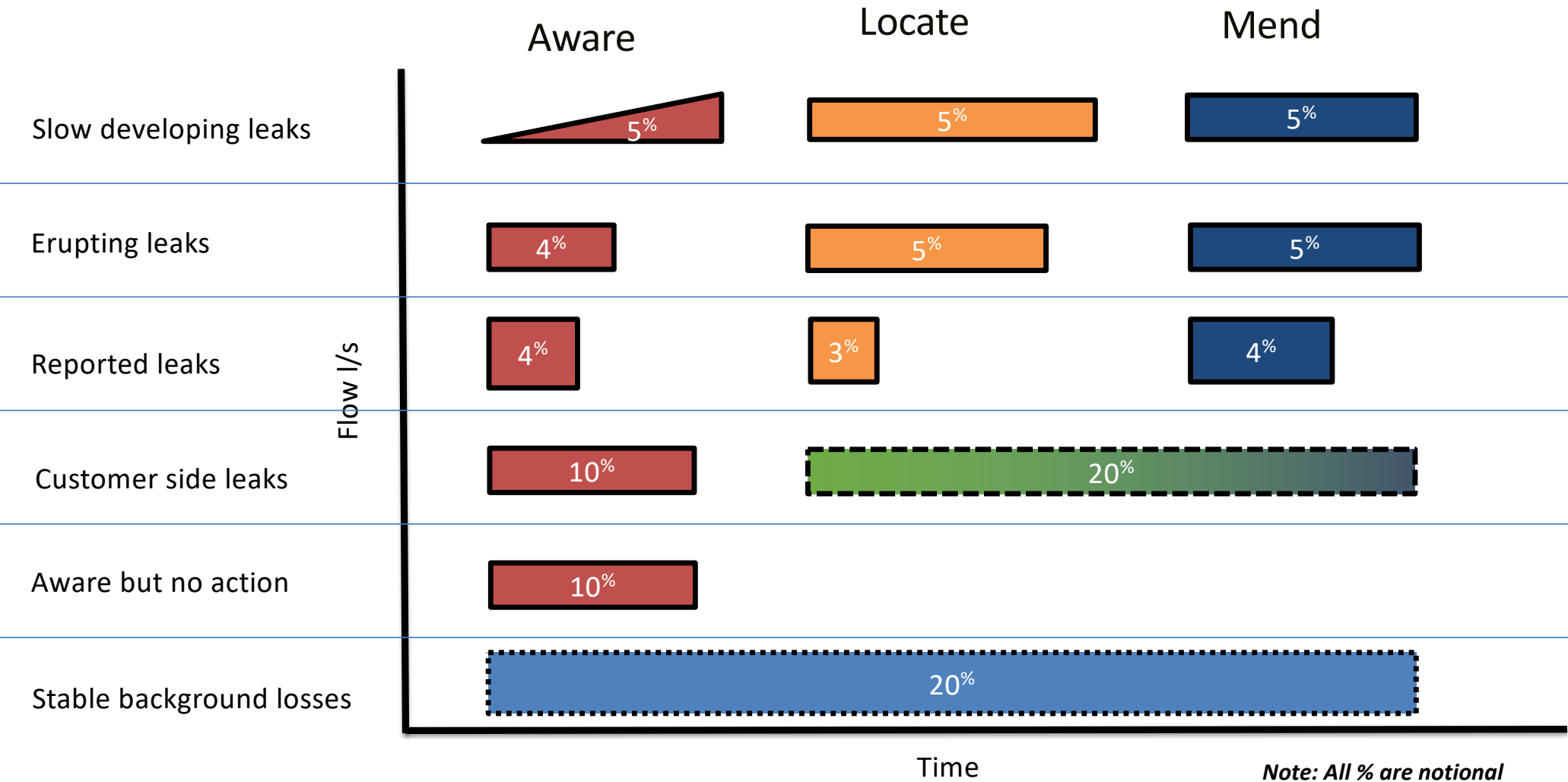


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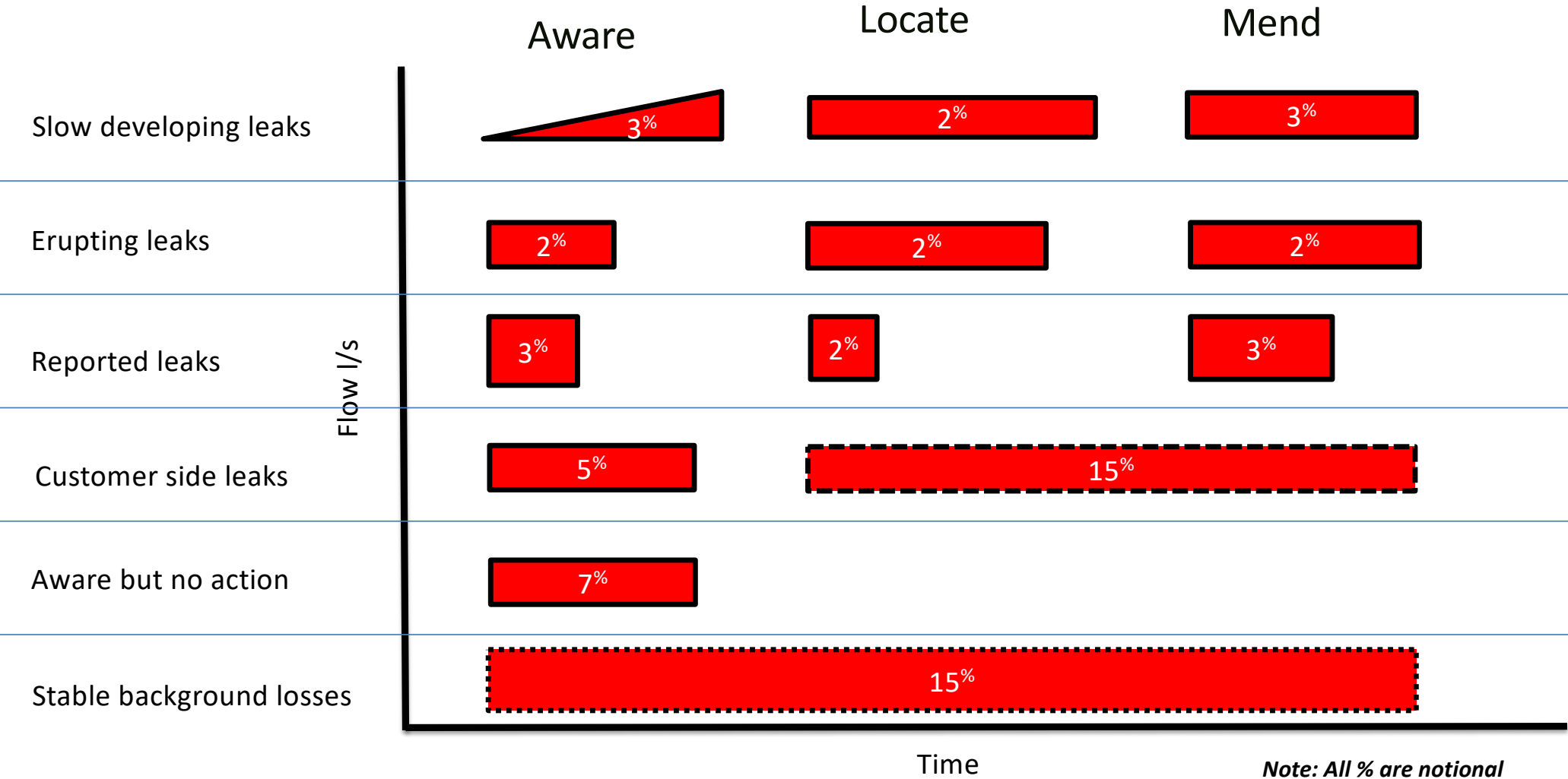


Quantum Leakage

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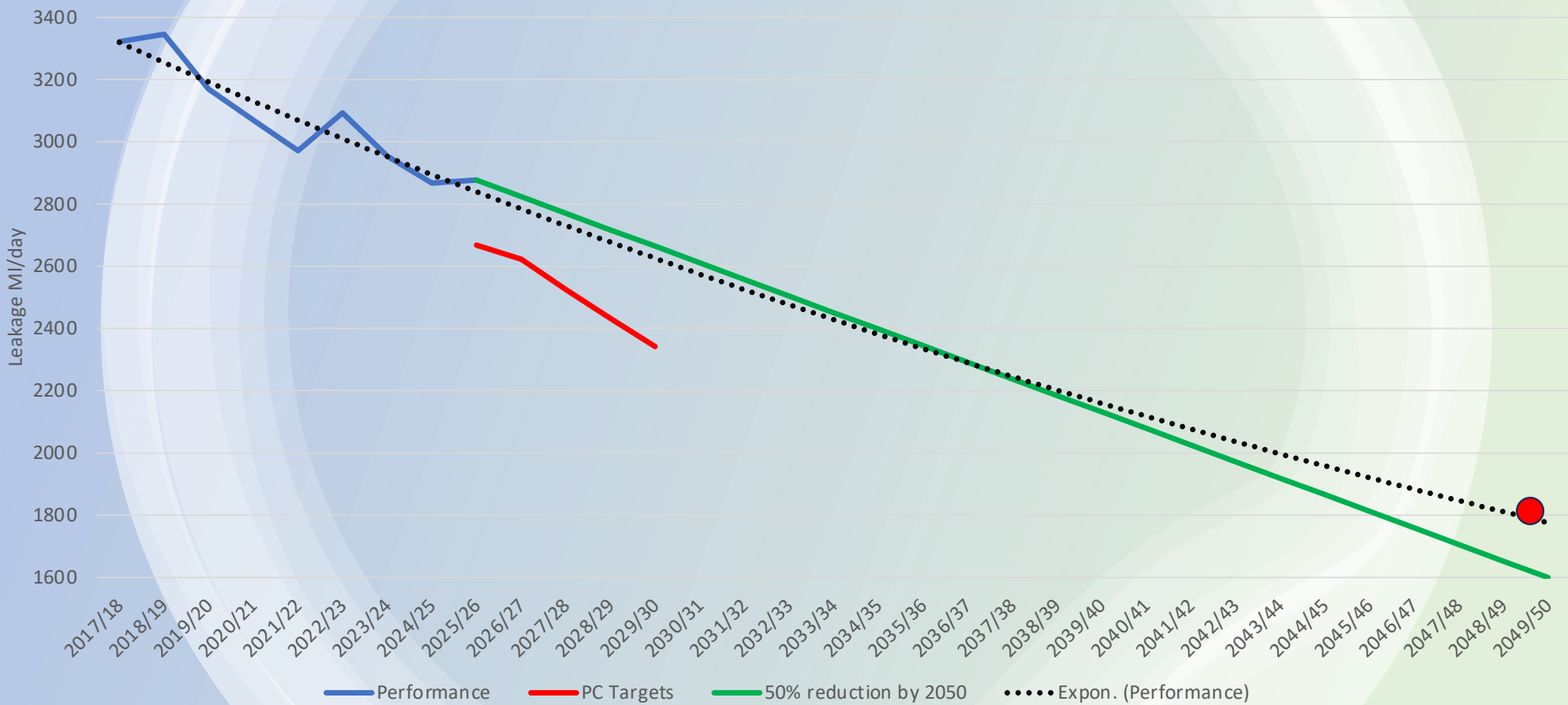


Quantum Leakage Future 2050



Understanding leakage

England & Wales leakage reduction to 2050



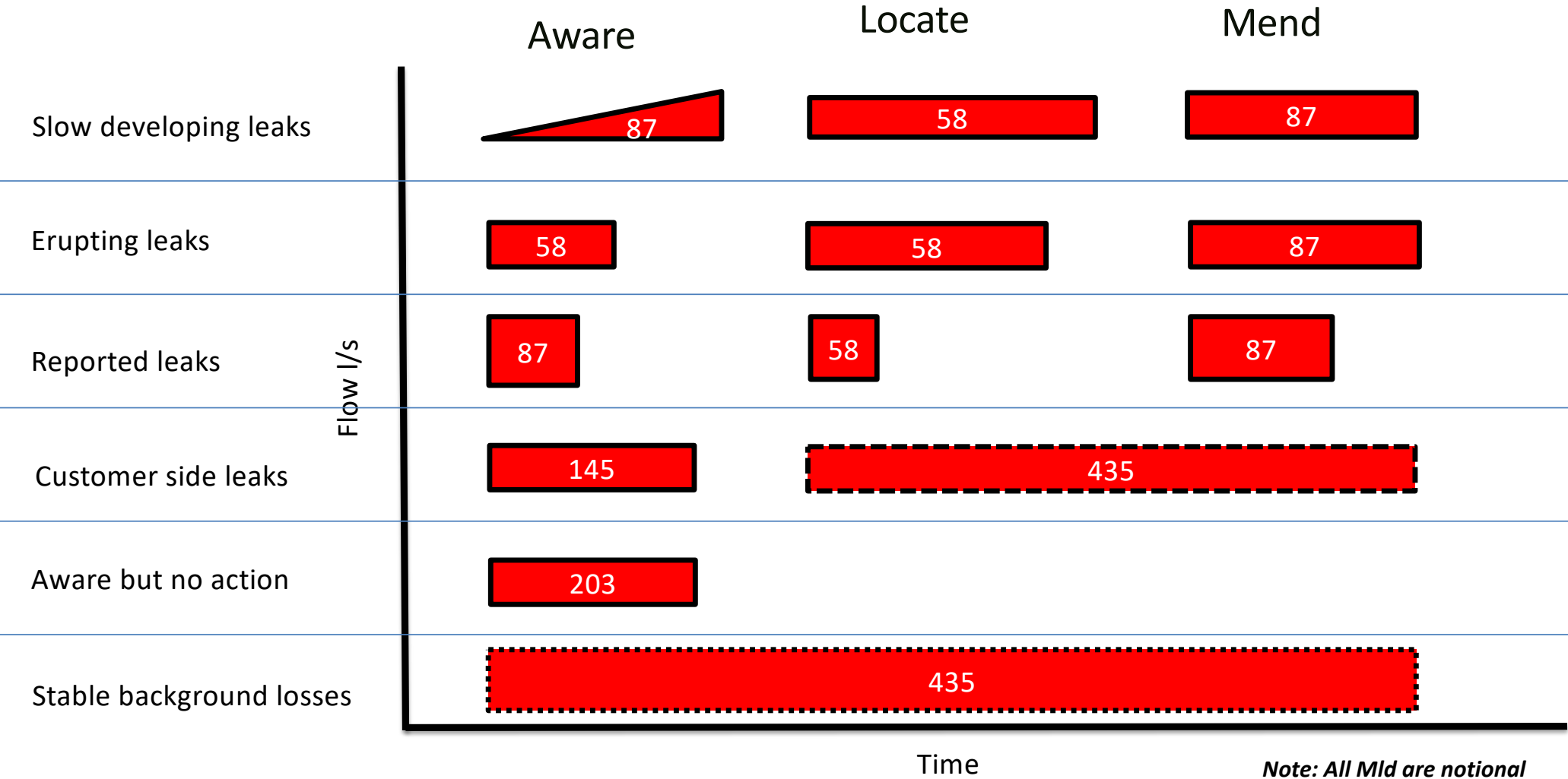
Quantum Leakage

Future 2050 1884 Mld

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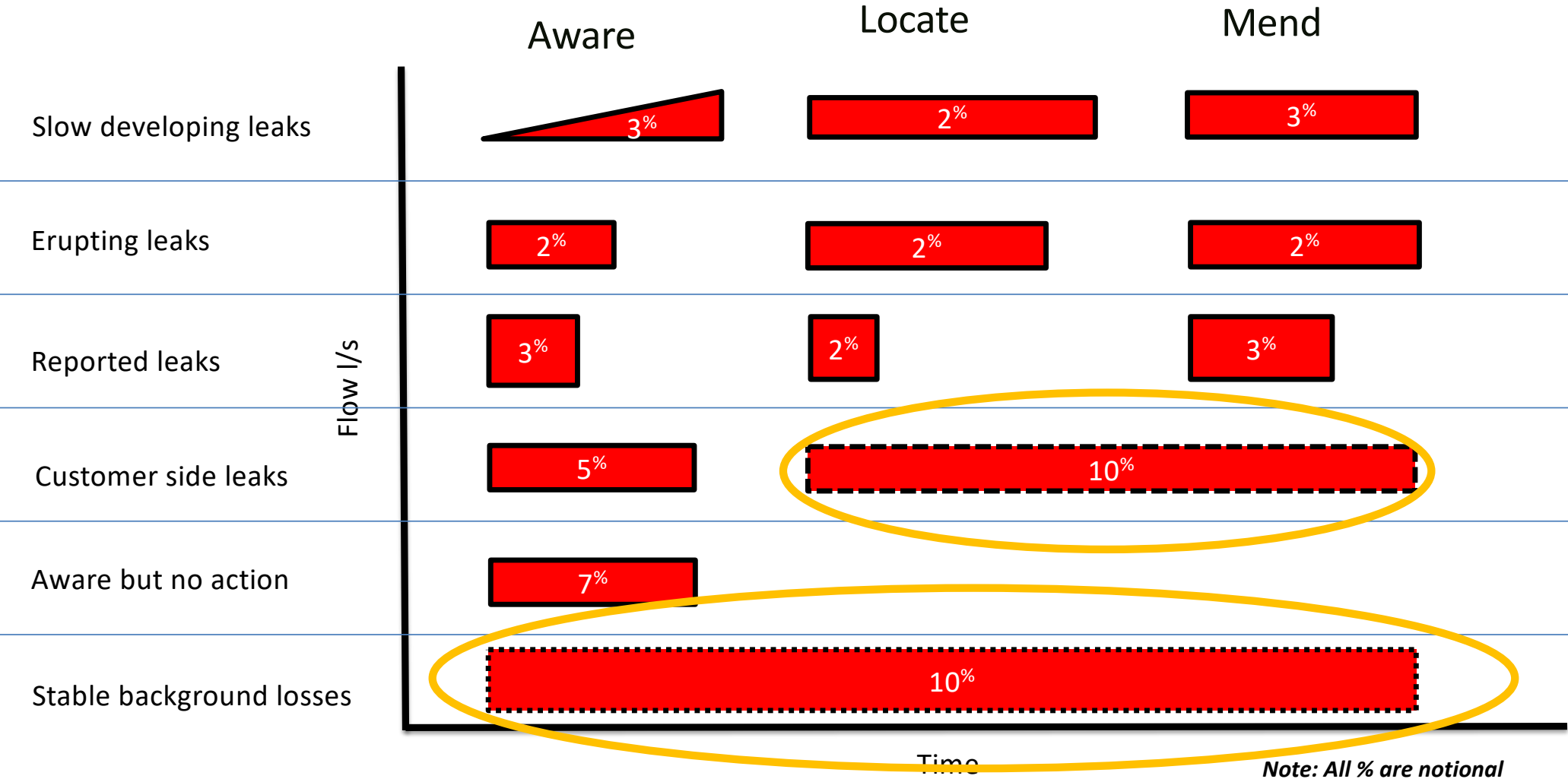
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Future 2050 1594 Mld

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Quantum Leakage

We anticipate that the required data will be drawn from a variety of sources.

- Existing Company returns (e.g. Total Company and CSL leakage, Number of repairs)
- Existing Company data collected but not required to be reported (Company mains leakage, CSL leakage)
- Current UK standards (e.g. internal plumping losses)
- UKWIR and other investigations (Background losses)
- Additional data calculations (Leak run times broken down by Awareness, Location and Mend)
- Estimates (Leak volumes, sub divided by type)
- QL will also require extensive modelling to manage the data, the inherent inaccuracies and inter-relationships between leak quanta.