British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Gateway to the Earth

25-29th September 2016
Montpellier, France
CORUM CONFERENCE CENTER
43rd IAH congress

‘Accounting for groundwater in future city visions?’

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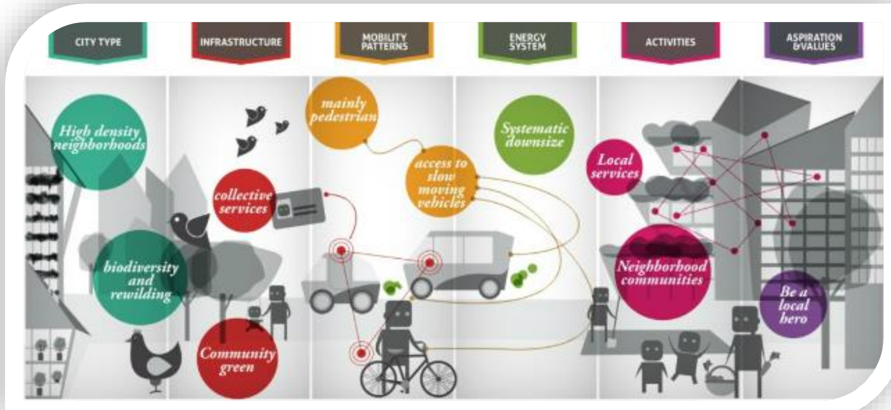
Future Cities Agenda

CATAPULT
Future Cities

Liveable Cities

URBAN
INNOVATION
CENTRE



urban living
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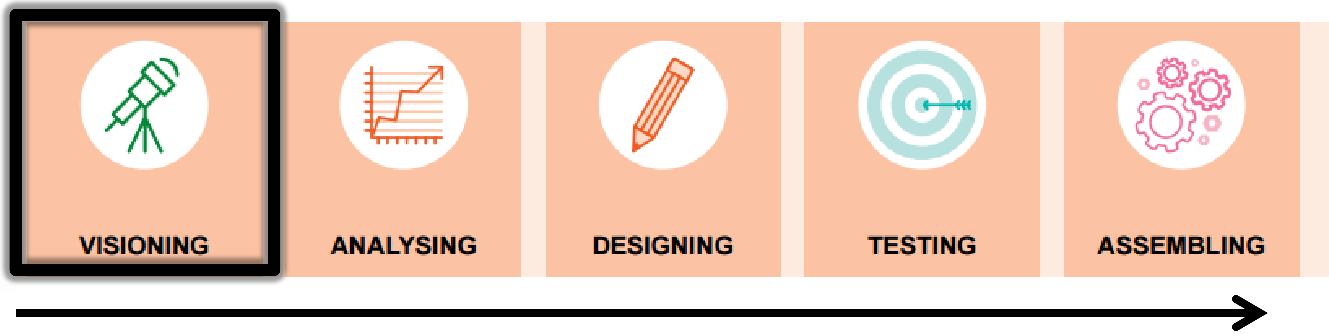
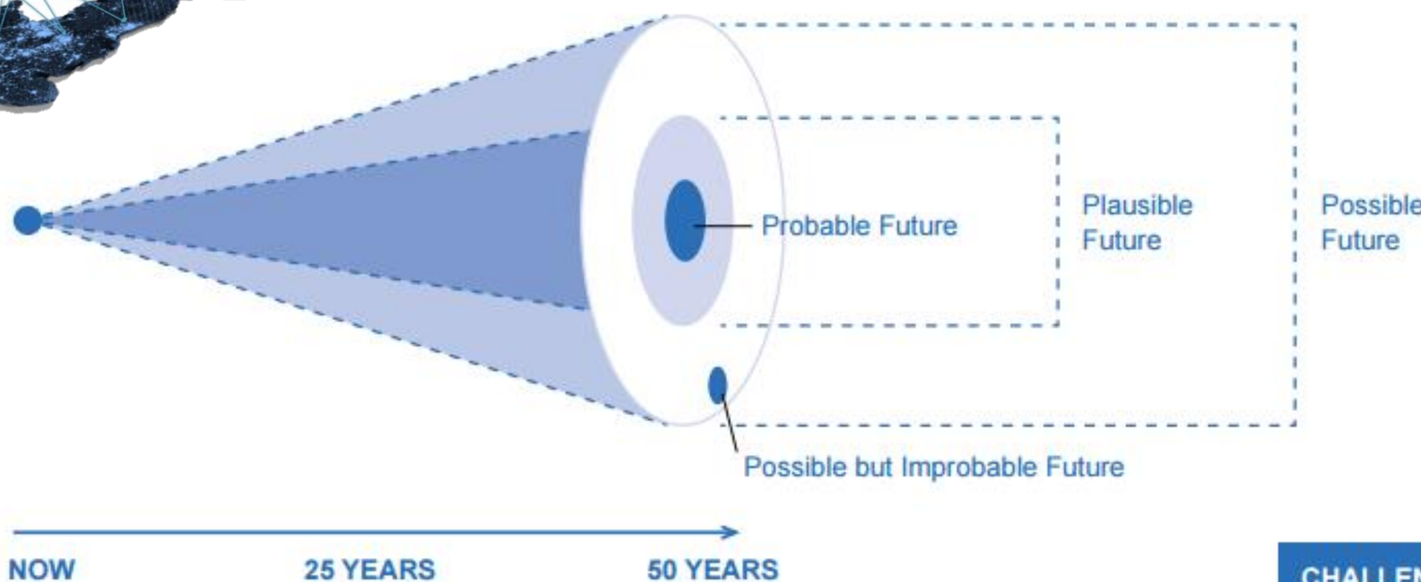
City visions

Foresight
Government Office for Science





CHALLENGE 1
Future beyond 25 years rarely considered for city planning

CHALLENGE 2
Non-probable, non-business-as-usual infrequently considered in city futures

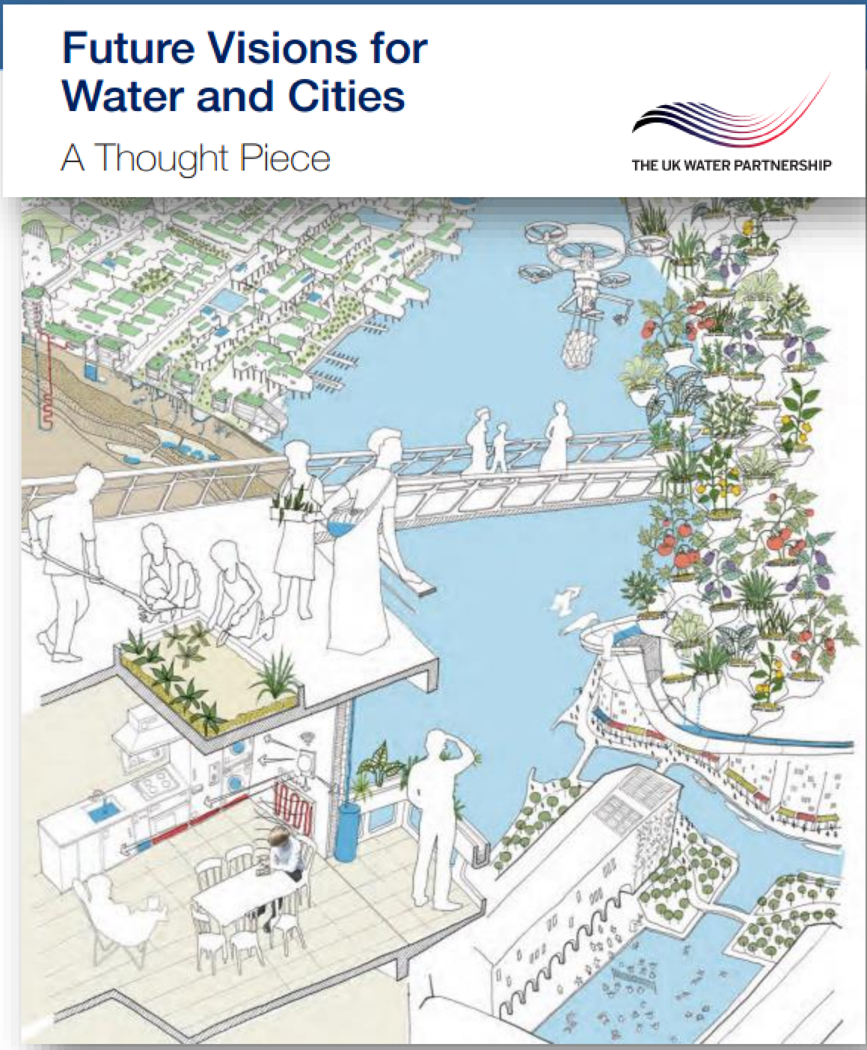
VISIONING

Visions for water and cities

Resource Plans ⟷ City Visions

- Resource planning e.g. water is robust but often done on 5 year cycles
- Long-term planning rarely goes beyond 25yrs
- Strategic plans are constrained by organisational procedures, business drivers, existing technology and infrastructure.
- Planning tends to be sector specific
- Sustainability principles are often lacking in city visions
- Value of urban groundwater systems and urban underground space is not yet fully recognised by city representatives in their plans/visions

Cities and the underworld



Water and Cities: Five visions

1. Green Food & Garden Cityscapes
2. Flood-proof Cities
3. Smart Homes & City Networks
4. **Cities & the Underworld**
5. Community Transition Cities

*'Interdependent underground systems provide **megacity-scale storage of water, heat and cold**, and manage the exchange of fresh, **saline and geothermal** water as well as the recharging of aquifers.'*

Cities and the underworld

- Integrated water-energy-underground-transport infrastructure.
- Increased use of underground water storage and aquifer storage and recovery.
- Use of minor aquifers to dampen climatic extremes.
- Use of marginal groundwater for non-potable uses.
- Building- to community-scale water distribution and water recycling.
- Assessment of urban aquifer capacity to deliver city ecosystem services.

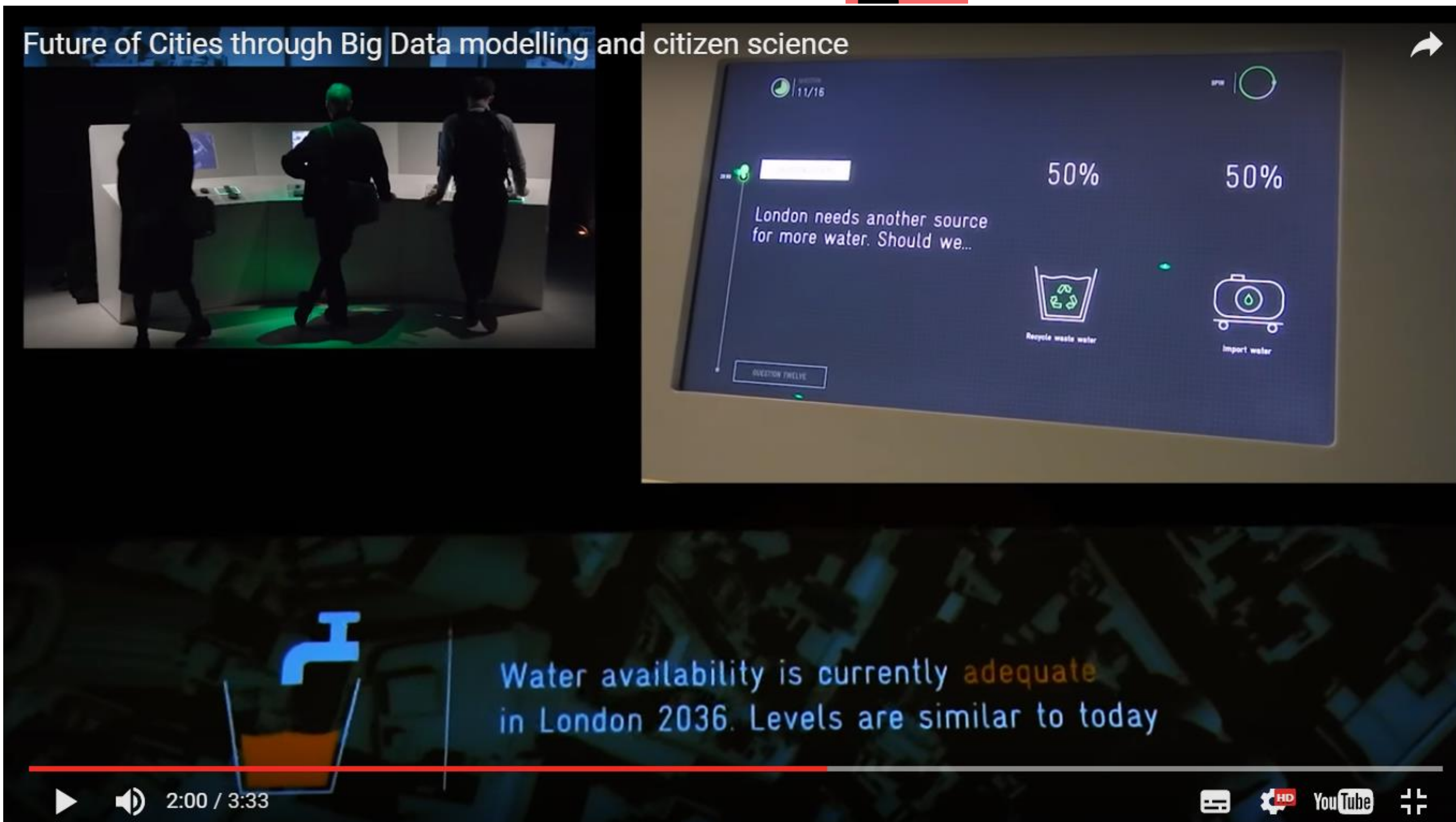
City-scale		
Interactive **mapping**	Smart **monitoring**	Integrated **modelling**
Infrastructure; aquifers groundwater; heat		

London 2036

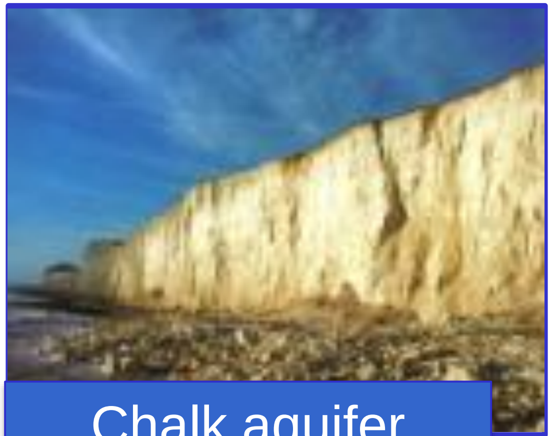
SOMERSET HOUSE

BIG BANG DATA

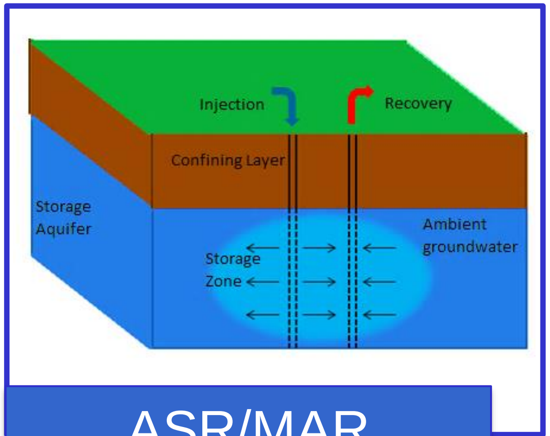
CATAPULT Future Cities



Groundwater in London

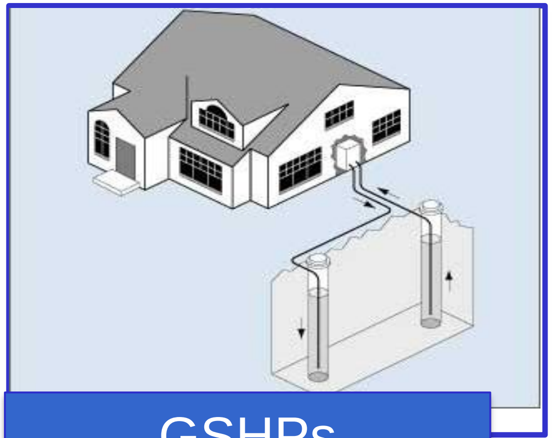


Chalk aquifer

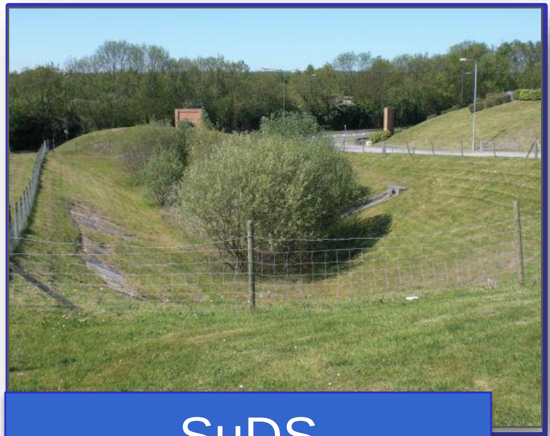


ASR/MAR

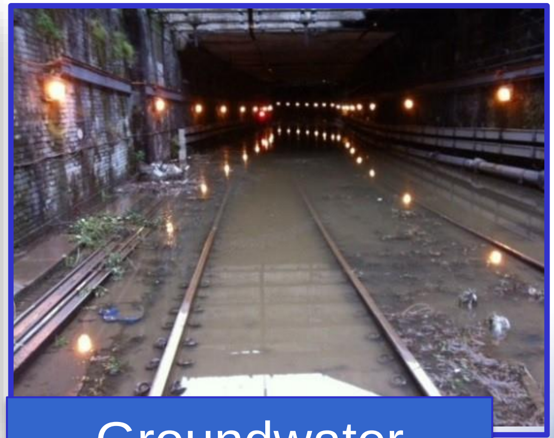
Pipe leakage



GSHPs



SuDS



Groundwater infiltration

Groundwater visions for London in 2036

Strategic future	Aspirational future
Organisational policy	New sustainability paradigm

City interventions

Supply

- Rainwater harvesting
- Sustainable drainage systems
- Aquifer storage and recovery
- Wastewater recycling
- Leakage reduction
- New groundwater boreholes
- Water transfers
- Greywater recycling

Demand

- Smart Home – water efficiency
- Smart water meters
- New water tariffs and behaviour change

Neutral

- Groundwater sourced heating systems

Groundwater in London 2036: SuDS

Example

Intervention: Infiltration sustainable drainage systems (SuDS)

City actors: Home builders, local planners, landscape architects

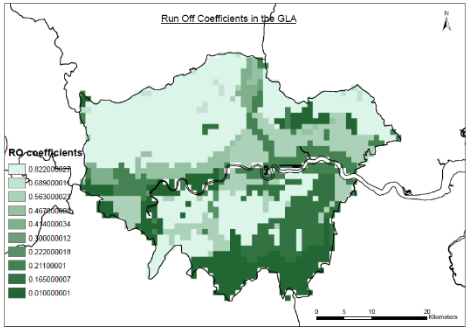
Change to water cycle:

- volume of surface water going to piped drainage is reduced
- reduced the risk of storm 'overflows' and pollution
- natural urban groundwater recharge is increased

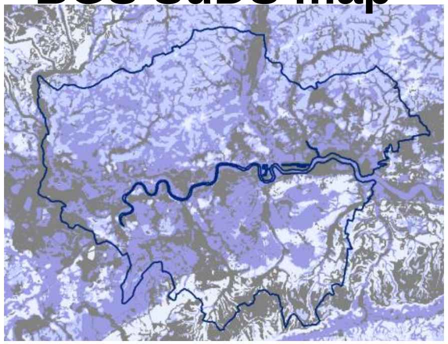
	Scale of intervention	Data sources
Strategic future	SuDS are installed to reduce the volume of surface water flowing into the combined sewer network in London. **(= 87 Ml/d)**	Defra regulatory impact assessment – sewage collection and treatment for London.
Aspirational future	Infiltration sustainable drainage systems are installed across 10% of London land area where run-off rates are high and infiltration SuDS are suitable. **(= 282 Ml/d)**	BGS SuDS Suitability Map BGS Thames Run-off - Recharge Model HR Wallingford SuDS tool

Aspirational future	Infiltration sustainable drainage systems are installed across 10% of London land area where run-off rates are high and infiltration SuDS are suitable.

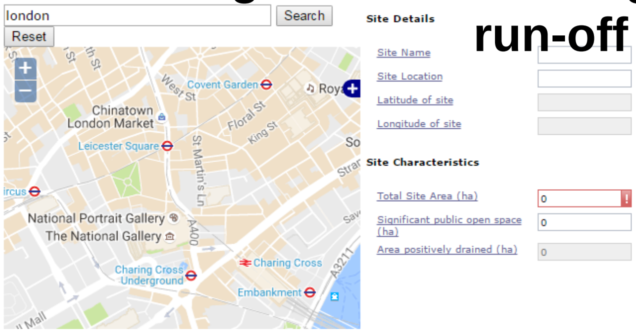
Run-off model



BGS SuDS map



HR Wallingford SuDS tool: green run-off rates



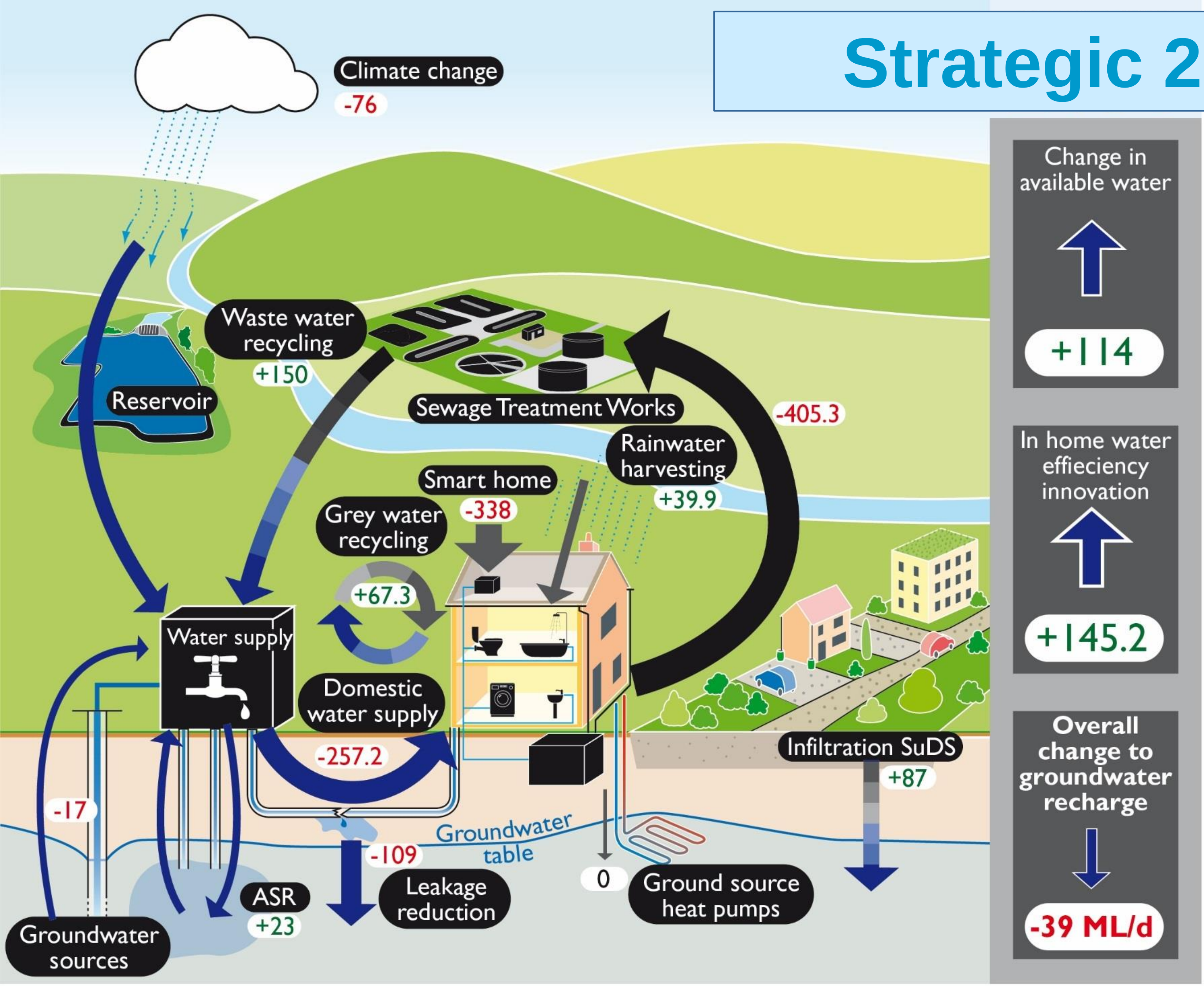
- ➢ Areas of high run-off, where infiltration SuDS are most suitable: **13069 hectares**
- ➢ Infiltration SuDS installed across 10% of suitable area by 2036: **1307 hectares**
- ➢ 1 in 1 year green run-off discharge rate for London: **~2.5 l/s per hectare**
  - ➢ **Total infiltration delivered through SuDS 3267l/s (282 Ml/d)**

Assumptions:

- 1 in 1 year estimated discharge for a 1 hectare site in London suitable for infiltration SuDS is 2.5-3 litres per second.
- Sites have 25% open area, i.e. 75% of land needs to be drainage at greenfield run-off rate.
- London's development rate is 0.5% of land per year, meaning 10% of land is developed by 2036.

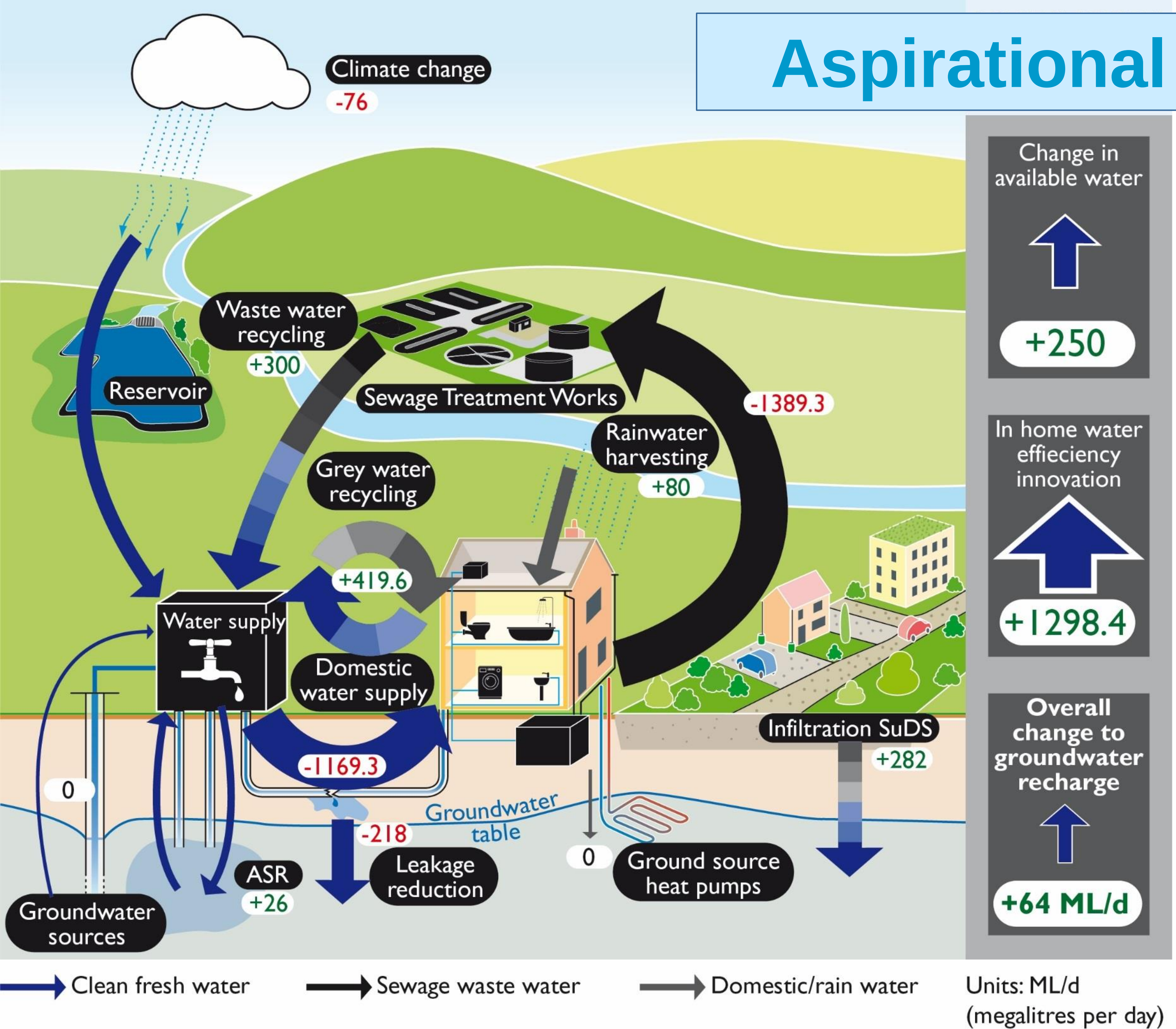
	Interventions	Future Vision for 2036	Total change in water balance (Ml/d)	% of London’s water demand in 2036 (2177 Ml/d)	% of London’s groundwater recharge in 2036 (308 Ml/d)
Supply	Rain water harvesting	Strategic	39.9	1.8	13.0
		Aspirational	80	3.7	26.0
	Wastewater recycling (effluent re-use)	Strategic	150	6.9	48.7
		Aspirational	300	13.8	97.4
	Greywater recycling (internal household water recycling)	Strategic	67.3	3.1	21.9
		Aspirational	419.6	19.3	136.2
	AR (Artificial recharge) ASR (Aquifer storage and recovery)	Strategic	23	1.1	7.5
		Aspirational	26	1.2	8.4
	Sustainable drainage implementation	Strategic	87	3.9	28.3
		Aspirational	282	13	91.6
	New groundwater sources	Strategic	17	0.8	5.5
		Aspirational	0	0	0
	Leakage reduction	Strategic	109	5.0	35.4
		Aspirational	218	10.0	70.8
Demand	Smart Home – water efficiency	Strategic	238	10.9	77.3
		Aspirational	590	27.1	191.6
	SMART meter installation	Strategic	38	1.8	12.3
		Aspirational	208.8	9.6	67.8
	New water tariffs and behaviour change	Strategic	62	2.9	20.1
		Aspirational	170.9	7.9	55.5
Neutral	Groundwater sourced heating	Strategic	118 new sites.		No net change
		Aspirational	338 new sites.	No net change	No net change

Strategic 2036



Clean fresh water
Sewage waste water
Domestic/rain water
Units: ML/d (megalitres per day)

Aspirational 2036



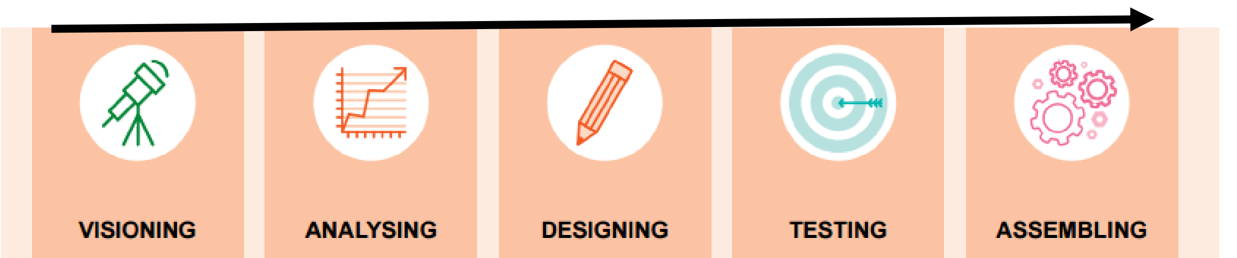
Summary

Findings

- Wastewater recycling and home water efficiency are most favourable under both strategic and aspirational futures.
- Greatest disparity between the strategic and aspirational future is seen for smart homes and greywater recycling.
- Implementation of rainwater harvesting, pipe leakage repair and sustainable drainage are more significant for urban groundwater systems than abstraction and ASR at the city-scale.

Benefits

- Progression from qualitative visions to quantitative analysis, to reduce uncertainty and assess plausibility.
- Allows for iterative assessment of options across integrated city systems.
- Potential to link with economic appraisal of options
- Steer for future investment.



Thank you

Questions?

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