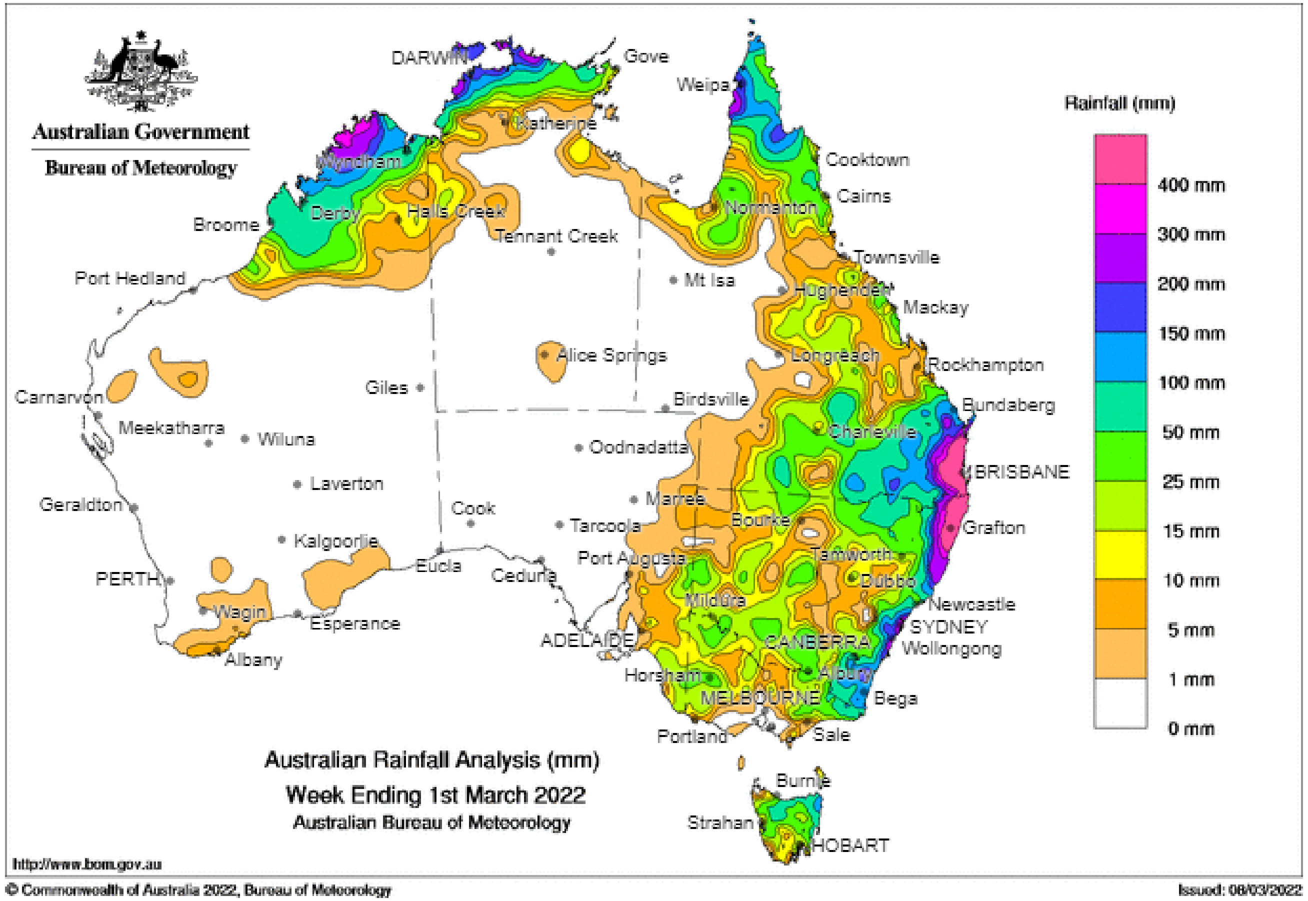
Leachate management during catastrophic weather conditions

→ Adrian Roberts

Technical Director – Waste Management


Australian Government
Bureau of Meteorology
Rainfall (mm)
400 mm
300 mm
200 mm
150 mm
100 mm
50 mm
25 mm
15 mm
10 mm
5 mm
1 mm
0 mm
DARWIN
Gove
Weipa
Katherine
Wyndham
Cooktown
Cairns
Broome
Derby
Halls Creek
Normanton
Tennant Creek
Townsville
Port Hedland
Mt Isa
Hughenden
Mackay
Alice Springs
Longreach
Rockhampton
Carnarvon
Giles
Birdsville
Bundaberg
Meekatharra
Wiluna
Charleville
Oodnadatta
BRISBANE
Laverton
Geraldton
Cook
Marree
Tarcoola
Bourke
Grafton
Kalgoorlie
Port Augusta
Tamworth
Eucla
Ceduna
Dubbo
PERTH
Mildura
Newcastle
Wagin
Esperance
SYDNEY
ADELAIDE
CANBERRA
Wollongong
Albany
Horsham
Albury
MELBOURNE
Bega
Portland
Sale
Australian Rainfall Analysis (mm)
Week Ending 1st March 2022
Australian Bureau of Meteorology
Burnie
Strahan
HOBART
http://www.bom.gov.au
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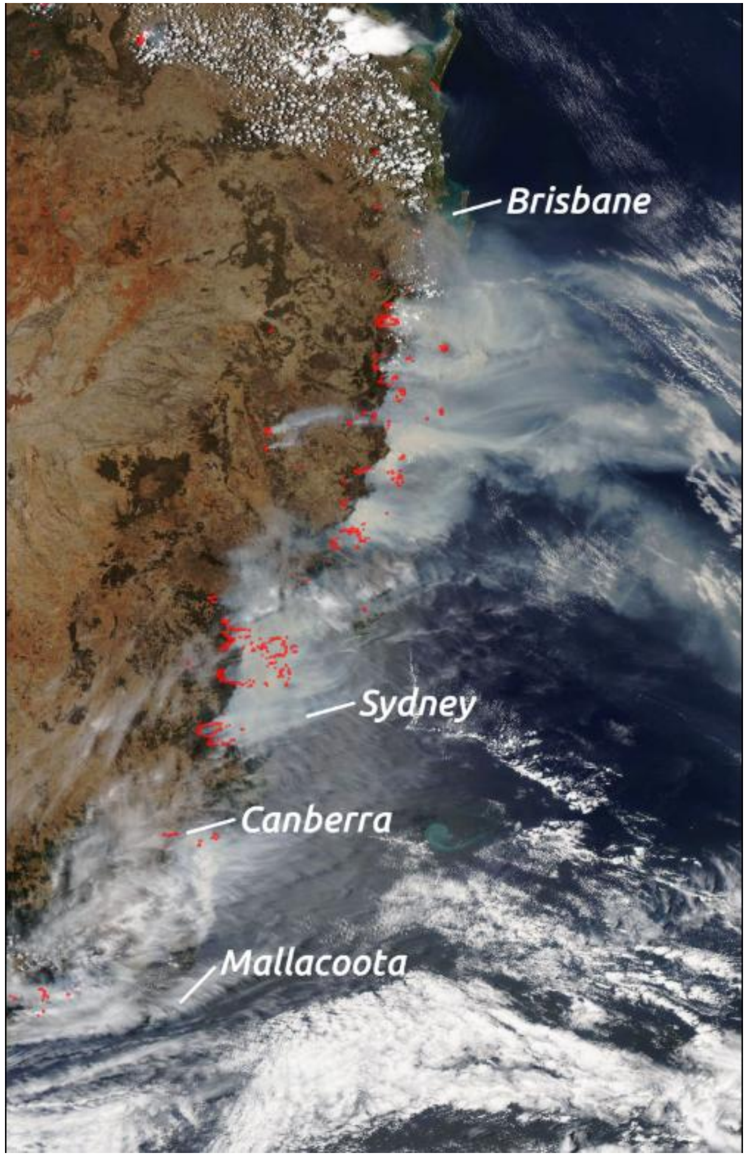
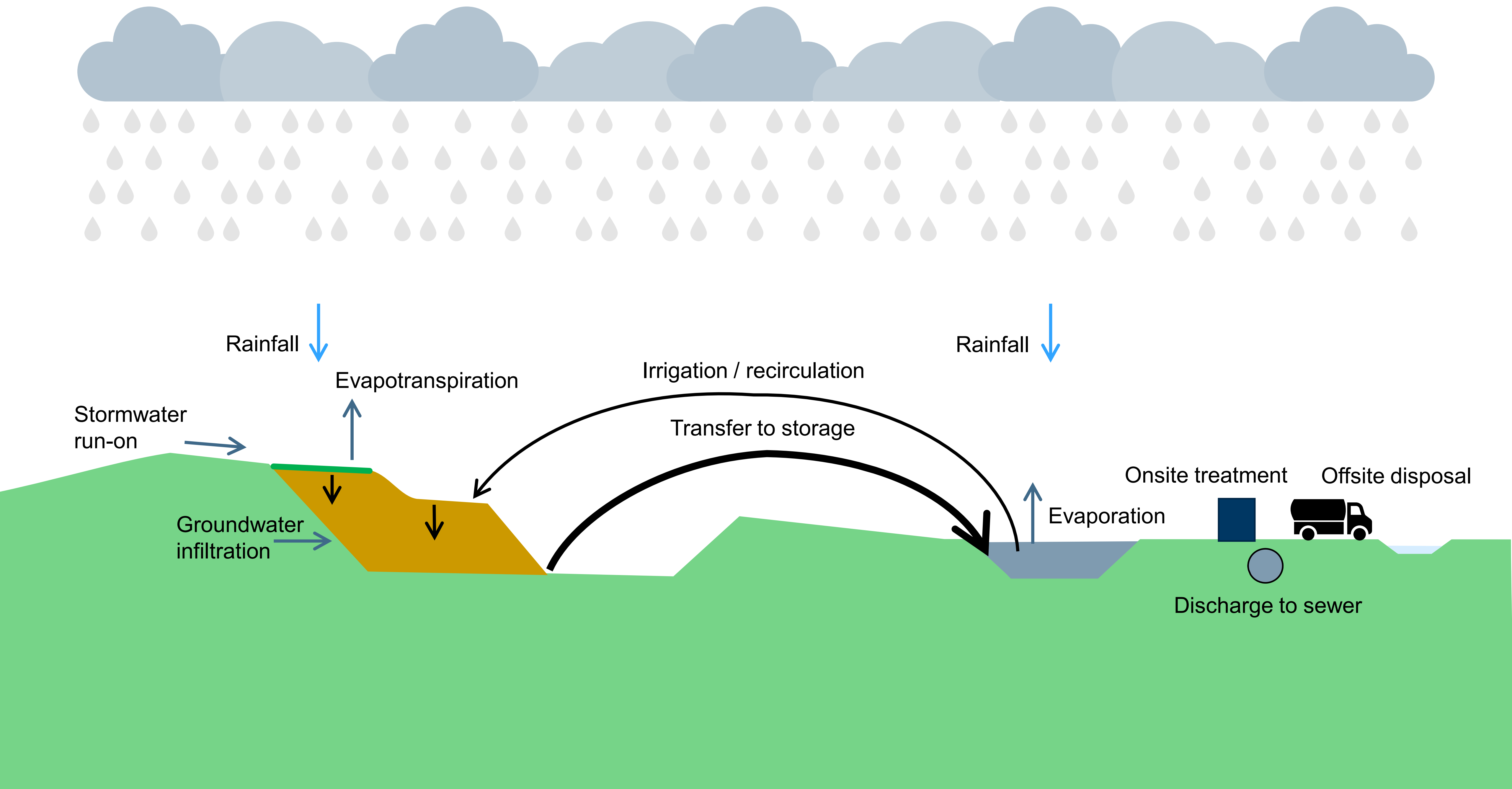
Issued: 08/03/2022


Brisbane
Sydney
Canberra
Mallacoota


STOP
ROAD
CLOSED


Rainfall
Evapotranspiration
Stormwater run-on
Groundwater infiltration
Irrigation / recirculation
Transfer to storage
Rainfall
Evaporation
Onsite treatment
Offsite disposal
Discharge to sewer

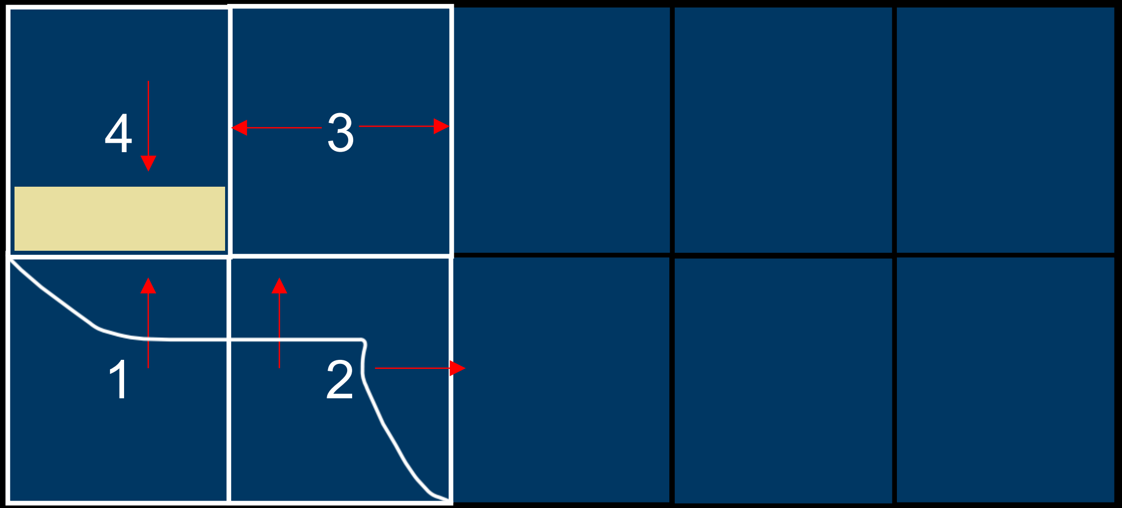
Have a logical site development plan

Site staging plans should:

- Maintain landfill capacity
- Minimise potential for stormwater run-on
  - Landfill cell location
  - Order of filling
- Minimise potential for leachate generation
  - Optimum cell footprint size
  - Reduce area of interim cover and interim batters

Case study 1

- Cells historically developed and filled “out of order” resulting in large areas of interim batter
- Low filling rate resulting in exposed leachate collection system



Have a realistic leachate management plan

Leachate management plans and leachate water balances should :

- Include all sources of leachate (many don't!)
- The site's current and future arrangements (do you have a final landform?)
- Include realistic storage and disposal options (spray and pray)
- Be calibrated with collected site data
- Be regularly reviewed and recalibrated (changing climate, materials and site operations)

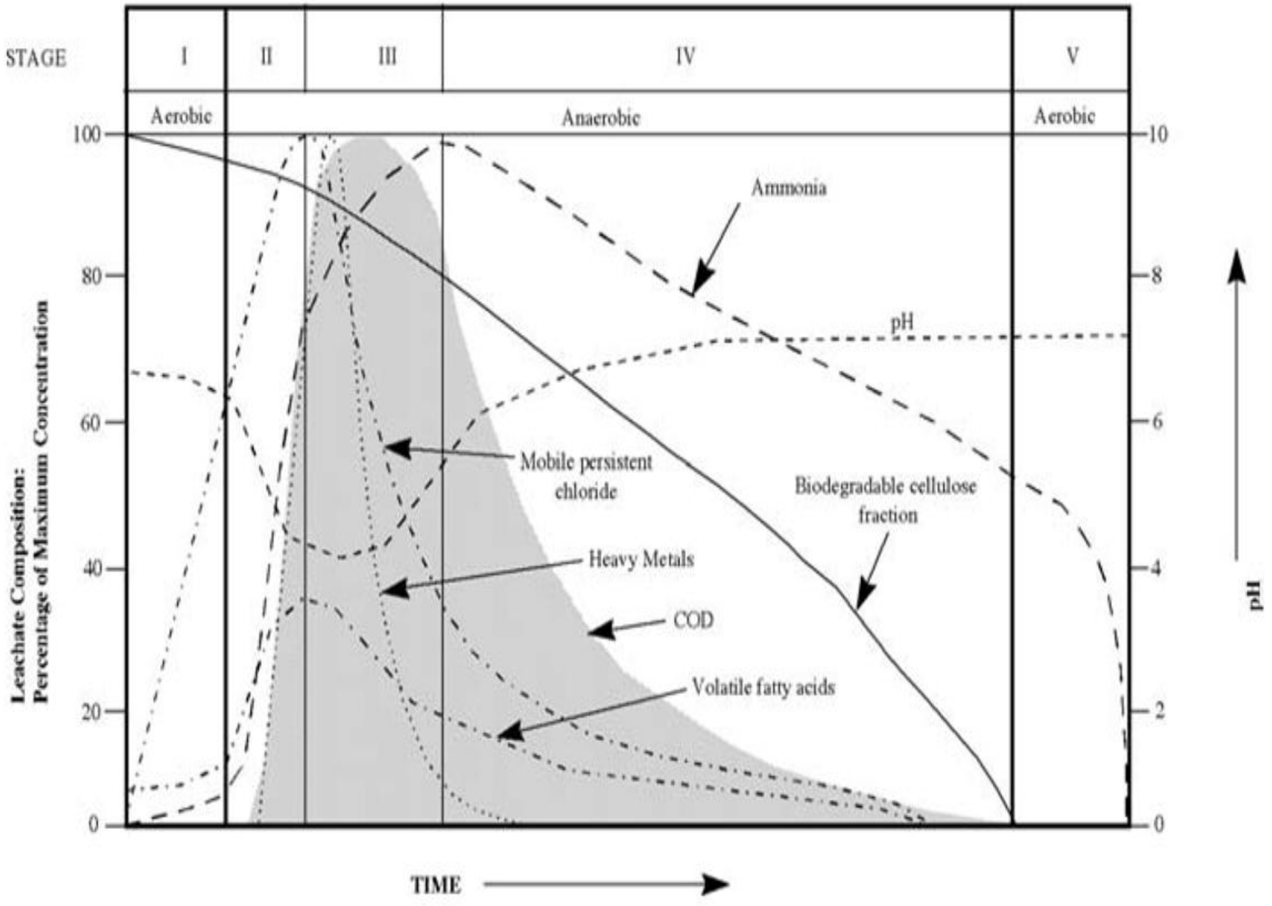
Site water balance can identify:

- When more storage, treatment or disposal capacity is required
- Which operational or design improvements will be effective
- Stages of site development when contingency measures may be required

Gather site data

Quantity data for sizing infrastructure

Quality data for assessing treatment and disposal options



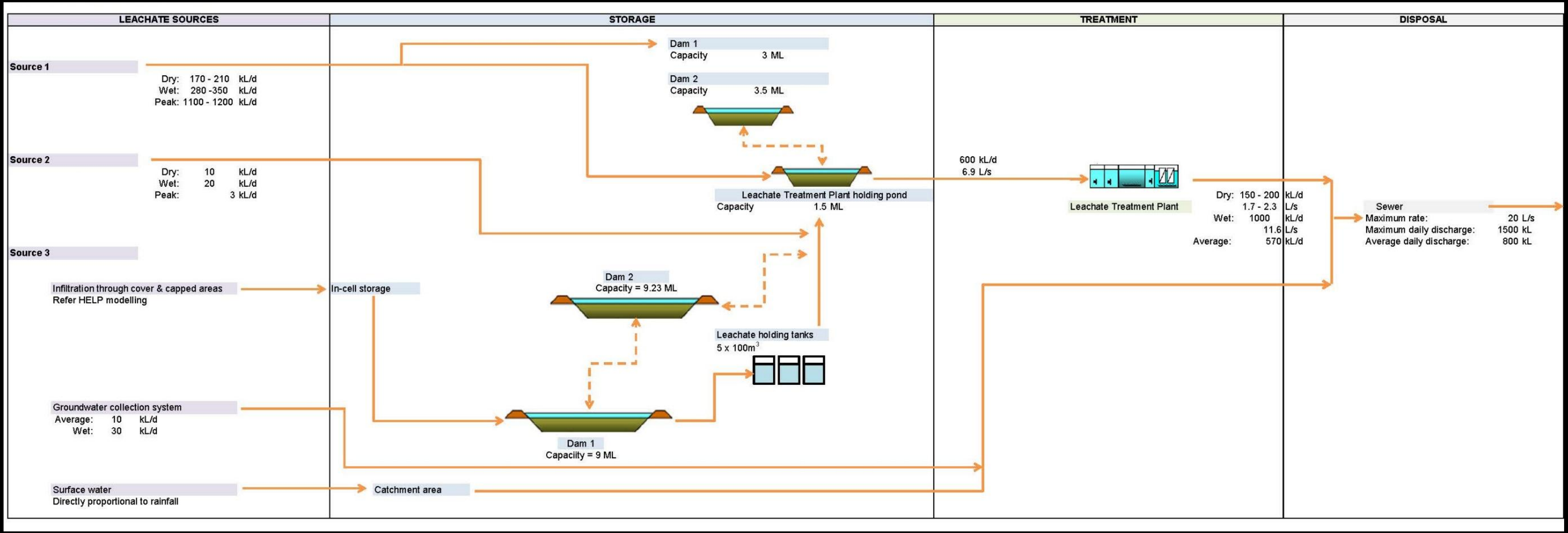
Quantity will change over time:

- Weather
- Landfill footprint
- Landfill operation
- Landfill design

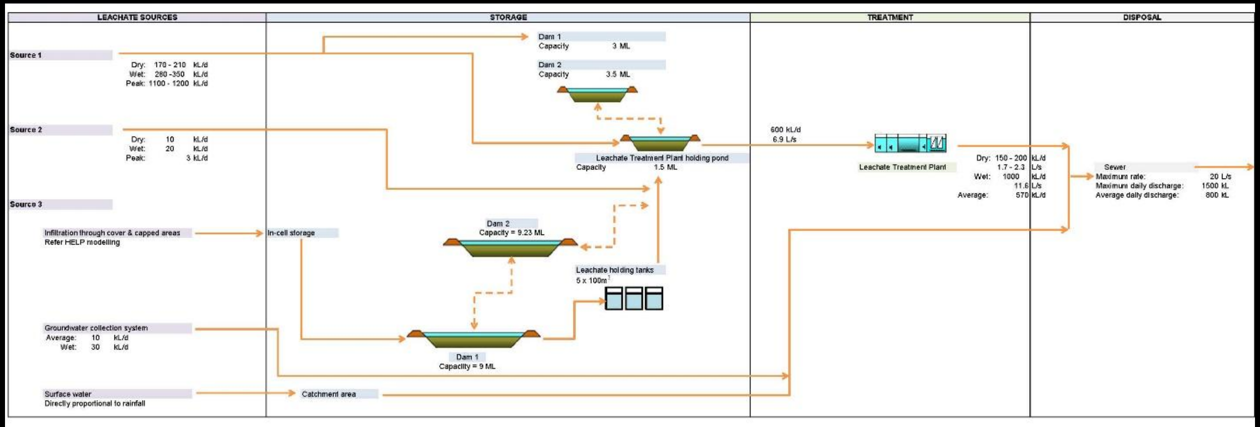
Quality will change over time:

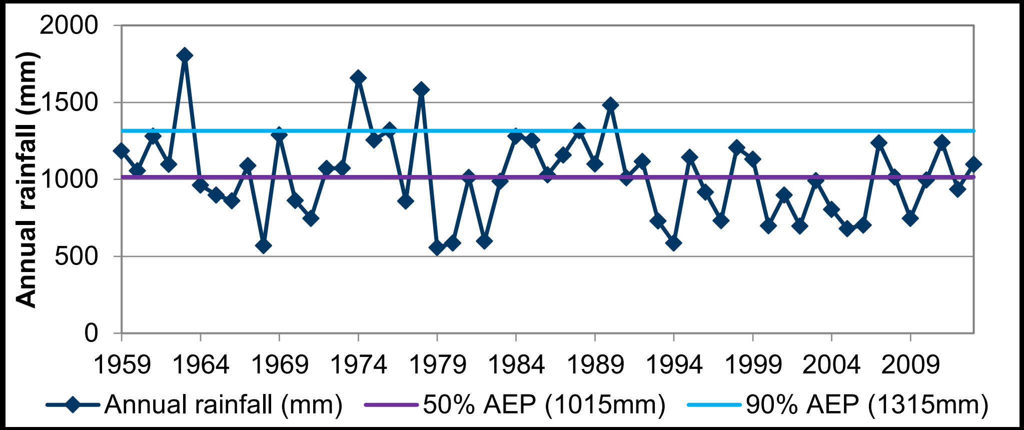
- Type of waste
- Age of waste
  - Phase I = initial adjustment
  - Phase II = transition phase
  - Phase III = acid phase
  - Phase IV = methane fermentation
  - Phase V = maturation phase

Case study 2

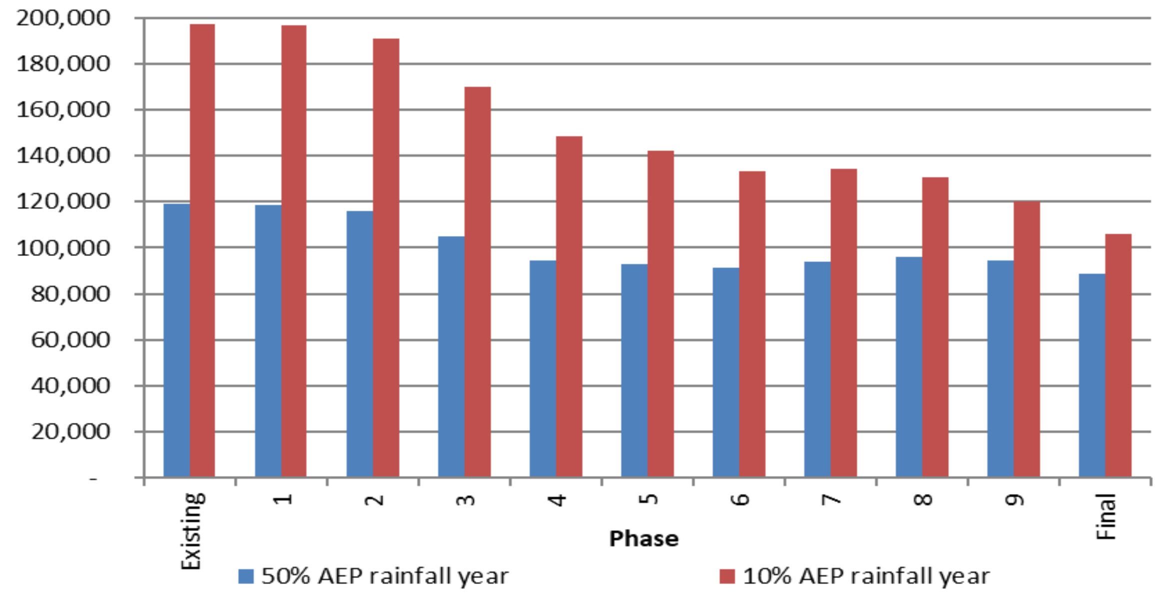

LEACHATE SOURCES
STORAGE
TREATMENT
DISPOSAL
Source 1
Dry: 170 - 210 kL/d
Wet: 280 -350 kL/d
Peak: 1100 - 1200 kL/d
Source 2
Dry: 10 kL/d
Wet: 20 kL/d
Peak: 3 kL/d
Source 3
Infiltration through cover & capped areas
Refer HELP modelling
Groundwater collection system
Average: 10 kL/d
Wet: 30 kL/d
Surface water
Directly proportional to rainfall
Dam 1
Capacity 3 ML
Dam 2
Capacity 3.5 ML
Leachate Treatment Plant holding pond
Capacity 1.5 ML
In-cell storage
Dam 2
Capacity = 9.23 ML
Leachate holding tanks
5 x 100m3
Dam 1
Capacity = 9 ML
Catchment area
600 kL/d
6.9 L/s
Leachate Treatment Plant
Dry: 150 - 200 kL/d
1.7 - 2.3 L/s
Wet: 1000 kL/d
11.6 L/s
Average: 570 kL/d
Sewer
Maximum rate: 20 L/s
Maximum daily discharge: 1500 kL
Average daily discharge: 800 kL

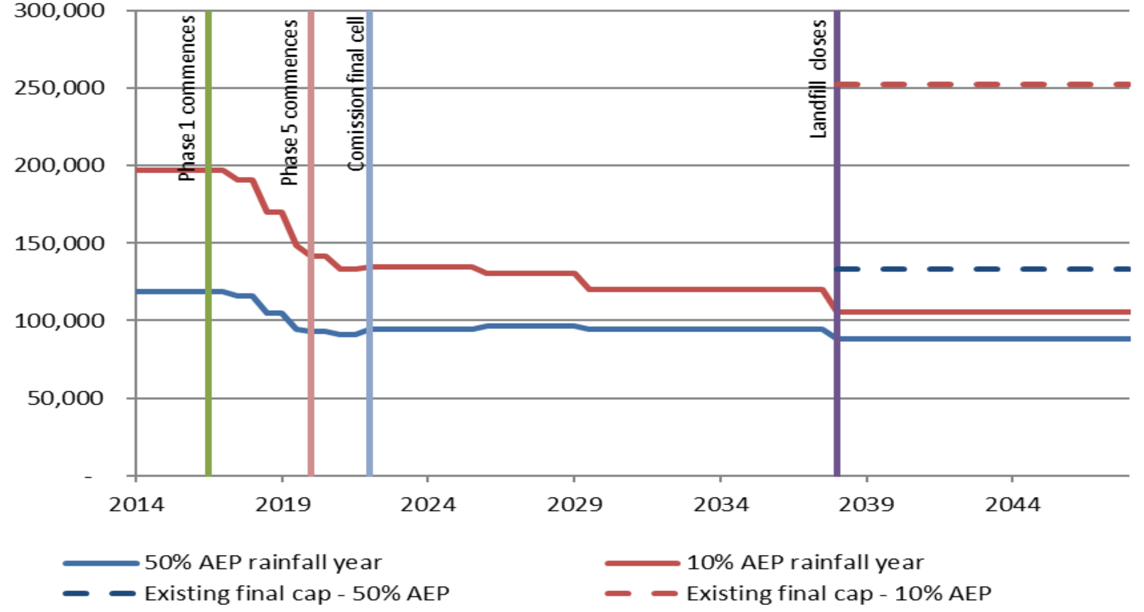
Case study 2

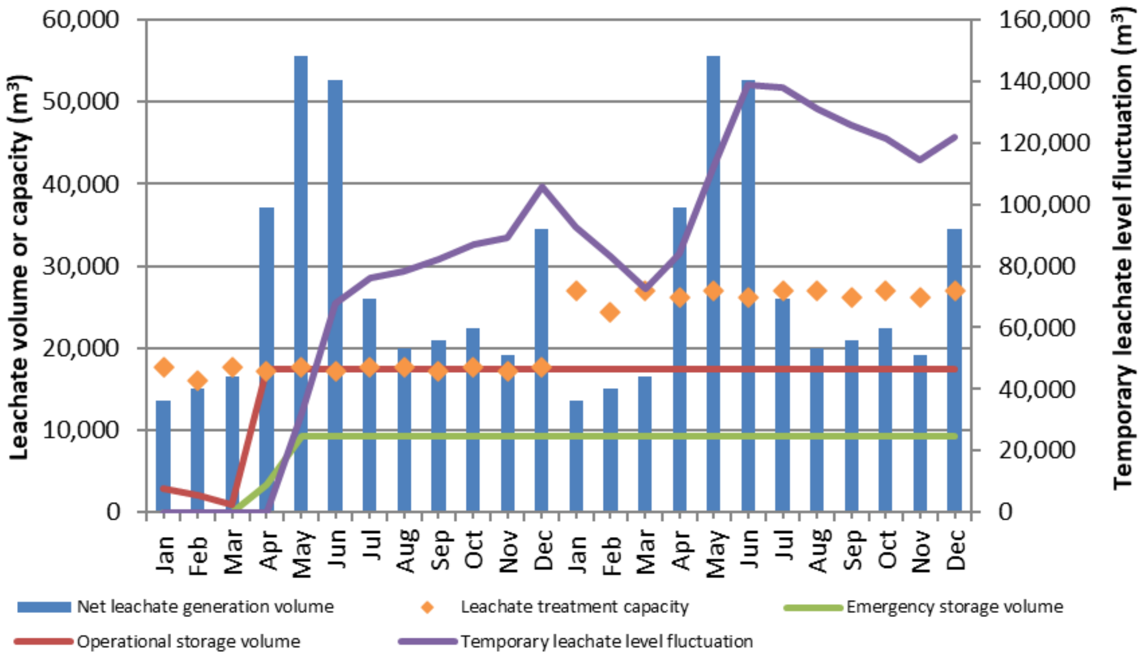


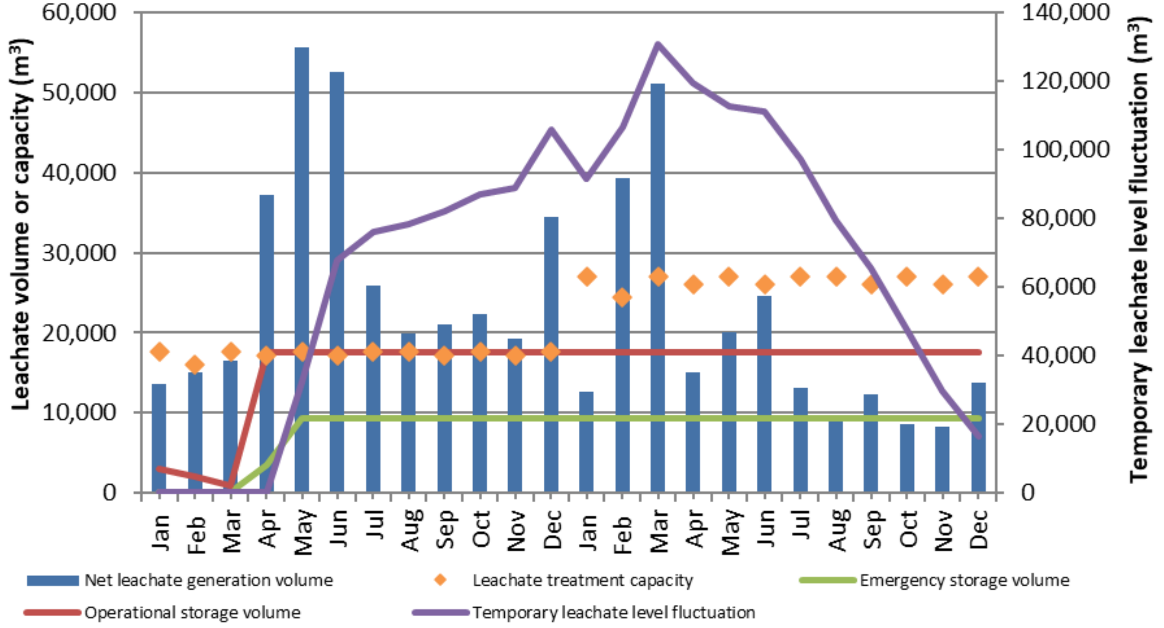


- Develop site leachate flow diagram to understand typical and emergency operating arrangements
- Comparison of historical BOM data and site collected weather data
- Estimation of rainfall infiltration through all cover and cap scenarios (HELP)
- Developed a site water balance model for a range of climatic conditions
- Undertook calibration of model using historical leachate collection, treatment and disposal volumes
- Used calibrated model to estimate future storage, treatment and disposal requirements


200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
Existing
1
2
3
4
5
6
7
8
9
Final
Phase
50% AEP rainfall year
10% AEP rainfall year


300,000
250,000
200,000
150,000
100,000
50,000
-
Phase 1 commences
Phase 5 commences
Comission final cell
Landfill closes
2014
2019
2024
2029
2034
2039
2044
50% AEP rainfall year
10% AEP rainfall year
Existing final cap - 50% AEP
Existing final cap - 10% AEP


Leachate volume or capacity (m³)
Temporary leachate level fluctuation (m³)
60,000
50,000
40,000
30,000
20,000
10,000
0
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Net leachate generation volume
Leachate treatment capacity
Emergency storage volume
Operational storage volume
Temporary leachate level fluctuation


Leachate volume or capacity (m³)
Temporary leachate level fluctuation (m³)
60,000
50,000
40,000
30,000
20,000
10,000
0
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Net leachate generation volume
Leachate treatment capacity
Emergency storage volume
Operational storage volume
Temporary leachate level fluctuation

Case study 3

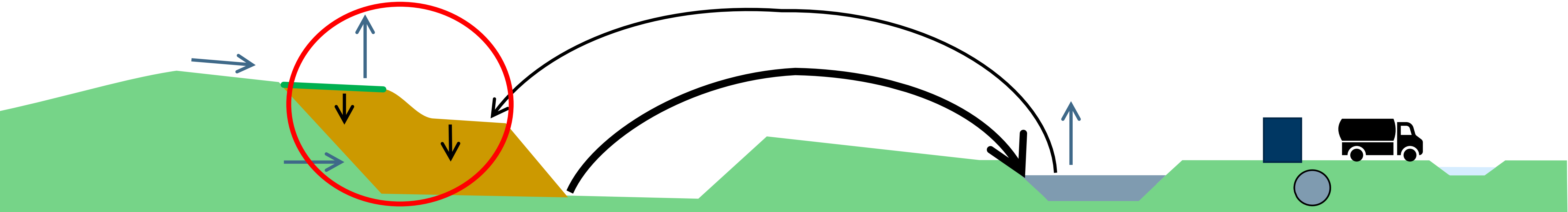
- Large areas of historically filled areas not capped
- Limited understanding of site performance
- Relied on evaporation for leachate disposal
- Sewerage treatment plant has insufficient capacity during extended wet weather
- Design and construction of additional storage pond was fast-tracked – high cost

Is your contingency plan reliable and practical?

Do you understand the financial implications?

Maintain good site management

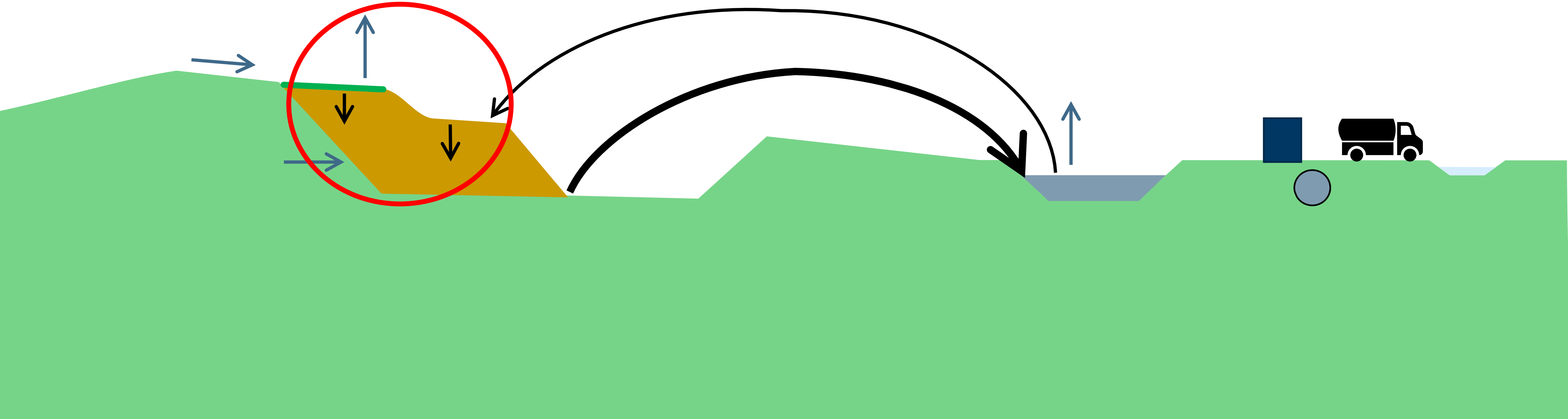
- Reducing active tip face areas
- Inspecting and repairing interim cover and capping as required
- Improving interim cover practices – placement and removal
- Avoid exposed leachate collection systems





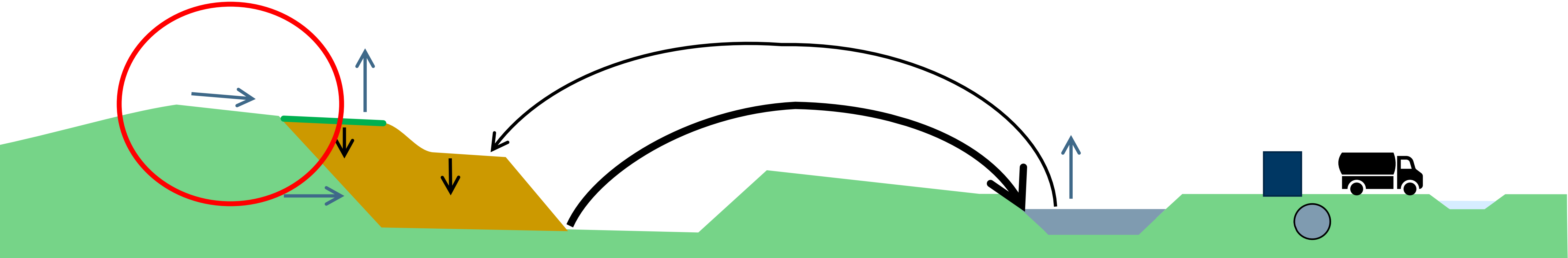

Maintain good site management

- Good upstream diversion systems, where they are required
- Good downstream containment systems, to prevent mixing with surface water

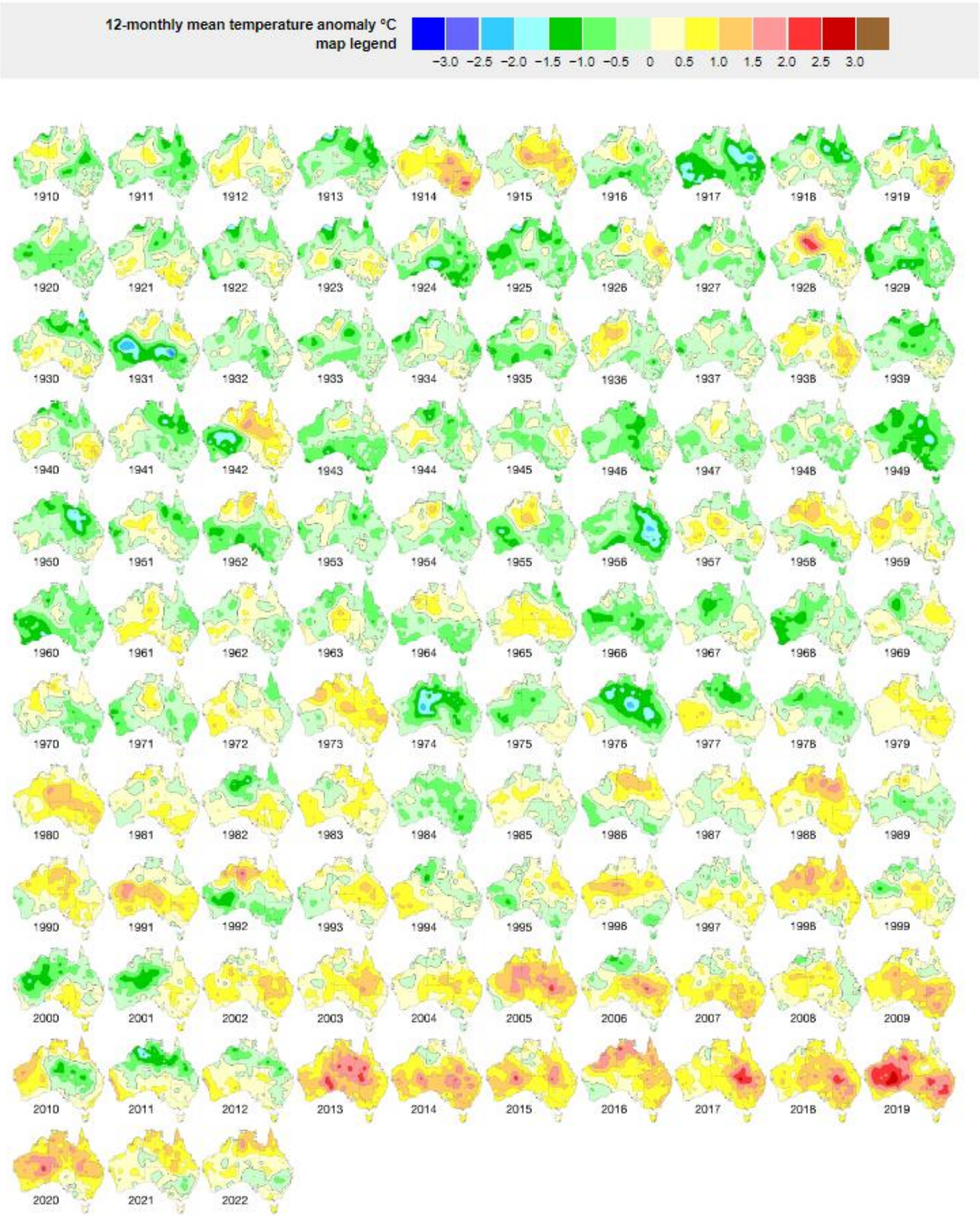


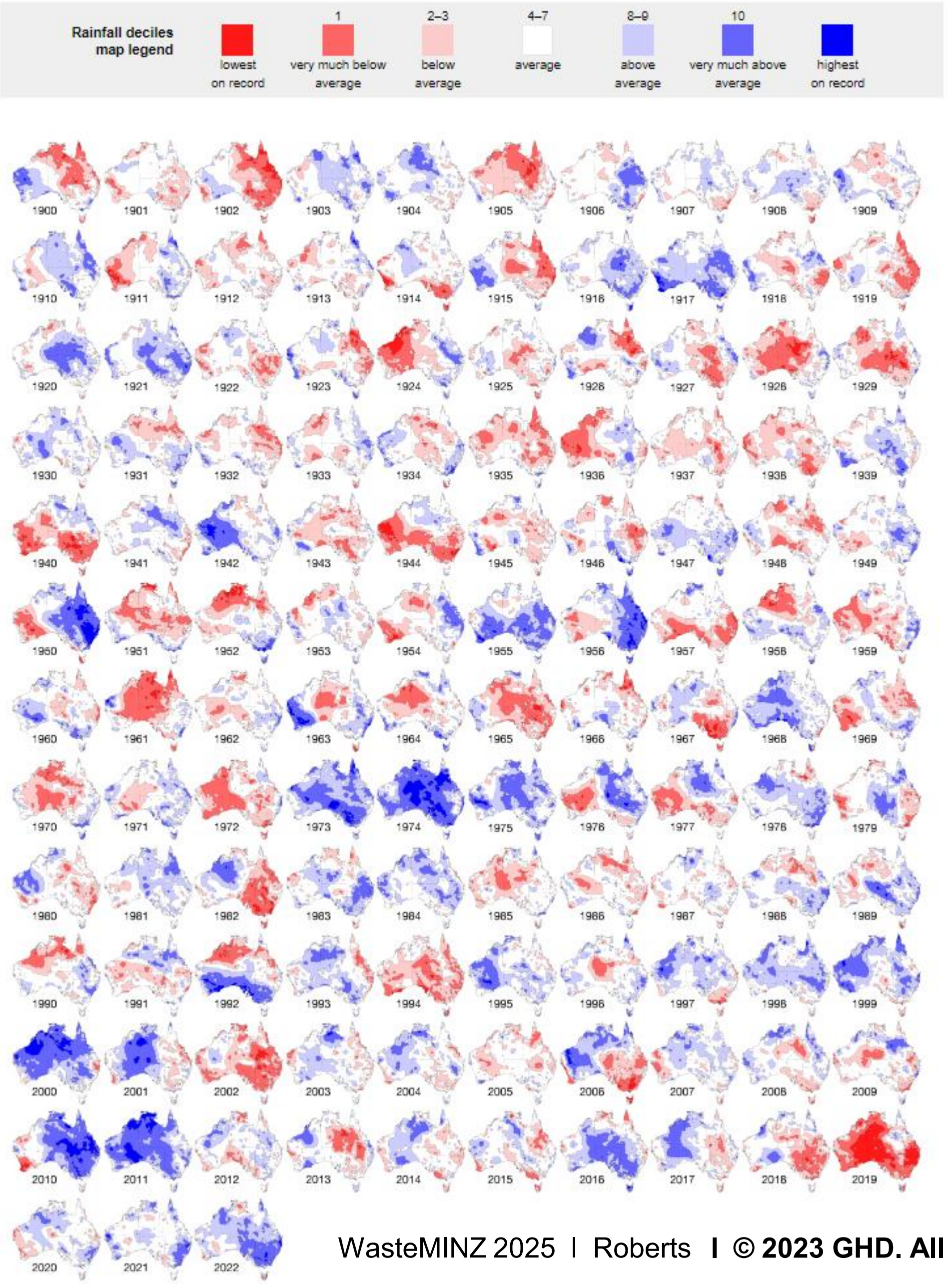
Maintain good site management

– Keep pumping equipment in good condition
– Install remote controls, alarms, instrumentation
– Maintain appropriate freeboard

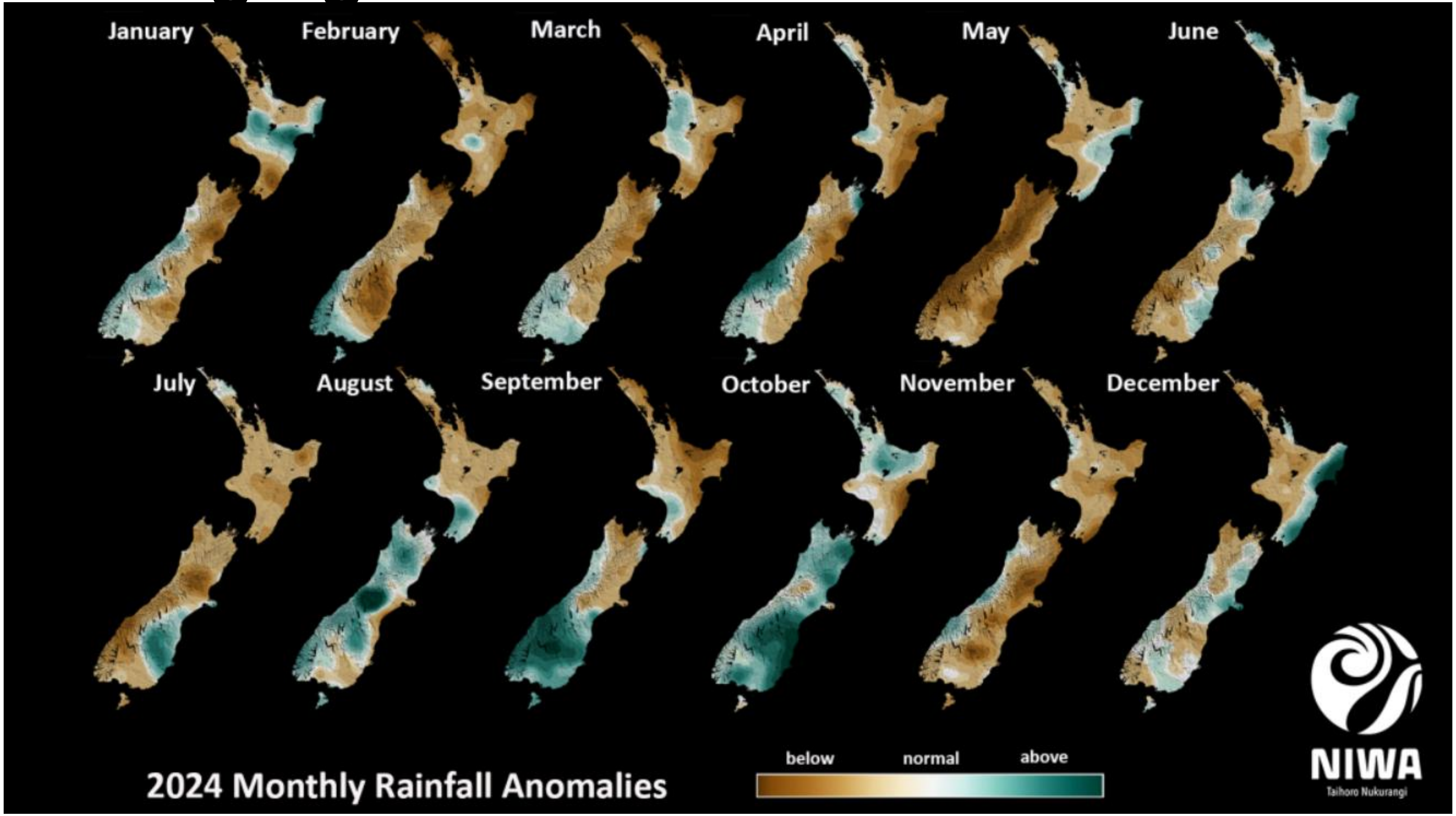


Our changing climate

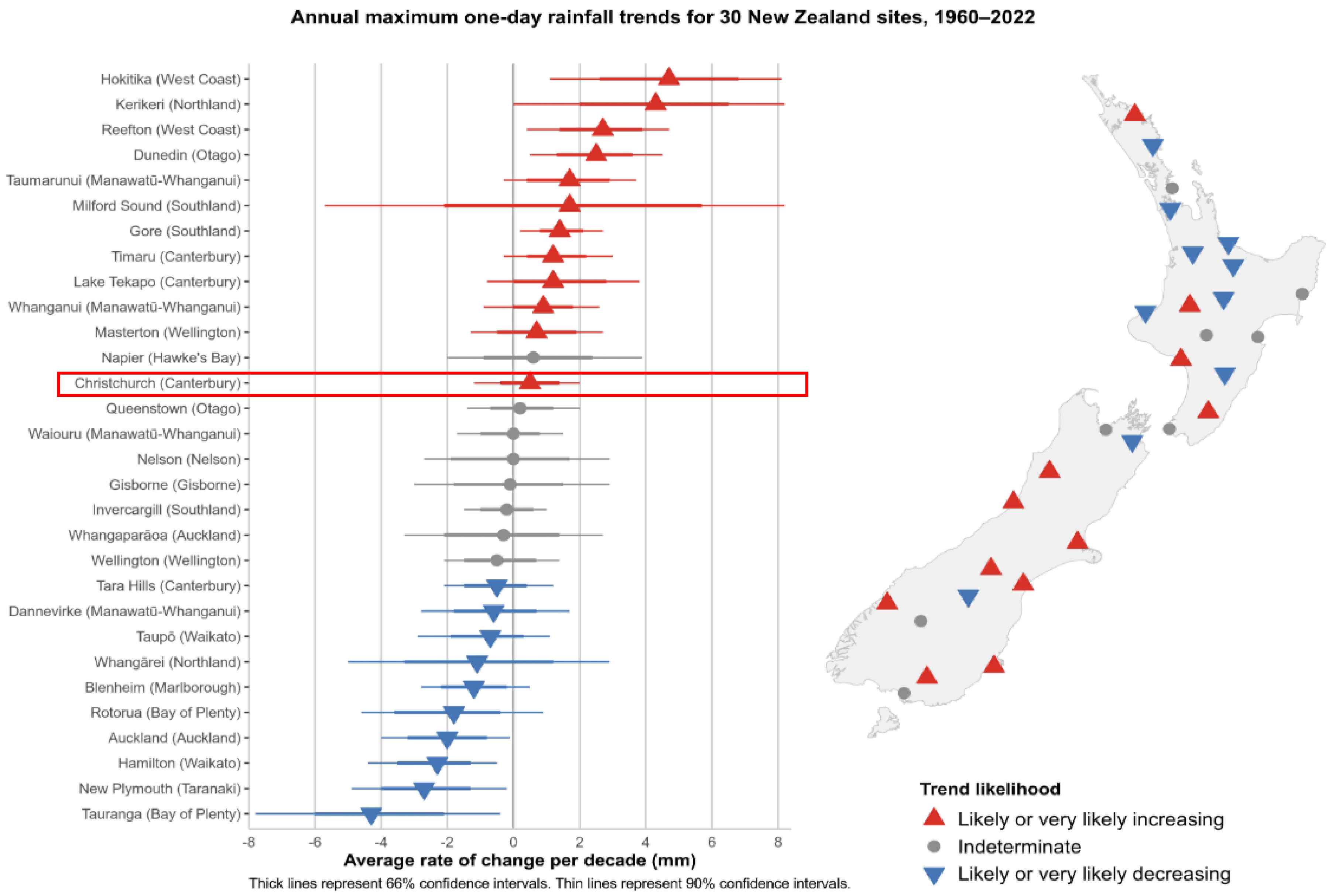




Our changing climate



NIWA (2024) Annual Climate Summary 2024


Annual maximum one-day rainfall trends for 30 New Zealand sites, 1960–2022
Hokitika (West Coast)
Kerikeri (Northland)
Reefton (West Coast)
Dunedin (Otago)
Taumarunui (Manawatū-Whanganui)
Milford Sound (Southland)
Gore (Southland)
Timaru (Canterbury)
Lake Tekapo (Canterbury)
Whanganui (Manawatū-Whanganui)
Masterton (Wellington)
Napier (Hawke's Bay)
Christchurch (Canterbury)
Queenstown (Otago)
Waiouru (Manawatū-Whanganui)
Nelson (Nelson)
Gisborne (Gisborne)
Invercargill (Southland)
Whangaparāoa (Auckland)
Wellington (Wellington)
Tara Hills (Canterbury)
Dannevirke (Manawatū-Whanganui)
Taupō (Waikato)
Whangārei (Northland)
Blenheim (Marlborough)
Rotorua (Bay of Plenty)
Auckland (Auckland)
Hamilton (Waikato)
New Plymouth (Taranaki)
Tauranga (Bay of Plenty)
-8
-6
-4
-2
0
2
4
6
8
Average rate of change per decade (mm)
Thick lines represent 66% confidence intervals. Thin lines represent 90% confidence intervals.
Trend likelihood
Likely or very likely increasing
Indeterminate
Likely or very likely decreasing

Our changing climate

A projected rainfall intensity or equivalent depth (I_p) can be obtained by:

$$I_p = I_{ARR} \times 1.05^{T_m}$$

I_{ARR} is the design rainfall intensity for current climate conditions

T_m is the a measure of temperature increase

Temperature increase	Projected rainfall intensity increase
1.5℃	8%
3℃	16%

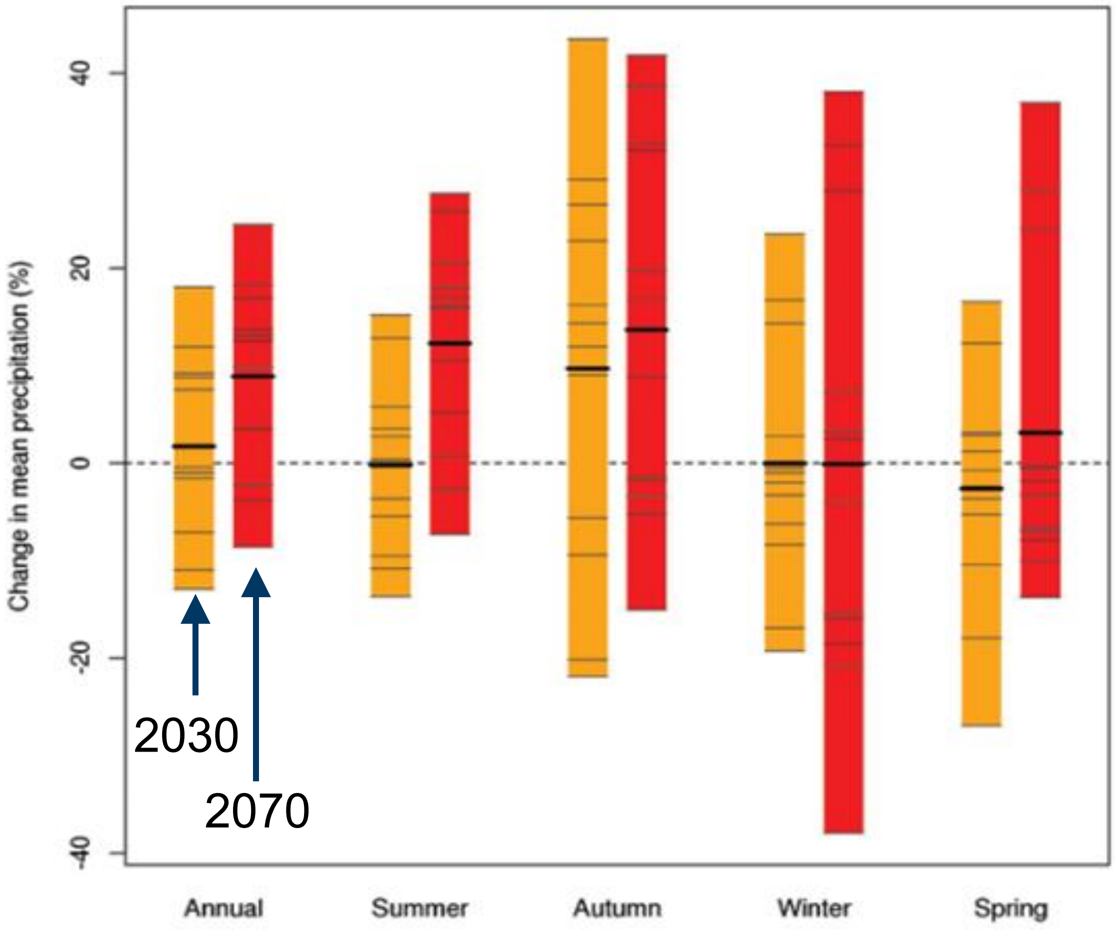
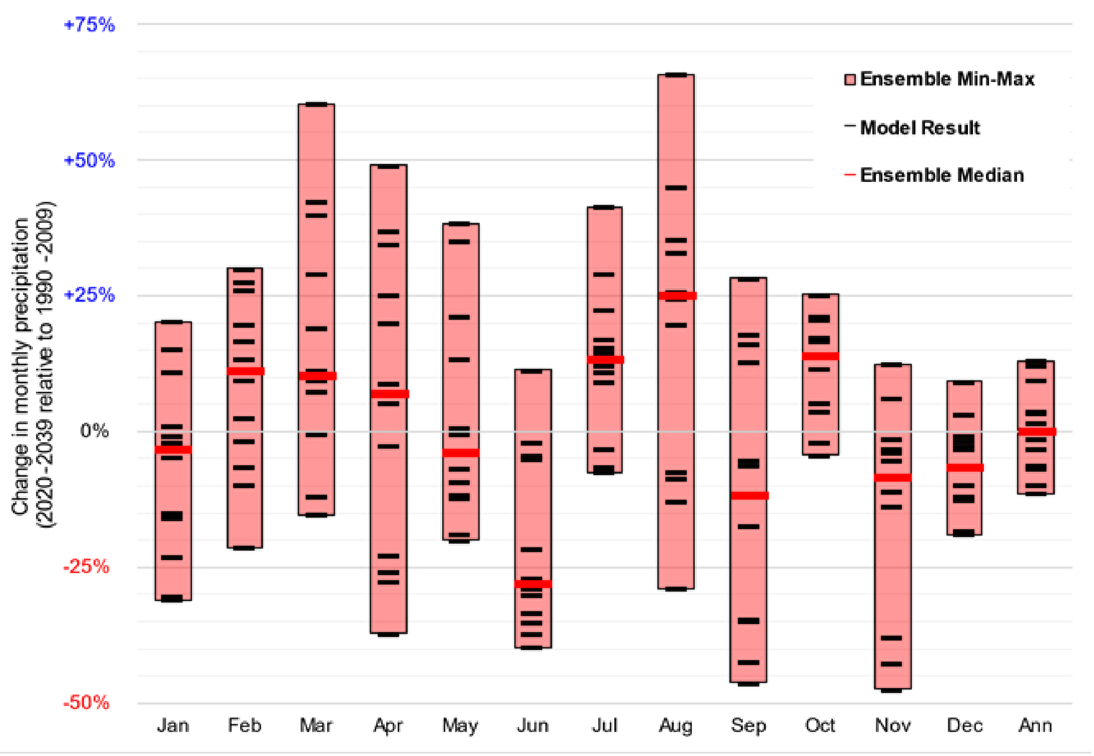
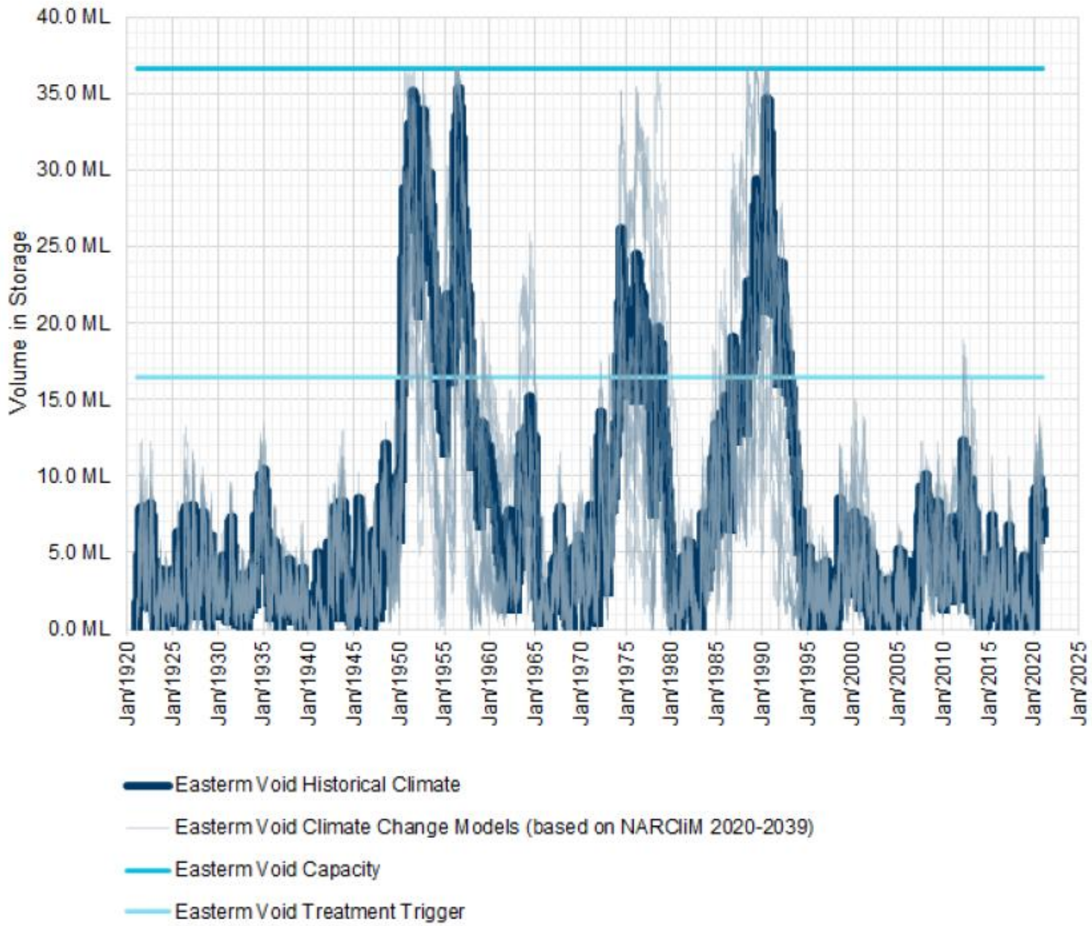


Figure 13: Projected changes in average rainfall for the Metropolitan Sydney Region, annually and by season (2030 yellow; 2070 red).

Nathan, R and Weinmann, E, 2019, Estimation of Very Rare to Extreme Floods, Book 6 in Australian Rainfall and Runoff - A Guide to Flood Estimation, Commonwealth of Australia

NSW Office of Environment and Heritage, 2021, Metropolitan Sydney Climate change snapshot





- Build a model with input climate based on historical observations
- Run model using a simulated climate based on historical observations (baseline)
- Run model with various climate futures
- Compare baseline to future scenarios to understand risk
- Design infrastructure based on risk profile

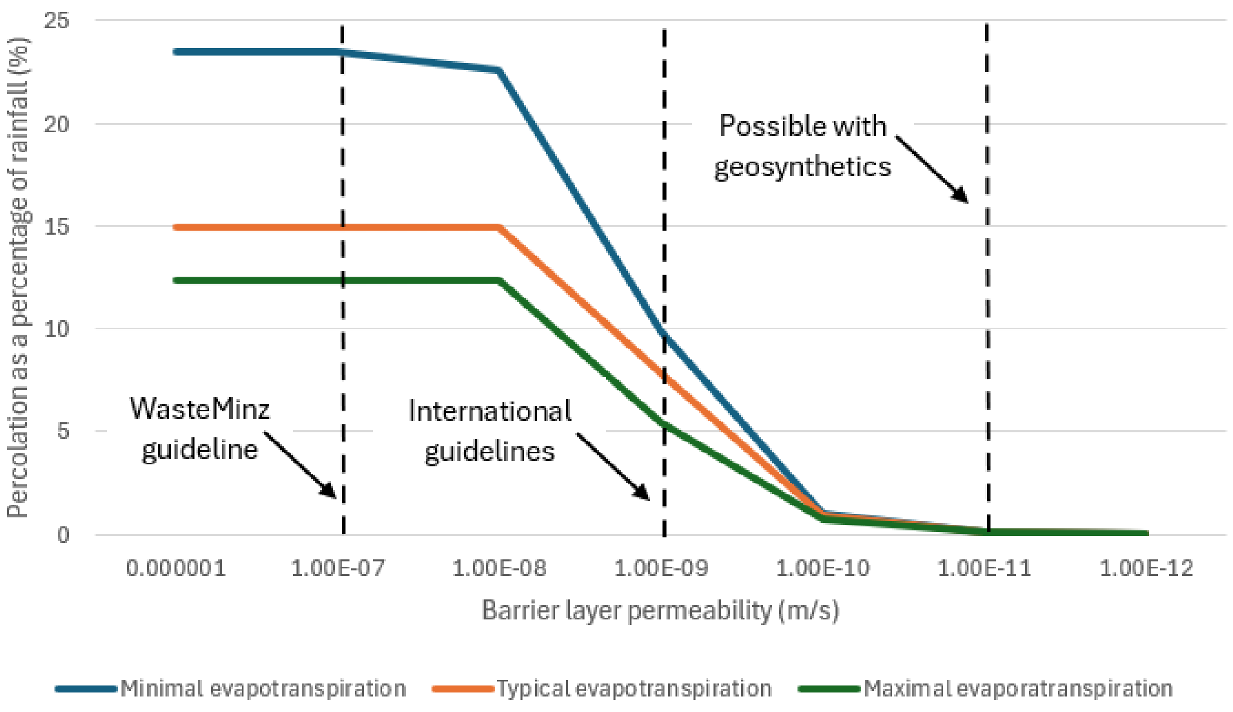
Lessons learnt

- Contingency plans may not be available during an extreme weather events
- Existing plans are not always followed and/or fail to deal with extreme events adequately
- Existing modelling/water balances fail to account for all sources during extreme events or assume linear increase
- Capping cost assessments do not consider the leachate disposal costs

Leachate disposal costs

Has my capping assessment considered leachate disposal?

Example modelling of leachate disposal for a generic landfill in Christchurch



Modelling assumptions:

- Hydrologic Evaluation of Landfill Performance (HELP) Model
- Type 2/3 WasteMINZ guideline cap
- Christchurch data (median = 630mm)
- Median year selected from modelled output
- Variables unchanged except evapotranspiration

What is the cost implication?

- Assuming $90-$150 per kL truck + disposal
- 10% reduction in leachate generation
- $57K to $95K per Ha per annum

What is my return on investment?

What if my median rainfall is much higher?

What if rainfall increases?

Summary

– Prepare for extreme weather conditions
– Have practical options for storage and disposal
– Consider the changing climate

* Thank You

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