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Water quality management in "new" urban developments – Analysis, issues and recommendations

Bartram Road catchment

Joel Hall, Water Science Branch, Department of Water, WA

Talk outline

- **Overview**
  - Nutrient issues in WA
- **Catchment description**
- **Data analysis**
  - Does ‘urbanising’ increase export load?
  - Groundwater issues
- **“New” urban vs “traditional” urban**
  - Flow and nutrient export
- **Where to from here?**

Unmanaged loads

Unmanaged loads

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Unmanaged loads

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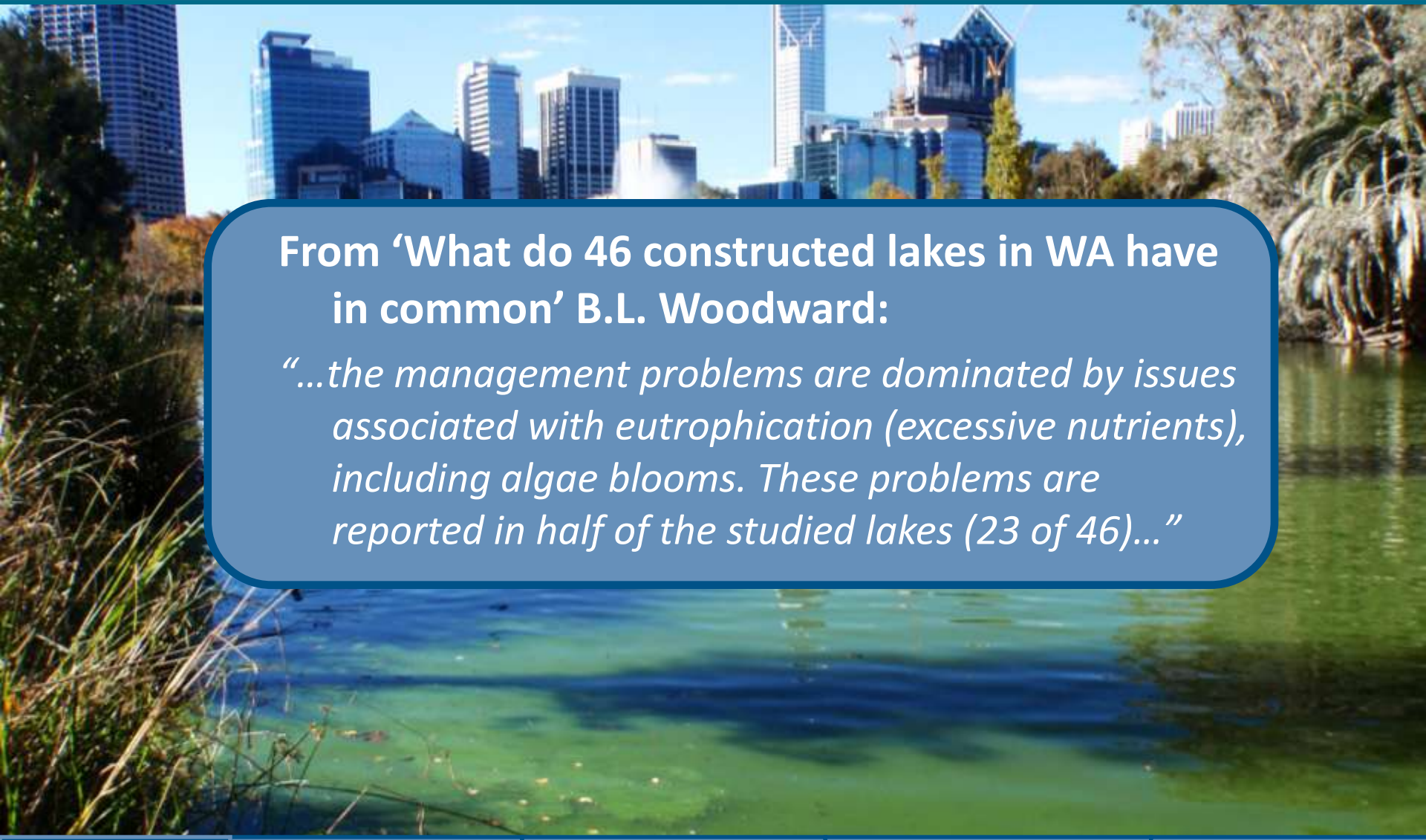
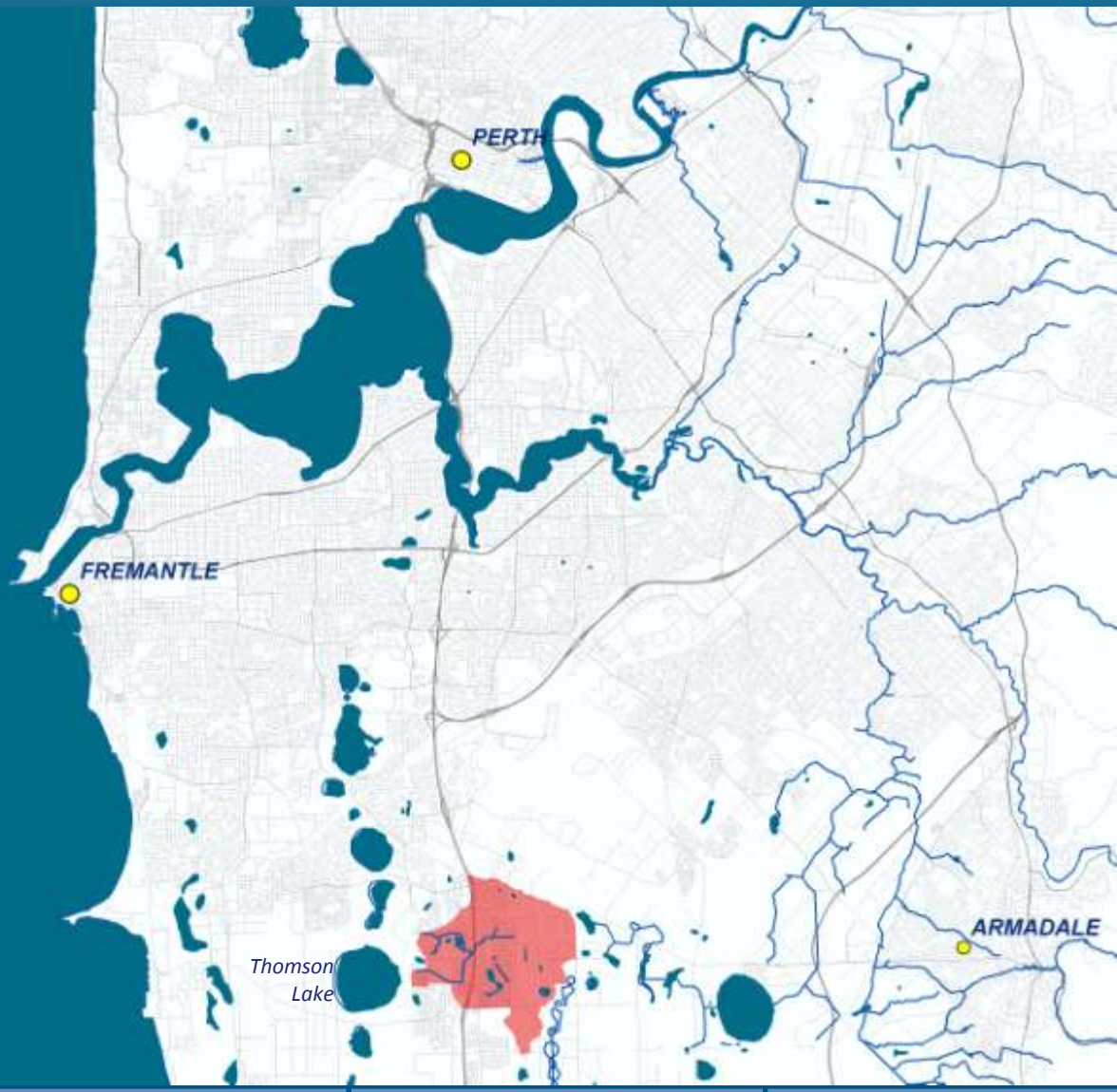
Unmanaged concentrations



From 'What do 46 constructed lakes in WA have in common' B.L. Woodward:

"…the management problems are dominated by issues associated with eutrophication (excessive nutrients), including algae blooms. These problems are reported in half of the studied lakes (23 of 46)…"

Catchment



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2000 aerial photograph

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2001 aerial photograph

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2002 aerial photograph

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2003 aerial photograph

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2004 aerial photograph

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2005 aerial photograph

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2006 aerial photograph

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2007 aerial photograph

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2008 aerial photograph

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LiDAR imagery

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Hydrology

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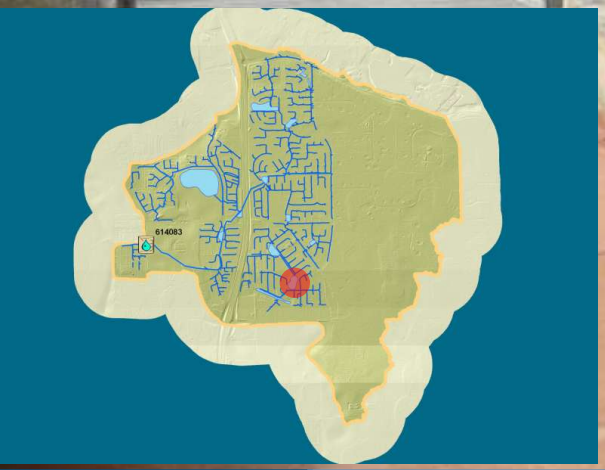
Hydrology



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Hydrology

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2000 land use

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2003 land use

2007 land use

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Land use – urban development

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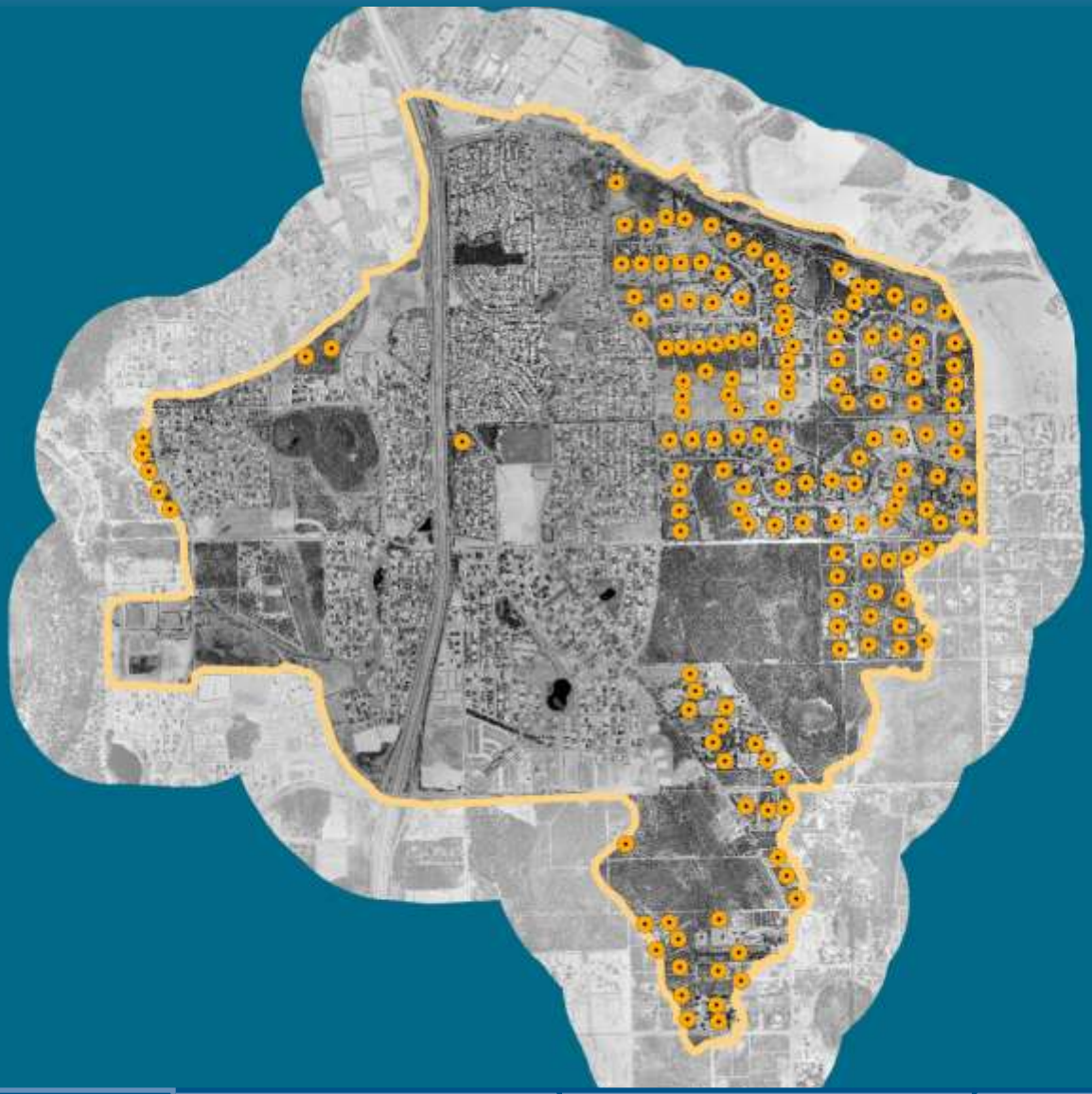
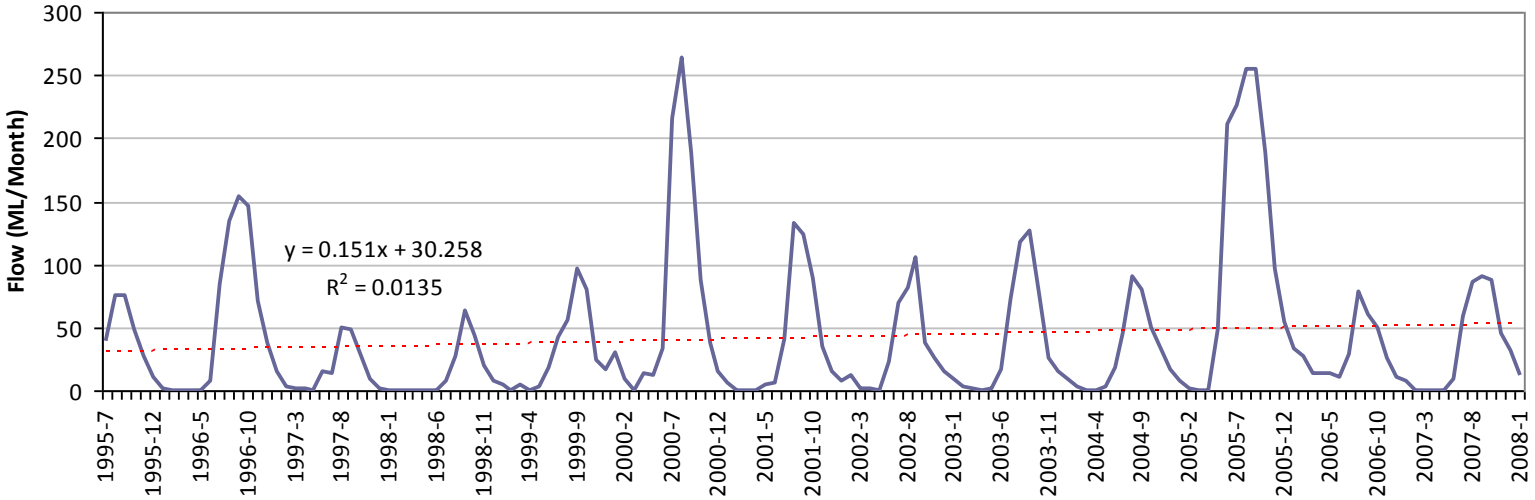
2007 septic tanks

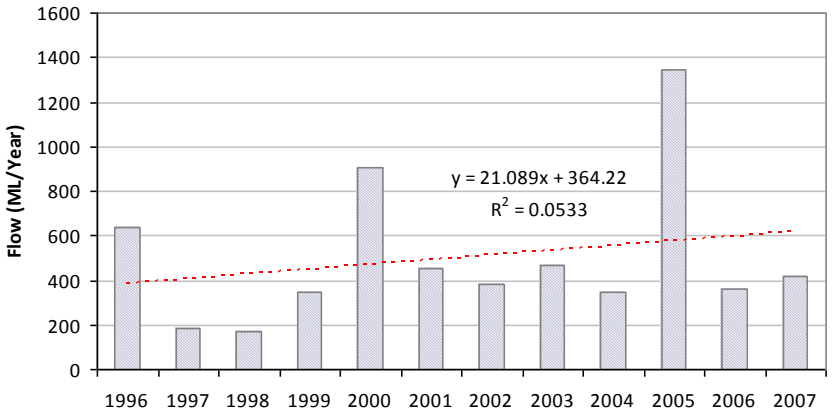


Data analysis overview

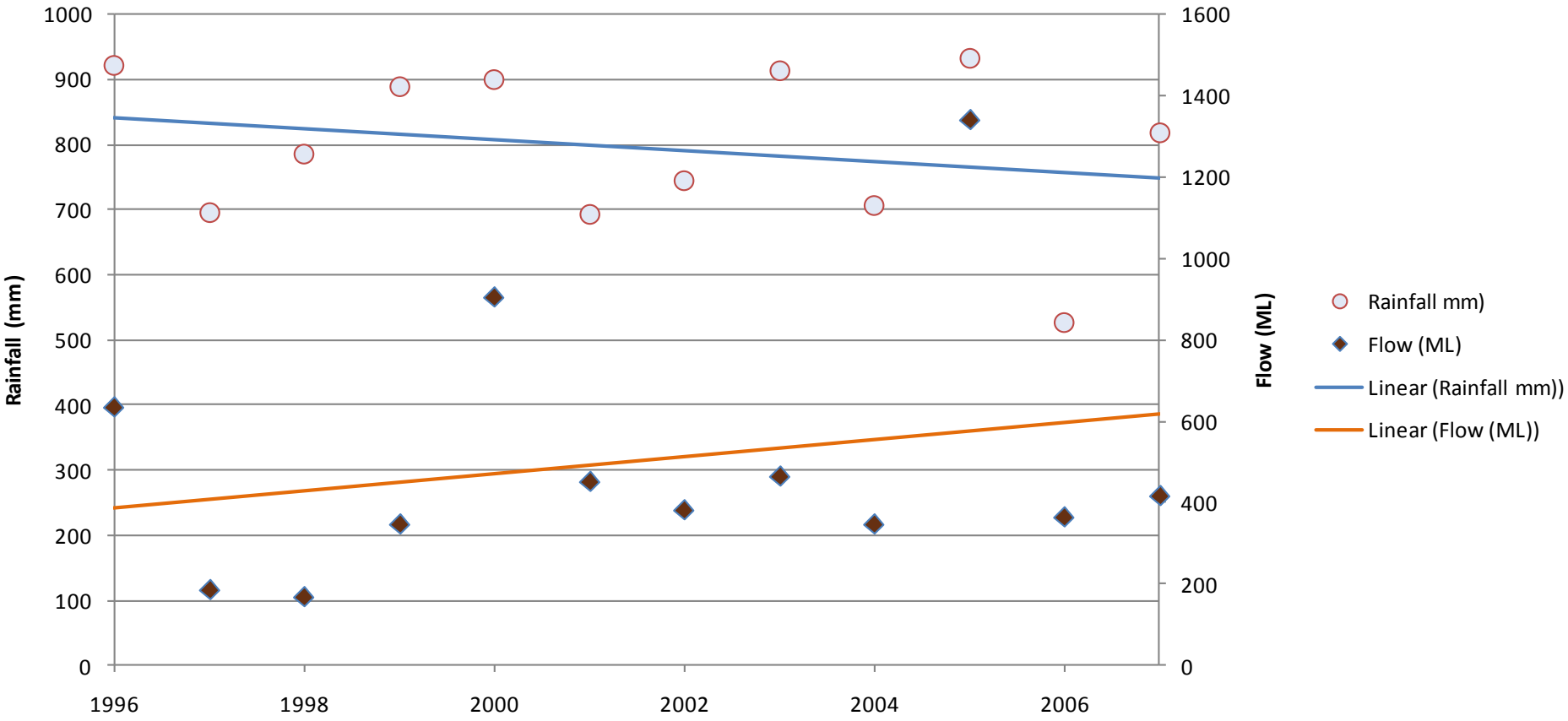
- **Analysis of Flow and *CR***
- **Trend analysis for nutrient concentrations**
  - All nutrient species
  - MK and SK non-parametric trend tests
- **Input data analysis**
  - Fertilisers and septics
  - Input vs output loads
- **Load analysis**
  - Multiple techniques for load calculation
  - Compare with current rainfall

Flow


Flow (ML/Month)
300
250
200
150
100
50
0
y = 0.151x + 30.258
R2 = 0.0135
1995-7
1995-12
1996-5
1996-10
1997-3
1997-8
1998-1
1998-6
1998-11
1999-4
1999-9
2000-2
2000-7
2000-12
2001-5
2001-10
2002-3
2002-8
2003-1
2003-6
2003-11
2004-4
2004-9
2005-2
2005-7
2005-12
2006-5
2006-10
2007-3
2007-8
2008-1


Flow (ML/Year)
1600
1400
1200
1000
800
600
400
200
0
y = 21.089x + 364.22
R2 = 0.0533
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007

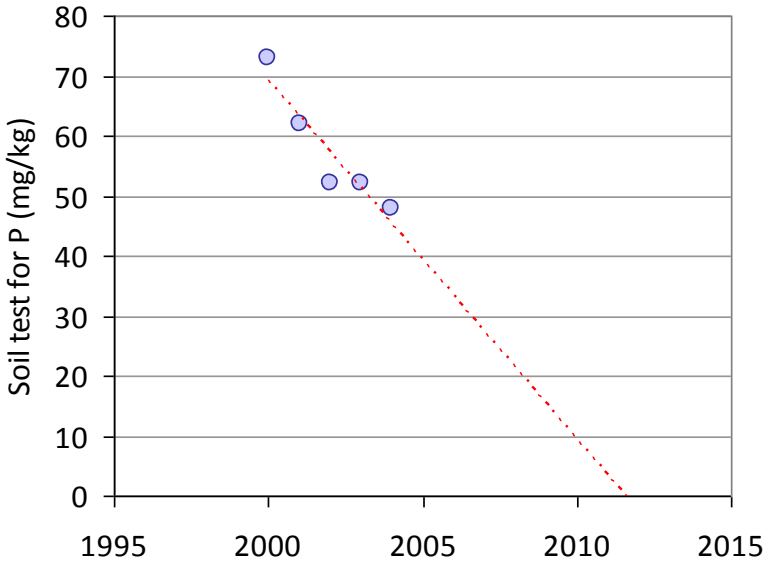
Flow and rainfall trends



Nutrient rundown

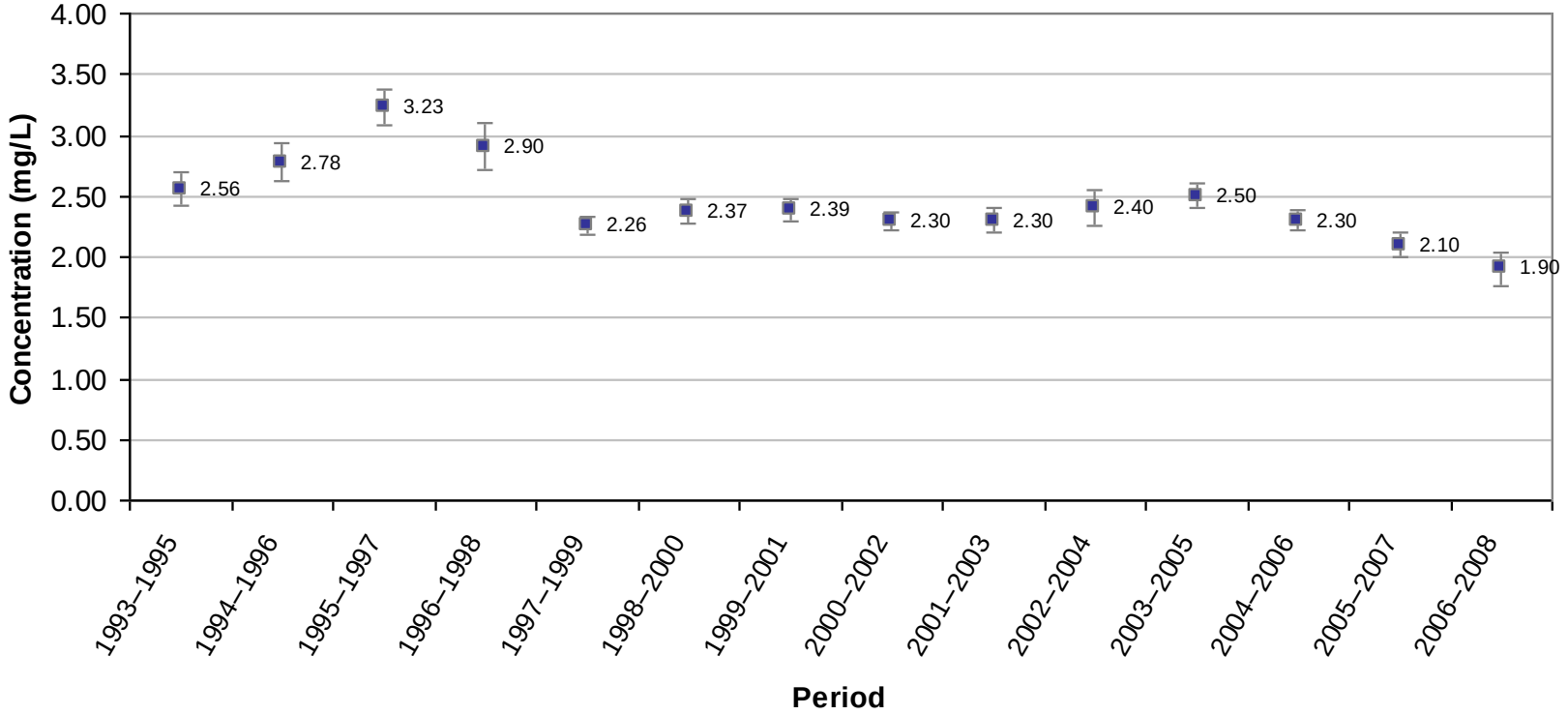
- Rundown in heavy soils approx. 10yrs
- In low PRI soils rundown expected to be much quicker (up to 50% per year)

(Data from DAFWA)



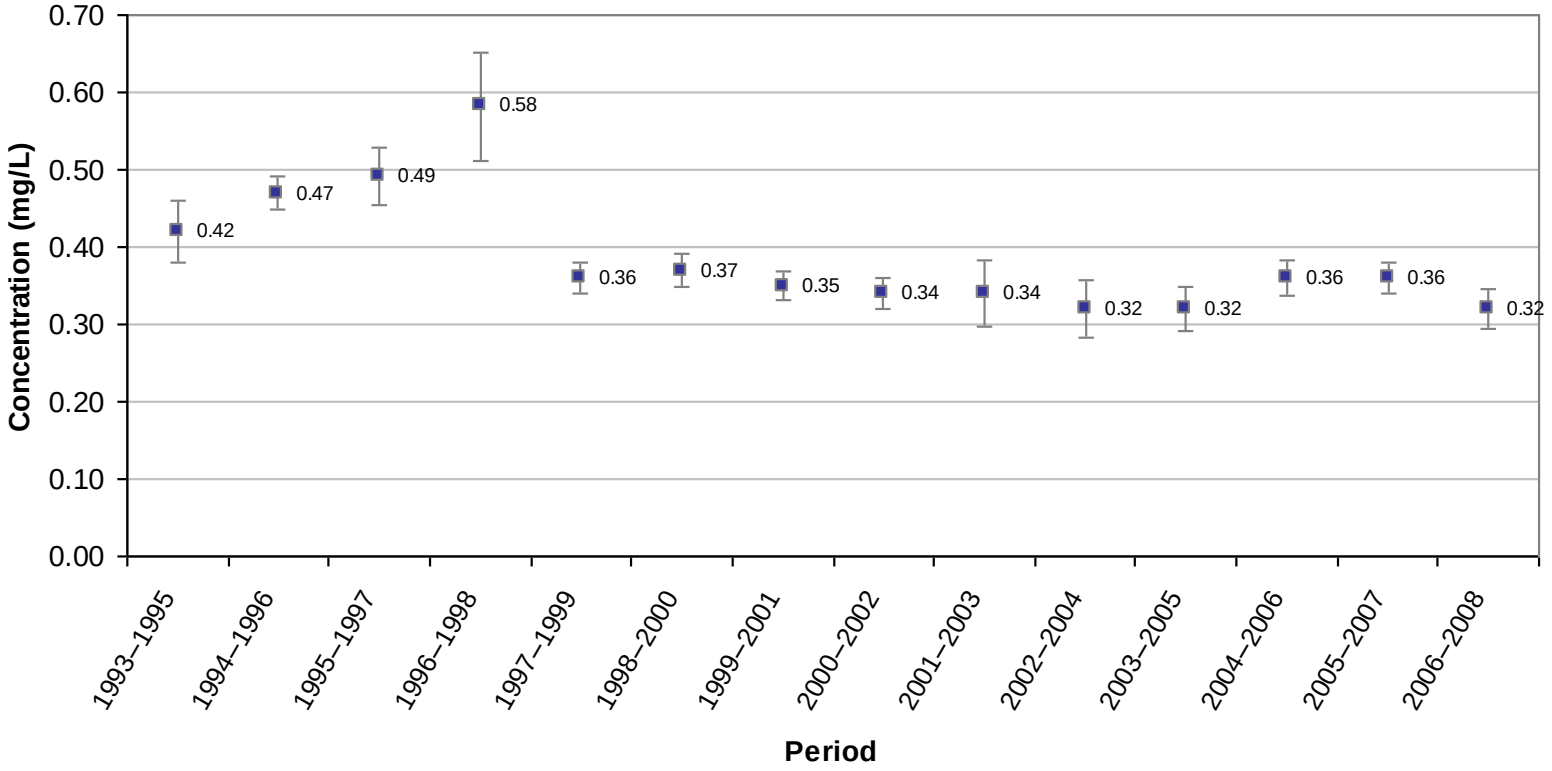
Trends – total nitrogen

Parameter	Period	Series	Test	Trend	Z	p	n	n*	n#	Trend results
TN	1993–2008	Obs.	MK	-0.041	-11.436	<0.05	1116	148	34	Decreasing trend
TN	1993–2008	Obs.	SK	-0.043	-8.550	<0.05	1116	170	30	Decreasing trend
TN	1993–2008	FAC	MK	-0.045	-12.753	<0.05	1115	150	30	Decreasing trend
TN	1993–2008	FAC	SK	-0.042	-8.752	<0.05	1115	151	33	Decreasing trend



Trends – total phosphorus

Parameter	Period	Series	Test	Trend	Z	p	n	n*	n#	Trend results
TP	1993–2008	Obs.	MK	-0.007	-14.089	<0.05	1192	122	68	Decreasing trend
TP	1993–2008	Obs.	SK	-0.012	-12.076	<0.05	1192	166	25	Decreasing trend
TP	1993–2008	FAC	MK	-0.012	-16.886	<0.05	1133	130	49	Decreasing trend
TP	1993–2008	FAC	SK	-0.014	-13.589	<0.05	1133	128	32	Decreasing trend



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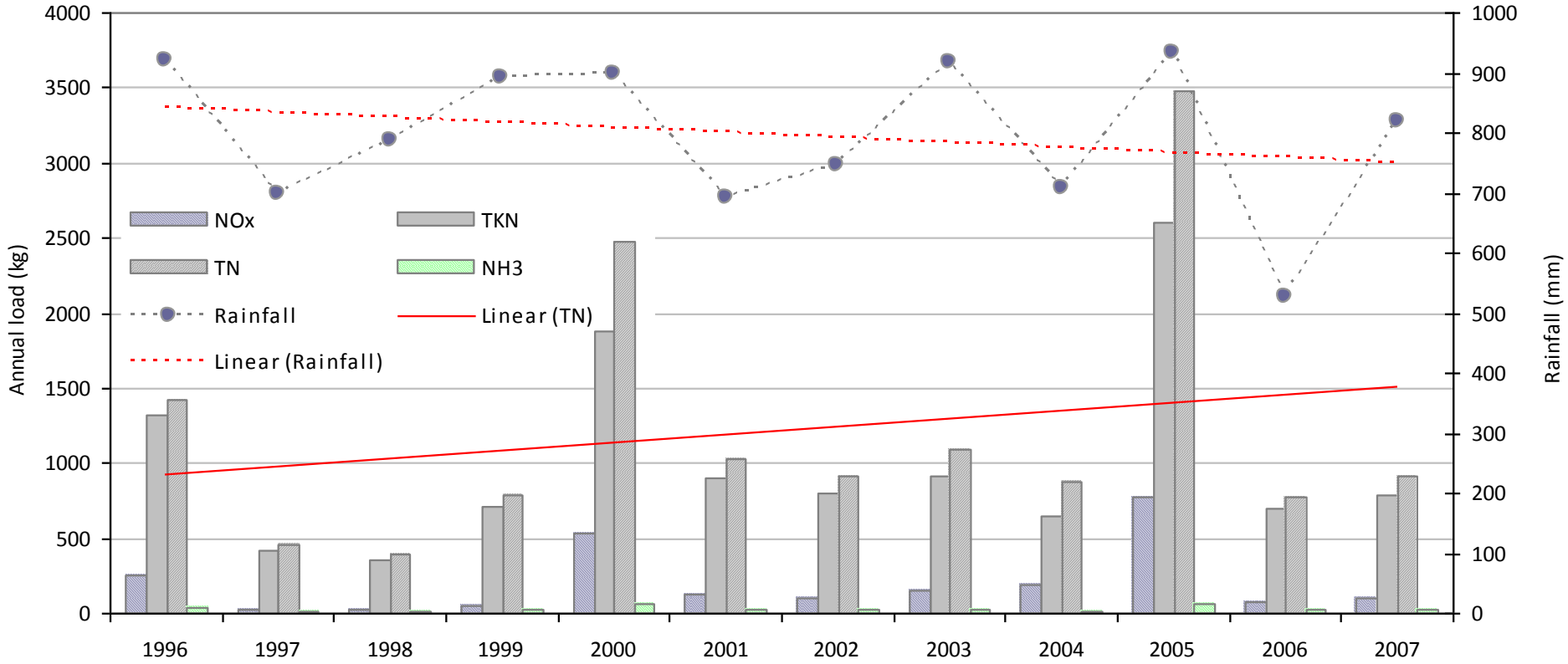
Loads – LOESS - nitrogen



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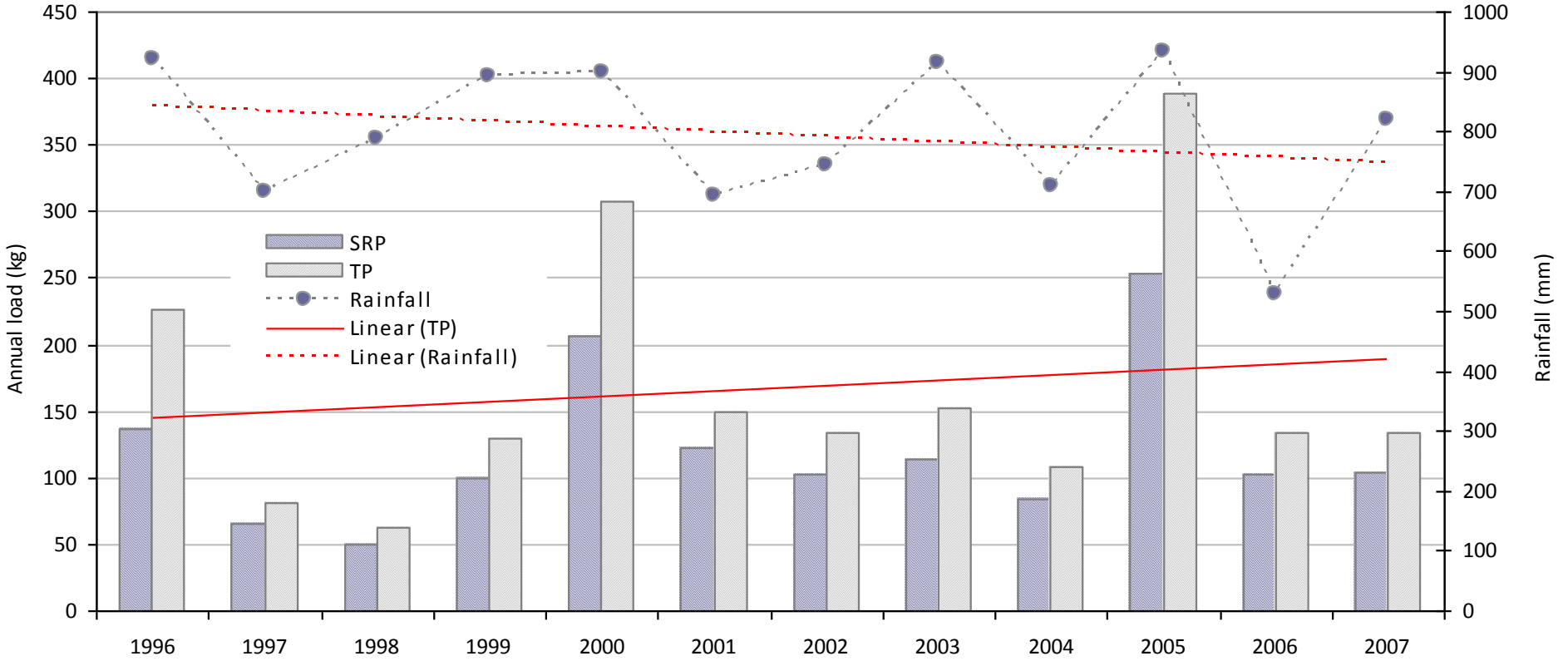
Loads – LOESS - phosphorus



Groundwater analysis

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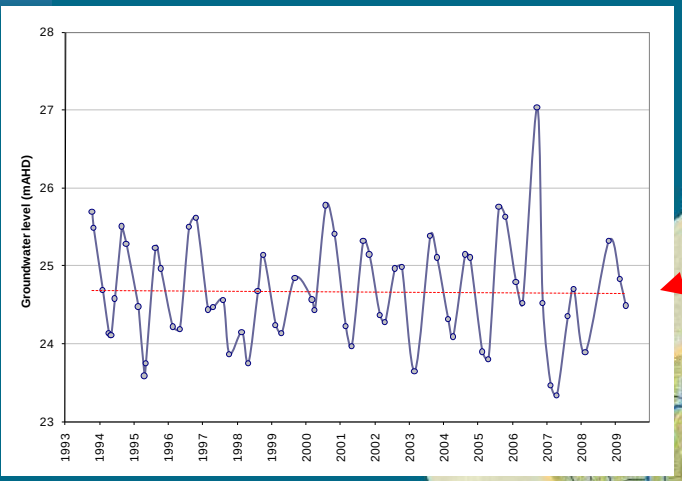
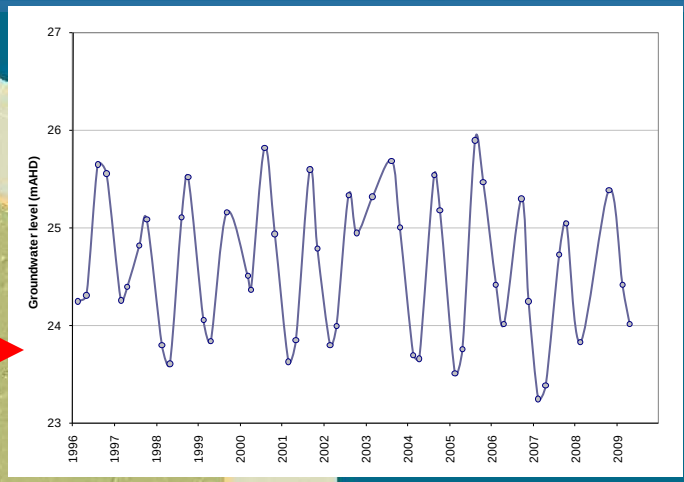
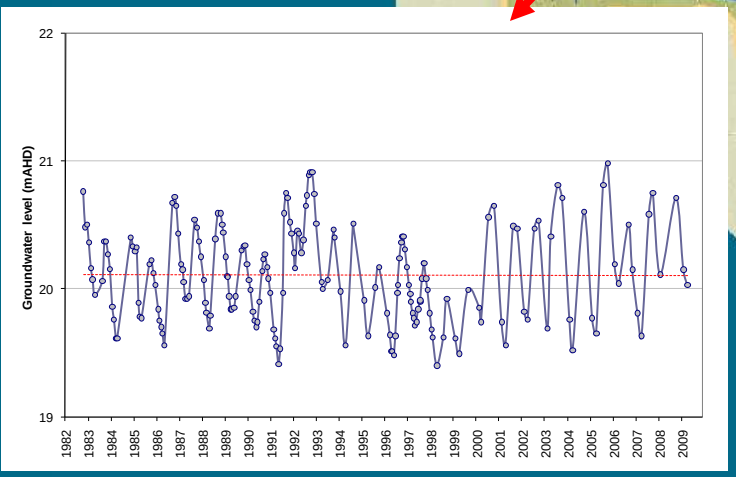
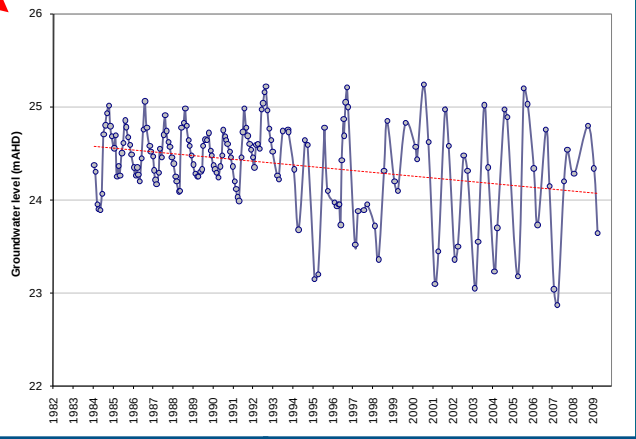
Groundwater analysis

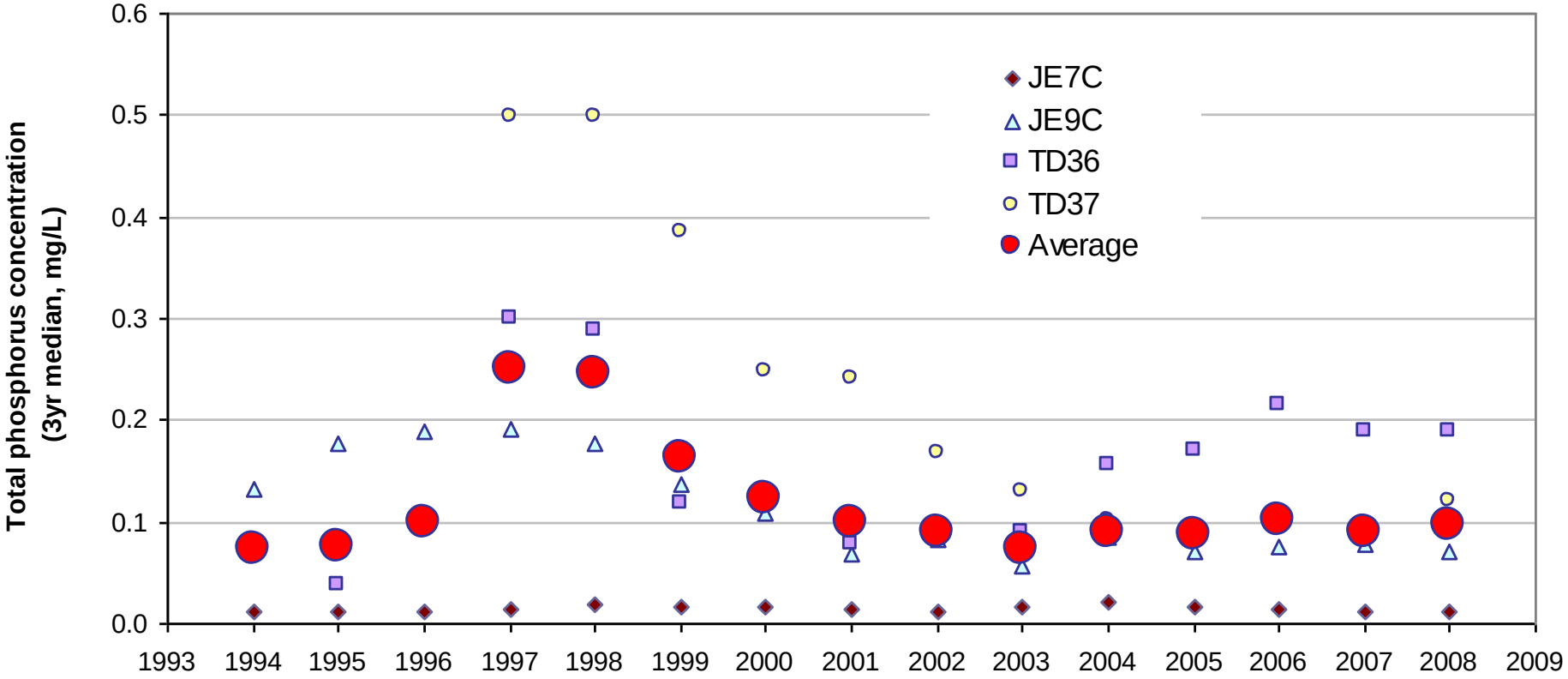








Groundwater analysis



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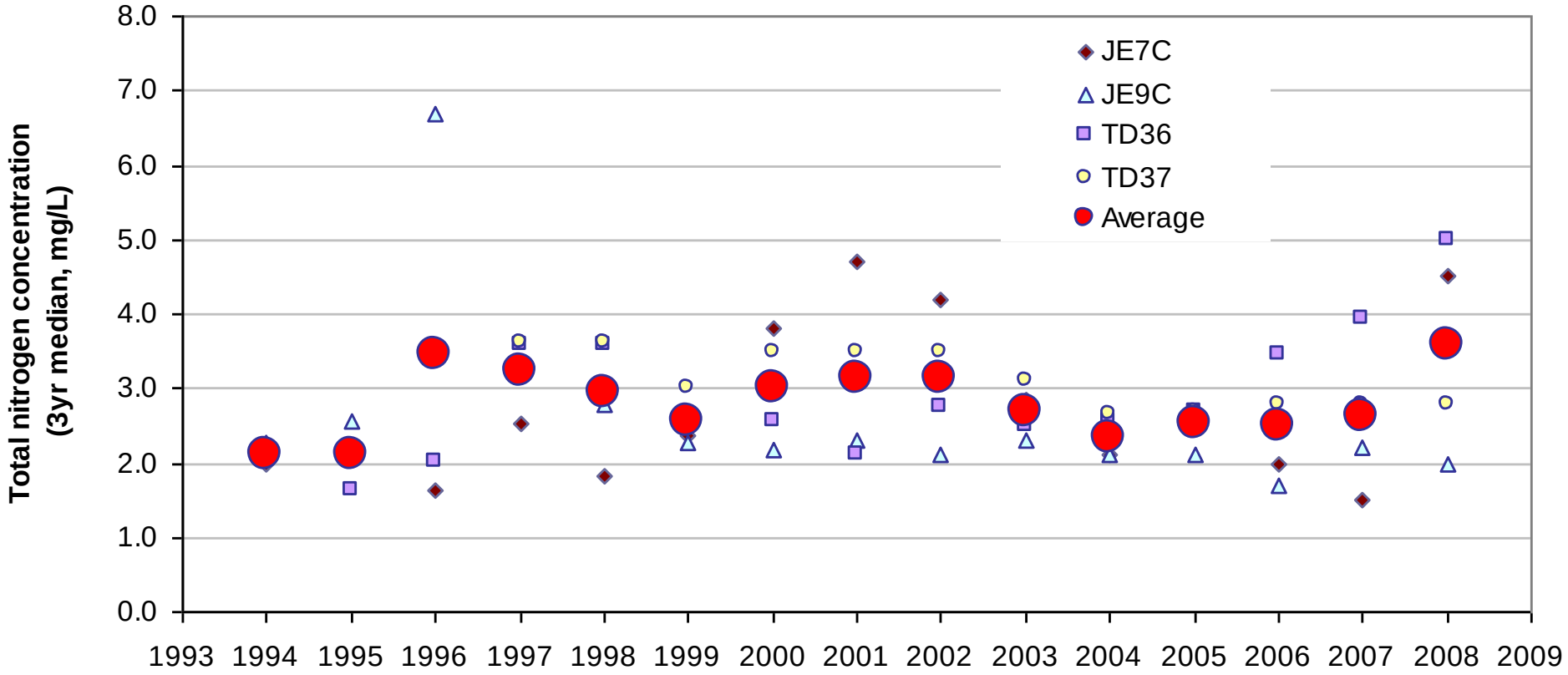
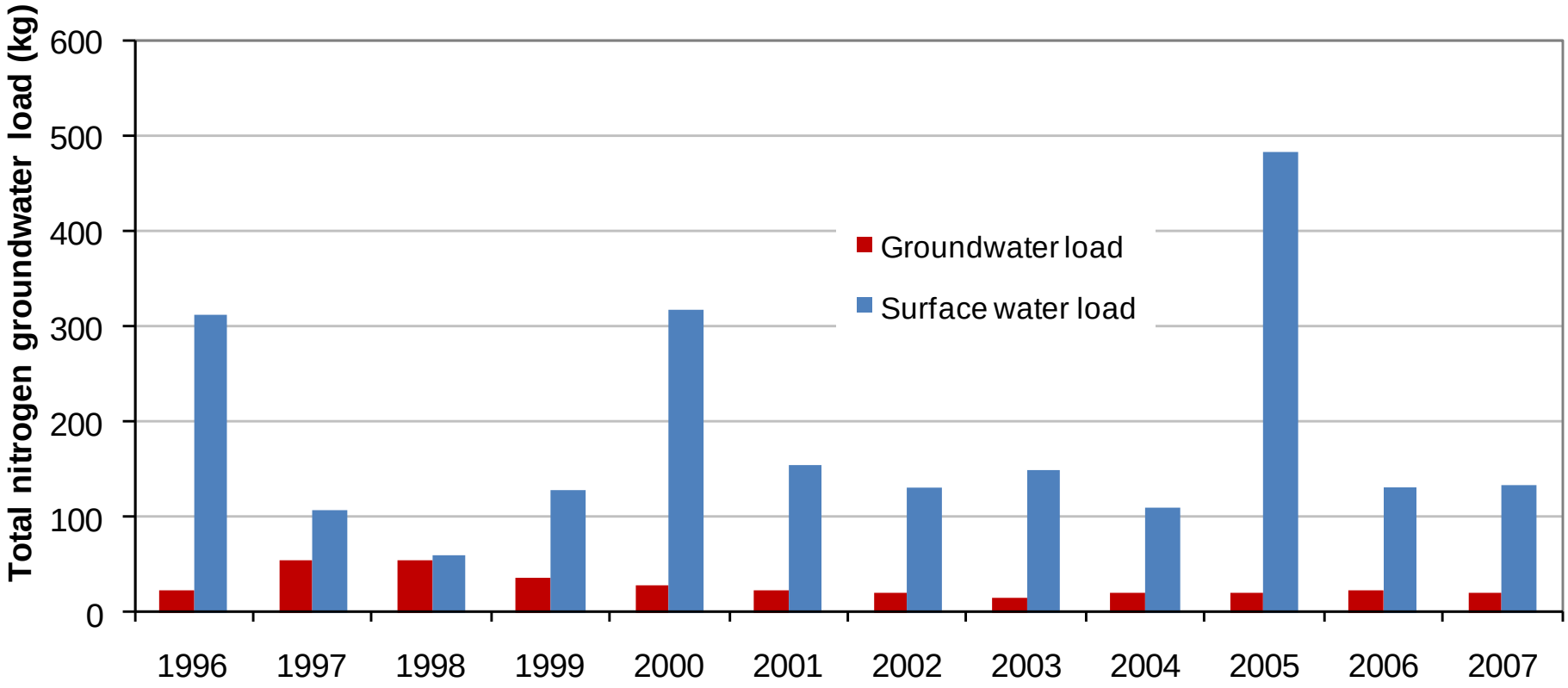
Groundwater concentrations



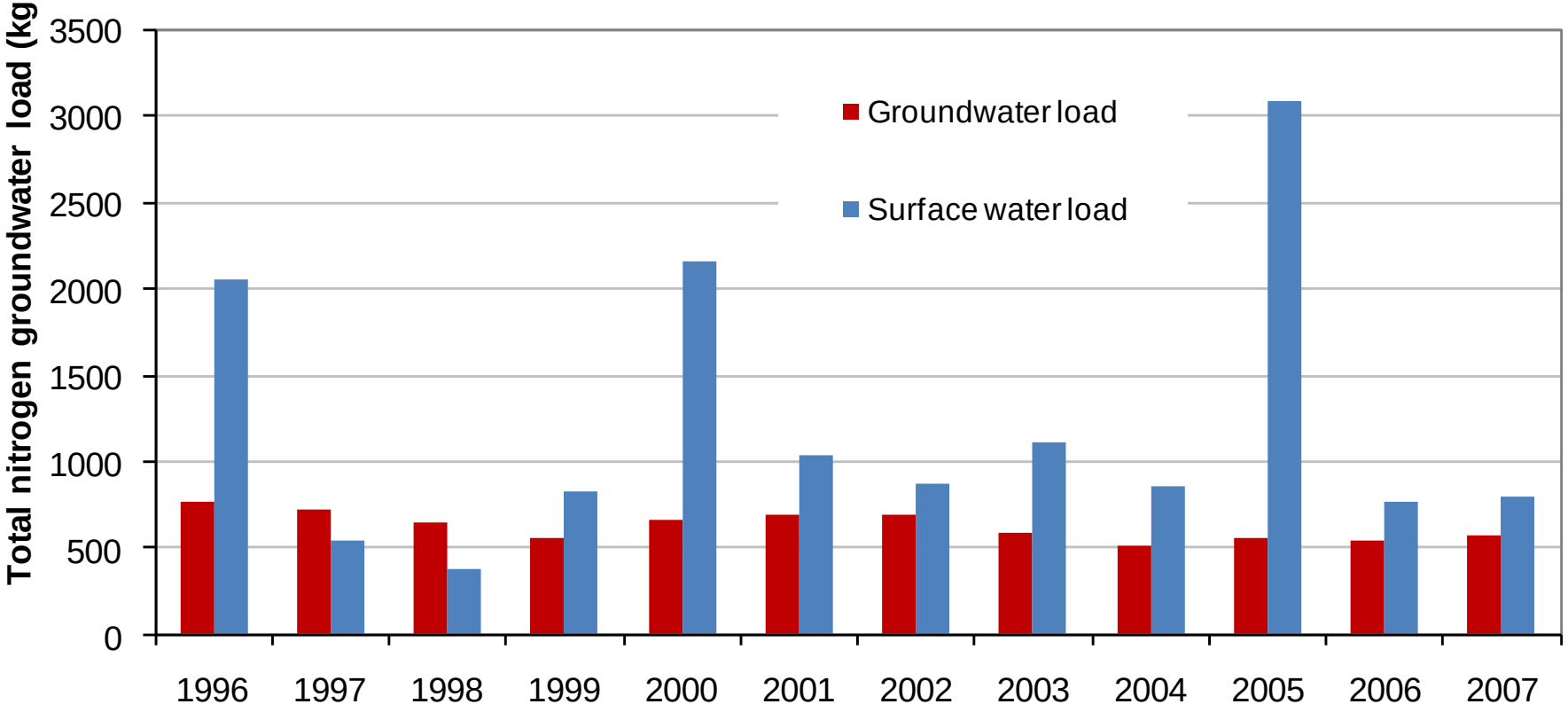
Groundwater loads - TP

$$\text{Load} = Q_{Darcey} * C = kibL * C$$



Groundwater loads - TN

$$\text{Load} = Q_{Darcey} * C = kibL * C$$



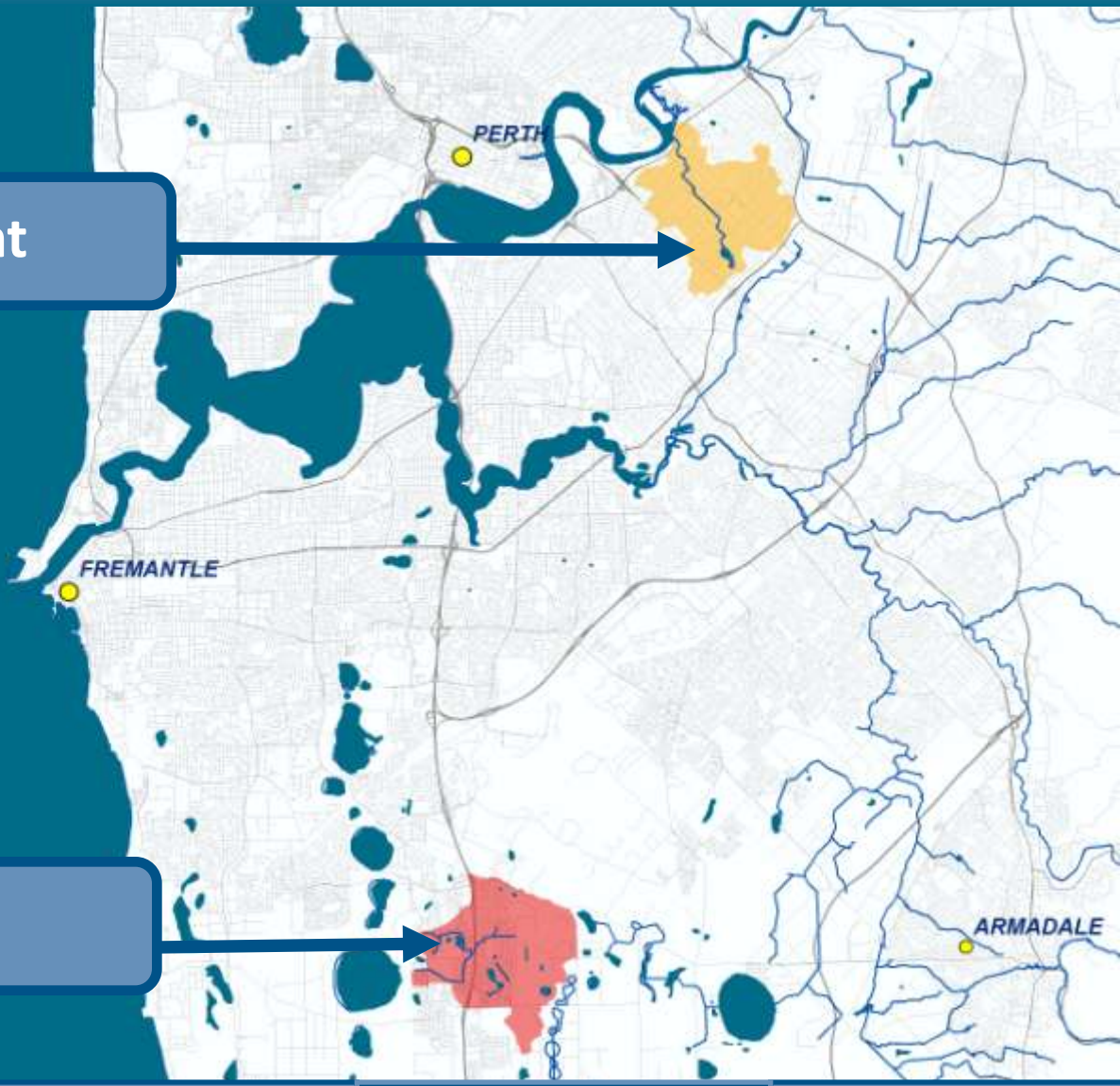
"New" vs "traditional" urban

- **Difference in flow from catchments**
- **Difference in export loads**
  - Output vs input loads
- **Differences in concentrations**
- **Mechanisms**

South Belmont – location

South Belmont catchment

Bartram Road catchment



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South Belmont – aerial photo

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South Belmont – land use

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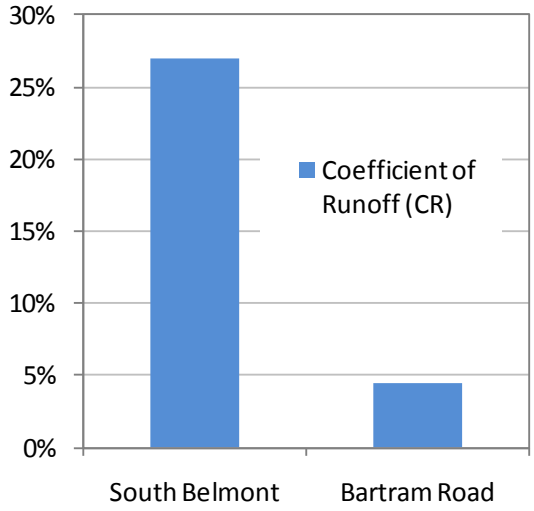
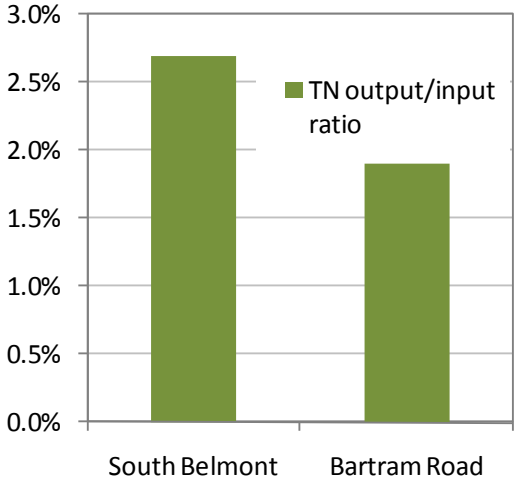
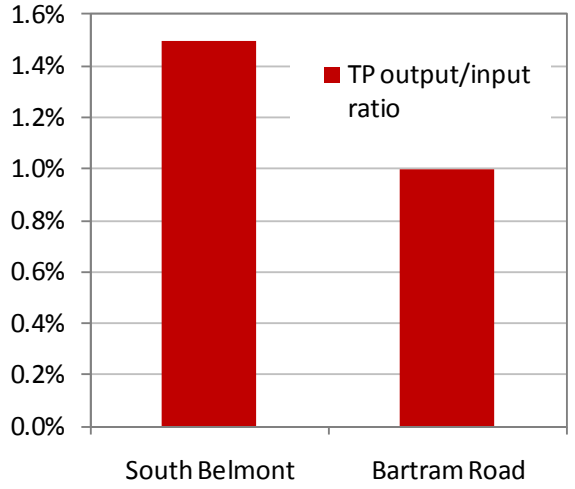
Bartram Road – land use

2007 comparison

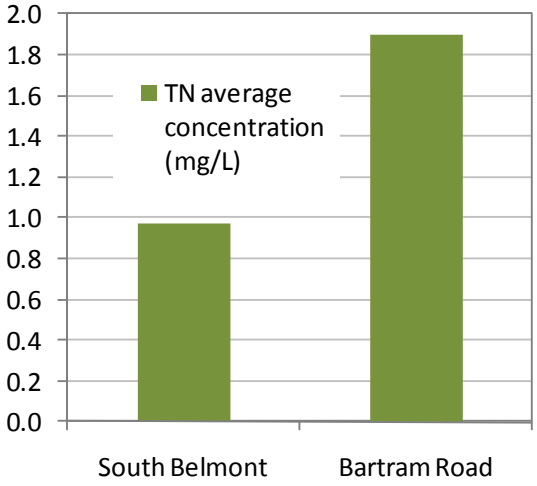
Load

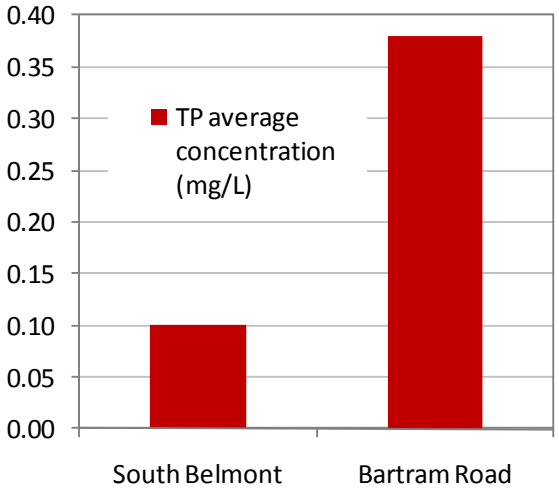






Concentration





Managing loads

- **WA manages 1 in 1 year event flows**
  - Nationwide leader in this field
- **Flows and loads closely related**
- **We are seeing 1/3 less load coming from these new developments due to the control of water quantity**
- **Good result, especially when considering the tools available in WA**

Mechanisms

Shallow bores reuse water and nutrients

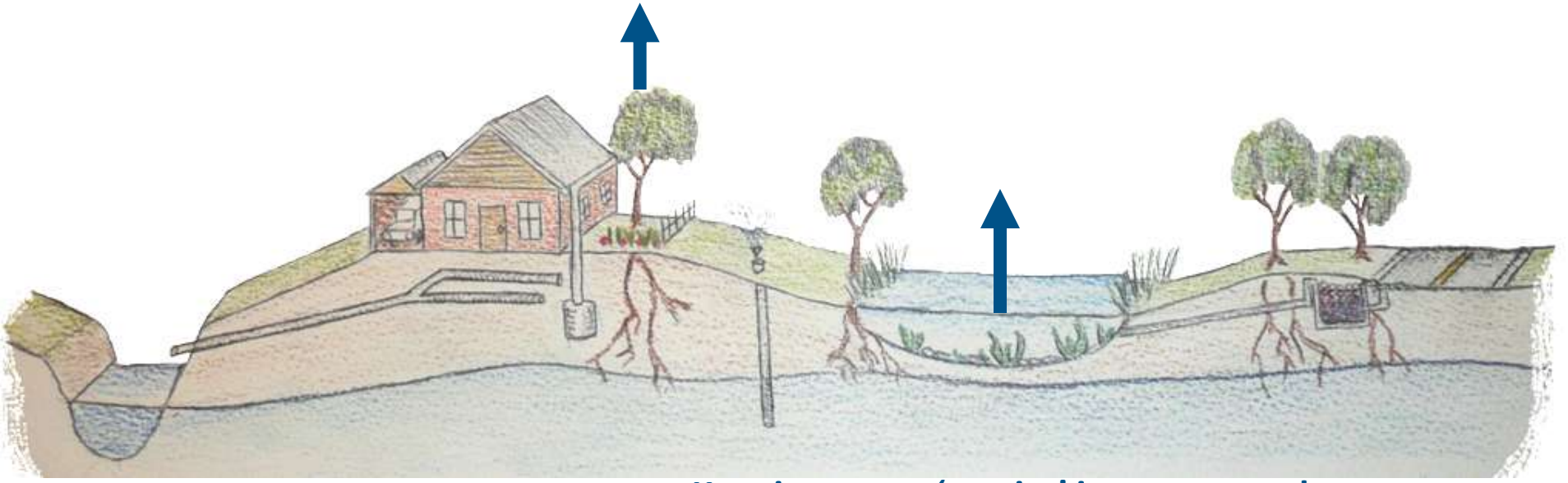
Constructed lakes increase plant uptake of nutrients and de-nitrification

Urbanisation increases groundwater recharge

Bio-retention systems uptake nutrients

Mechanisms

Plants transpire water from shallow groundwater



Keeping water 'on-site' in constructed lakes/ other systems increases evaporation and ET, and increases nutrient concentrations

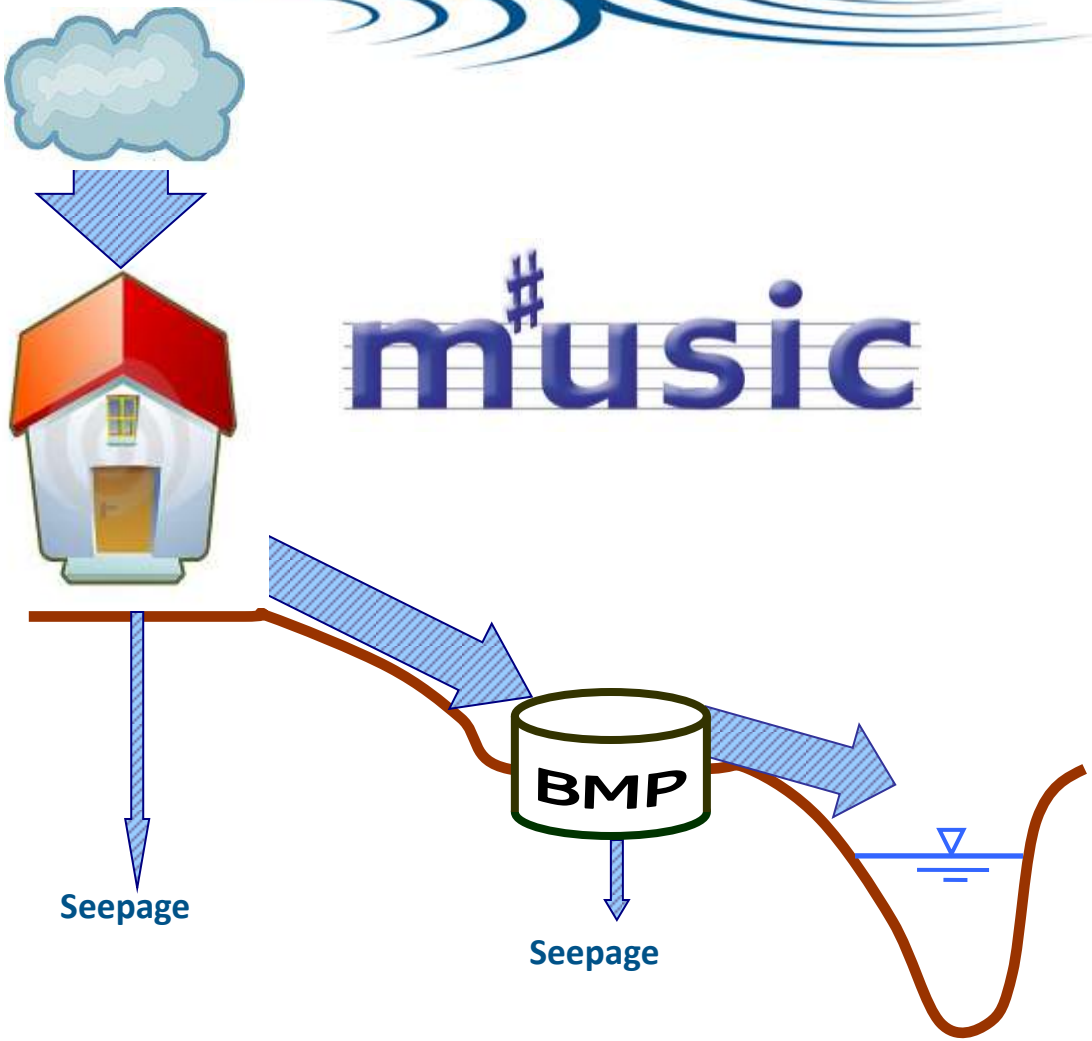
Issues with managing concentration

- **Lack of assessment technique**
  - MUSIC for WA
- **Cannot easily be solved by engineering structures**
  - Historically difficult to implement (Red Mud)
- **No single solution**
  - General disagreement amongst professionals
- **“Rundown” complicates policy**
  - Fuels disagreement

The problem with MUSIC for WA

Clay soils example:

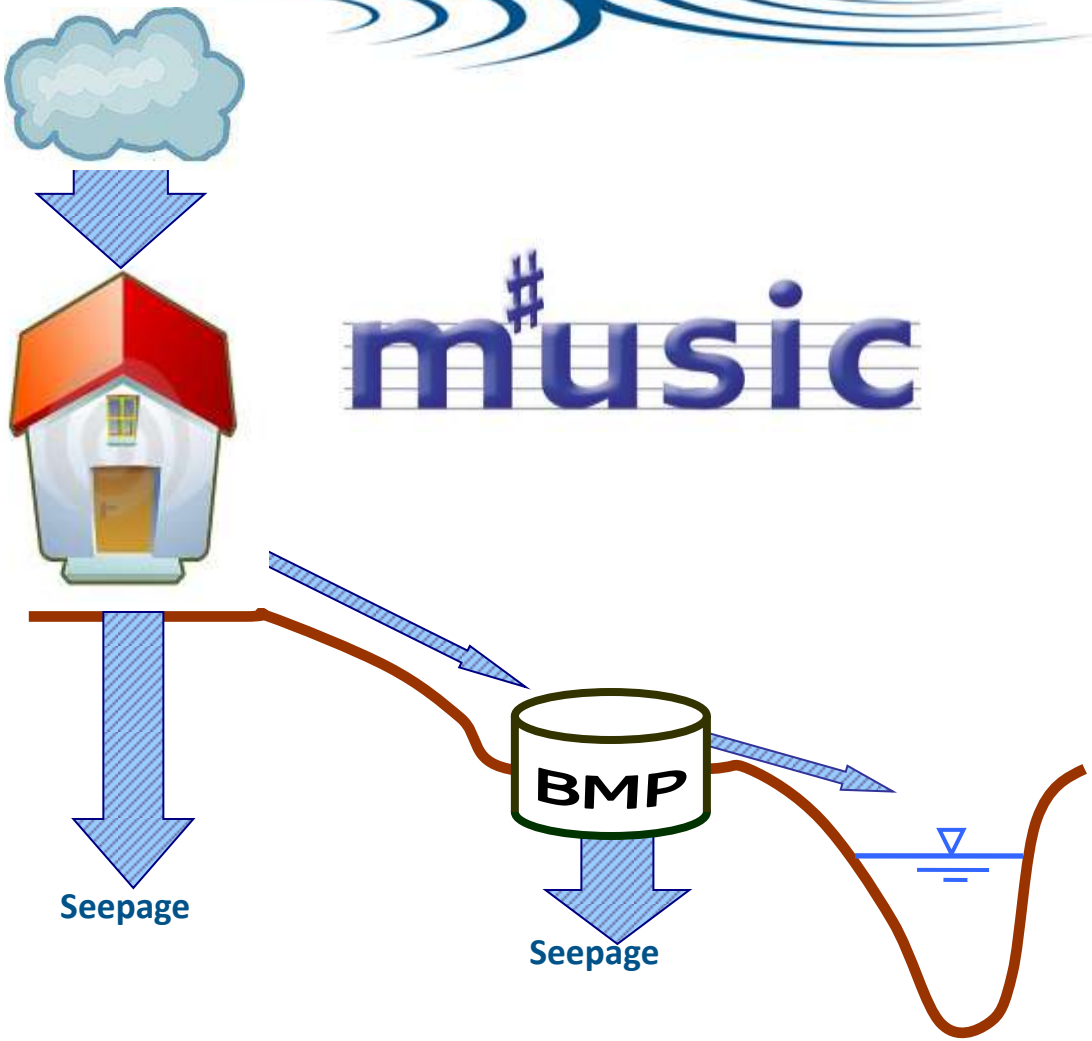
- Seepage is lost from model (effectively treatment)
- Small % of water balance so doesn't affect results



The problem with MUSIC for WA

Sand soils example:

- Seepage is lost from model (effectively treatment)
- Major % of water balance, loss means GW not accounted for



The problem with MUSIC for WA

Sand soils example:

- Tracks and treats seepage
- Load reductions need to be based on surface AND groundwater flow

The problem with MUSIC for WA

Sand soils example:

- Needs to take into account sub-surface drainage

Improving MUSIC for WA

- **Needs to be:**
  - scientifically rigorous
  - easy to use by practitioners
  - easy to assess by regulators
- **Requires collaboration between regulators, practitioners and developers**

Learnings from Bartram Road

- **Nutrient loads tend to increase as urban development intensifies**
  - due to increase in flow
  - concentrations tend to decrease at Bartram Rd
  - likely to be development specific
- **Groundwater cannot be ignored**
- **'New' urban exports less load than 'traditional' urban**
  - managing quality by managing quantity
- **Improvements can and should be made**
  - concentrations are very high
  - input loads need to be addressed

Reccommendations…

- **Facilitate source fertiliser treatment:**
  - Support Fertiliser Action Plan for urban
  - Support the release of NUA (NutriSorb)
- **Facilitate urban BMPs investigation:**
  - Measure and store in central database
  - Partnerships with developers/LGAs
- **Support numerical model development:**
  - MUSIC WA or alternative tool
  - Regulators/practitioners/developers

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Questions?