Academia Brasileira De Ciencias

Enhancing Water Management Capacity in a Changing World.

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Lake Chivero:

Case study of urban water supply.

Issues and possibilities

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In a nutshell

- The Harare Municipality supplies water to close to 7 million people, i.e close to 50% of current Zimbabwe population.
- The Waterworks can only supply 60% of demand.
- 20% of produced water is lost through leakages
- 40% of consumption is paid for; i.e. 32% of production
- Lake Chivero, supplemented from Lake Manyame, is principal source of water.

Google earth view of L. Chivero watershed with overlays

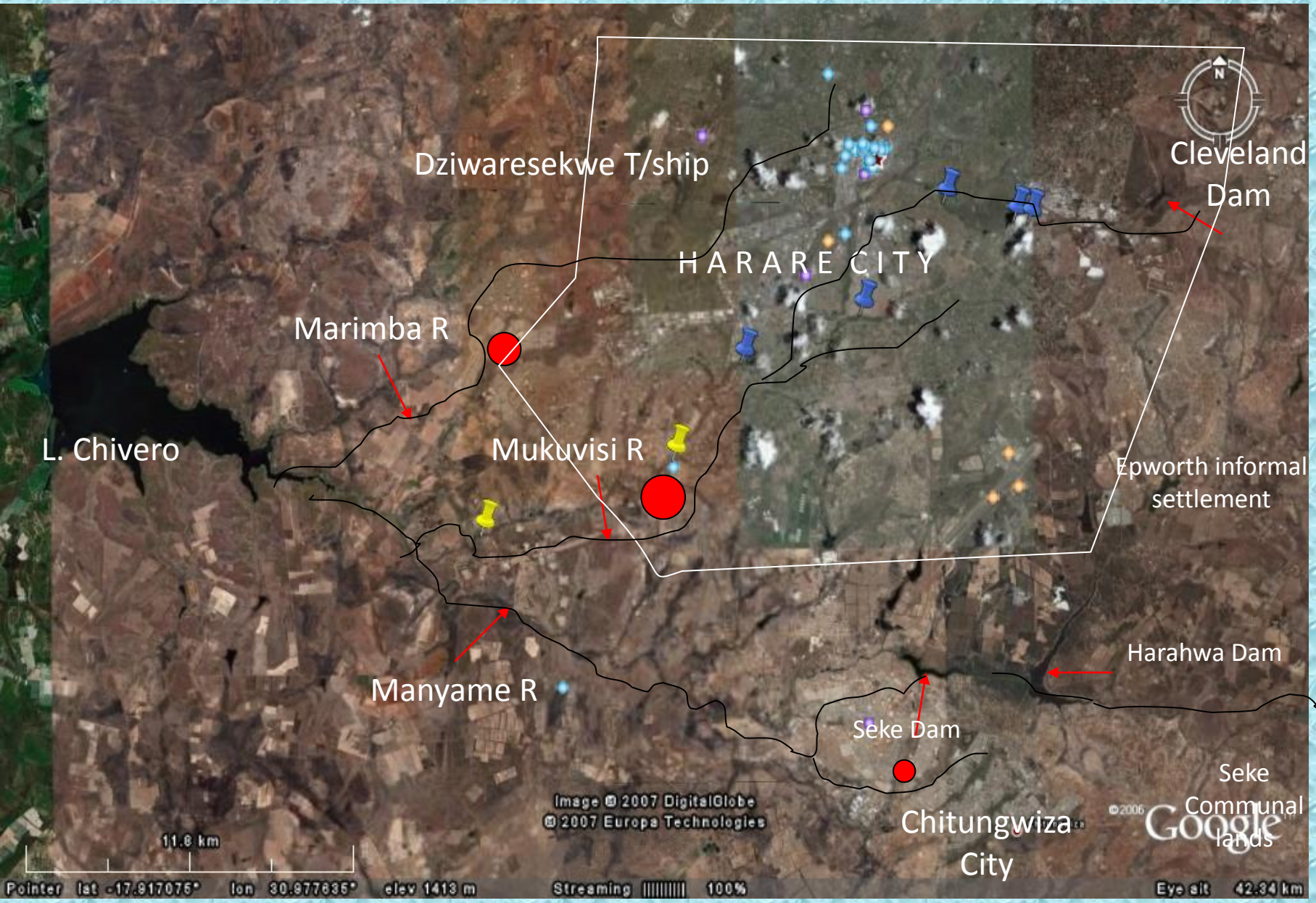


Table 1.Hydrological and morphometric features of Lake Chivero

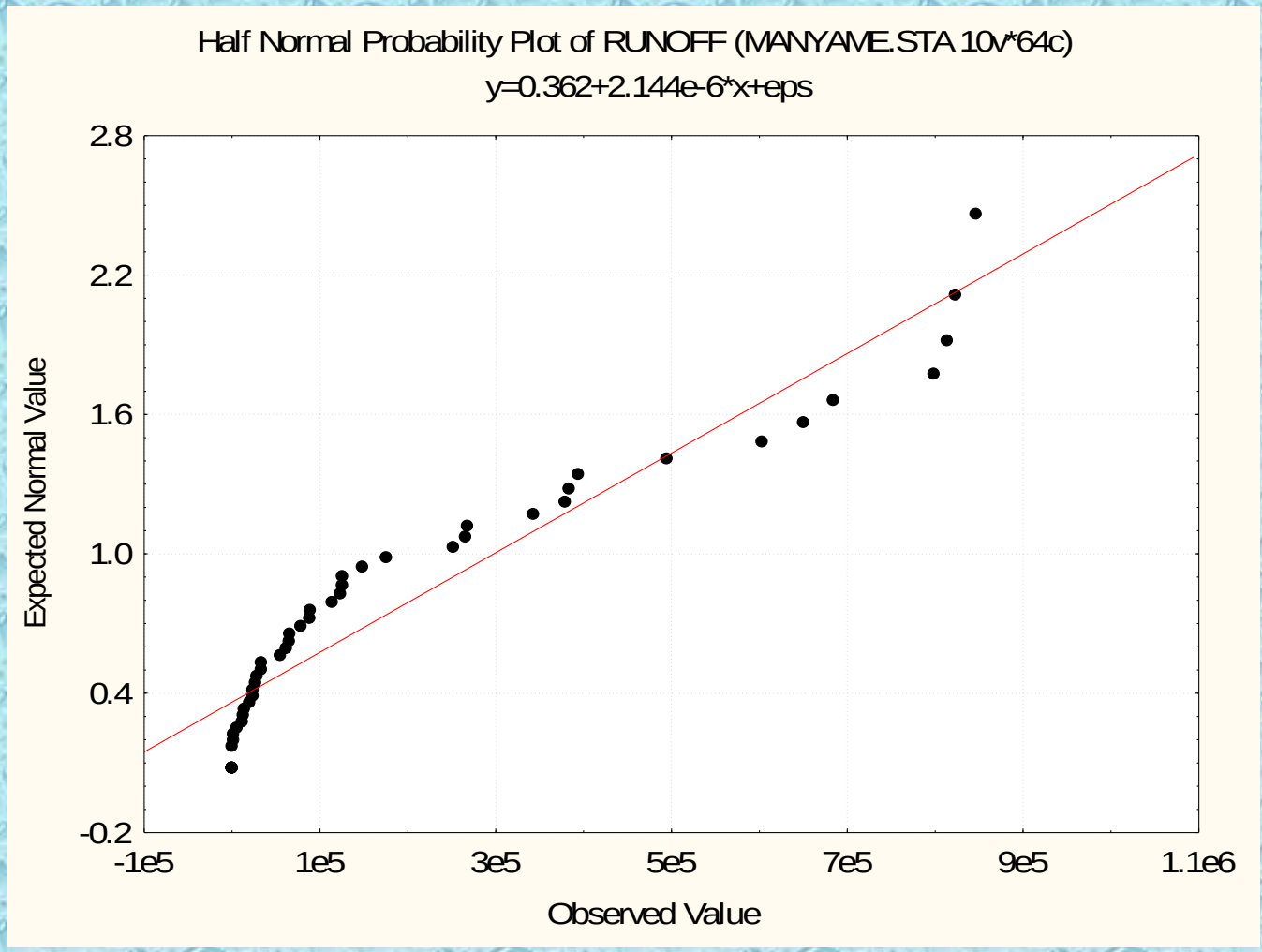
Full supply volume	250 x $10^6 m^3$
Full supply surface area	26.30 km^2
Catchment area	2227 km^2
Shoreline length	74 km
Maximum depth	27.43 m
Mean depth	9.4 m
Maximum breadth	8.0 km
Mean breadth	1.68 km
Length	15.7 km
Catchment : lake area ratio	8.9
Shoreline development	4.1
Year construction	1952

Paintings by the Xan people


20000000000 RESERVE BANK OF ZIMBABWE 20000000000
I promise to pay the bearer on demand
TWENTY BILLION DOLLARS
for the Reserve Bank of Zimbabwe
AA1062844
20000000000
HARARE 2008
AA1062844

Hydrology

Runoff, Manyame River



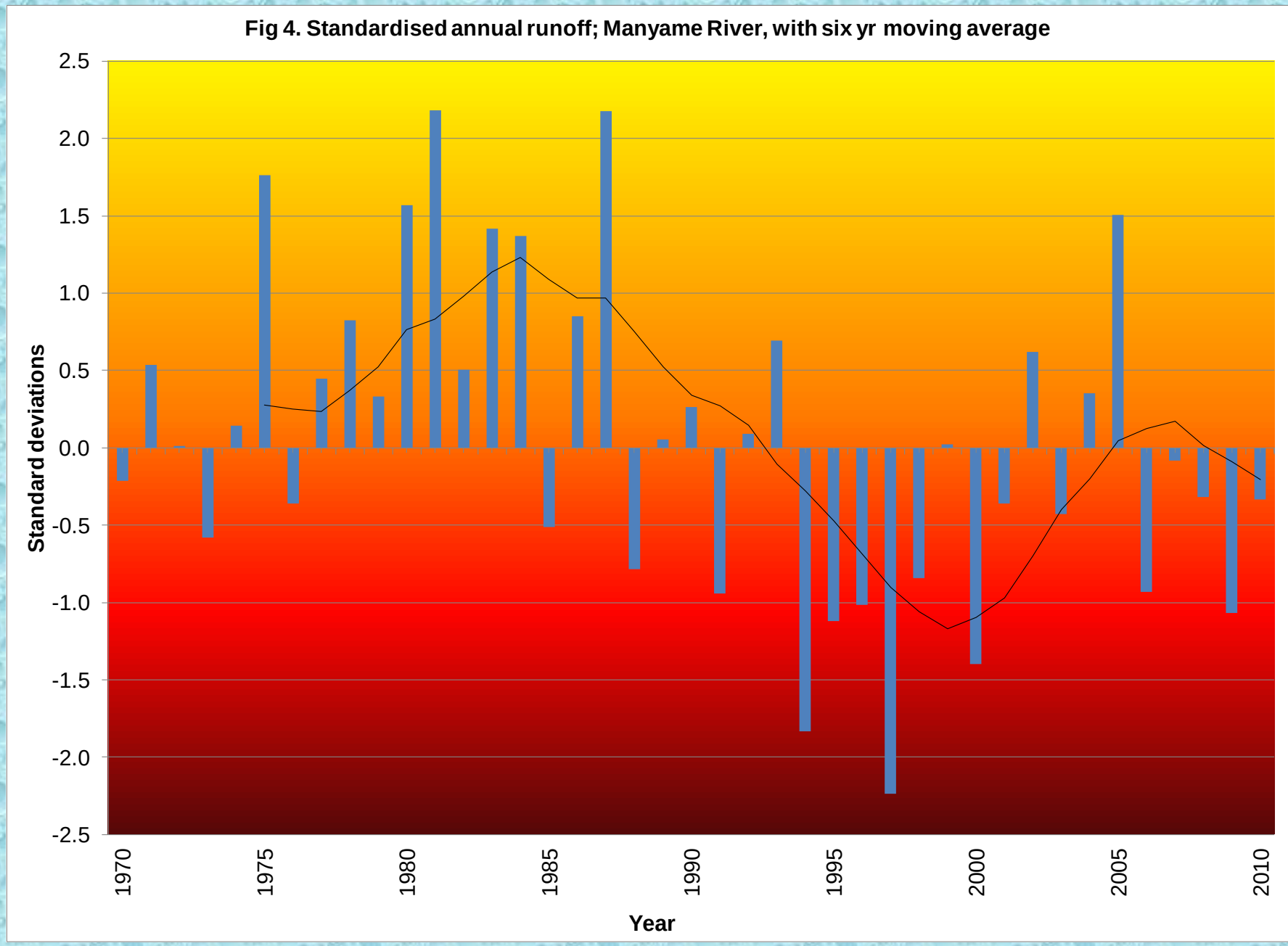
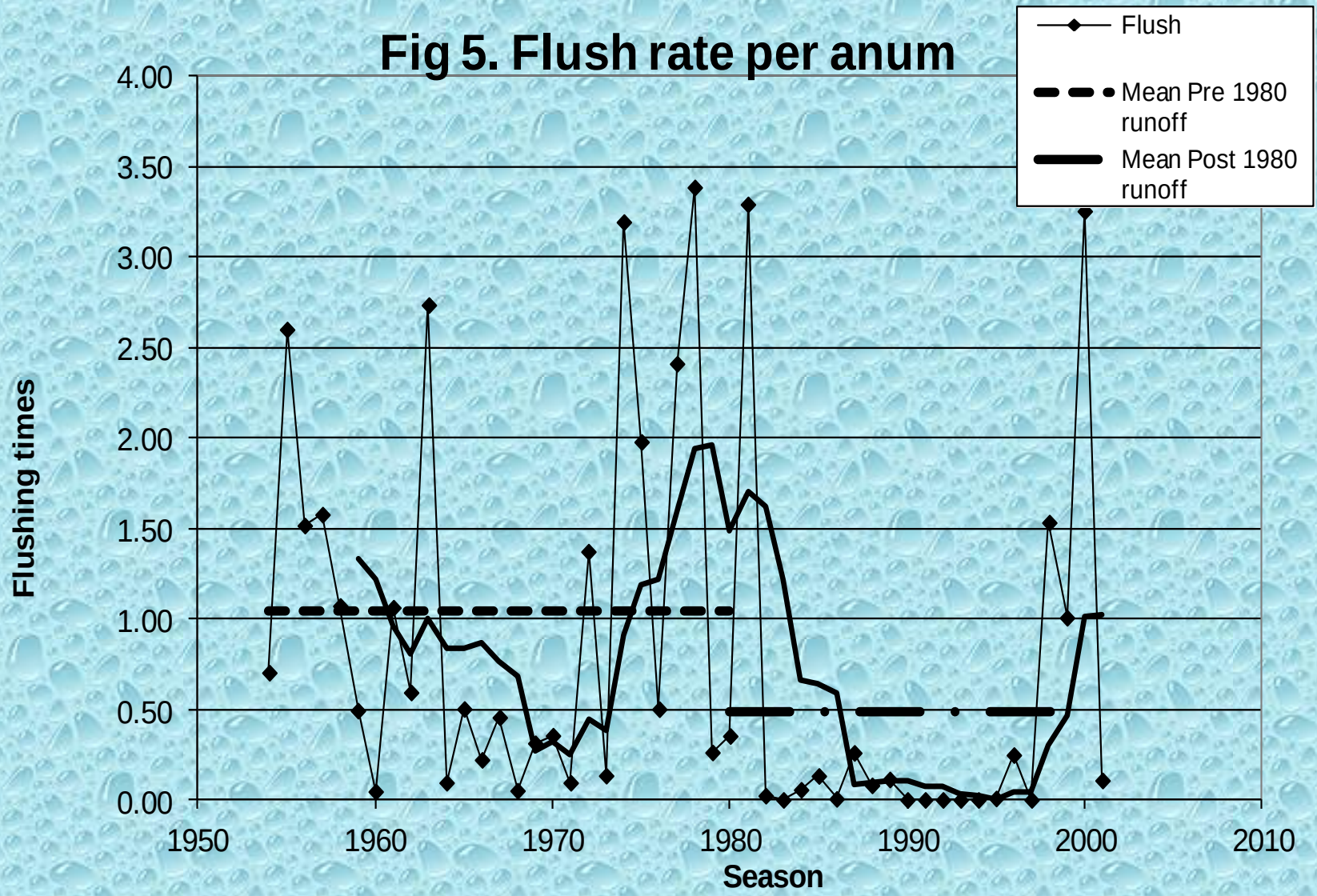


Fig 4. Standardised annual runoff; Manyame River, with six yr moving average
Standard deviations
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

Fig 5. Flush rate per anum



Comparative run-off flow and wastewater flow into L. Chivero

Fig 6. Proportionate flows of sewage bearing streams and Manyame runoff

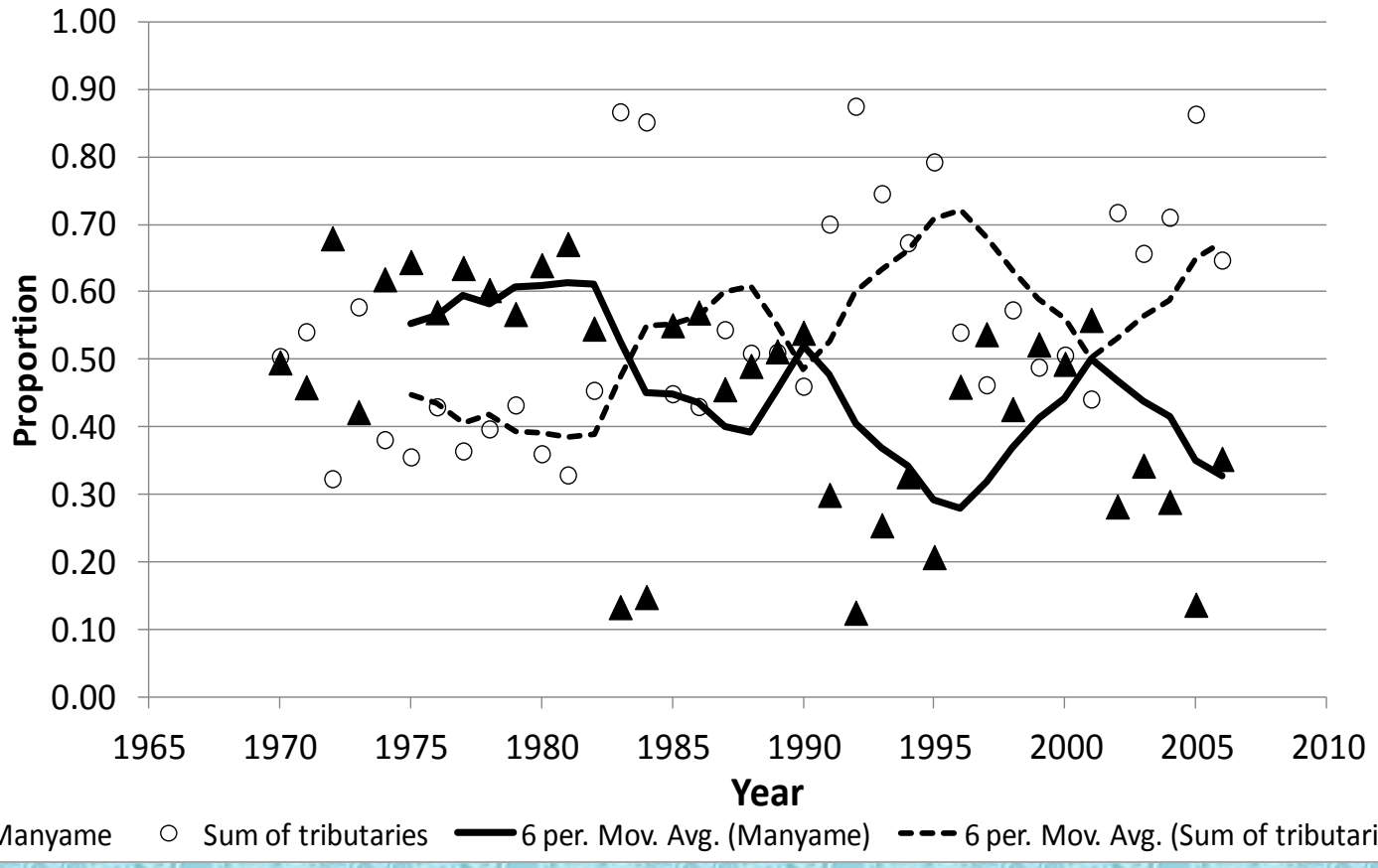
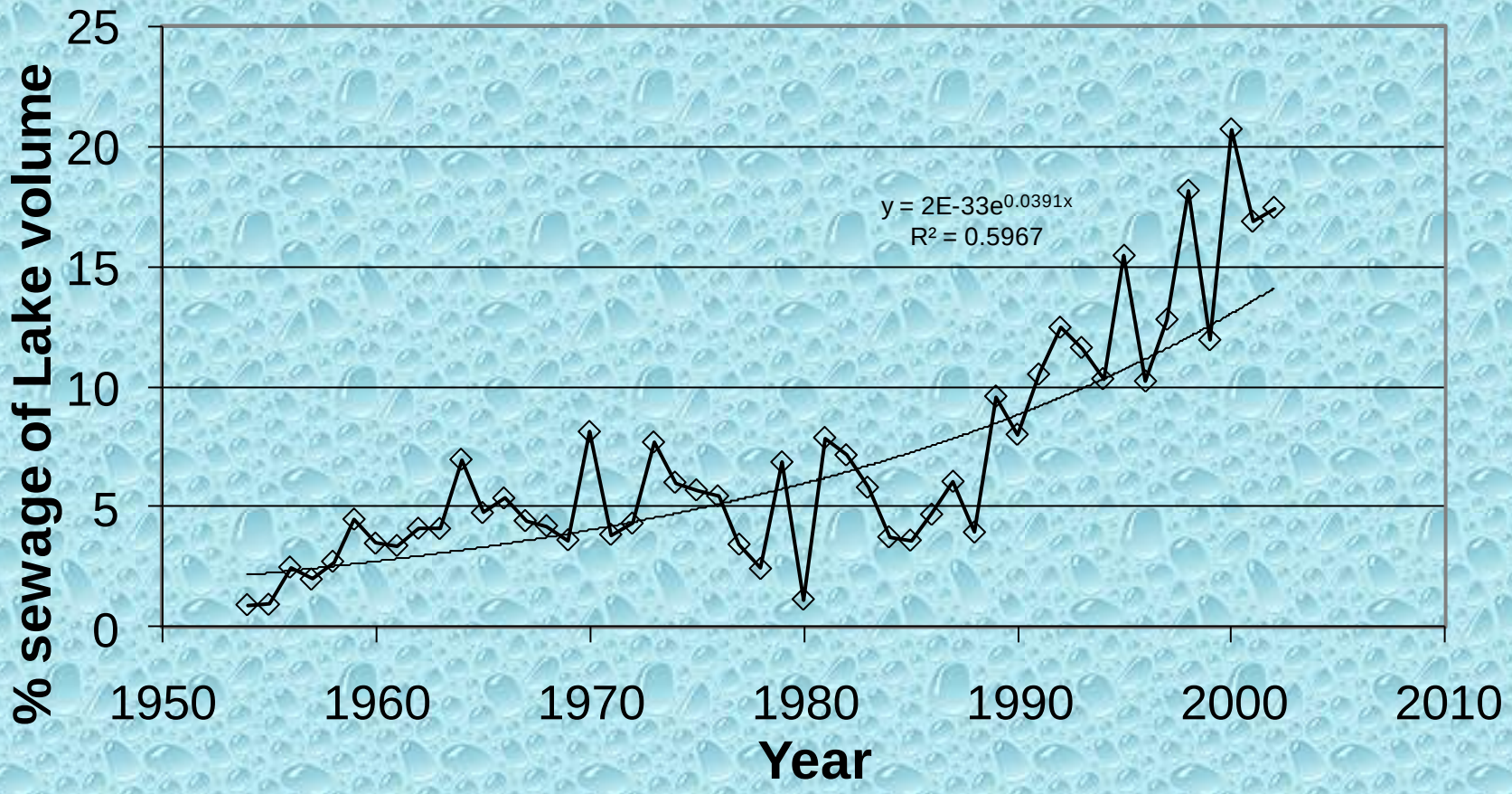
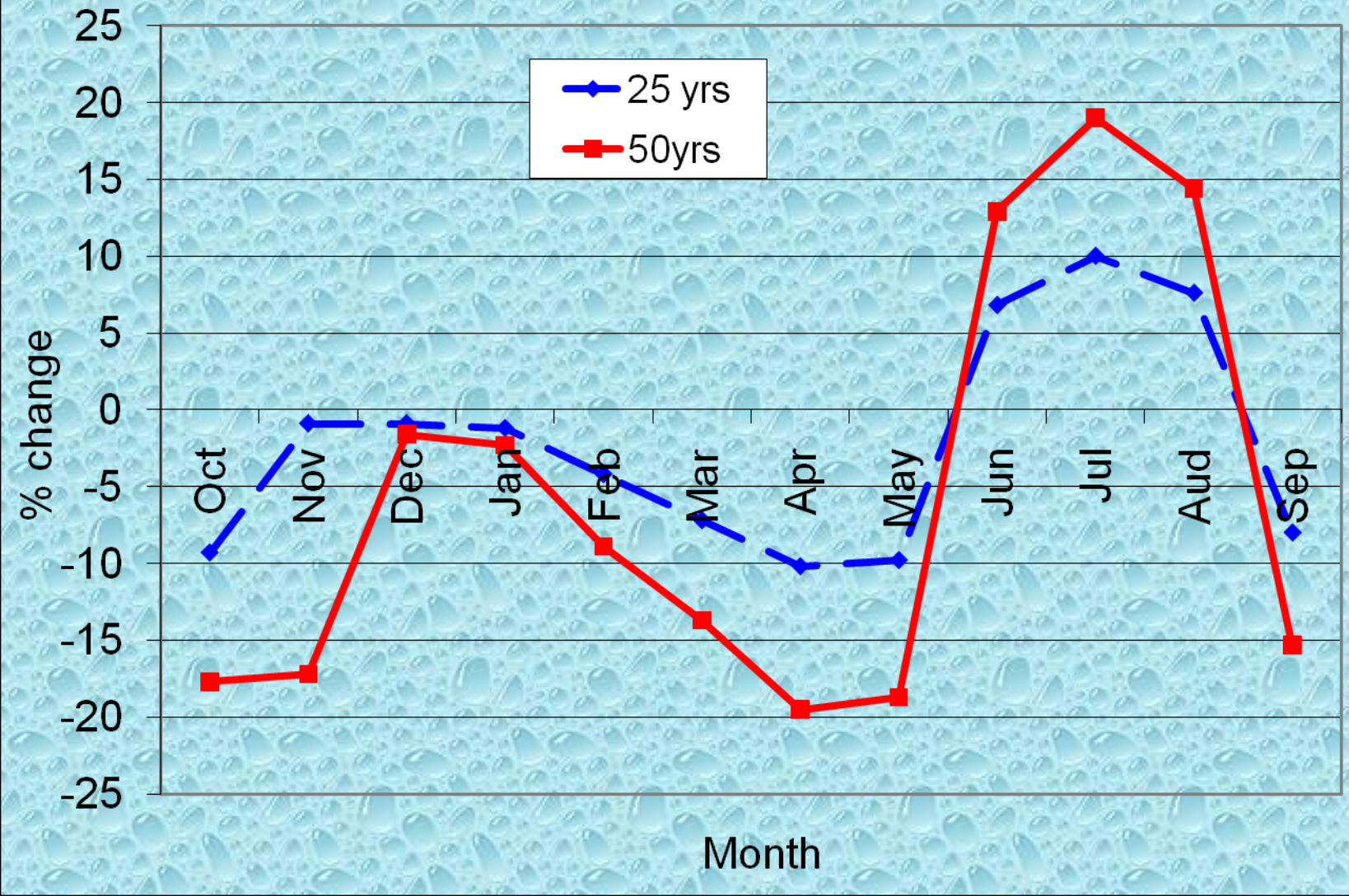


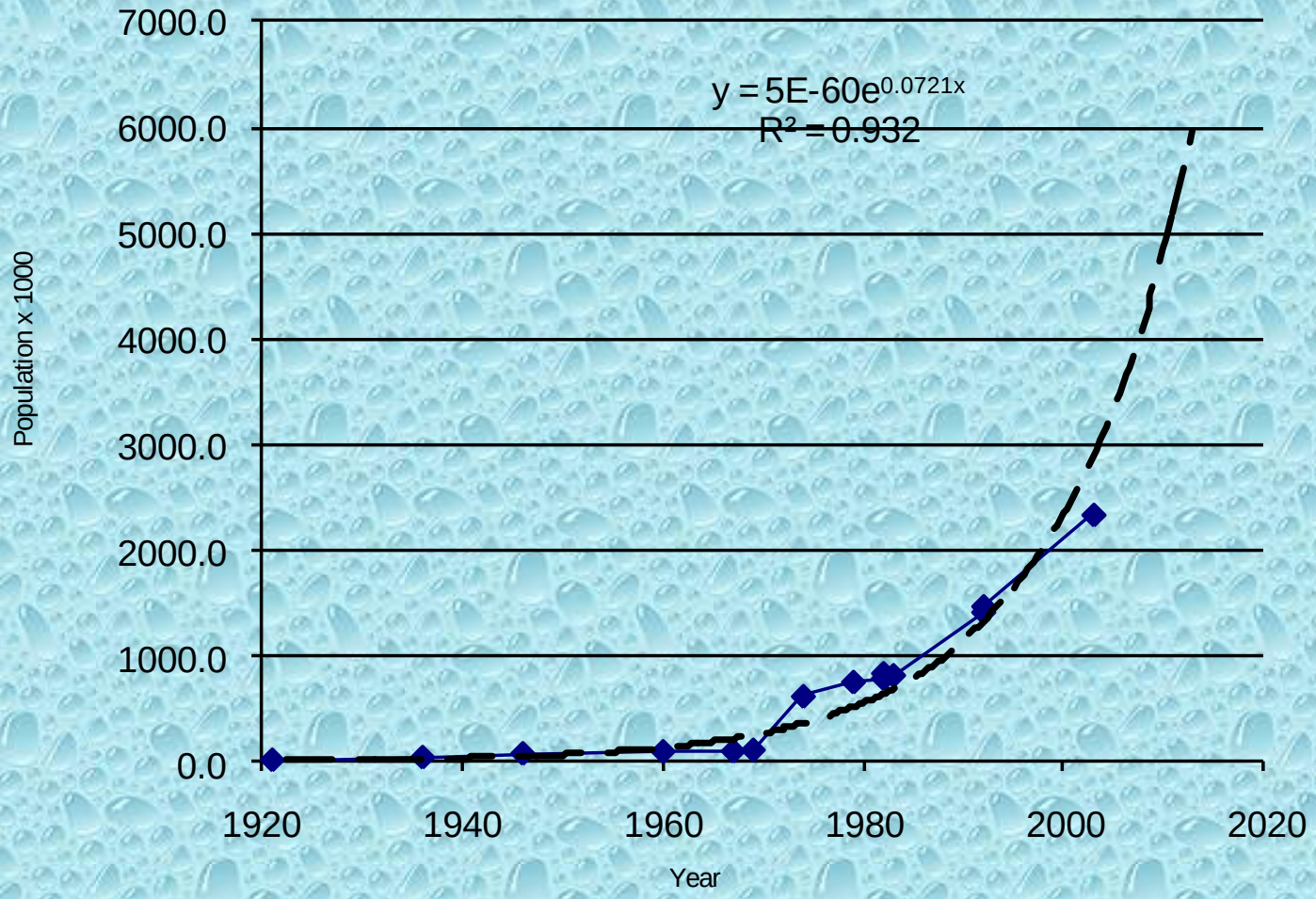
Fig.7. % contribution of sewage to lake volume from Ferle & Croborough sewage works



Projected changes in precipitation in L. Chivero catchment



Reconstructed Harare population: doubling period ~12 years



Diffuse source

Breached sewer effluent flowing along suburban road in a middle to high income area


LIQUID WASTE REMOV
011 714 430
0912 422 654 0912 951 400
Honey Bucker
0912 422 654

Dog on uncollected refuse heap

The facilities


WORKSHOP

Untreated wastewater outflow from a sewage treatment plant, Harare

Table. 2. Waste water treatment capacity ($_{ML}{}^{d}$) at some of the Manyame watershed sewage works (excluding Chitungwiza, Ruwa and Norton)

Plant	Trickle filter	Year	Activated sludge (BNR)	Year	Ponds	Year	Total capacity	Present flow
Ferle	36	1960	18	1982			144	**250**
			18	1974				
			72	1998				
Crowborough	36	1957	18	1982			54	**120**
Donnybrook					2.3	1953 - 1972	2.3	**10**
Marlborough					2	Post 1980	2	**7**
Chitunwiza								54
Total							202.3	**387**
Capacity deficit								**441**

Pressures on the Water supply Reservoirs

Table 4 Historical trend in P loading to Lake Chivero. (Magadza 2003, Nyumbu 2012).

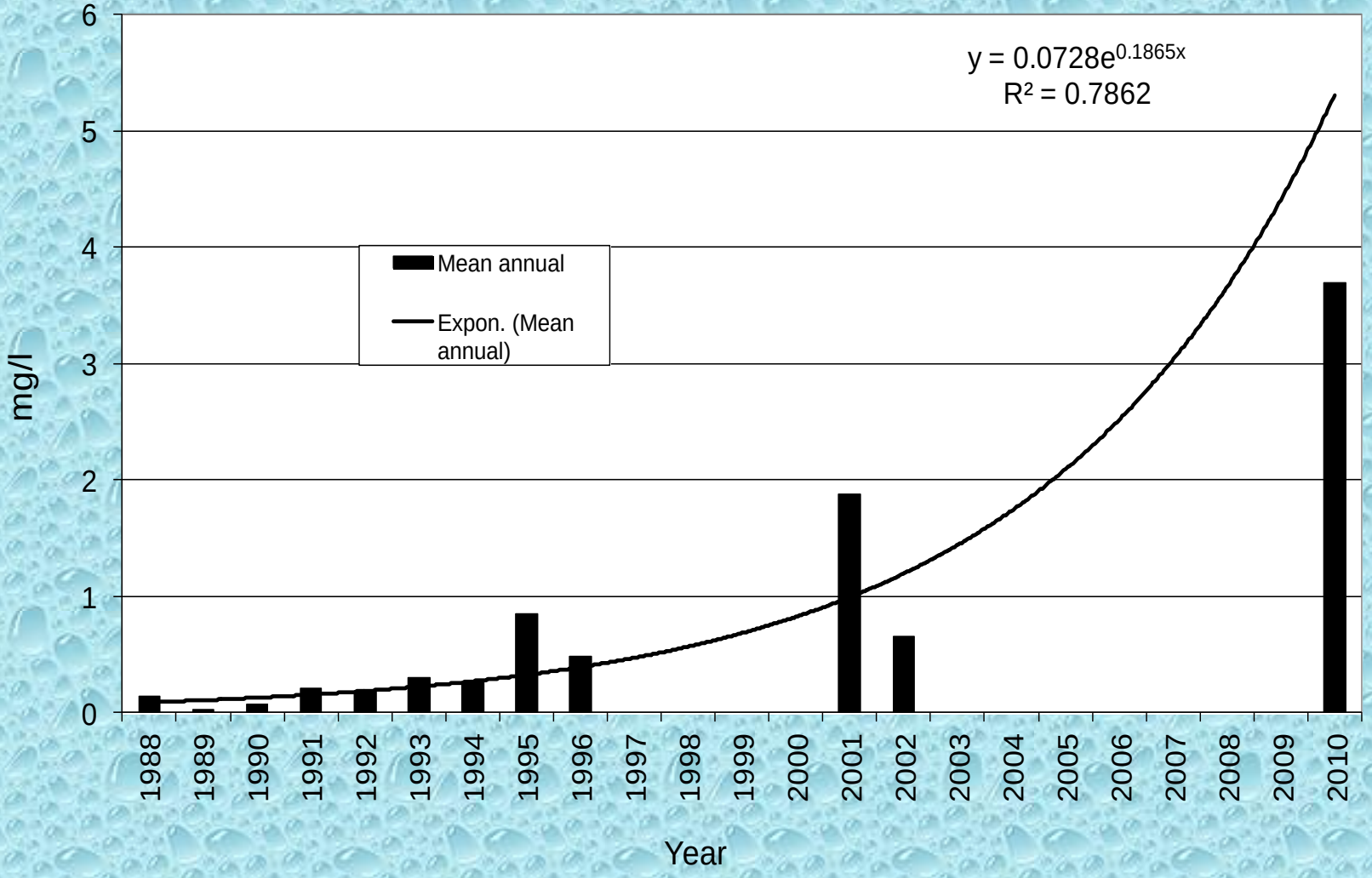
Variable	1967	1978	1996	**2010**
P concentration (mg/l)	2.8	0.13	1.8 (Manyame)	**2.77**
P load g (m^2)	27.4	1.5	14	**27.8**
P load (tonnes/pa)	685.0	39.6	350.0	**697**

Table 2. Phosphorus and Nitrogen export through surface runoff from Harare suburbs. Dry season; after Mufaro 2002

		Phosphorus		Nitrogen			Total export	
Catchment/ Suburb	Type	Tonne km^{-2}	Kg $Capita^{-1}$	Tonne km^{-2}	Kg $Capita^{-1}$	Ratio P: N	P- tonne	N- Tonne
Gwebi	Low	0.02	0.04	0.16	0.42	5.81	0.99	9.31
Muwisindale	Low	0.07	2.31	1.22	41.39	5.99	5.24	93.96
Kuwadzana	Medium	0.08	0.17	0.47	0.96	3.89	2.88	16.75
Mukuvisi	High/ Industrial	10.28	1.00	39.98	3.89	3.61	98.99	385.04
Marimba	High/ Industrial	0.13	0.77	0.86	4.98	3.68	9.28	60.31
Budiriro	High	2.30	0.23	13.77	1.35	9.42	22.08	132.17
Epworth	High	3.38	1.11	12.20	4.00	17.95	103.12	371.88
Glenview	High	0.30	0.39	1.09	1.44	6.50	30.23	111.39
Total or mean		1.62	0.56	7.53	6.38	5.69	272.81	1180.81
P loading gm^{-2}	7.6 gm^{-2}							

Conditions in Lake Chivero

Fig 7. Annual mean phosphate: 2010 data after Nyumbu (2012), 1988 - 1994 Harare Minucipality, other data by author.



Lake Chivero from Dam wall

Macrophytes in eutrophic waters: warmer climate promotes faster growth, therefore higher management costs

Algal scum, Chivero (Photo C.H.D. Magadza)

Methane bubbles from the sediments: L. Chivero

Health issues

Fig 7. Enteritis deaths per thosant infectd

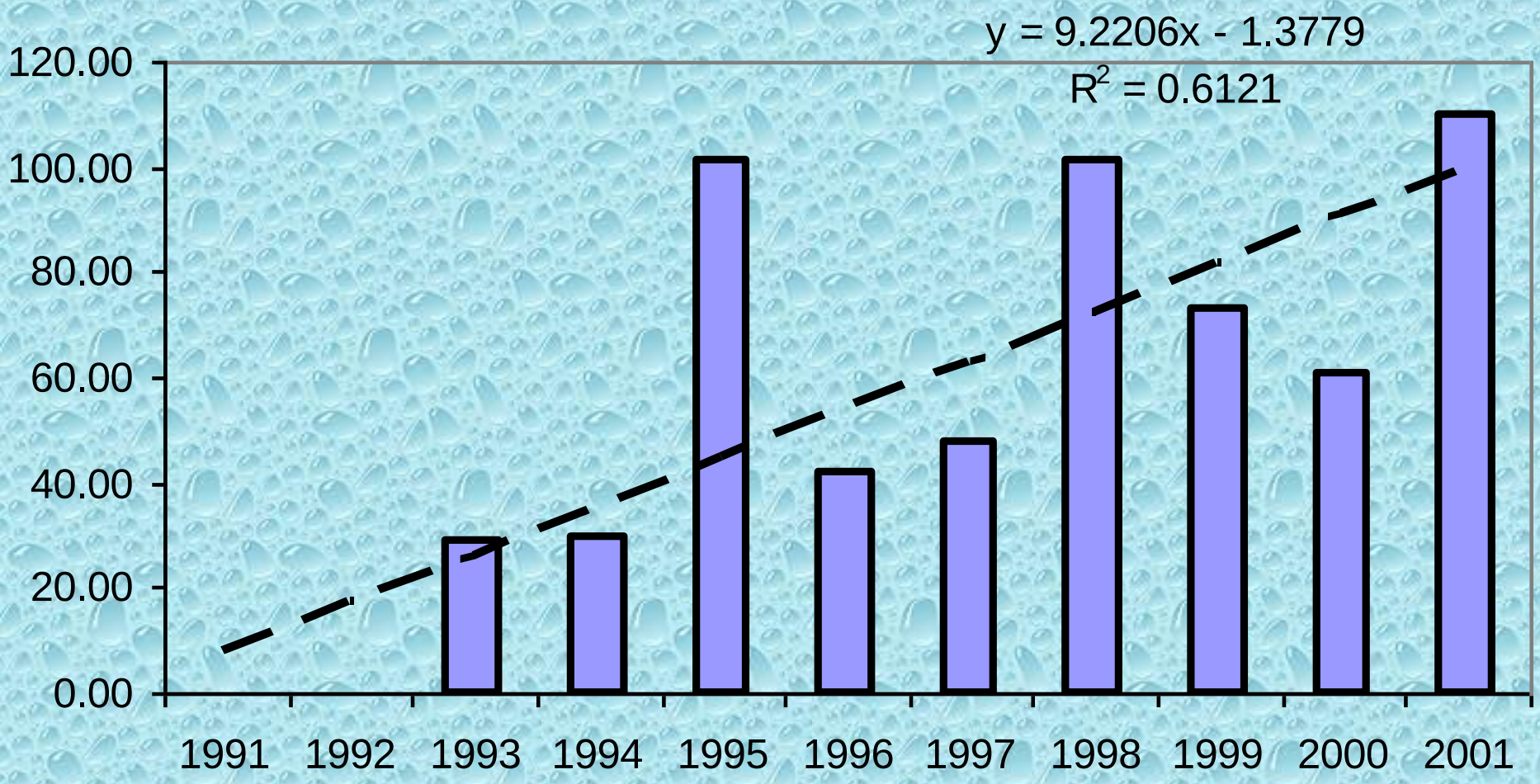
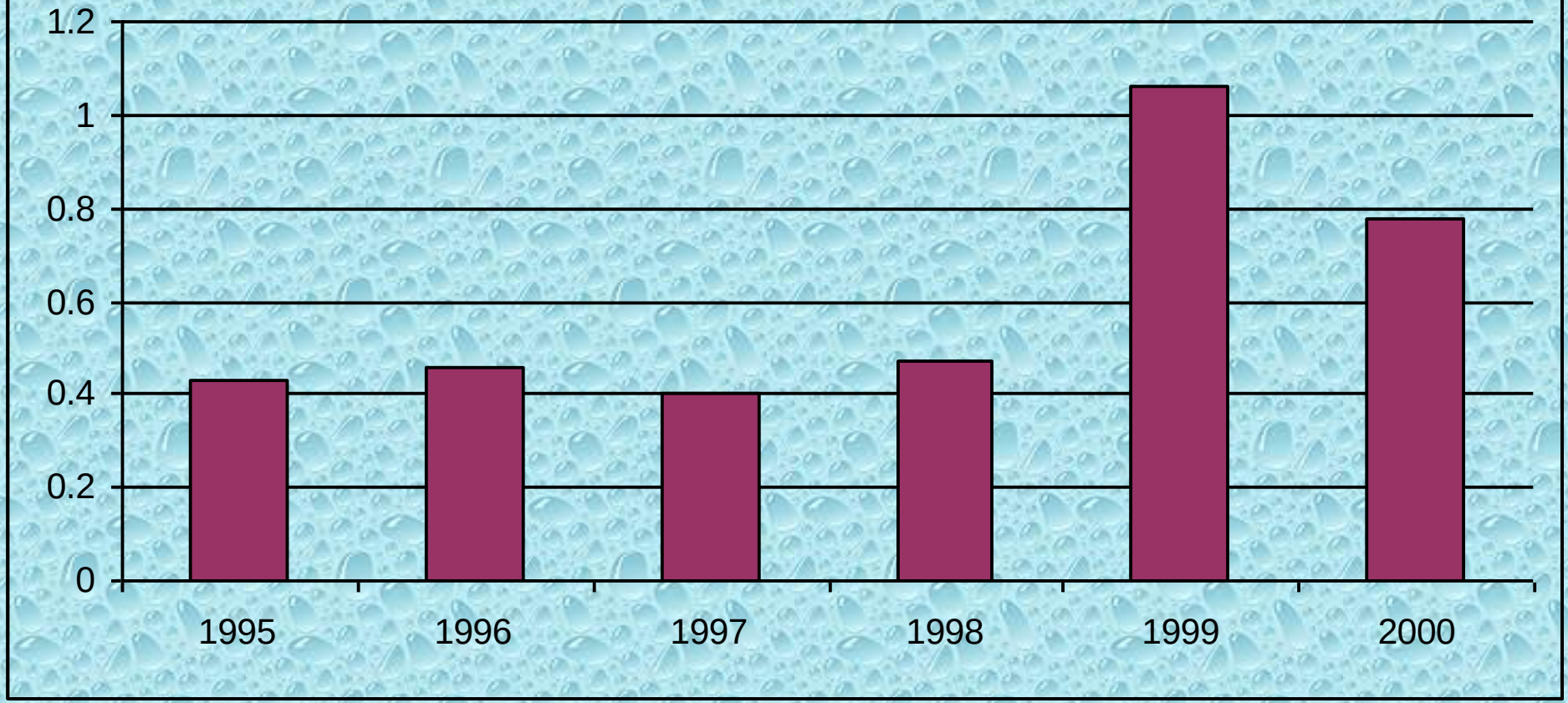


Fig. 8. Liver cancer: incidence/1000. This disease is associated with microcystin from cynobacteria



Unexplored health hazards

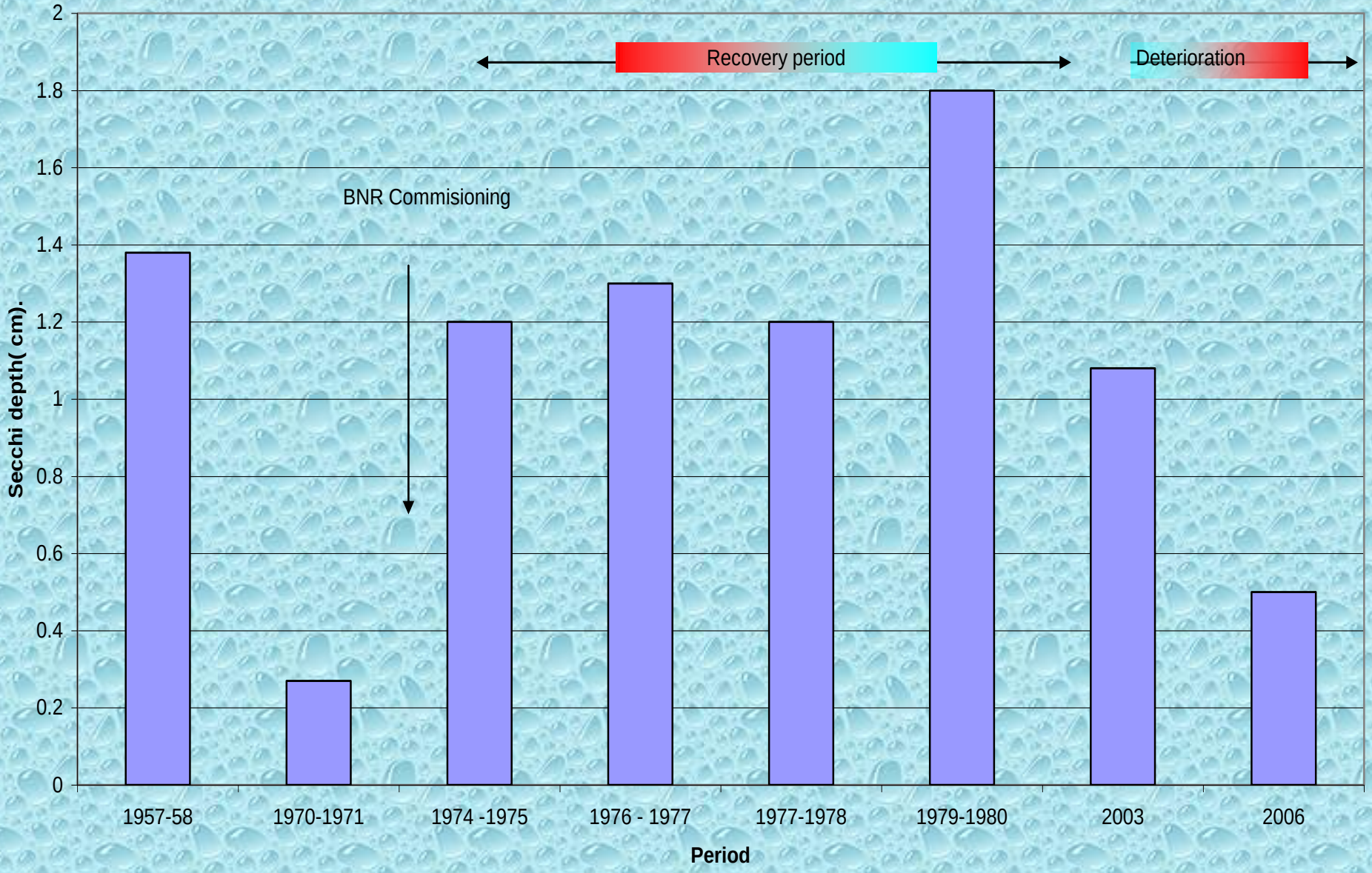
- Health hazards associated with chlorinating water with high dissolved organic content
- Heavy metals
- Other industrial pollutants.
- Parasites

Remedies??

Technology solution

- The 1970 innovative use of BNR technology proved that it was a feasible method of eutrophication control
- The infrastructure and technical know-how is still available
- It however needs extensive investment to rehabilitate increase its capacity
- Plans for expansion of these sewage works have been completed

Secchi disc chneges following restoration measures (data from Thornton 1982, Ndebele and Magadza 2006, Magadza unpublished. The 2003 data refer to wet period.)



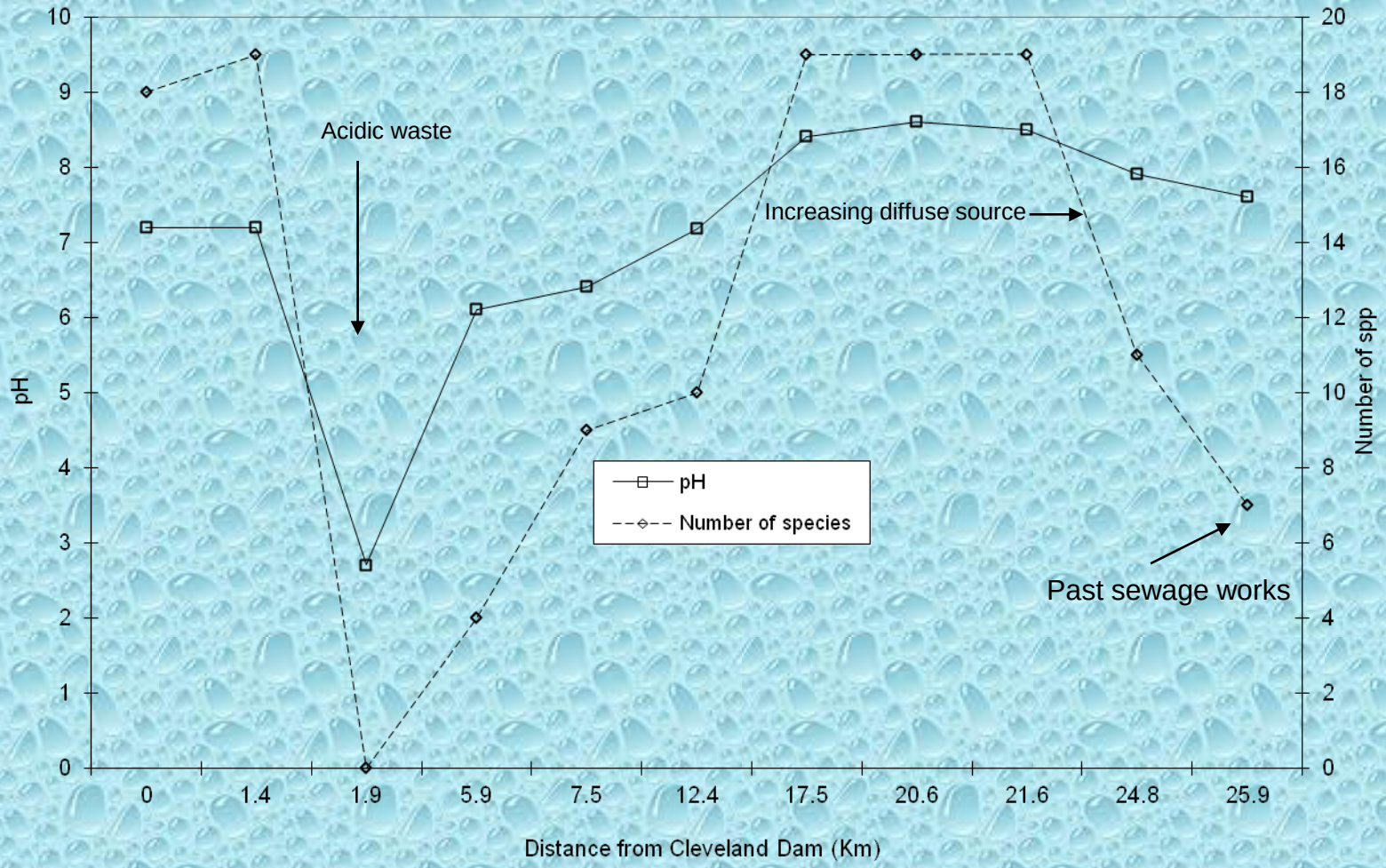
Google earth view: Ferle BNR sewage works. Green colour of reactors and clarifiers indicate dysfunctional state.

Ecological approach

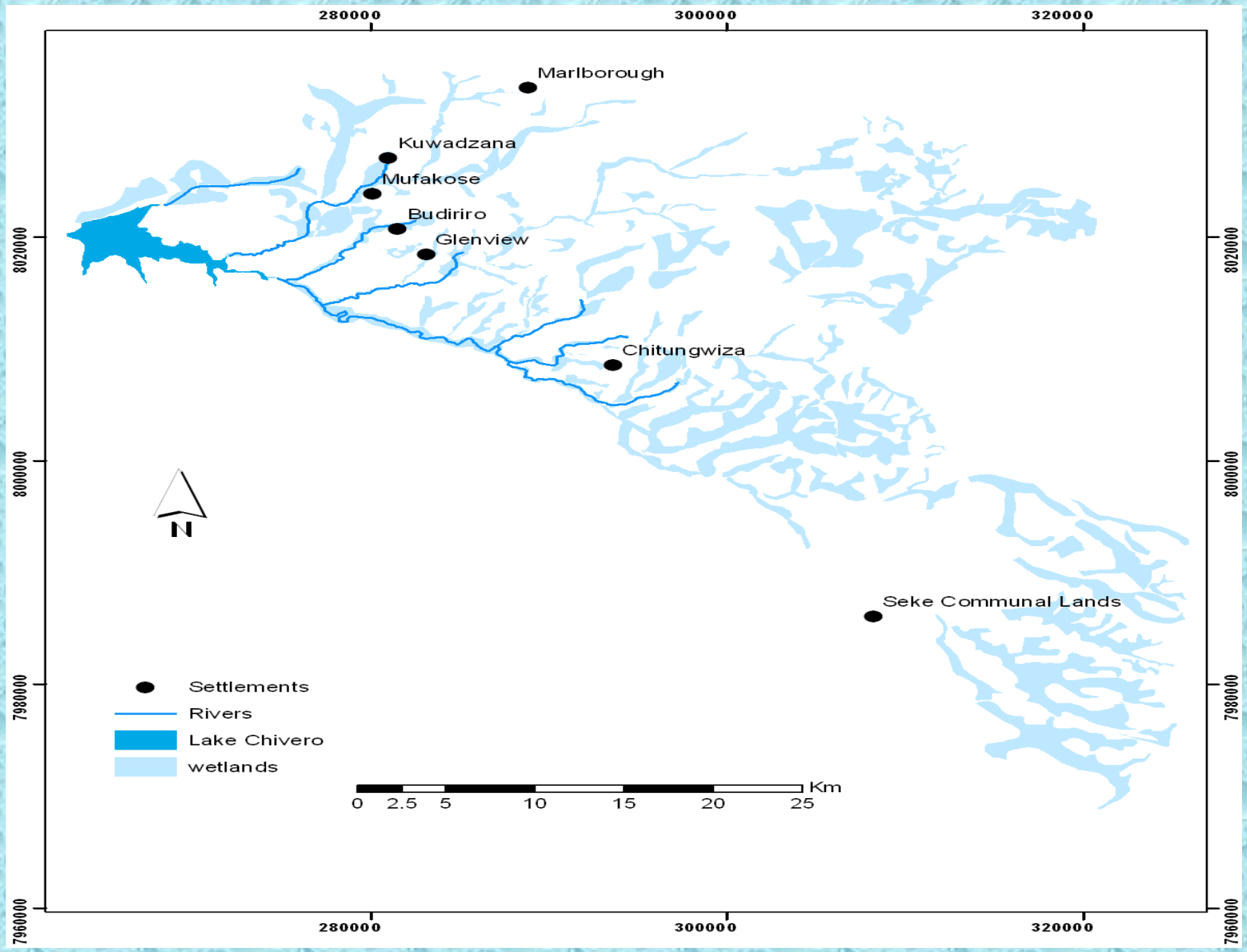
Diffuse source pollution control.

Cleveland dam: 1913

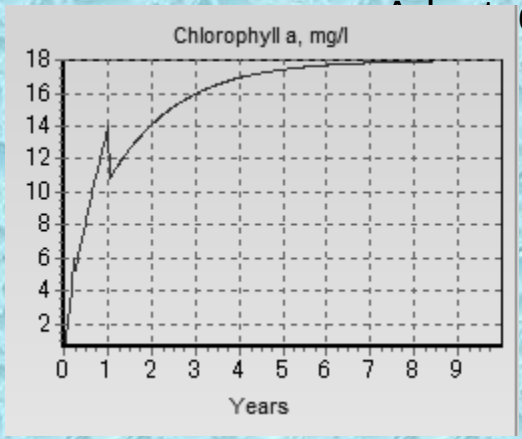
Fig. Recovery of Mukuvisi stream from acid pollution

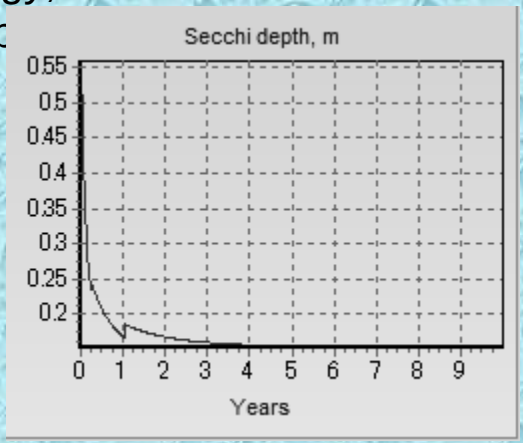


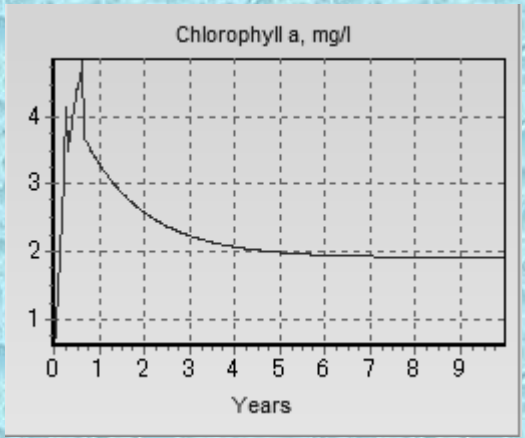
Wetlands distribution in Lake Chivero watershed: total estimated area = 40 000 ha (After Nyumbu 2012)

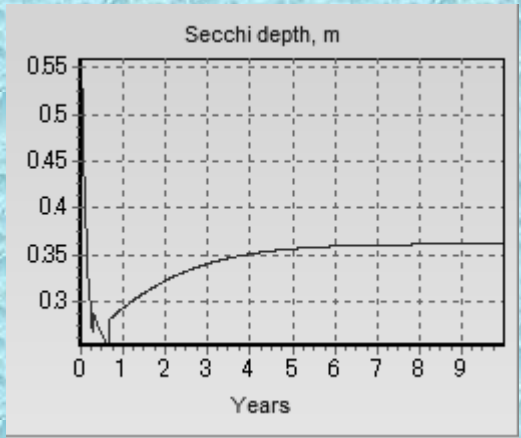


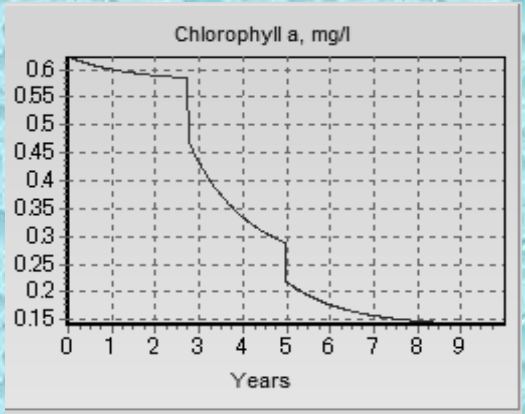
Time projections of lake response to three waste-water management scenarios: Top: Business as usual. Middle: BNR technology; Bottom BNR +wetlands. Adapted from (Nyumb

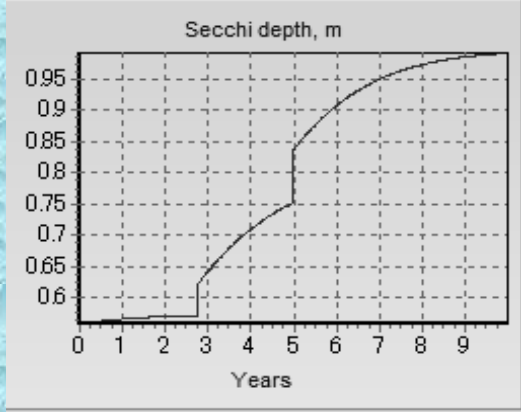












Historical, current and projected phosphorus loading on Lake Chivero

Parameter	1967	1978	1996	2010	2020 (Projections)
P concentration (mg/l)	2.8	0.13	1.8	**2.77**	0.22
P load gm^{-2}	27.4	1.5	14	**22.56**	1.36
P load (tonnes/pa)	685.0	39.6	350.0	**564**	34.1

CONCLUSION

Harare water supply issues

1. Declining runoff
2. Growing urban population: communal lands issues
3. Wastewater returns to supply reservoirs
4. Large diffuse source pollution component
5. Insufficient wastewater treatment capacity
6. An economic meltdown leading to dysfunctional wastewater treatment facilities

Results:

1. Hypereutrophication
2. High costs of potable water production
3. Inability to meet water demand

Consequences

1. Disease outbreaks
2. Water shortage in cities

Restoration strategy

1. The ILEC Integrated Lake Basin Management strategy.

The ILBM platform

Thank you for listening to us on Wetlands day