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Cost analysis of a buy-back program of water rights for Chile

Water Markets Workshop – ANU

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3 August 2012

Outline

1. Background
2. Purpose and contribution of the study
3. Relevant information for the analysis
4. Methodology
5. Results
6. Conclusions

1. Background – Chilean case I

- Water supply
  - Chile is a privileged country in terms of water resources (average runoff is almost 10 times greater than the world average)
  - BUT distribution is uneven, arid conditions prevail in the northern half of the country (World Bank 2011)
- Water demand
  - Fast growth during the last 30 years (6 % in average)
  - Economic activity relies heavily in natural resources exploitation that demand significant amount of water (forestry, mining, etc.)

→ Rivers present problems associated with EF and water quality, specially in the northern half of the country (State of the Environment Report, 2012)

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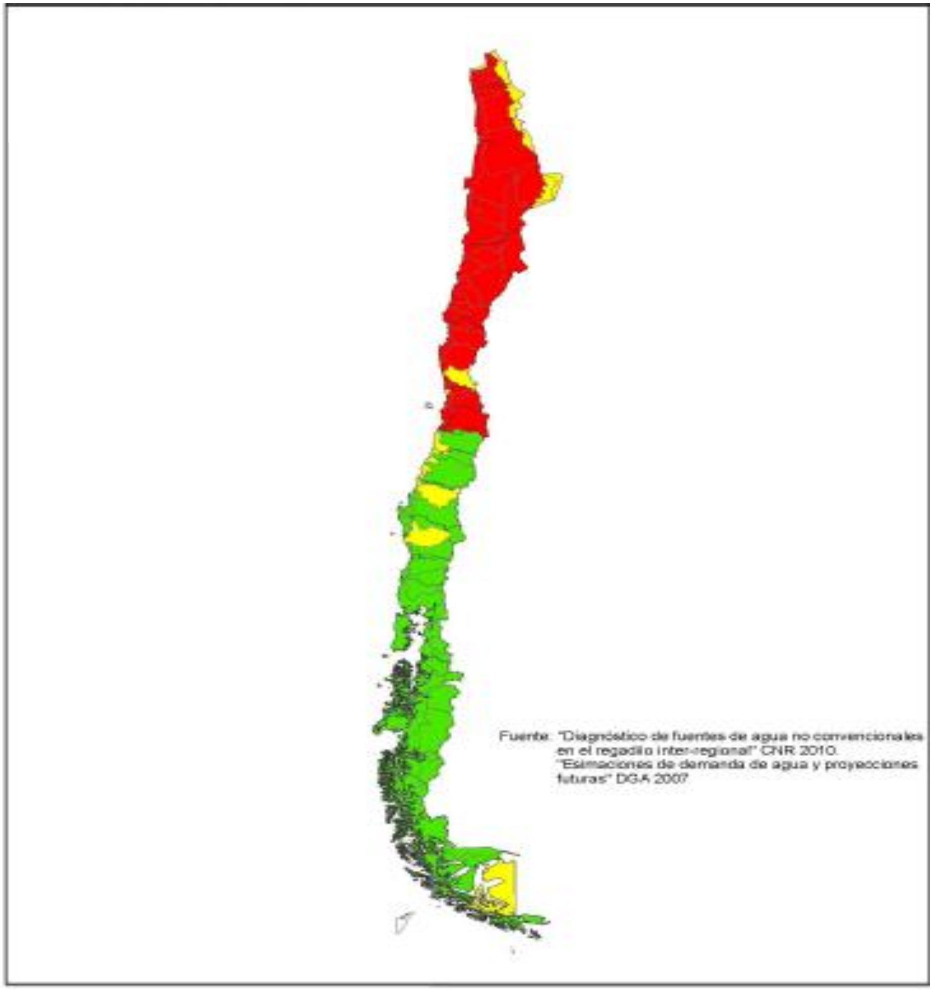
Hydrological projections for 2020



Deficit

At risk

No problem

- Chile is specially vulnerable to climate change

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1. Background – Chilean case II

- Quality
  - Increasingly deteriorating (e.g. excess of nutrients) (MMA 2012)
  - Actual approach: regulation through secondary standards (SS)
    - Goal is to protect ecosystems by limiting pollutants concentration
- EF
  - Legislation
    - 1981: Permanent and transferable water rights (WR) can be granted to individuals (nothing about EF)
    - 1994: EF considerations were included in environmental impact assessment studies
    - 2005: EF must be considered in the allocation of new rights
  - **Effect:** Reduced availability of EF mainly due to over allocation of water rights (Geo Chile 2008)
  - Possible options to restore EF: **buy back allocated WR**

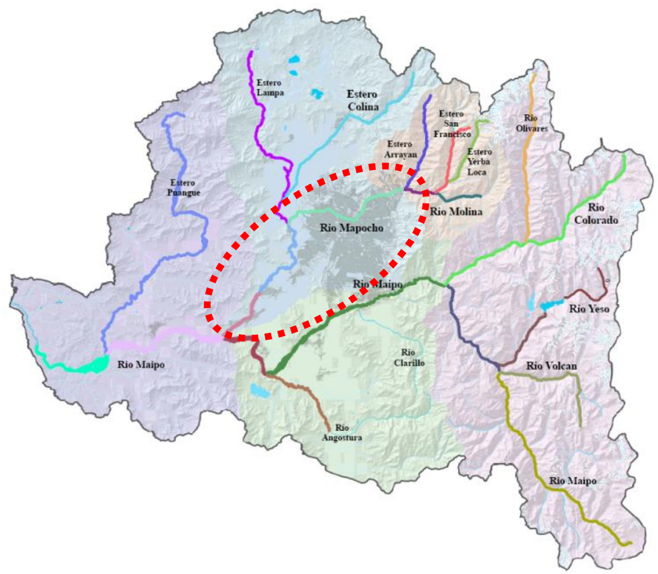
2. Purpose and contribution of the study

- **Purpose**: If a buy-back program (BBP) is implemented in a regulated Chilean Basin:
  - What are the costs for the public sector?
  - Are there any savings due to less investment to comply with the regulation?
  - Is a BBP an efficient and effective measure for addressing water pollution problems?
- **Contribution**
  - First analysis of a BBP in Chile
  - Applied case based on present concerns (The World Bank (2011) & personal communication)
  - Lack of similar studies (Aftab 2007)

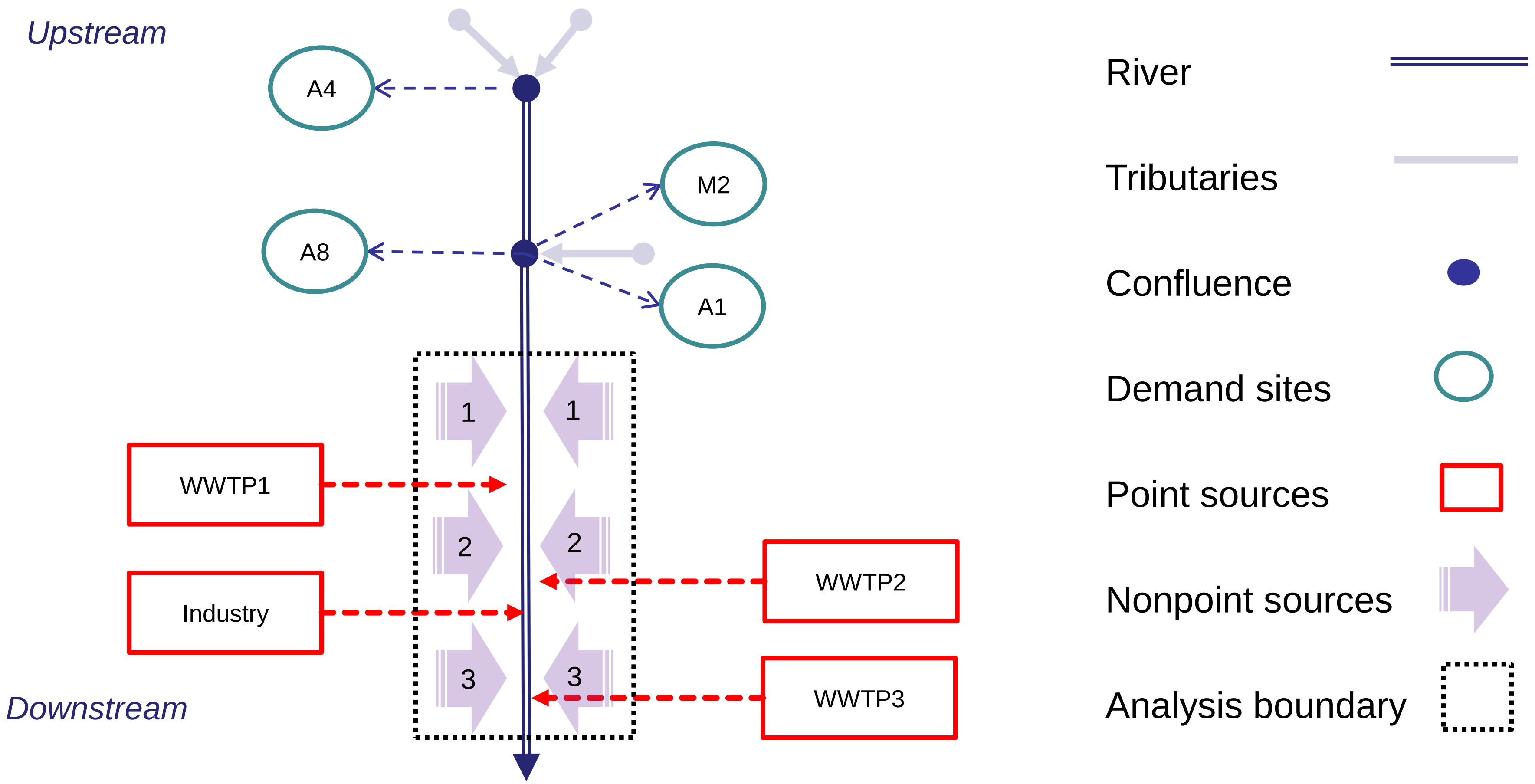
3. Relevant information for the analysis

Spatial analysis

- Analysis focused in Mapocho river (Maipo Basin)
- EF and WQ problems
- Currently undertaken the process of implementing a secondary standard



3. Relevant information for the analysis **Mapocho river diagram**



Source: Own elaboration based on Cai et al. (2006)

3. Relevant information for the analysis

- Secondary standard to comply
  - Maximum average concentration of total nitrogen (TN) (10 mg/L)

- Type of measures considered
  - Point sources
    - 15 abatement technologies options for pollution control
  - Nonpoint sources
    - Riparian protection

4. Methodology

i. Buy-back program costs

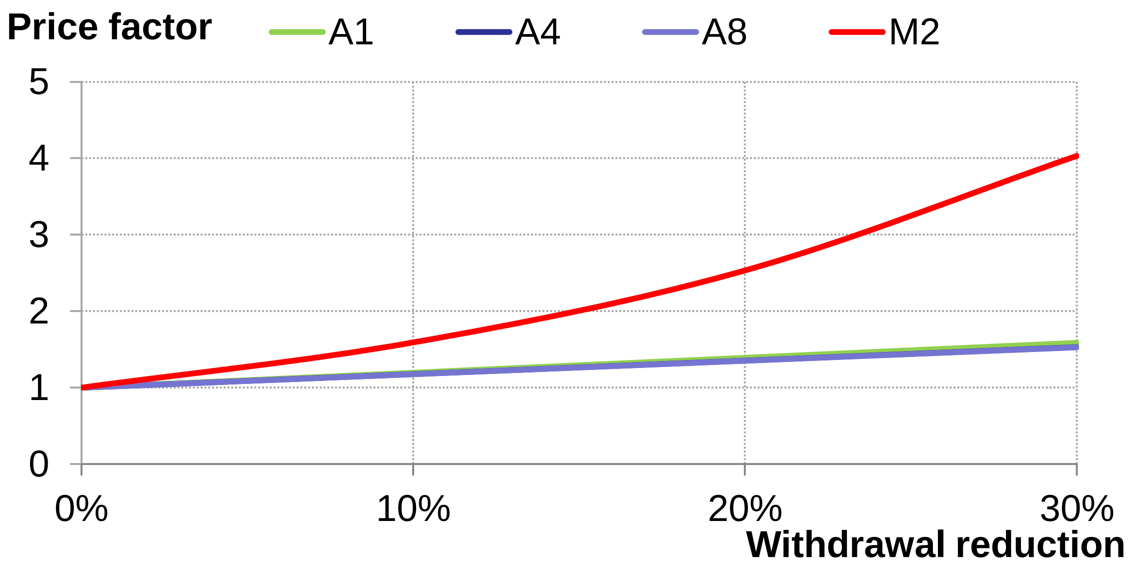
ii. Savings in SS compliance costs

4. Methodology – Buy-back costs

- Objective of the BBP
  - Restore EF according to actual legislation (10% of annual average flow = 440l/s)

- Given the amount of EF to purchase, government will buy the pool of WR that **minimizes** total **costs**

- **WR price varies according to value of water marginal productivity**



Source: Own elaboration based on Cai et al. (2006)

4. Methodology – Savings in SS compliance costs I

- Scenarios:
  - **Baseline**: SS compliance with EF=0
  - **Buy-back**: SS compliance with EF>0

- Savings :
  - Difference between SS compliance costs (Baseline – BBP)

4. Methodology – Savings in SS complying costs II

- SS compliance costs:

$$\underset{x_i, y_j}{Min}\left\{\sum_{i}^{PS} C_{at}(x_i) + \sum_{j}^{NPS} C_{rp}(y_j)\right\} \quad \text{s.t.} \quad TN_f(x_i, y_j) \le TN_m(x_i, y_j)$$

- Where:
  - **X_i: Technology implemented** for ith PS
  - **Y_j: Length of protected riparian** area for jth NPS
  - C_{at}, C_{rp}: **Costs** of abatement technology and riparian protection
  - TN_f, TN_m: Final and max **TN concentration**

The model accounts for

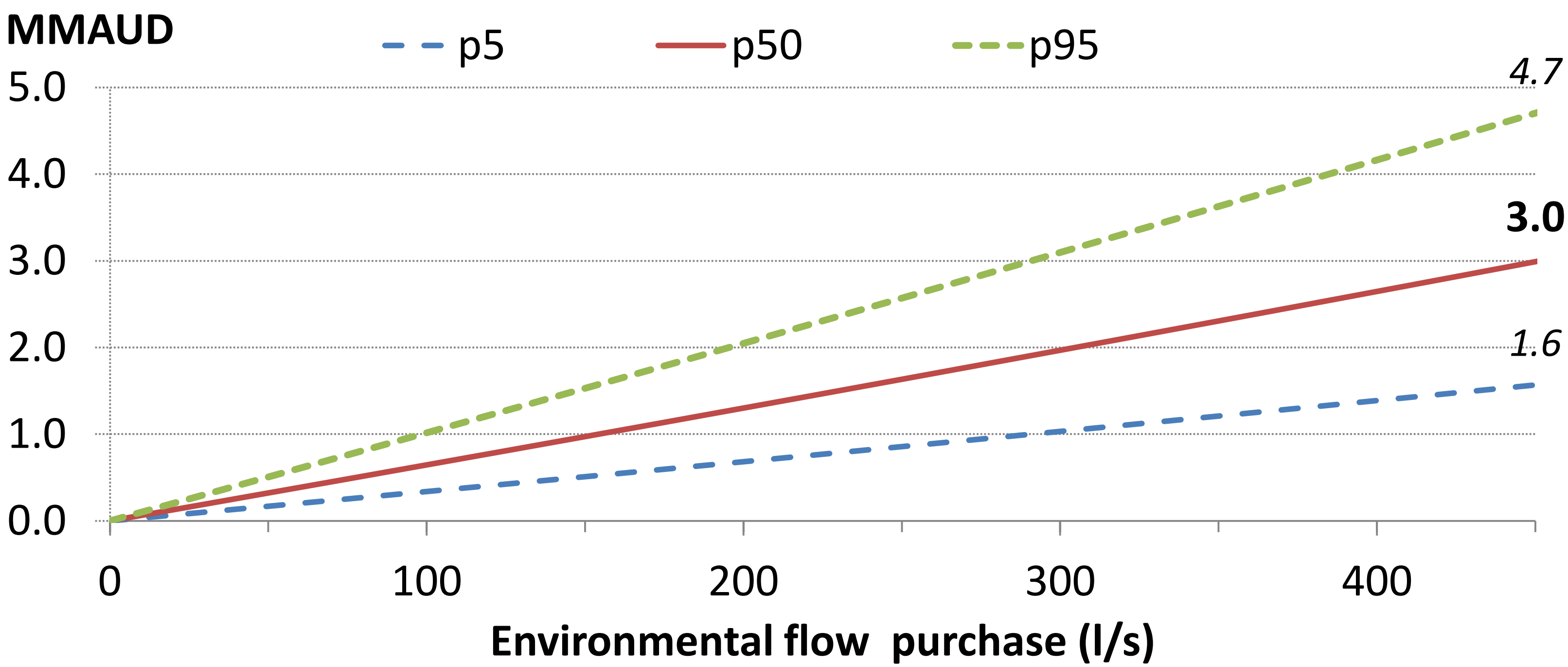
- Uncertainty:
  - Abatement efficiencies for PS and NPS
  - Water rights prices

- Different hydrological years modeled

- Emission - concentration relationship from QUAL2K (stream water quality model)

Results – **Buy-back program**

Total costs (percentiles 5, 50, 95)

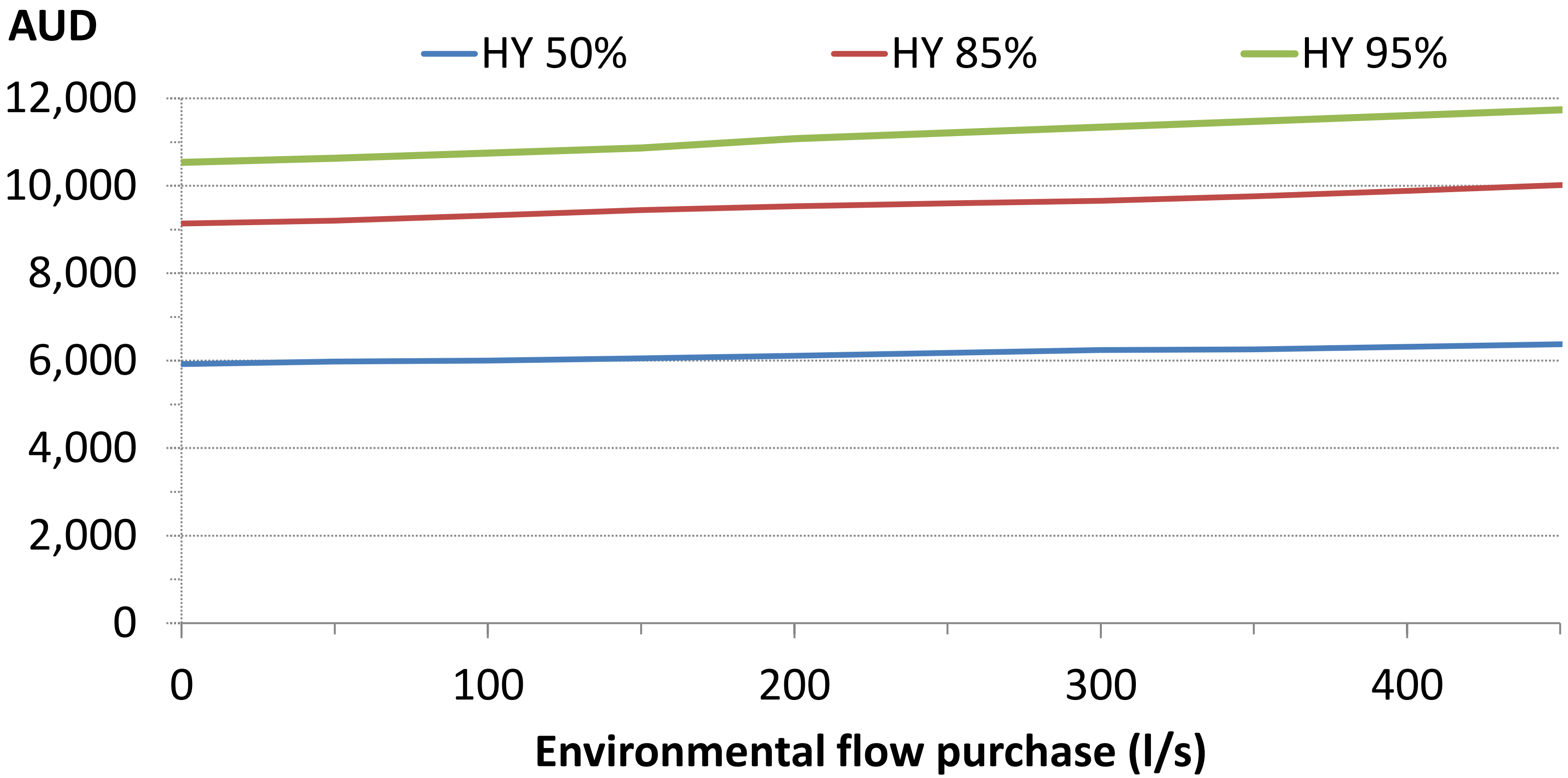


Note: Net present values. Discount rate: 6%. Horizon: 50 years. Hydrological year: 50 per cent of exceedance probability

- The purchase of 440 l/s requires expenditures of around **AUD 3 million**
- Value ranges from **1.6 to 4.7** million of AUD (90 per cent of confidence)

Results – **Buy-back program**

Marginal price of WR for different hydrological years

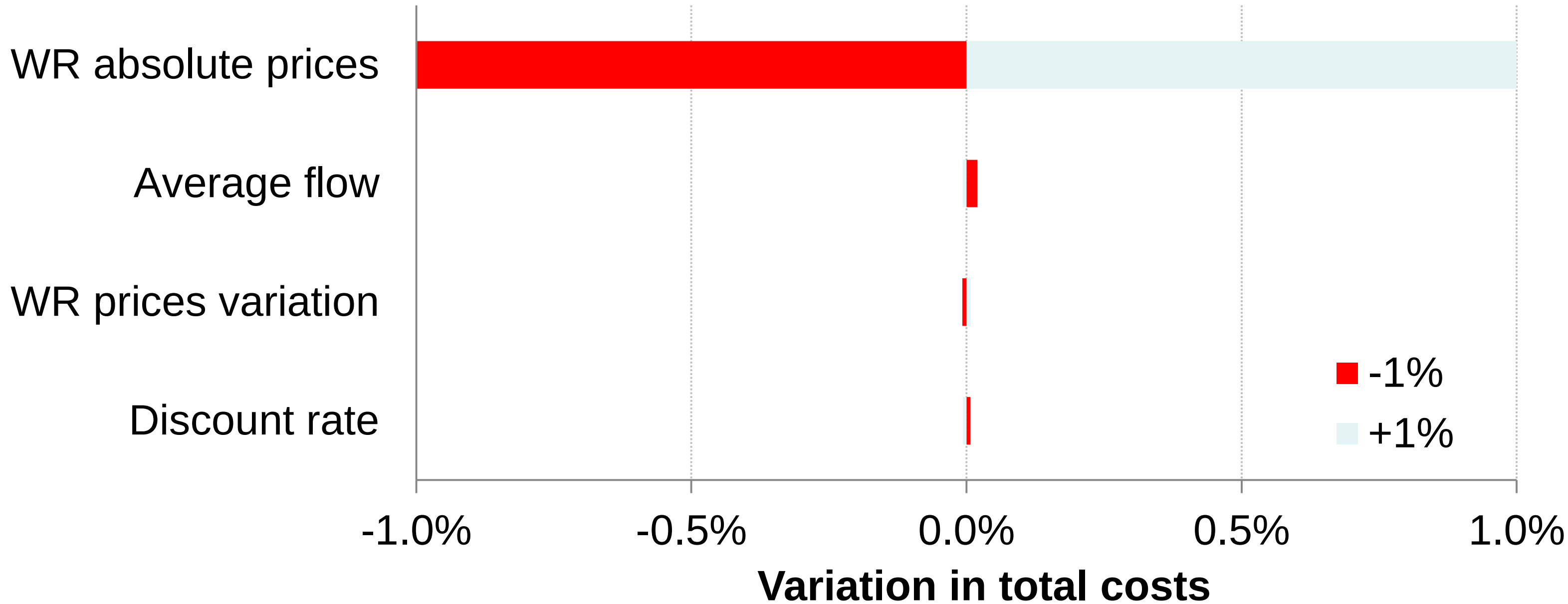


Note: Net present values (discount rate: 6%, horizon: 50 years)

- Variation 0 v/s 440 EF : **8 %** (HY 50%) to **11%** (HY 95%)

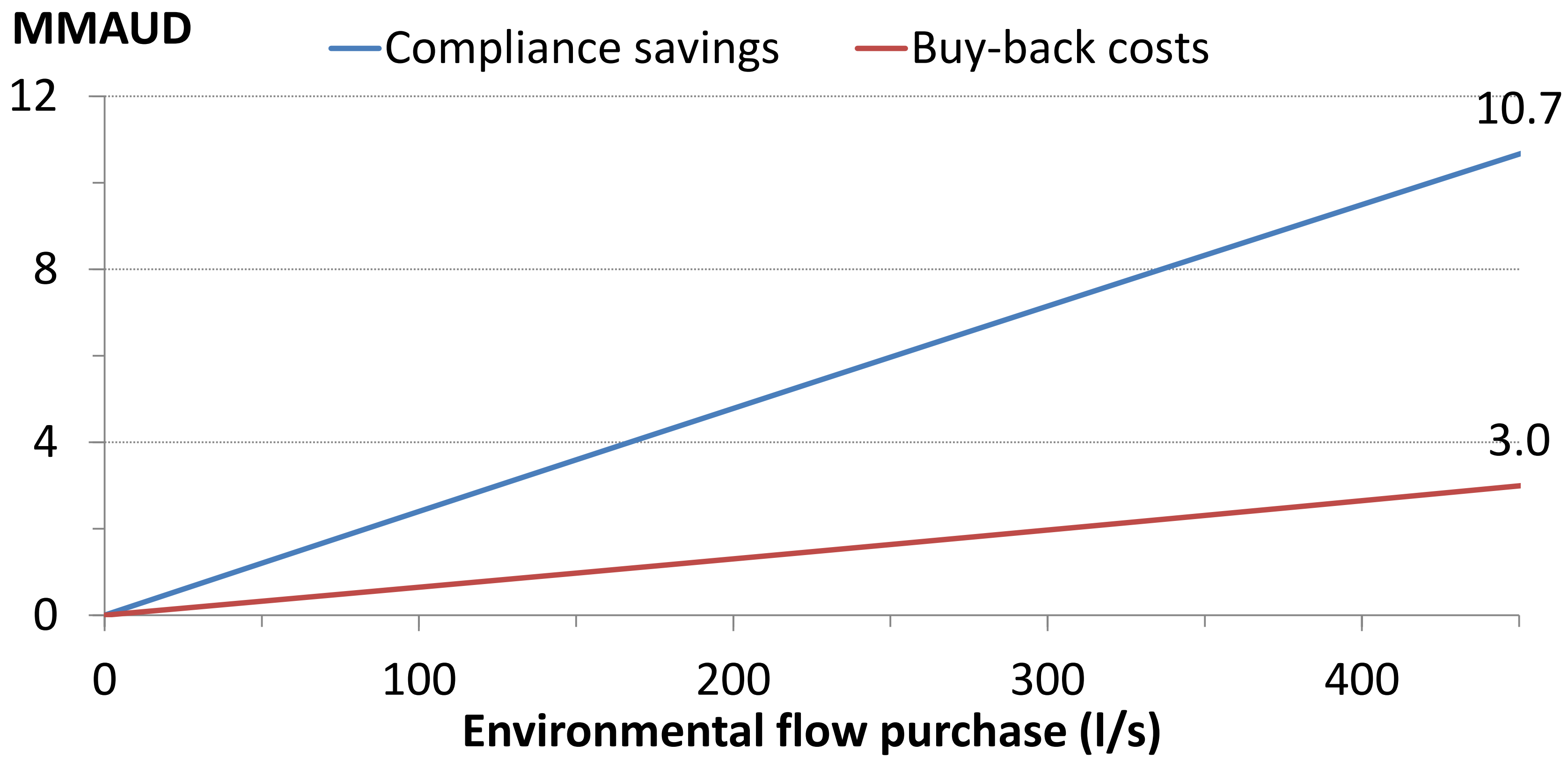
Results – **Buy-back program**

Sensitivity analysis



- Variation in total costs according to inputs variation
- Buy back costs depends more heavily on WR absolute prices and, in a lesser extent, on average flow

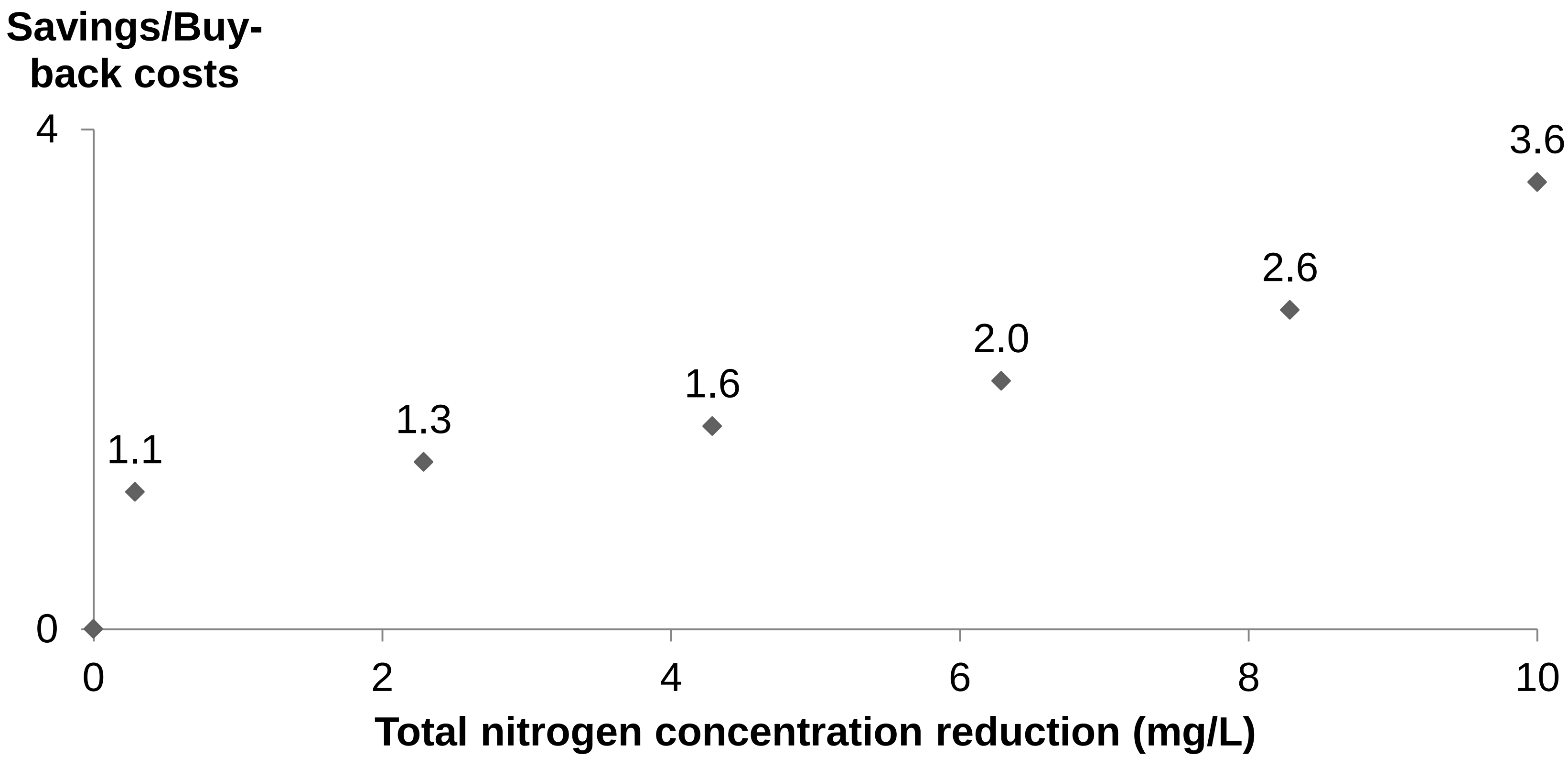
Results – **Savings v/s BBP costs**



Note: Net present values (discount rate: 6%, horizon: 50 years), TN reduction from 20 to 10 mg/L. Hydrological year: 50 per cent of exceedance probability

- Ratio Savings/Buy-back cost ~ 4

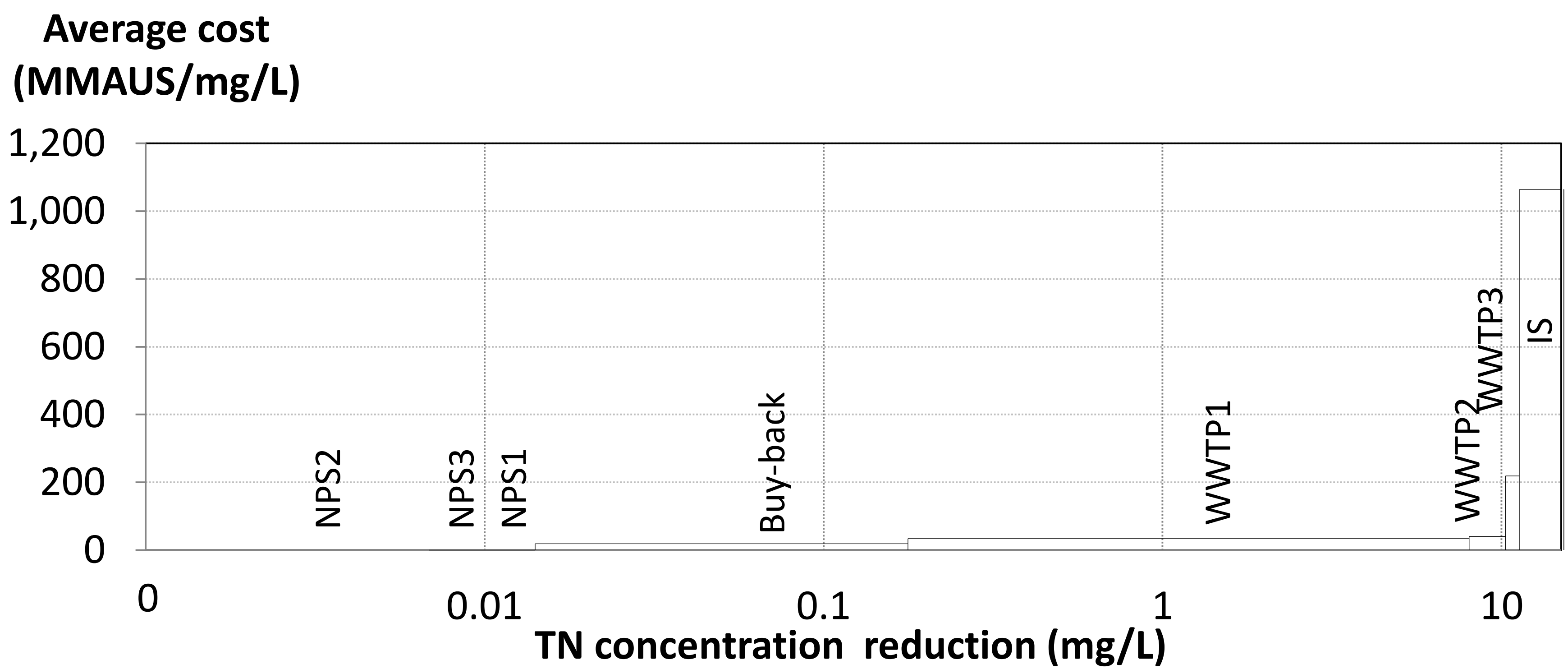
Results – Ratio savings v/s BBP costs



Note: 440 l/s purchase. Hydrological year: 50 per cent of exceedance probability

- ↑ strict the desire concentration level → ↑ savings in compliance

Results - **Average cost of measures**



Note: Logarithmic scale. Net present value. Discount rate: 6 per cent. Horizon: 50 years. Hydrological year: 50 per cent of exceedance probability. Purchase of 440 l/s. Reduction of 15 mg/L of TN.

- BBP efficiency worse than NPS measures, but better than PS
- Nevertheless, BBP and NPS effectiveness are limited

Conclusions I

- Buy-back costs ~ 3 MMAUD for 440 l/s
- Savings in compliance costs may be 4 times greater than Buy-back expenses
- BBP as a measure to control nutrient pollution:
  - Not as efficient as NPS measures (coincides with other studies (Aftab et. Al 2007))
  - BBP may outperform PS control measures (no other studies)
  - Efficient but limited effectiveness

Conclusions II

- Distributive effects:
  - Public sector perceive the costs and private sector the savings
  - Opportunity to transfer costs to the private sector

- Policy questions
  - Is it worthy?
    - Assessment of benefits needed
  - How politically feasible it is?
    - Strong opposition to the immobilization of goods
    - Strong opposition to the State paying for national resources

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Conclusions III

- Analysis comply with water policy recommendations (EU's Water Framework directive, OECD 2012):
  - Integrated analysis (quality and quantity)
  - Based on the cost- effectiveness of the measures

THANKS

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ANNEX

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Data

- Prices of water rights (Donoso et al. 2007; ODEPA 2010))
- Water flow availability (DGA 2003)
- Hydrological scenarios (ECLAC 2009)
- Marginal productivity of water (Cai et al. 2006)

Australia' s case

- Murray-Darling Basin has faced ecosystems' deterioration due to reduced water flow availability for the environment (Jones et al. 2002)

- This impelled efforts of the Australian government for recovering Murray-Darling Basin's health.

- From 2008 'Water for the future' plan is active, with the purpose of recover environmental flows mainly by a buy back of water allocations (SEWPaC 2010).

Abatement technologies

Tecnologia	N	NH3	NH4	NKT	NO3
Lagunas Aireadas				63%	
Lodos Activados				23%	
Lodos Activados+complemento Nt	80%			80%	
Lombrifiltro				70%	
Reactor Anaerobico				70%	
Reactor Anaerobico				70%	
Reactor Aerobico de Lecho Fijo Sumergible (RALFS)				90%	
Reactores Biologicos Secuenciales (SBR)				90%	
Wetlands				90%	
Arrastre por Aire (Air Sripping)		93%			
Electrodialisis					95%
Electroxidacion		95%			
Intercambio Ionico			99%		99%
Nanofiltracion					90%
Oxidacion con Aire Humedo		95%			

Methodology – Savings in complying costs

- For every PS the abatement costs are given by

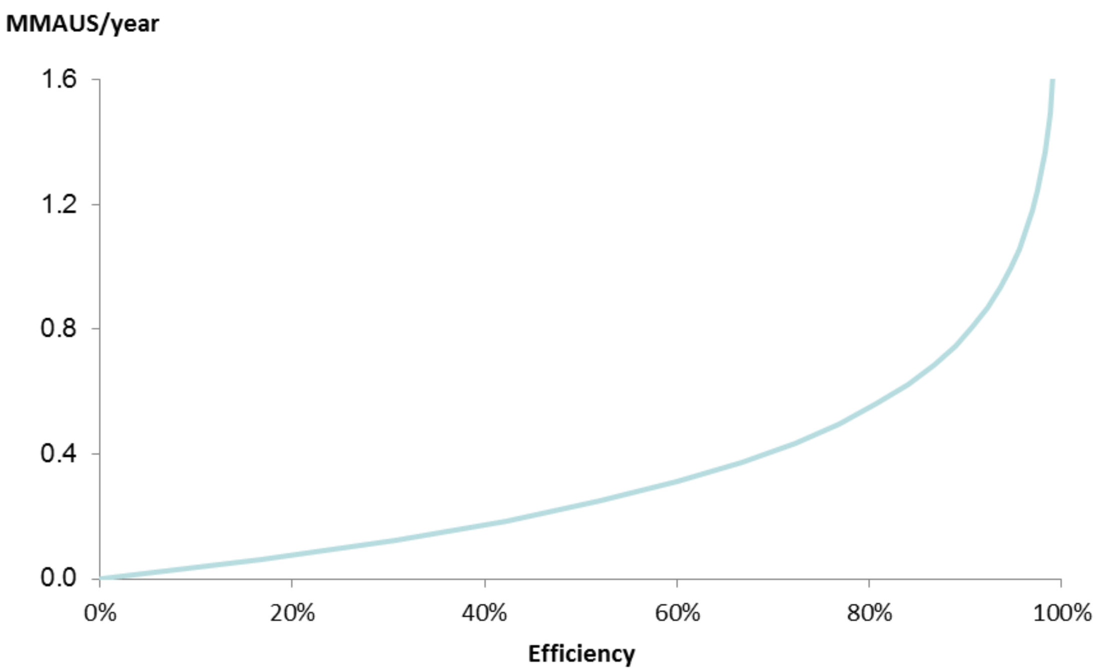
$$Min \sum_i C_i$$

s.t.

$$E_p = E_{0p} \times \prod_i (1 - ef_{p,i})^{x_i} \leq Limit$$

Example: Costs variation according to efficiency

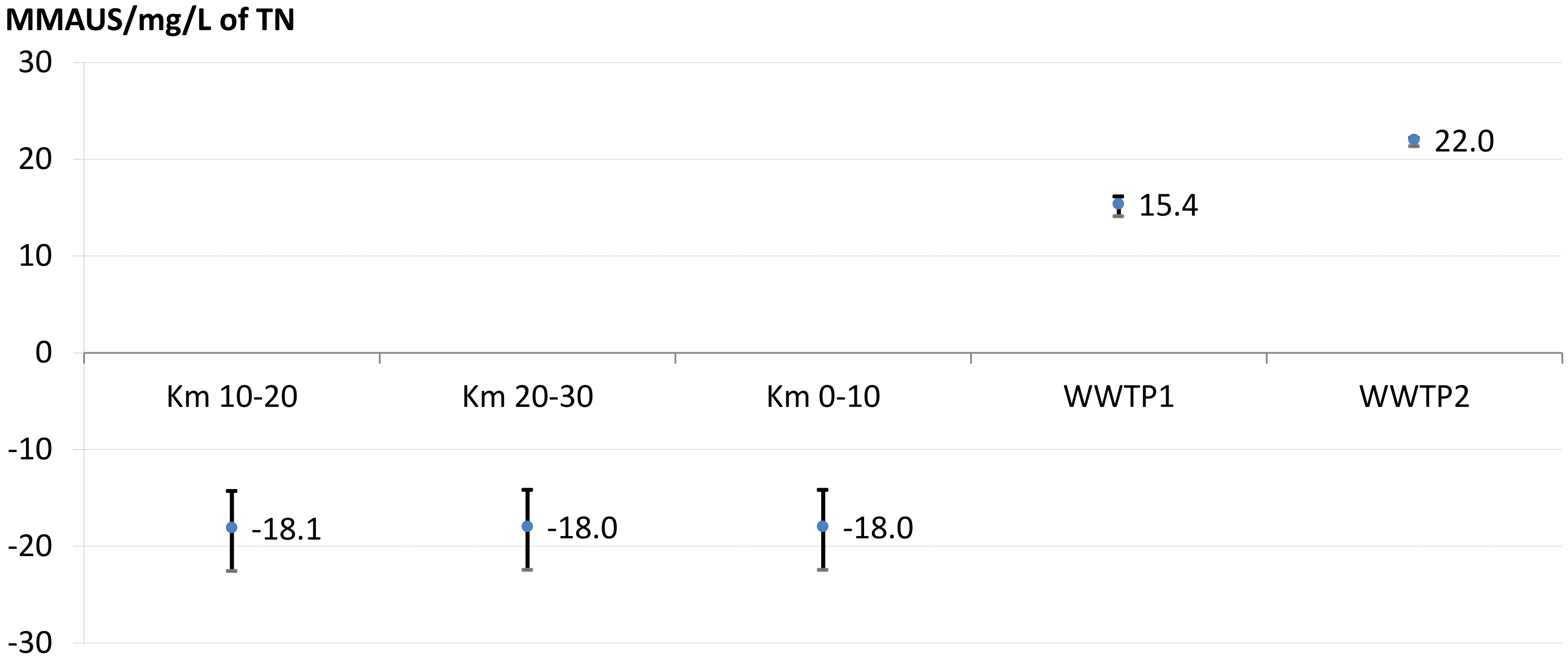
- Efficiency : 60%
- Costs: 300.000 AUD per year



Average costs and TN reduction

Measure	Average cost (AUS/mg/L)	TN concentration reduction (mg/L)
Km 10-20	205,120	0.007
Km 20-30	330,072	0.003
Km 0-10	332,071	0.004
EF	18,302,890	0.163
WWTP_Farfana	33,681,590	7.853
WWTP_Trebal	40,308,026	2.256
WWTP_Talagante	219,318,540	1.000
IM_Trusal	1,063,774,446	4.000

Average costs: Difference between measures and Buy-back



Note: Net present value. Discount rate: 6 per cent. Horizon: 50 years. Hydrological year: 50 per cent of exceedance probability. Purchase of 440 l/s.

- Difference are significative with 90 per cent of confidence