Agència Catalana de l'Aigua

Generalitat de Catalunya
Departament de Medi Ambient i Habitatge

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ECONOMIC ANALYSIS OF THE HYDROLOGICAL MANAGEMENT IN CATALONIA (SPAIN)

EURO INBO 2008
Sibiu, 1-4 October

An Innovative Approach and a Cost-Effective Methodological Application to WFD Implementation

Introduction

- **Water Framework Directive (WFD) (2000/60/EC)**: its main objective is to achieve a “good status” of water by 2015 in all water bodies.

- EU Member States should deliver a draft version of the **River Basin Management Plan (RBMP)** by the end of 2009. This document should include a **Program of Measures (PoM)** designed to meet the 2015 objectives.

BUT

! **No specific methodology** has been validated **to evaluate the technical efficiency** of the hypothetical program of measures that would lead to the target results.

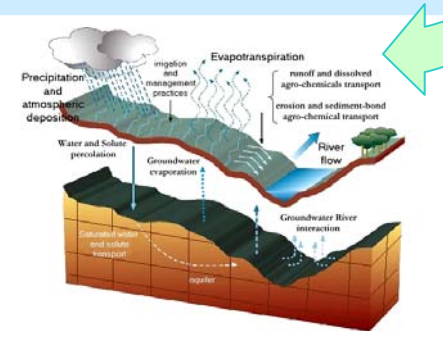
! **Nor** it has been established how these measures or combination of measures should be evaluated to attain **the most cost-effective solution**.

Objectives

Optimization of the PoM: looking at the catalogue of measure and considering its estimated cost, it is important to develop tools able to asses the efficiency of the measures and their interactions...

Art. 5: IMPRESS → Identification of the GAP to fill for each Water Body → **PoM**

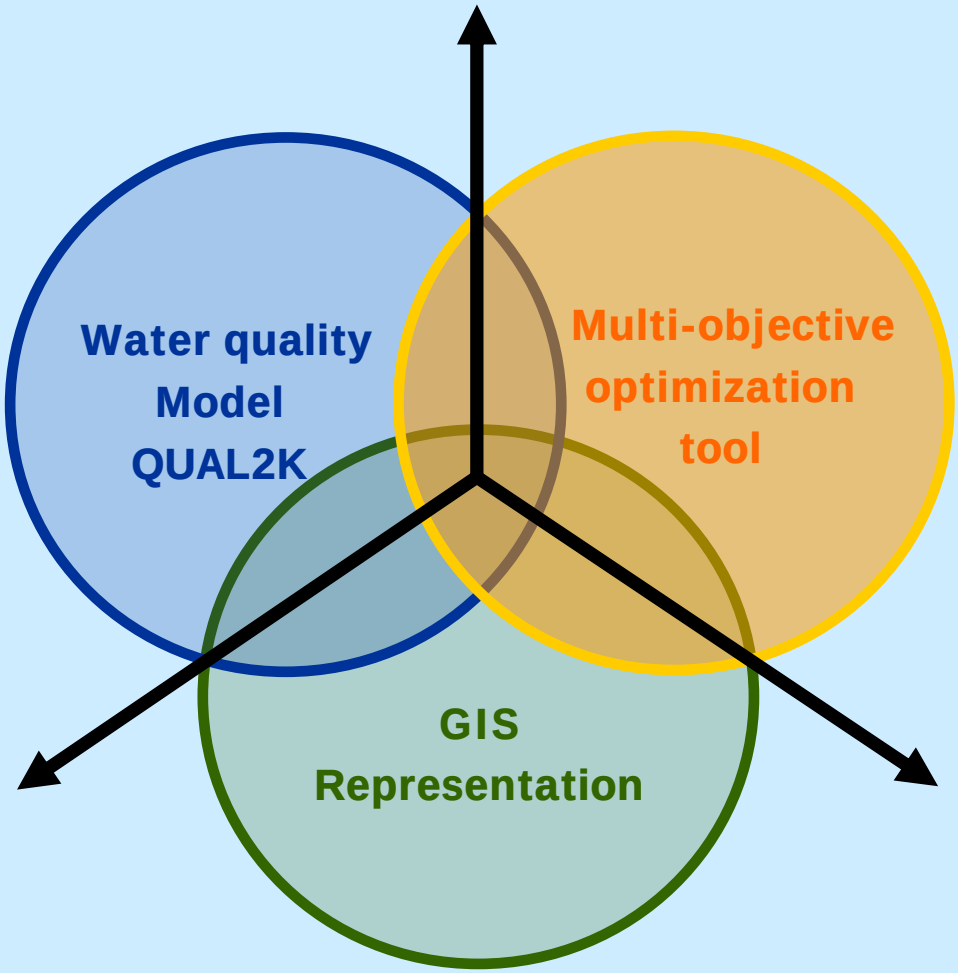
Economic Analysis → Estimation of the costs of the PoM, assignation of these costs to water uses



P/I tool – decision making process → **PoM optimization and application of the cost-effective criteria** → **River Basin Management Plan for Catalonia**

Methodology

Allows to evaluate the effect and the efficiency of the different measures in reaching the WFD's goals AND permits to assess combinations of measures.



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Methodology

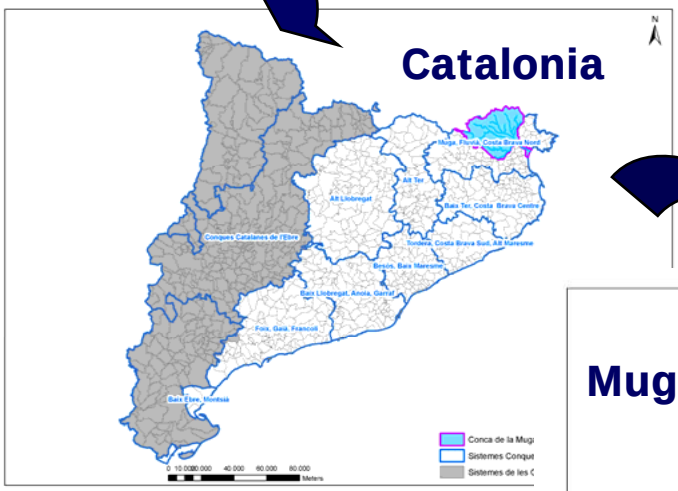
QUAL2K Model

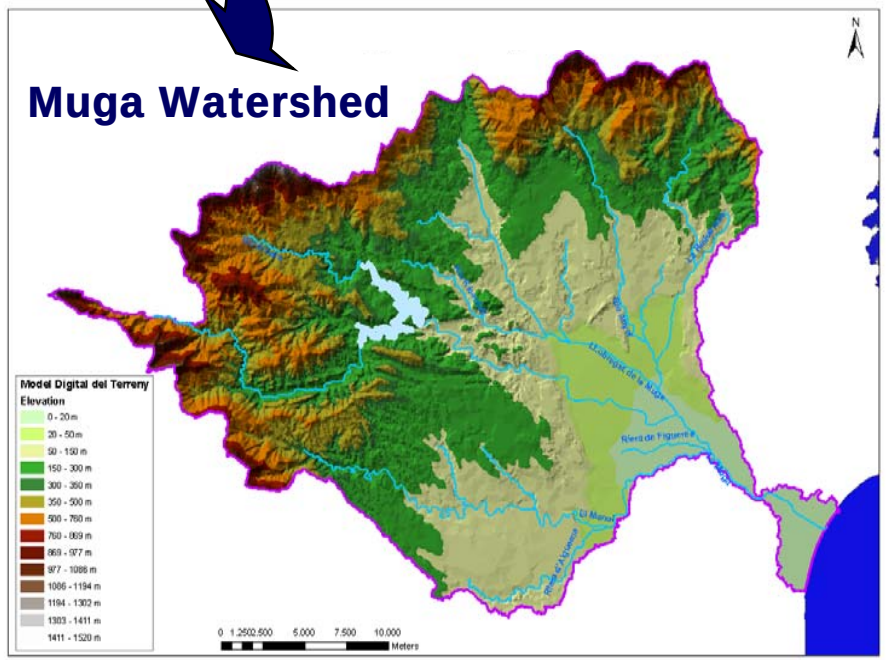
- Simulates water quality and quantity in streams and rivers.
- One dimensional model, based on steady state hydraulics, with non-uniform, simulated steady flow.
- Allows water system to consist of a mainstream river and branched tributaries, segmented as unequally-spaced reaches.
- Multiple loadings and abstractions can be input to any reach
- Conventional Pollutants (Nitrogen, Phosphorus, Dissolved Oxygen, BOD, Sediment Oxygen Demand, Algae), pH, Periphyton, Pathogens
- Simulates the physical-chemical and biological processes of constituents in the water system.
- Qual2k is a well know - well referenced model and is used by the EPA since the end of the '70s.

Multi-objective criteria tool

- Integrates a solutions-finding engine based on genetic algorithm.
- It is able to tradeoff among several solutions according to N criteria.
- Based on *K. Deb, A. Pratap, S. Agarwal, and T. Meyarivan*. NSGA-II. IEEE Transactions on Evolutionary Computation, 6(2):182–197, 2002.
- Developed by A. Udías, F.J. Elorza (2005), "Optimización de perímetros de protección de acuíferos mediante un algoritmo genético" pp :155-166. Boletín Geológico y Minero. Ed: J.J. Duran; ISSN:0366-0176

The application of the P/I tool to the Muga Watershed





- area: 760 km2
- population: 65.756 inhabitants
- 807 mm of annual rain

The application of the P/I tool to the Muga Watershed

Existing Pressures on the Muga System

- X Superficial withdrawals (urban, irrigation)
- X Urban waste water treatment plants effluents
- X Untreated urban discharges
- X Industrial effluents discharges
- X Agriculture return flows

PoM Main actions

- ✓ Upgrading technology at the 3 existing treatment plants
- ✓ Construction of 37 new treatment plants
- ✓ Removal of untreated urban effluents
- ✓ Water ru-use

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The application of the P/I tool to the Muga Watershed

Starting information

- Dimensional characteristics
- Type of treatment
- Cost of investment

Type of treatment	TSS (mg/l)	Dissolved Oxygen (mg/l)	BOD (mg/l)	Inorganic N (mg/l)	NH^+_4 (mg/l)	NO^-_3 (mg/l)	Organic P (mg/l)	PO_4^{2-} (mg/l)	Alkalinity ($mgCaCO_3$/l)	pH (s.u.)
Primary								0%	10%	5%
Secondary								0%	20%	5%
Nitrification 60%								0%	20%	5%
Nitrification and desnitrification 70%								0%	30%	5%
Nitrification and desnitrification 70% and dephosphating								100%	30%	5%
Nitrification and desnitrification 70% and dephosphating	95%	2	95%	85%	85%	100%	50%	100%	40%	5%
Advanced treatment	100%	7	100%	95%	95%	100%	50%	100%	40%	5%

Art. 5: IMPRESS

Projection of 2015 men-induced pressures on the system

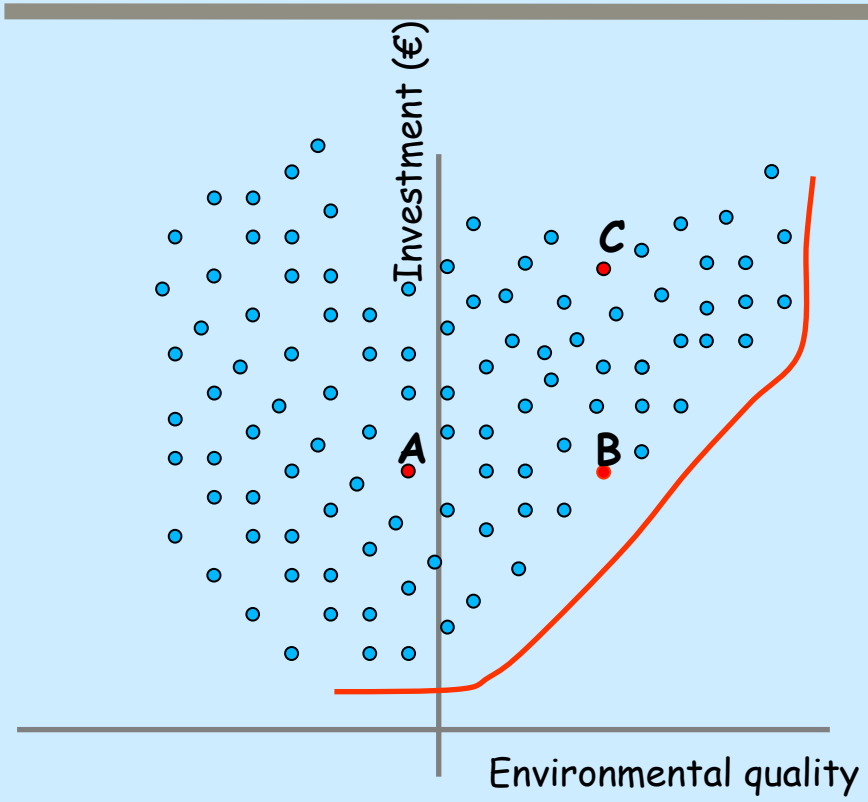
The application of the P/I tool to the Muga Watershed

In the Muga system 40 treatment plants are planned with 7 types of possible treatments

7^{40} alternatives = $6x10^{33}$ possible strategies

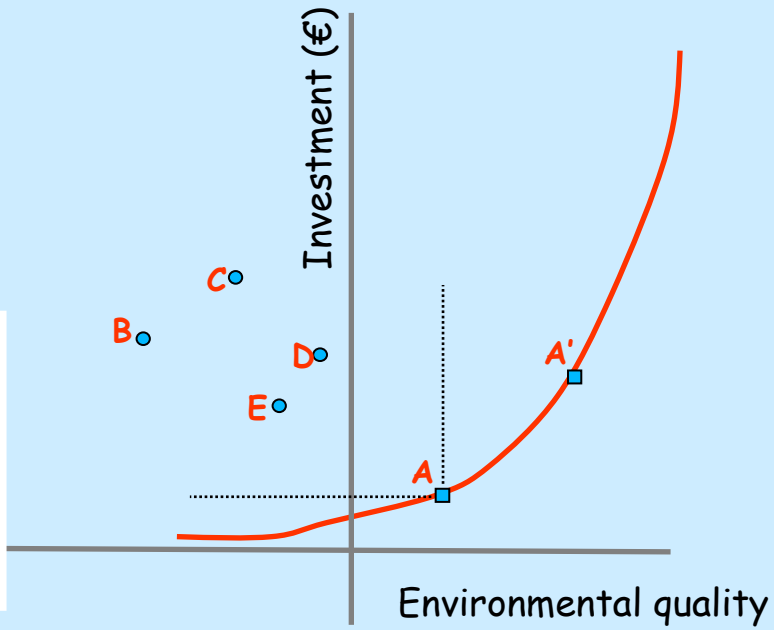
Which is the optimum strategy that allows reaching WFD goals in a efficient way?

The application of the P/I tool to the Muga Watershed



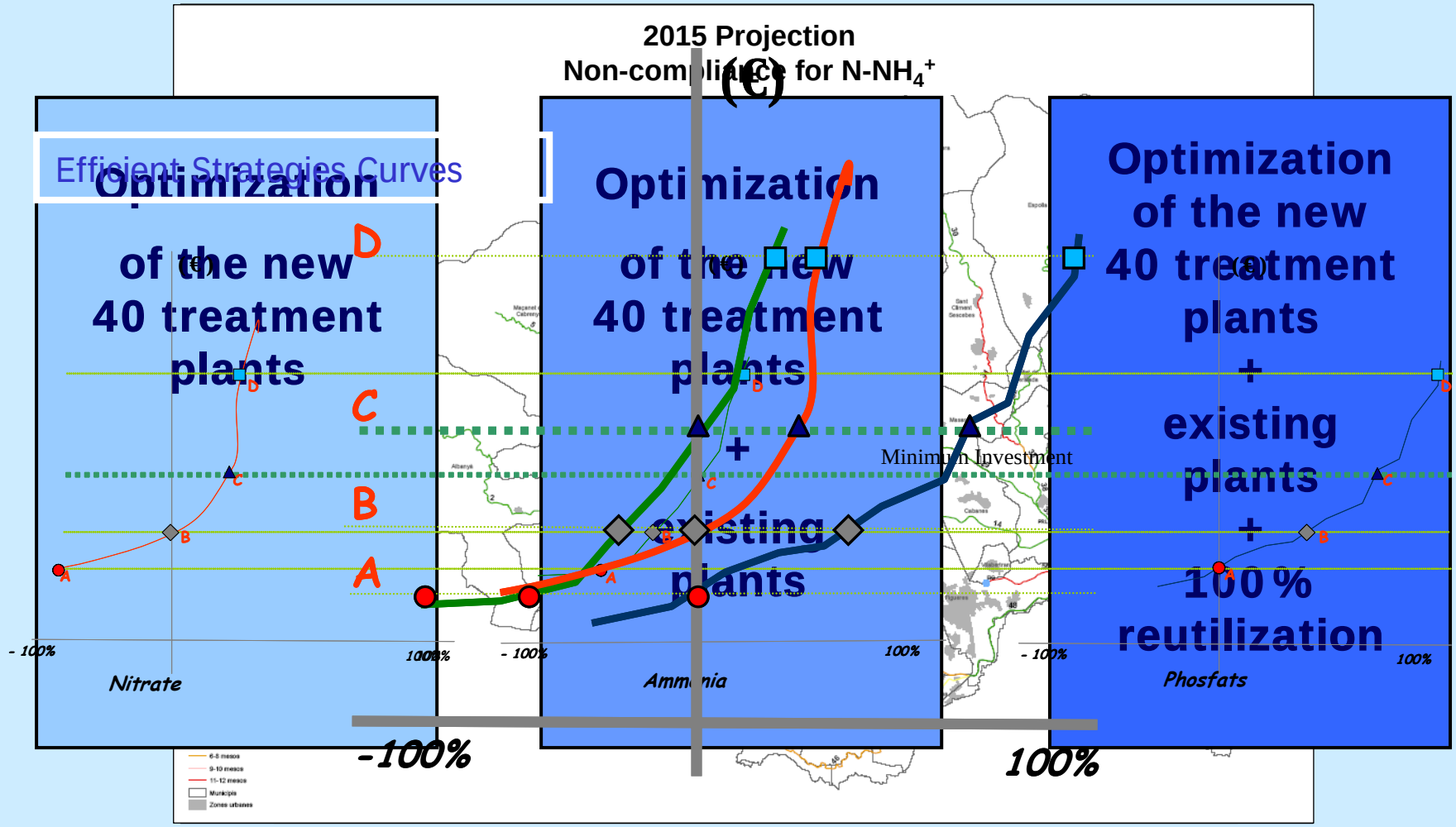
1. Points **A** and **B**: same investment but point **B** allows better Env. Quality → **B is the best choice**
2. Points **C** and **B**: same Env. quality but **C** implies higher investment → **B is the best choice**

1. Point **A is better choice** than points **B-C-D-E**
2. **A** has a lower cost, but **A'** allows better environmental quality...both options are valid choices.



The application of the P/I tool to the Muga Watershed

5. Apply the multi-objective optimization tool to identify the optimal PoM that leads to the achievement of the WFD's objectives at the best cost/effectiveness ratio



Reach	River	WFD Target (mg/l)	Actual Situation		2015 Projection		2015 Projection New plants + Existing Plants	
			Nº Months Non-Compl.	Mean Non-Compl.Conc. (mg/l) 1/	Nº Months Non-Compl	Mean Non-Compl.Conc. (mg/l)	Nº Months Non-Compl	Mean Non-Compl.Conc. (mg/l)
7	Arnera	0,2	6	0,40	9	0,37	0	-
13	Muga	0,5	1	0,64	2	0,55	0	-
18	Llobregat de la Muga	0,5	12	2,88	12	3,08	1	0,52
19	Llobregat de la Muga	0,5	12	1,73	12	1,85	0	-
20	Llobregat de la Muga	0,5	3	0,61	3	0,68	0	-
21	Llobregat de la Muga	0,5	1	0,58	2	0,58	0	-

WFD Target (mg/l)	Actual Situation			2015 Projection			2015 Projection with measures		
	Nº of reaches	Mean nº of Non-Compl Months	Mean Non-Compl. Conc. (mg/l)	Nº of reaches	Mean nº of Non-Compl Months	Mean Non-Compl. Conc. (mg/l)	Nº of reaches	Mean nº of Non-Compl Months	Mean Non-Compl. Conc. (mg/l)
0,2	**1**	**6**	**0,4**	**1**	**9**	**0,37**	**0**	**0**	**-**
0,5	**23**	**6,8**	**1,3**	**23**	**8,0**	**1,4**	**7**	**1,7**	**0,6**

43	Manol	0,5	11	1,26	12	1,34	2	0,56
44	Manol	0,5	7	0,83	9	0,83	0	-
45	Manol	0,5	4	0,88	6	0,83	0	-
46	Riera de Alguema	0,5	4	0,92	6	0,87	2	0,58
47	Riera de Alguema	0,5	1	0,53	2	0,56	0	-
50	Riera de Figueres	0,5	12	9,25	12	10,19	2	0,54
51	Muga	0,5	10	1,03	12	1,10	0	-
52	Muga	0,5	10	0,82	12	0,89	0	-
53	Muga	0,5	9	0,73	11	0,79	0	-
54	Muga	0,5	8	0,77	11	0,86	2	1,11

Conclusions

- The application of the P/I tool can be useful during WFD implementation.
- It allows finding the most cost-effective combination of PoMs, being helpful, as in the Catalan basin, in managing significant items of the total investment for the WFD implementation.
- Results of modeling and analysis can be represented by a GIS tool to better support the decision making process.
- Further developments of this methodology include coupling a new module related to agriculture aimed at managing and decreasing DIFFUSE SOURCES of pollution and optimizing all those PoMs which are dealing with the whole watershed management.
- Advanced characterization/estimation of the DIFFUSE SOURCES opens up the possibility to groundwater systems management and to the interaction between surface water and aquifers.

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