

REMOC special meeting – TARRAGONA - 12 May 2010

**Use of Decision Support Systems for
Participative Water Resources Planning &
Management and Drought Mitigation in the
Jucar River Basin, Spain**

by

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www.upv.es/aquatool/

Need for tools and models

- Process of making good decisions: information must be managed and analyzed about
 - **feasible alternatives**,
 - their **impact on the multiple objectives**,
 - the **tradeoffs among them**, as well as
 - **risks** associated with them.
- To elaborate and analyze such information, **sound science, technology, and expertise have to be involved**.
- **Tools for data management and analysis**, and **models** are needed to cope with the complexity, the basin scale scope, and the huge amount of information, alternatives, and scenarios.

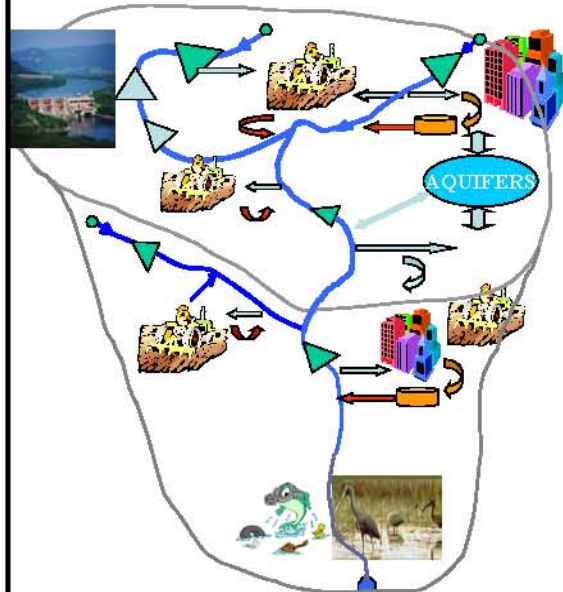
Need for Decision Support Systems (DSS)

- We agree that the **political process is important**, but insist that debates must be on the basis of **transparency and knowledge**
- Frequently, decision makers, stakeholders and general public (Policy Making Actors -PMA), **are not prepared to produce and understand such information.**
- a transfer of technology and ideas from scientist to PMA is needed: **effective transfer: PMA must be able to apply the technology easily and in a repeatable and scientifically defensible manner** (NRC 2000).
- Development of **DSS: best way** to conduct this transfer & build a **shared vision of the basin**

DSS

- suites of computer programs including, among others:
 - geographically based **design** facilities,
 - geographically based **databases** handling,
 - integrated **simulation** and/or **optimization** models, including several aspects (rainfall-runoff, w.rights, w.allocation, quality, economics, ...)
 - capabilities for **analyzing and displaying the results**,
- **essential feature:** a unique and user friendly interface that provides **easiness of data management, model use** and **results analysis**.

**WR Systems INTEGRATE at the BASIN SCALE:
WaterBodies, W.Uses (Demands), Infrastructures**



Complex relationships that affect water availability both in SPACE & TIME

Implications on all aspects (w. quality, environment, economy, ...) **can only be captured by means of adequate integrated**



Integrative DSS



- In order to complete basin identification, and **for the development of further analysis activities, it is crucial to have**
- a DSS integrating, in a **single model and for the entire basin**, all the relevant
 - surface water elements (e.g., river reaches, lakes, ...),
 - aquifers,
 - infrastructures (e.g., dams, reservoirs, diversions, returns, groundwater abstraction, ...),
 - water uses (e.g., agricultural uses, urban uses, industrial uses, ...),
 - environmental requirements on flows,
 - water rights and priorities, and operating rules for the system.

DSS Shells (DSSS)

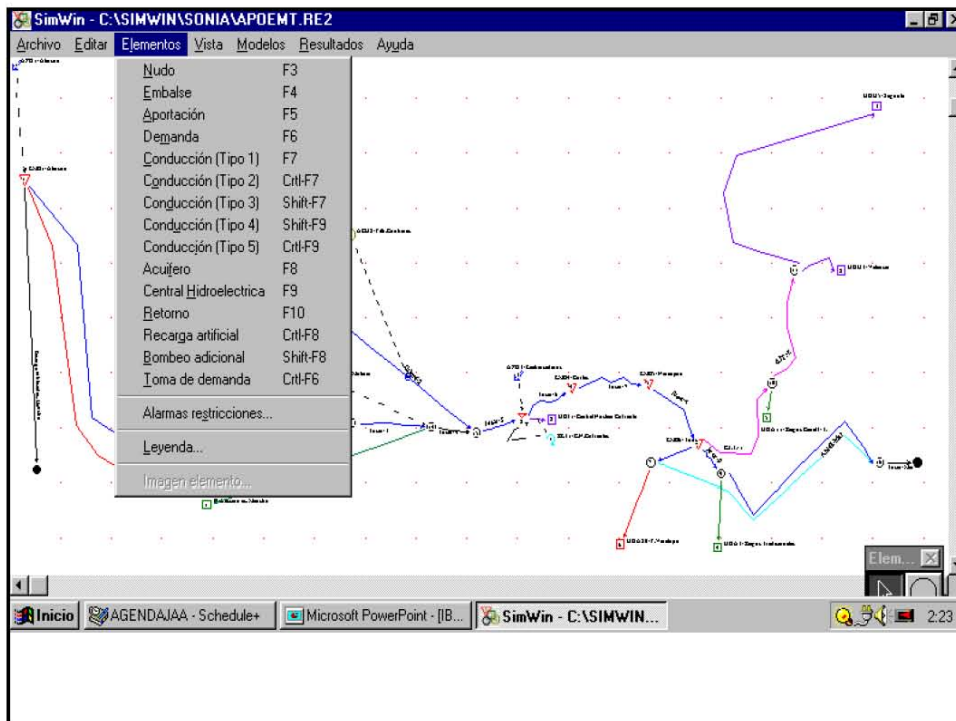
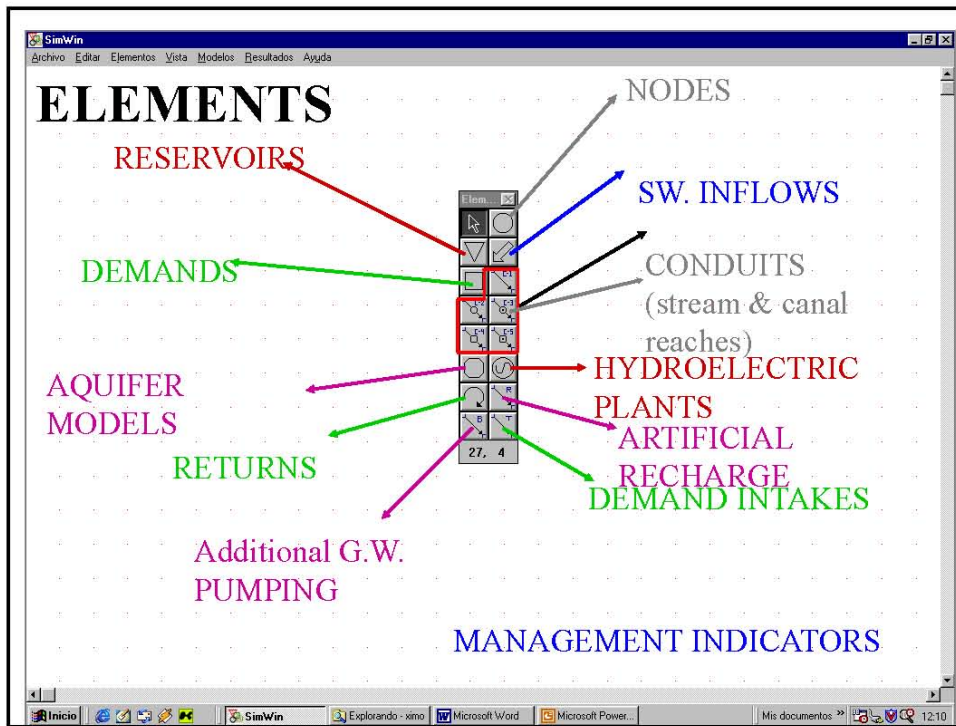
- Generalized tools to build DSS,
- bring the possibility of relatively easy, systematic and homogeneous application of DSS over wide regions, as for instance many river basins in Spain
- provide guidance in the development of the DSS
- Example: AQUATOOL DSSS (Andreu et. al. 1996),

AQUATOOL:

DSSS designed for integrated management of complex water resource systems



J. Andreu, J. Capilla, y E. Sanchis, “Generalized decision support system for water resources planning and management including conjunctive water use”, *Journal of Hydrology*, Vol. 177, pp. 269-291, 1996.



The DSS allows the user to:

- Input and modify the space configuration of a water resource system
- **Edit and manage geo-referenced data bases containing physical characteristics, management characteristics**

The screenshot displays the SimWin software interface with several configuration windows open. The main window shows a grid with the word "RESERVOIRS" in red. Overlaid windows include:

- Descripción del embalse:** A dialog box for configuring a reservoir named "Embalse n° 1". It includes fields for infiltration (Acuífero), coefficients (A, B, C), and evaporation column settings.
- VOLUMENES:** A table for setting volume objectives for each month.
- COTA/SUPERFICIE/VOLUMEN/EVAPORACION:** A table for setting elevation, surface area, volume, and average evaporation for each month.

At the bottom of the interface, the following text is displayed:

PHYSICAL CHARACTERISTICS
 FILTRATION (INTO AN AQUIFER) AND EVAPORATION LOSSES
 OPERATING RULES

AQUIFERS

Descripción del acuífero

Nombre: Acuífero n° 1

Tipo:

- Autovalores
- Unicelular
- Manantial
- Depósito
- Rectangular Homogéneo (1 Río)
- Rectangular Homogéneo (2 Ríos)
- Tres Niveles
- Manantial Multicelda

Datos acuífero:

- Interactivo
- Por fichero

Control de Bombeos:

- Volumen
- Salidas al Río
- Sin Control

Valor Umbral: 0

Valor de Alfa (mes⁻¹): 0

Volumen Inicial (Hm³): 0.000

Salida Gráficas:

- Volumen
- Caudal
- R. Neta
- Bombeo

Wide range of models available to embed aquifers in the basin mode

- Lumped approaches:
 - » Reservoir
 - » Single cell connected to stream
 - » Single cell with spring
 - » Multiple cells connected to stream
- Distributed approaches:
 - » Analytical solution for homogeneous & rectangular shape
 - » Numerical solution for heterogeneous and/or irregular shape:
 - AQUIVAL module

Integrated Basin model: Jucar Basin

integrating physical properties

- Water rights and priorities
- Operating rules (normal & Drought)

SIMULATION for given hydrologic inflows scenarios

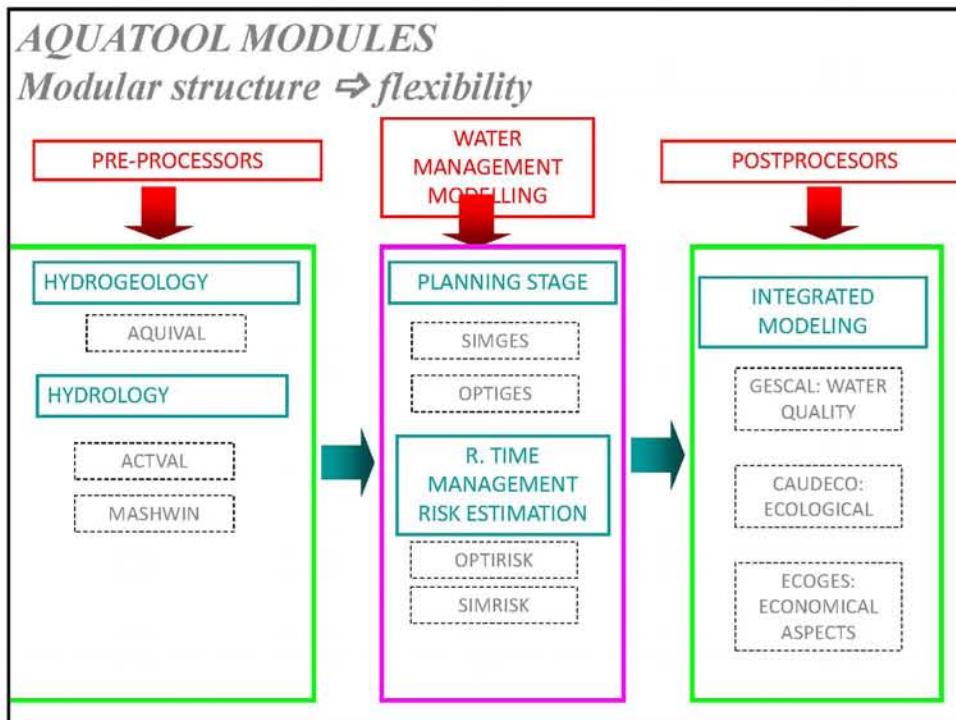
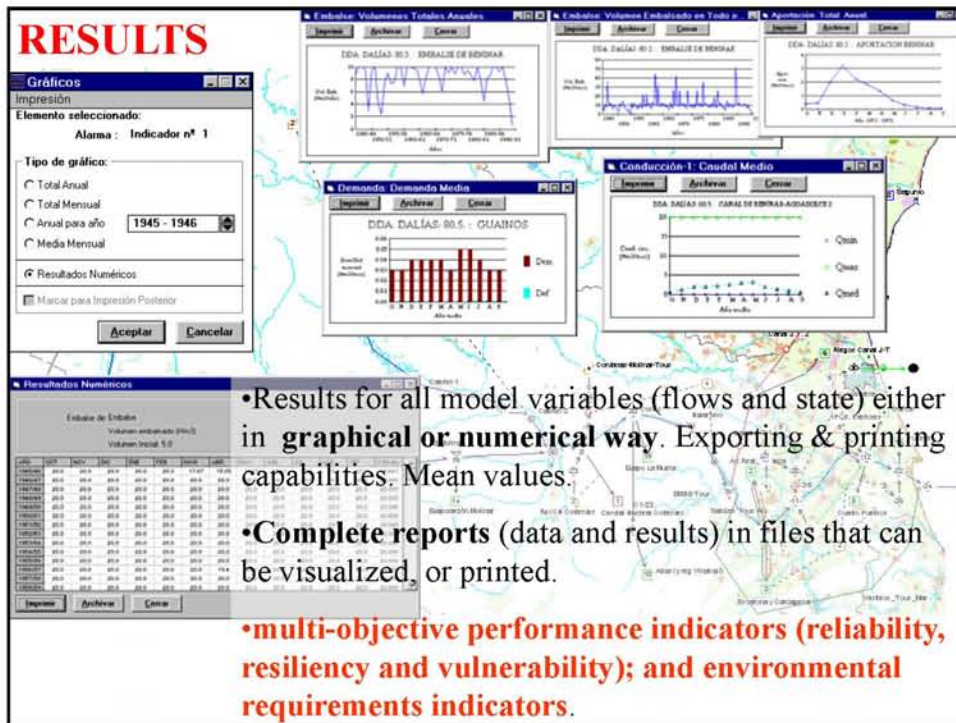
INTERNAL

In every month, a network flow optimization algorithm (Out-of-kilter) finds a flow solution which is compatible with the physical restrictions, and tries to minimize weighted deviations from operating rules (Target supplies, flows, and reservoir storage); respecting priorities.

Iteration is needed to take into account non-linearities and surface-groundwater relationships.

Integrative DSS

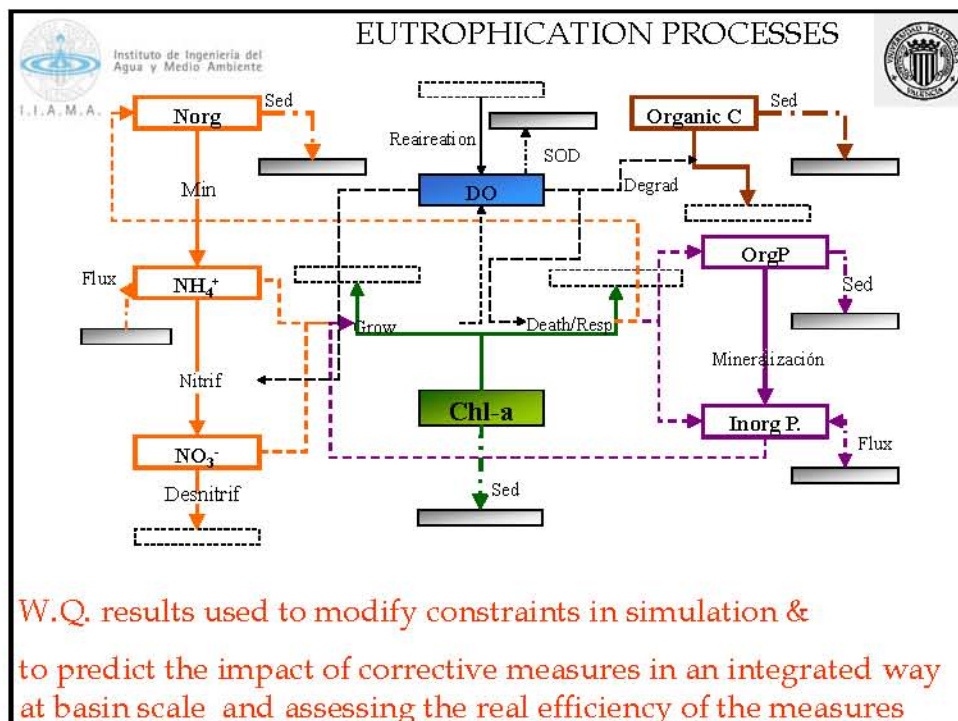
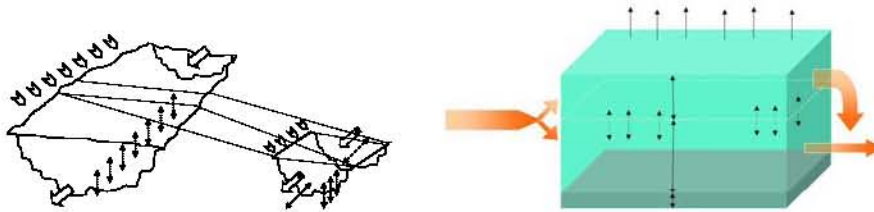
- purpose of this model is to **simulate the management** of the basin
- Once the system is completely defined, the user can perform simulation runs of the management for **multiple different alternatives**, time horizons and **scenarios**, using different hydrological data and also different **operating policies**.
- **Easiness in changing the infrastructures, scenarios, etc., and getting and analyzing the results is essential**



WATER QUALITY SIMULATION MODULE

Water quality model coupled with a simulation model.

- SIMULATES W.Q. FOR THE ENTIRE SYSTEM
- Mechanistic model for rivers and reservoirs.
- Conventional constituents.
 - Temperature
 - Nitrogen cycle
 - Arbitrary constituents
 - Eutrophication problem.
 - DO + OM

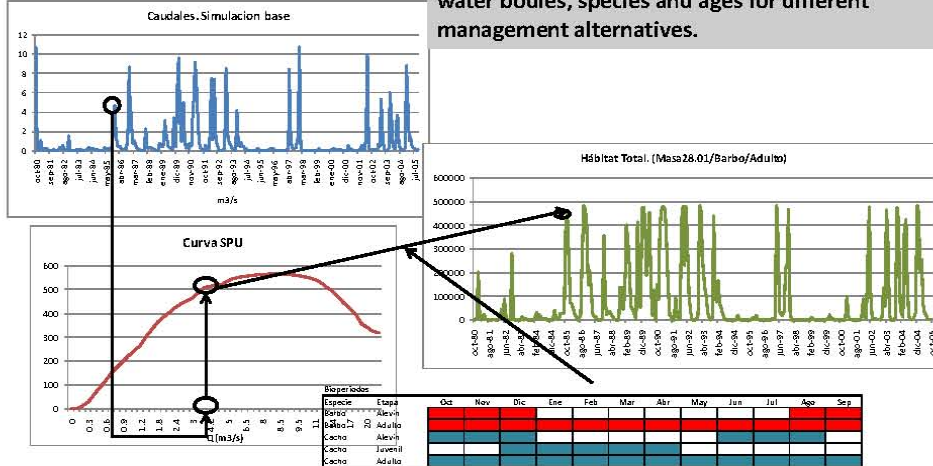


W.Q. results used to modify constraints in simulation & to predict the impact of corrective measures in an integrated way at basin scale and assessing the real efficiency of the measures

CAUDECO- Ecological flows module

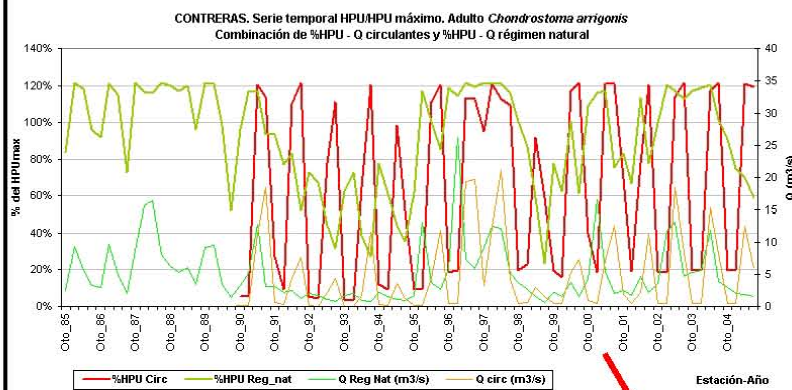
OBJECTIVE OF THE MODULE

- Estimation of Total Habitat Series in different water bodies, species and ages for different management alternatives.



INCORPORATING ECOLOGICAL ASPECTS IN PLANNING AND MANAGEMENT STUDIES

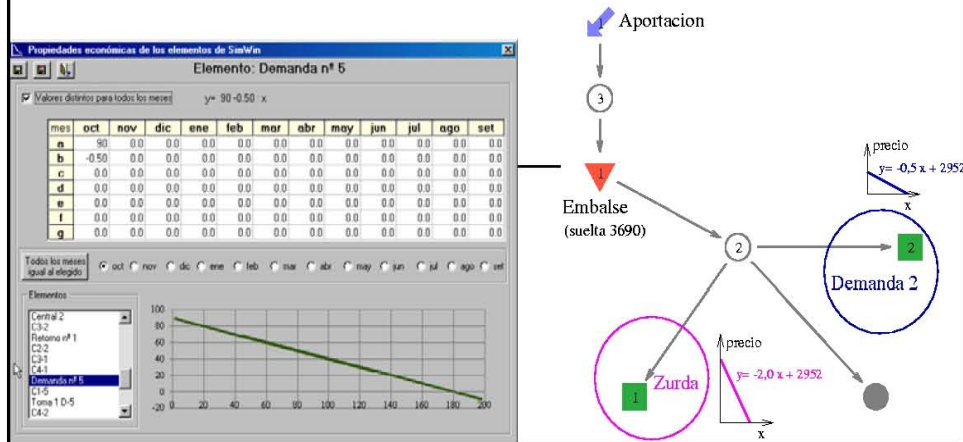
Caudeco Module





Estimating temporal status of Habitat for different management policies

ECONOMIC EVALUATION MODULE

- ASSESS ECONOMIC VALUE OF AN ALTERNATIVE
- USED to estimate **OPPORTUNITY COSTS of WATER USE** and **ENVIRONMENTAL FLOW** increments



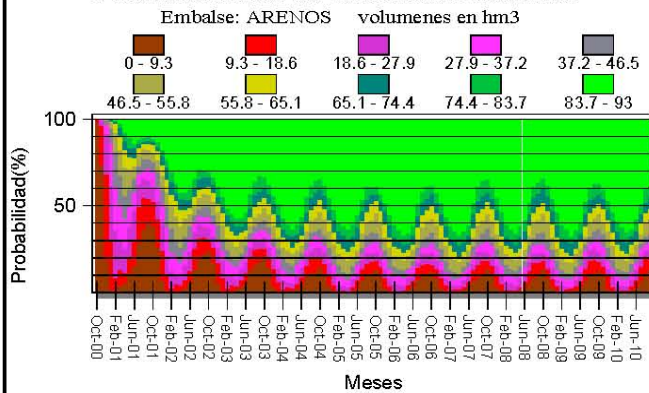



- Management Simulation and/or Optimization runs using **different**:
 - alternatives (e.g. infrastructure)
 - time horizons
 - demand scenarios
 - hydrological scenarios
 - operating policies
- Planning decisions can be analyzed and **tradeoffs between alternatives can be determined**.

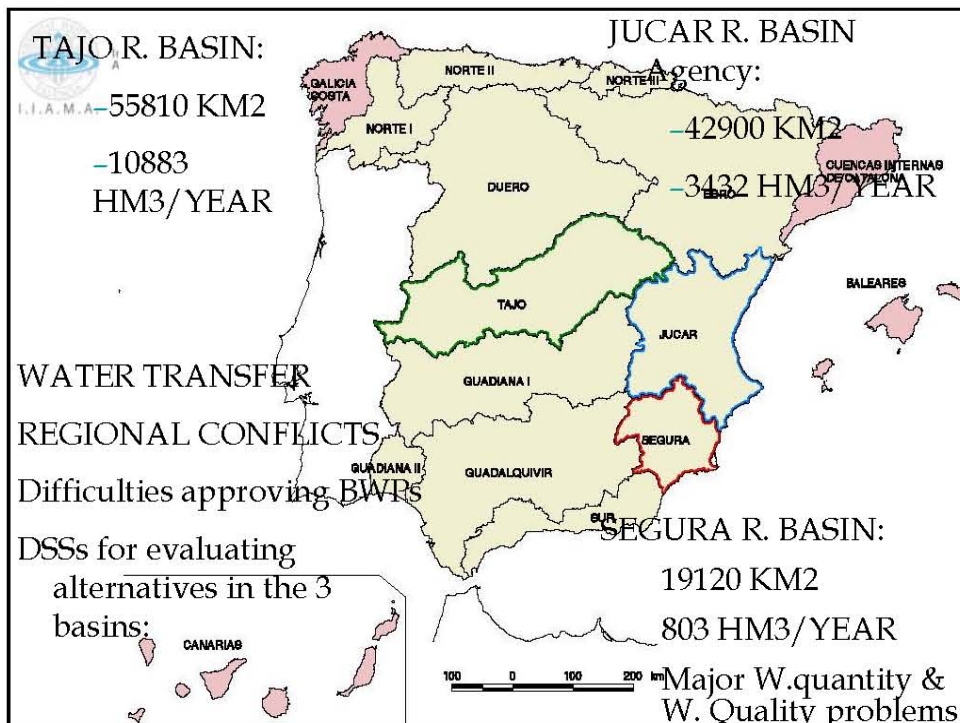
Risks associated to planning decisions (design of the system):

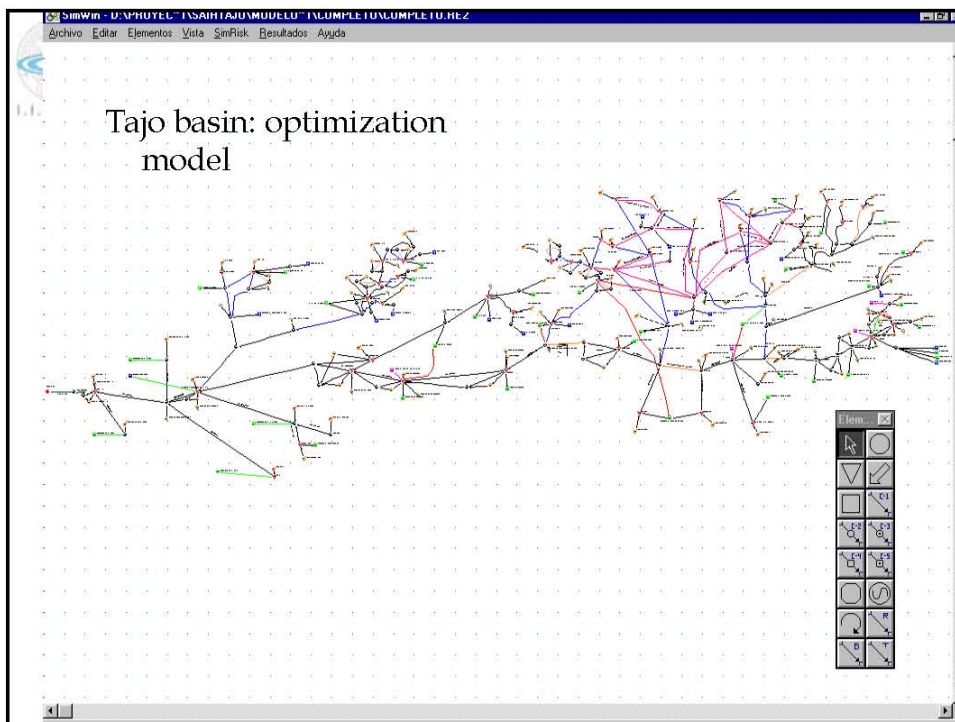
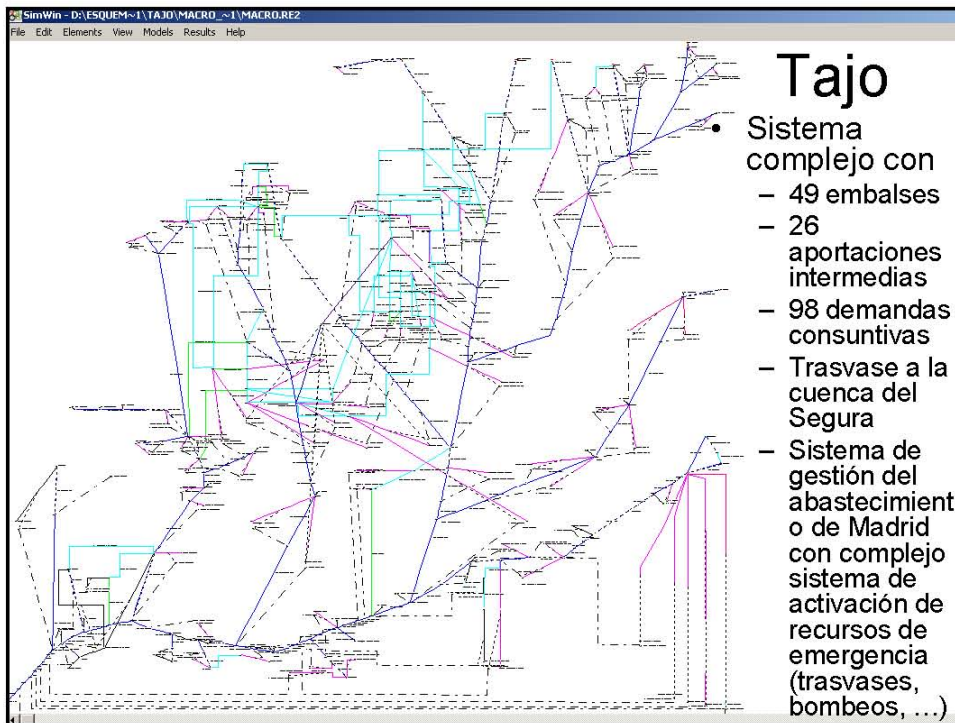
- **unconditioned** multiple future hydrological scenarios for **very long time horizons**
- after the effect of initial conditions are dissipated, the **probabilities stabilize:**

Probabilidades de Estado en Embalse.



Long
term
measur
es





- Actualización de los trabajos anteriores
- Modelos de Optimización y Simulación
- Modelos distribuidos de acuíferos Vega Alta, Vega Media, Sinclinal de Calasparra, ...

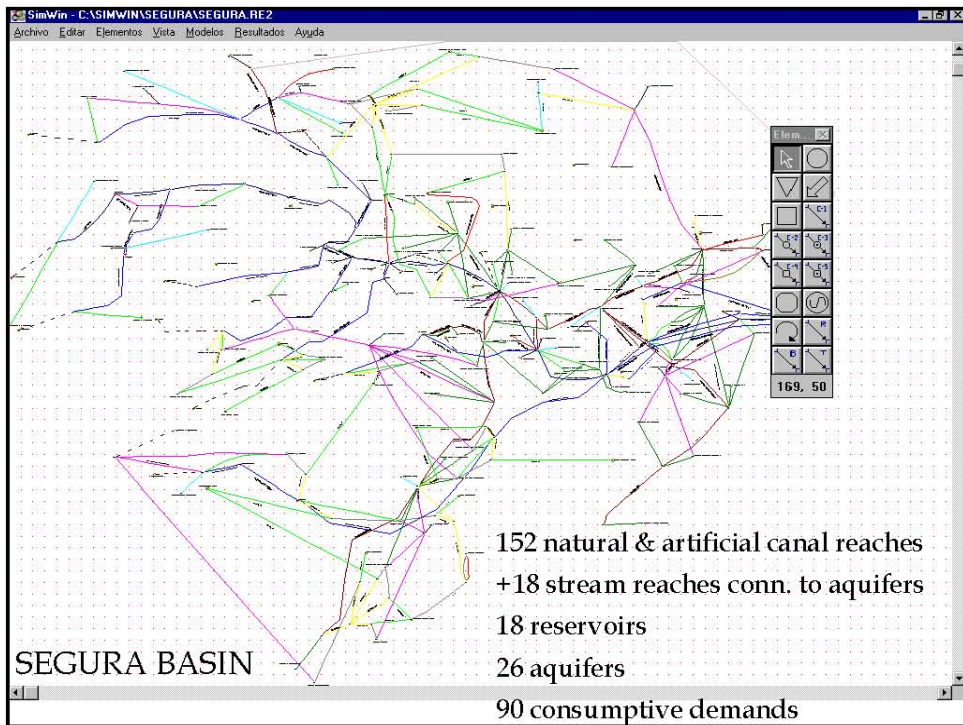
CUENCA DEL SEGURA

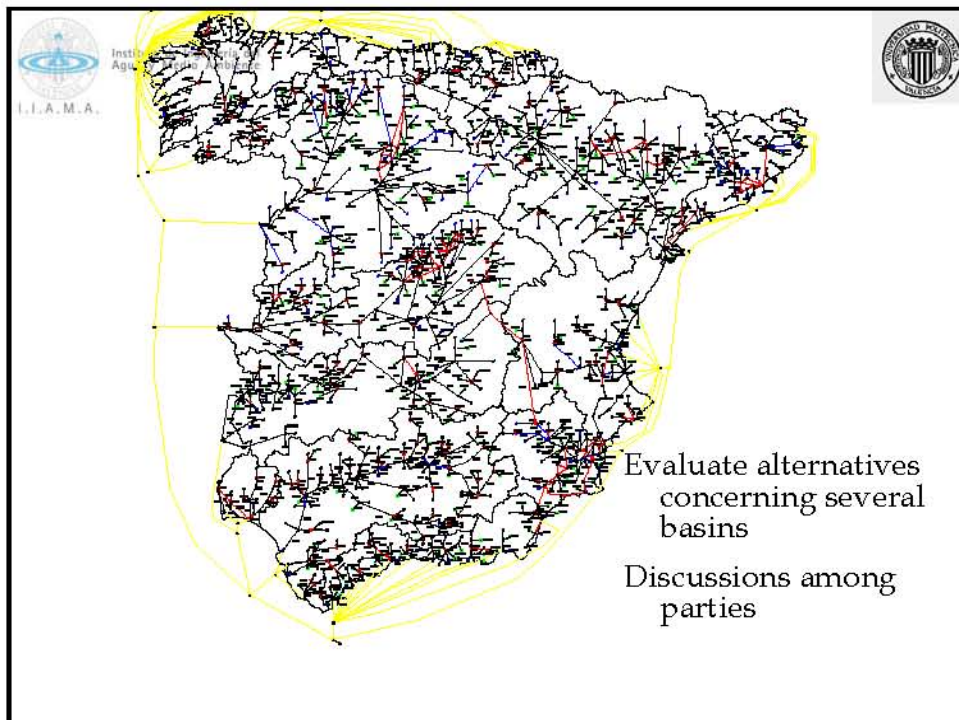
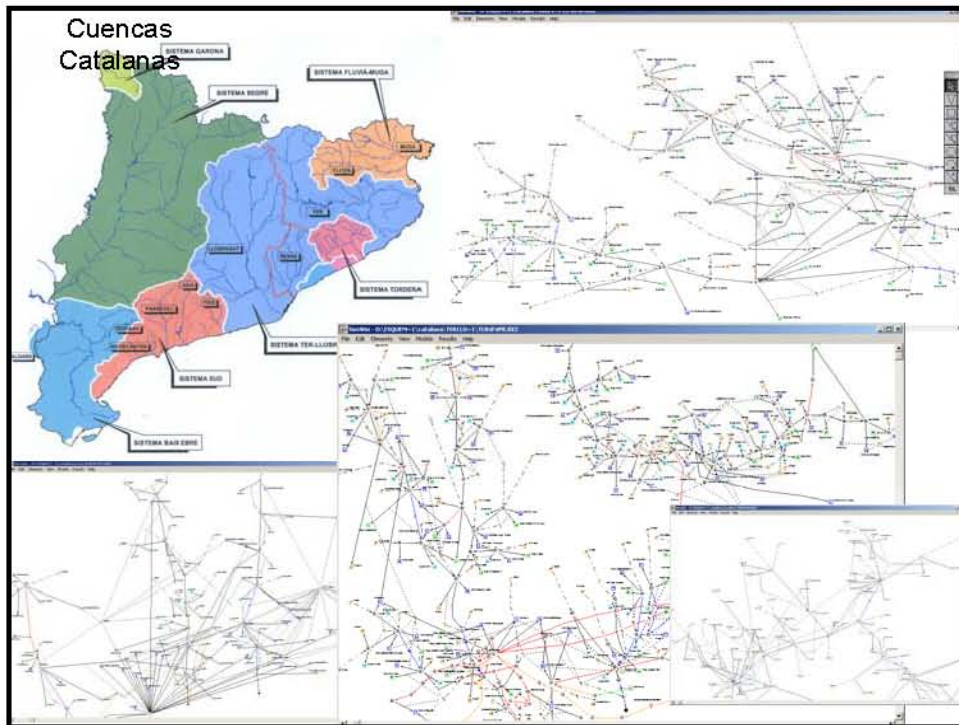


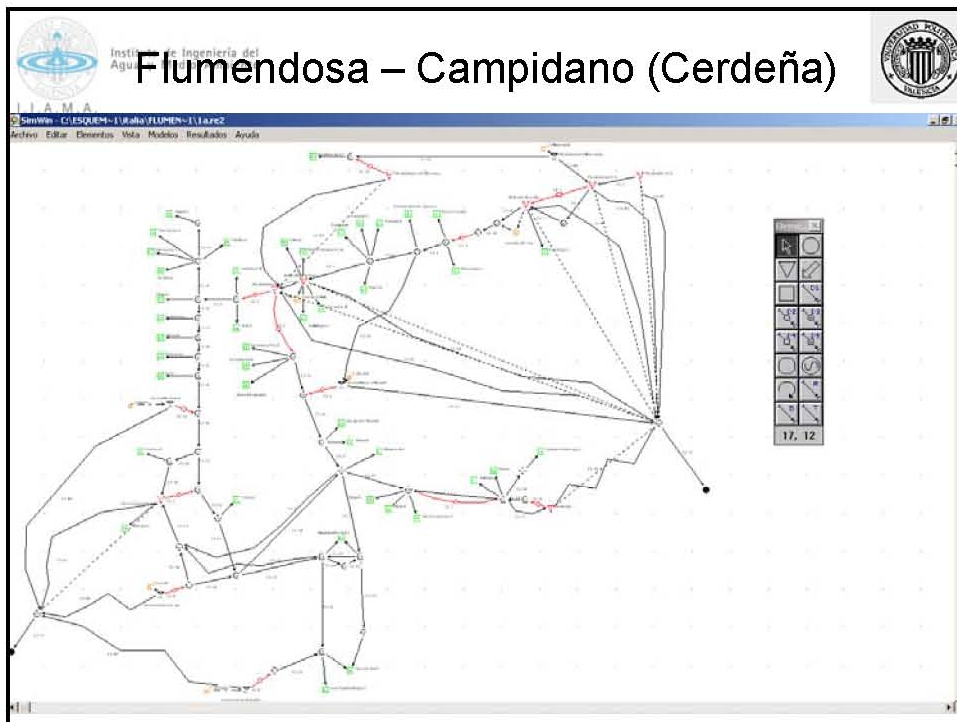
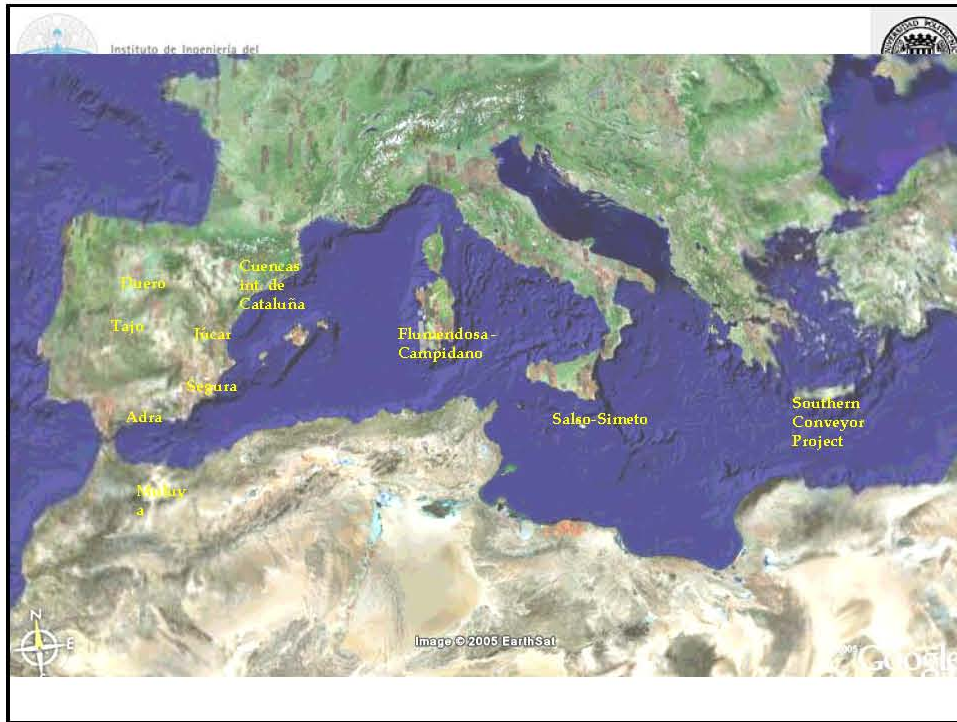


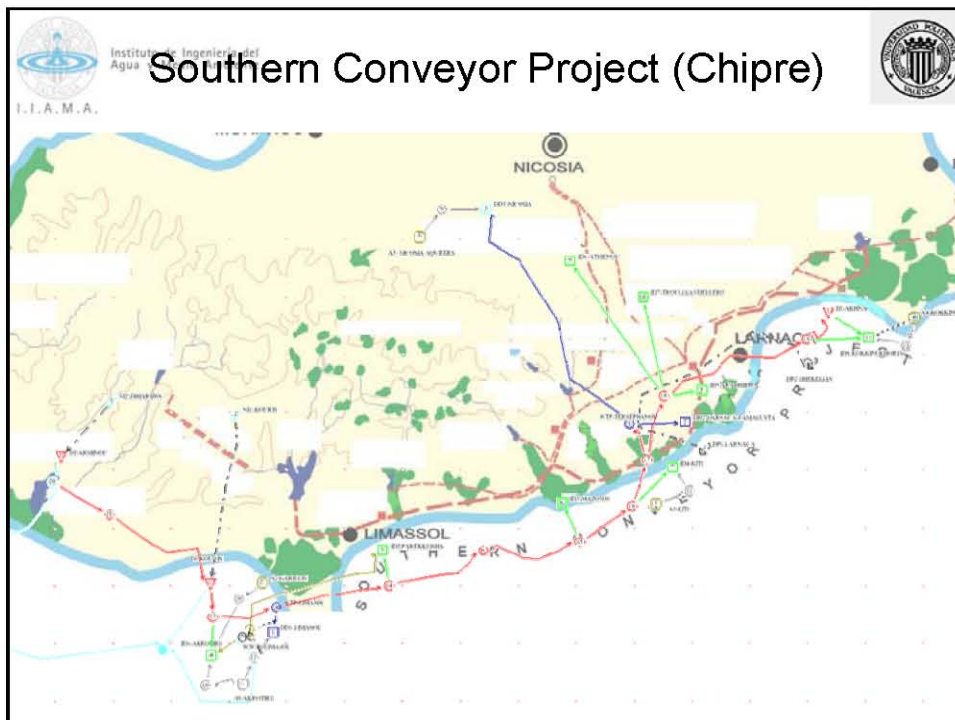
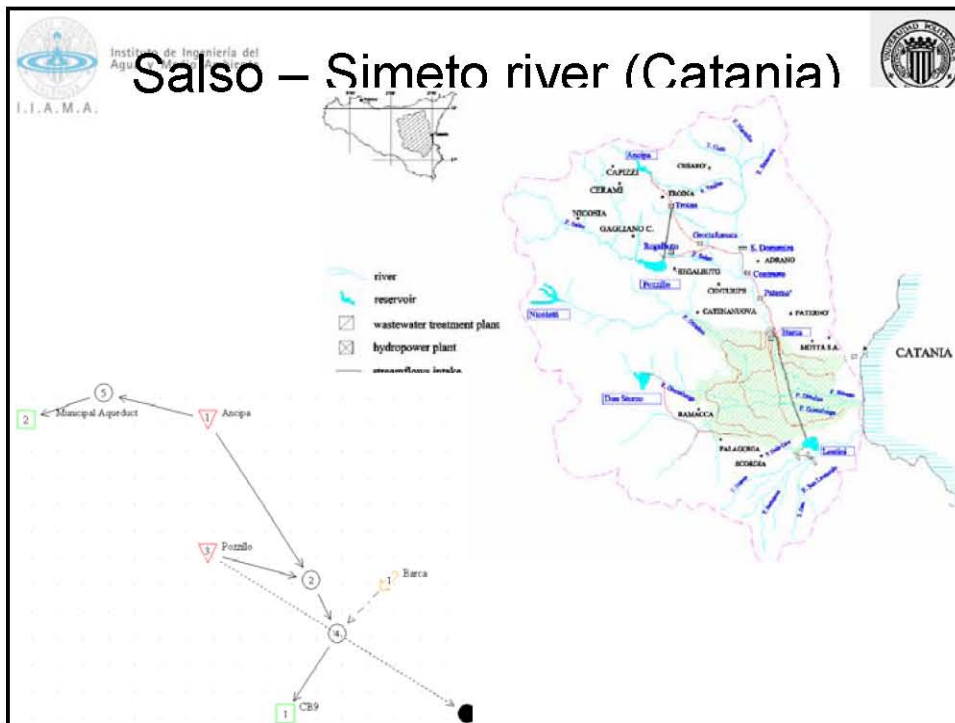
SEGURA BASIN

152 natural & artificial canal reaches
 +18 stream reaches conn. to aquifers
 18 reservoirs
 26 aquifers
 90 consumptive demands









Real case of application of DSS by
the

**Technical Committee to assess the
JÚCAR-VINALOPÓ PROJECT
(CONFLICT)**

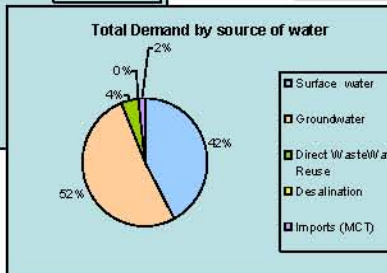
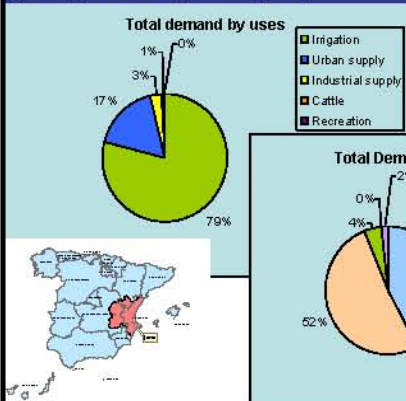
**Júcar River Basin Authority
(CHJ)**

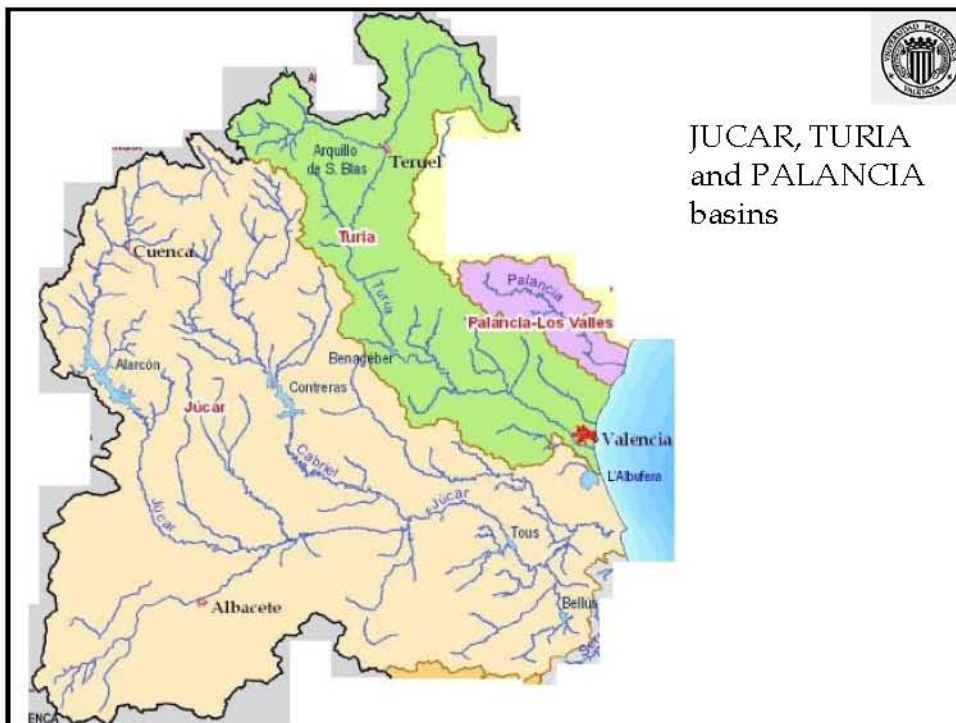
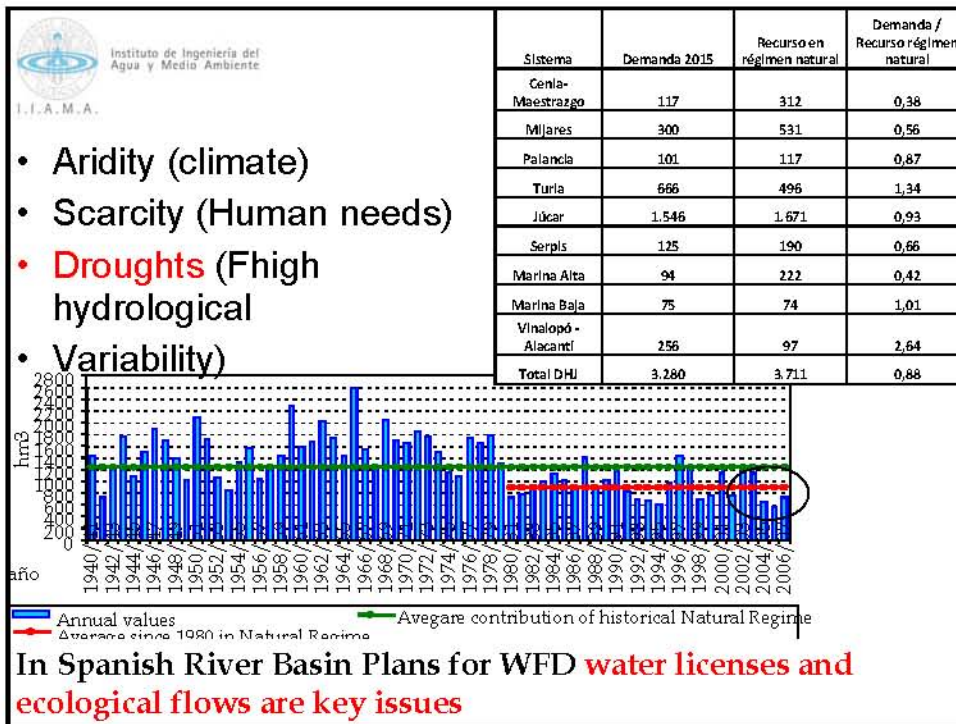
Surface (km ²)	43.000
Permanent population	4.792.528
Equivalent population due to tourism	367.322
Irrigation surface (ha)	347.275
Water demand (hm ³ /year) (Hm ³ /year = Gigaliters/year)	3.172

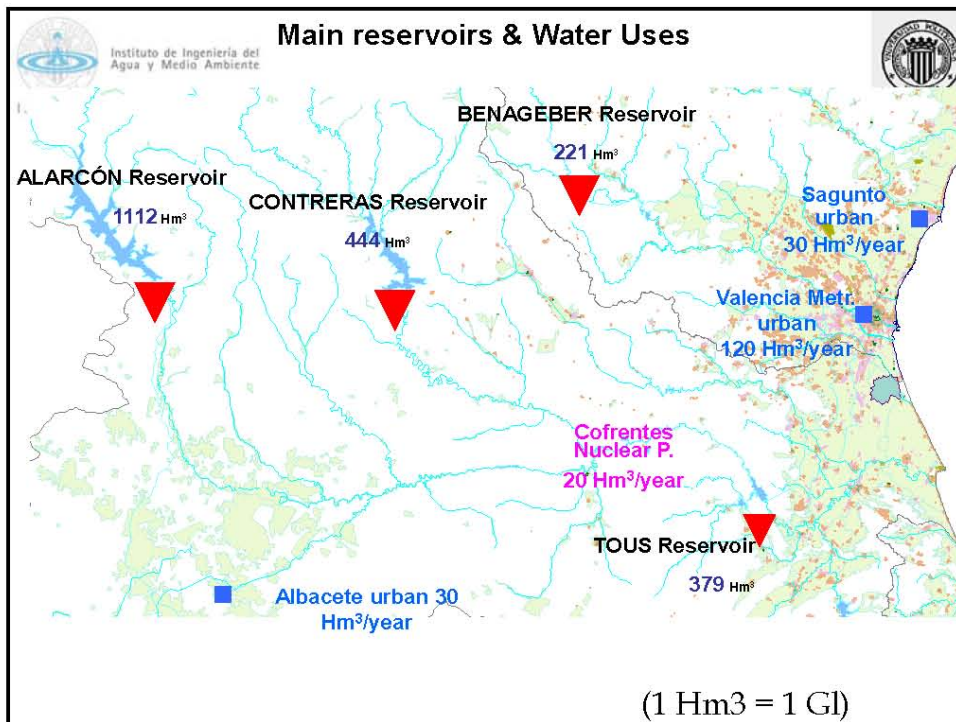
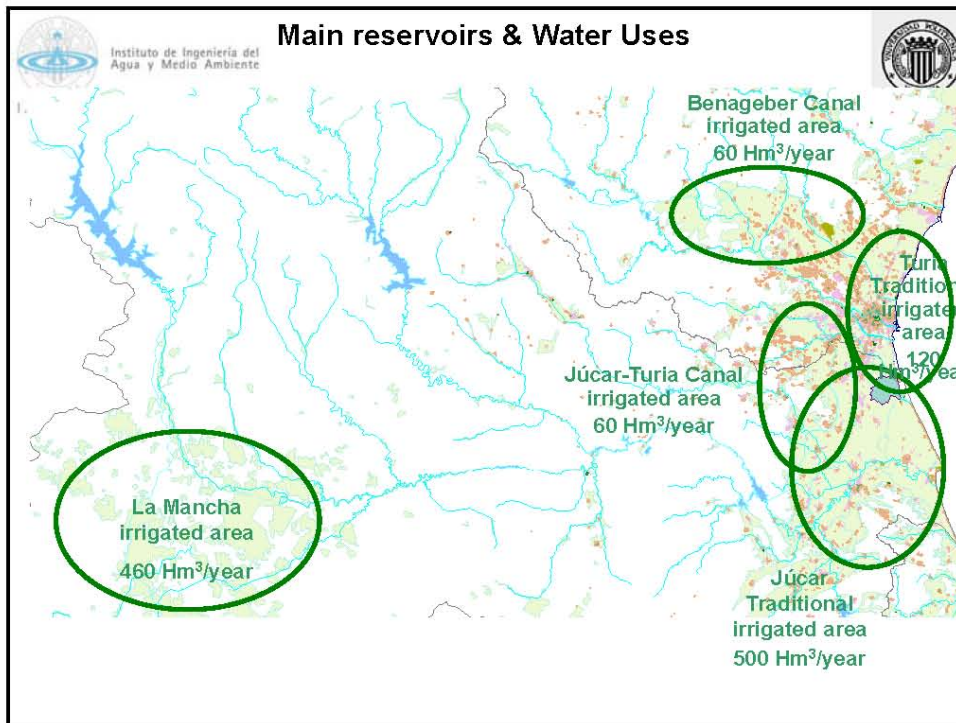


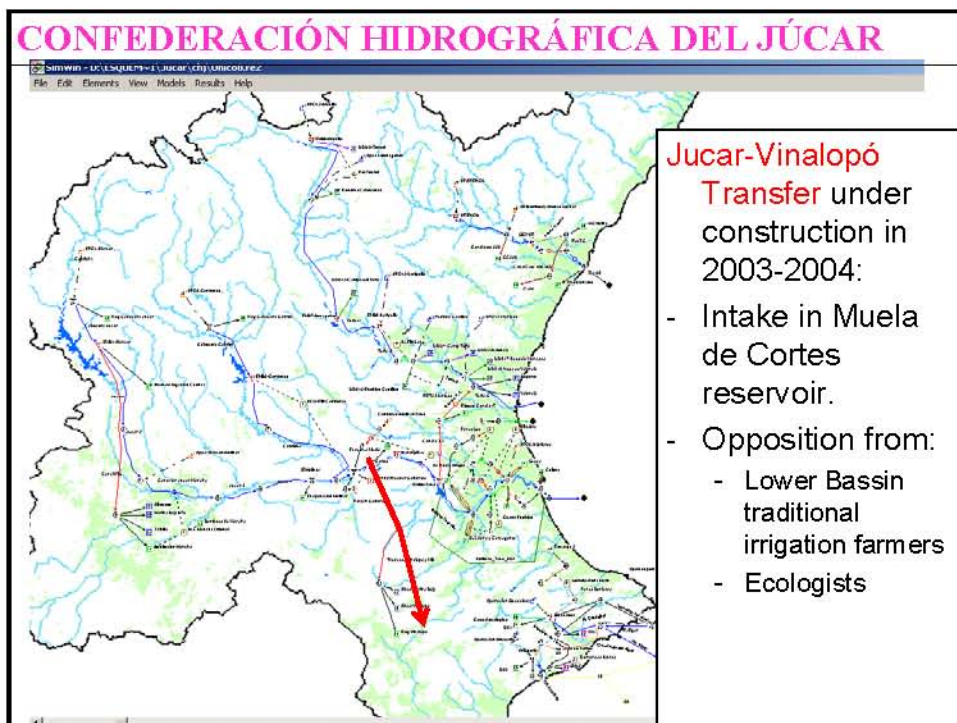
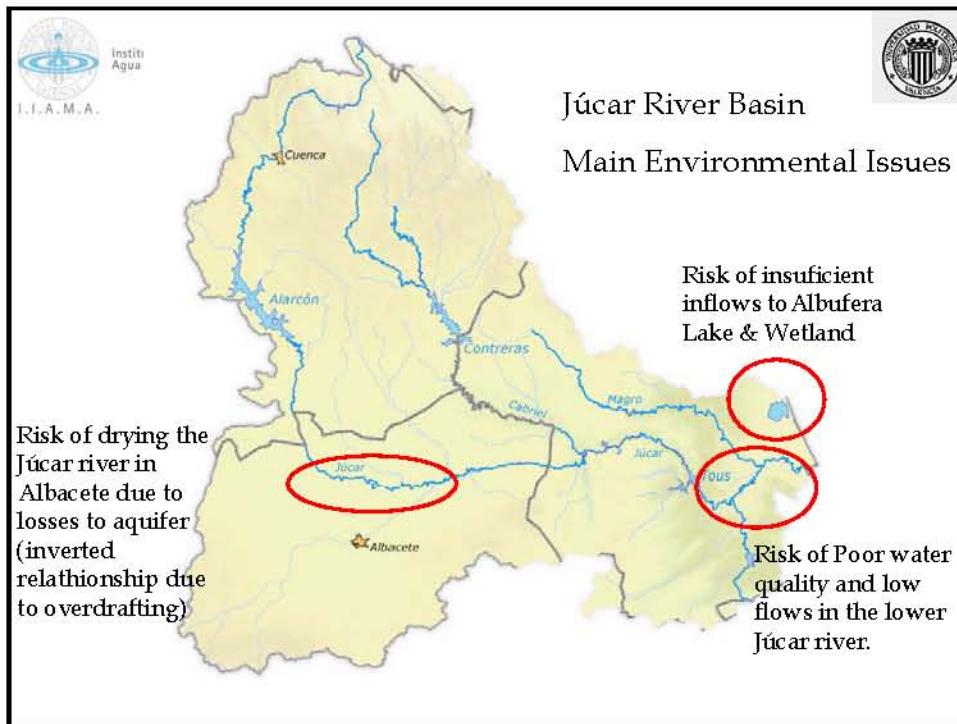
HALF OF THE AREA IS SEMIARID

**+HIGHEST
VARIABILITY IN
EUROPE
(IN SPACE AND
TIME)**









Jucar-Vinalopó conflict participatory solution

- **Technical Committee:** Policy Making actors + experts:
 - Ministry of environment
 - Regional Governments (Castilla La Mancha and Valencia)
 - Jucar Basin Authority
 - Traditional Farmers and industrial users of donor basin
 - Farmers and urban users at receptor basin
 - NGO's (2)
 - Experts from universities and other research institutions
- **Working for 4 months**
- **Joint development of DSS**

JOINT DSS DEVELOPMENT AND USE

The Technical Commission deeply **reviewed all the components** that constitute the simulation model in order to have an objective common tool to analyze the viability of the project.

In this way they were able to differentiate the objective elements from the subjective opinions on the alternatives and the results.

The **resulting model set up by the Technical Commission was assumed as a shared vision of the system** by all the members and as common tool to simulate the different alternatives and scenarios.

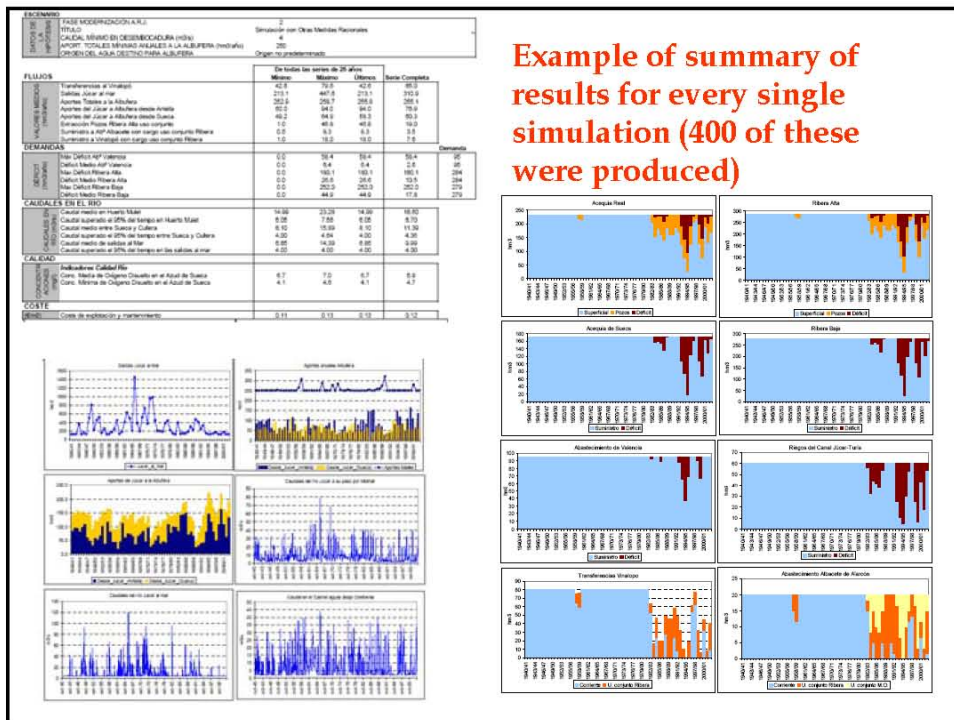
The DSS was put at the disposal of all the members of the Technical Commission, so that they could perform simulations on their own, or for verification of results offered by other parts.

JOINT DSS DEVELOPMENT AND USE

In order to simulate the alternatives, **all data and scenarios where agreed:**

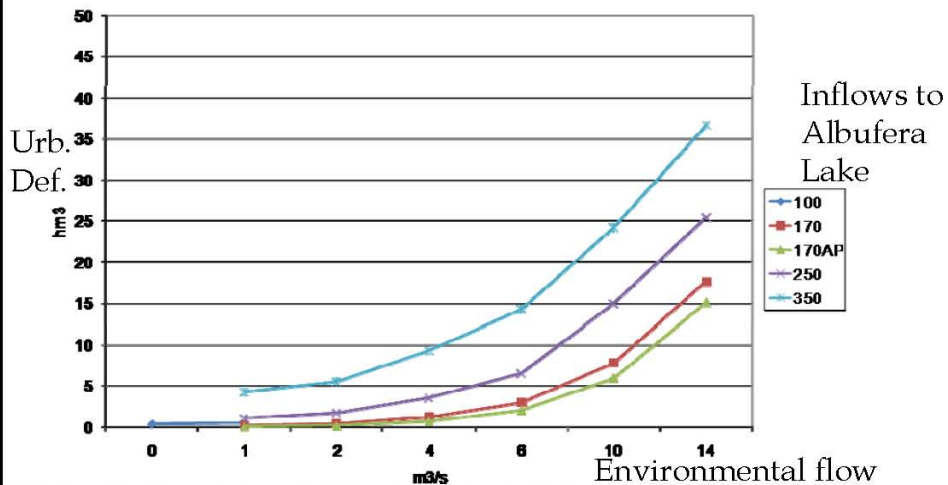
- Hydrological series (Hydrological scenarios) ▶
- Water need by economical uses in different times and different degrees of modernization of agricultural distribution systems (Demand scenarios)
- Environmental requirements in Júcar River and Albufera Wetland
- Operating rules of the system (priorities and drought restrictions, among others)
- Available infrastructure (Infrastructure scenarios)
- Conjunctive use of surface and groundwater and Direct treated waste water reuse (Alternative sources scenarios)

All the combinations of scenarios amount up to more than 600 alternatives to assess, that were reduced to **400 to be simulated** after a preliminary analysis.



Synthesis of results:

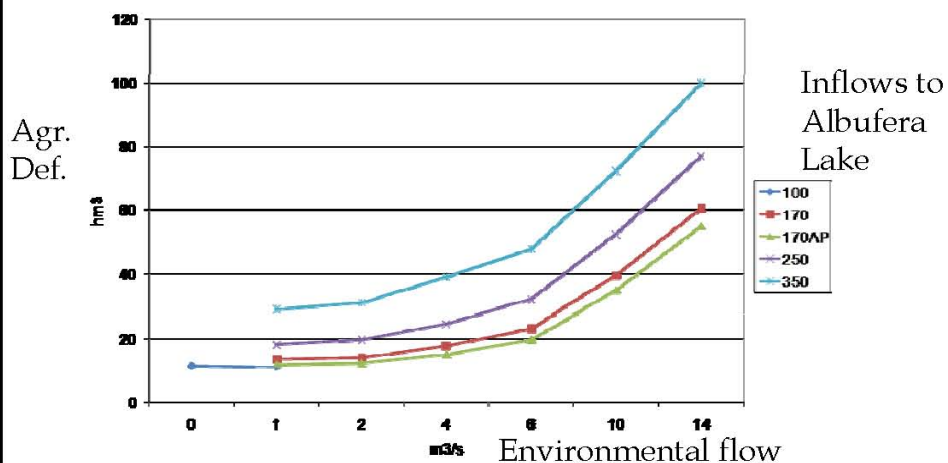
Trade-offs between urban water deficits and environmental requirements at Jucar River and Albufera wetland.



Déficit medio Abastecimiento de Valencia (hm³/año). Media de la última serie de 25 años. Modernización 2ª Fase. Simulación: Otras medidas racionales sin el Vinalopó. Valores para las diferentes alternativas de asignación a La Albufera (hm³/año) y de caudales ecológicos (m³/s)

Synthesis of results:

Trade-offs between agricultural water deficits and environmental requirements at Jucar River and Albufera wetland.

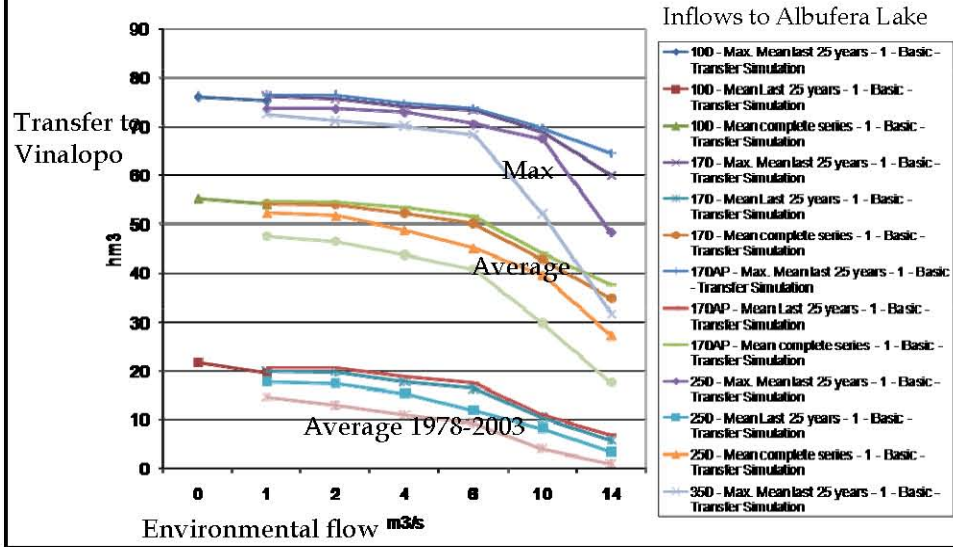


Déficit medio Ribera Baja (hm³/año). Media de la última serie de 25 años. Modernización 2ª Fase. Simulación: Otras medidas racionales sin el Vinalopó. Valores para las diferentes alternativas de asignación a La Albufera (hm³/año) y de caudales ecológicos (m³/s)

Synthesis of results:

Potential of average transfer for different environmental requirements at Jucar River and Albufera wetland.

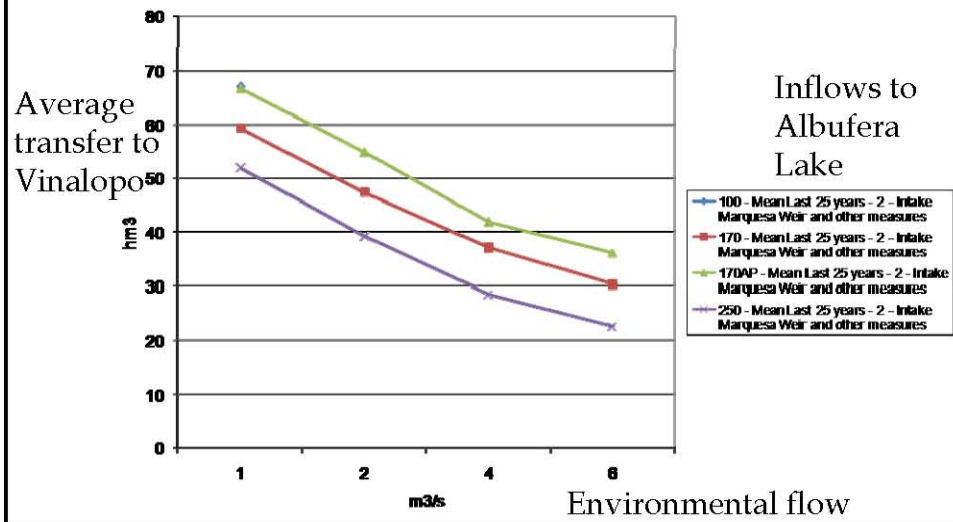
Escenario: F1. Simulación Traspase - Básica - Modernización de la ARJ en 1ª fase.



Synthesis of results: NEW INTAKE OPTION AT LA MARQUESA SMALL DAM

Potential of average transfer for different environmental requirements at Jucar River and Albufera wetland.

Escenario: F2. Toma en azud Marquesa y otras medidas. Modernización de la ARJ en 2ª fase. Media últimos 25 años



- A **complete report** was elaborated, including all agreements, disagreements and results, summaries and synthesis.
- The results were **presented in a general meeting** including additional representatives of the Regional governments, National Government, and European Commission.
- Finally, **it was decided by the Ministry of Environment to modify the project to set up the intake of the transfer in La Marquesa small dam** (close to the mouth of the river by the Mediterranean sea).

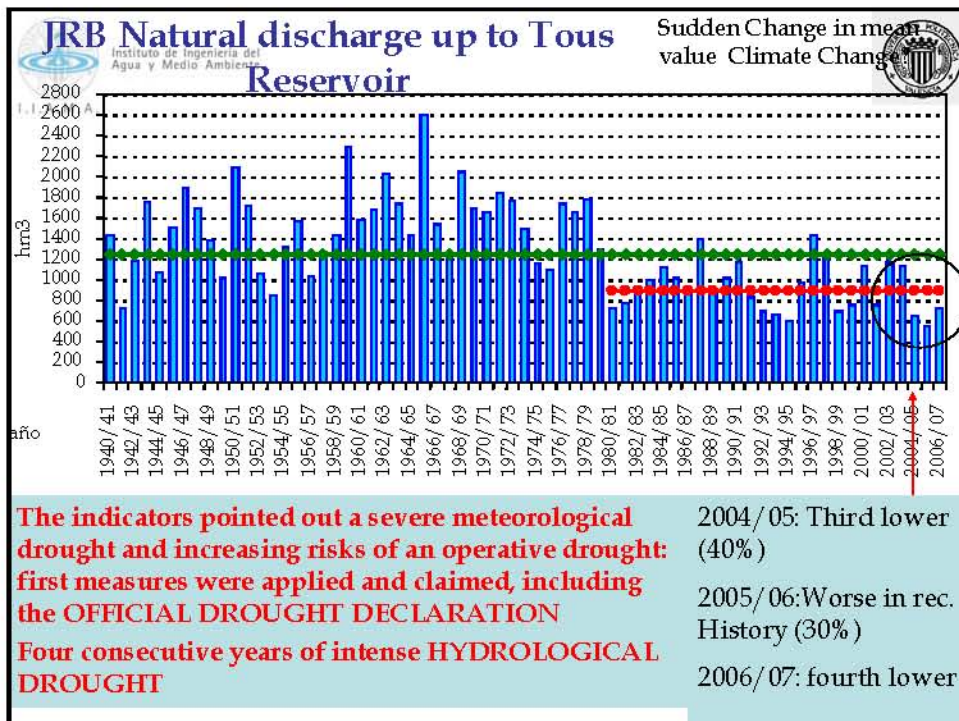




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Assessment of Drought Risk and the effectiveness of measures in Water Resources Systems: Experience in the Jucar basins.



 **Permanent Drought Commission: RD 1265/2005** 

(Delegate board from the Governing Board of CHJ (JRBA))

Entitled to vote (13):

- President of JRBA
- JRBA (3) : Commissary, Technical Director, Head of Planning Office.
- Spanish Ministries (2): Industry (IGME) and Environment
- Autonomous Regional Governments (4)
- Urban users representative (Valencia Metr. Area W. Supply)
- Agricultural users representative (Real del Júcar Ditch).
- Industrial users representative (Iberdrola, S.A.)

In advisory capacity (4)

- Environmental Interest Defence: Agró
- Entrepreneurial Representation: AVA
- Labor Unions representation: CCOO
- Local Entities representative: Albacete municipality

Numerous "guests"

 **PDC Meeting Calendar** 




- 1) 1st December 2005
- 2) 21st December 2005
- 3) 21st January 2006
- 4) 13th February 2006
- 5) 15th March 2006
- 6) 18th April 2006
- 7) 22nd May 2006
- 8) 27th June 2006
- 9) 19th July 2006
- 10) 24th August 2006
- 11) 12th September 2006
- 12) 28th September 2006
- 13) 15th November 2006
- 14) 15th December 2006
- 15) 15th February 2007
- 16) 20th April 2007
- 17) 18th July 2007
- 18) 17th September 2007
- 19) 31st October 2007
- 20) 12th December 2007
- 21) 15th February 2008
- 22) 14th March 2008
- 23) 18th April 2008
- 24) 12th June 2008
- 25) 16th September 2008
- 26) 17th October 2008
- 27) 22nd December 2008
- 28) 12th March 2009

PDC PROCEDURE:
 Instituto de Ingeniería del Agua y Medio Ambiente
METEO & HYDROLOGICAL INFORMATION
 I.I.A.M.A.
+ DROUGHT INDEXES



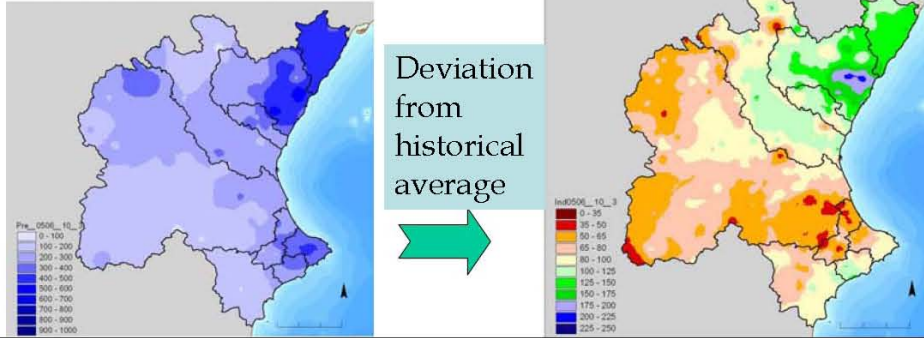
Allow to identify droughts and to compare situations (s-t)

Percentage of normal cumulative rainfall

Available resource / normal (average) resource

Advantage: easy to understand

Octubre 2005 a marzo 2006



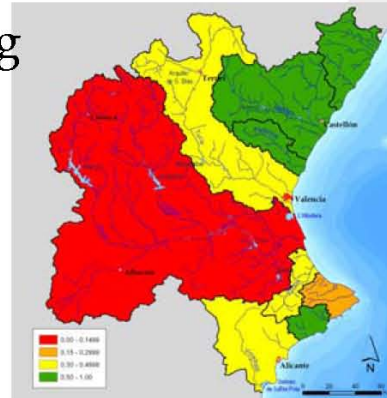
Continuous monitoring

I.I.A.M.A.

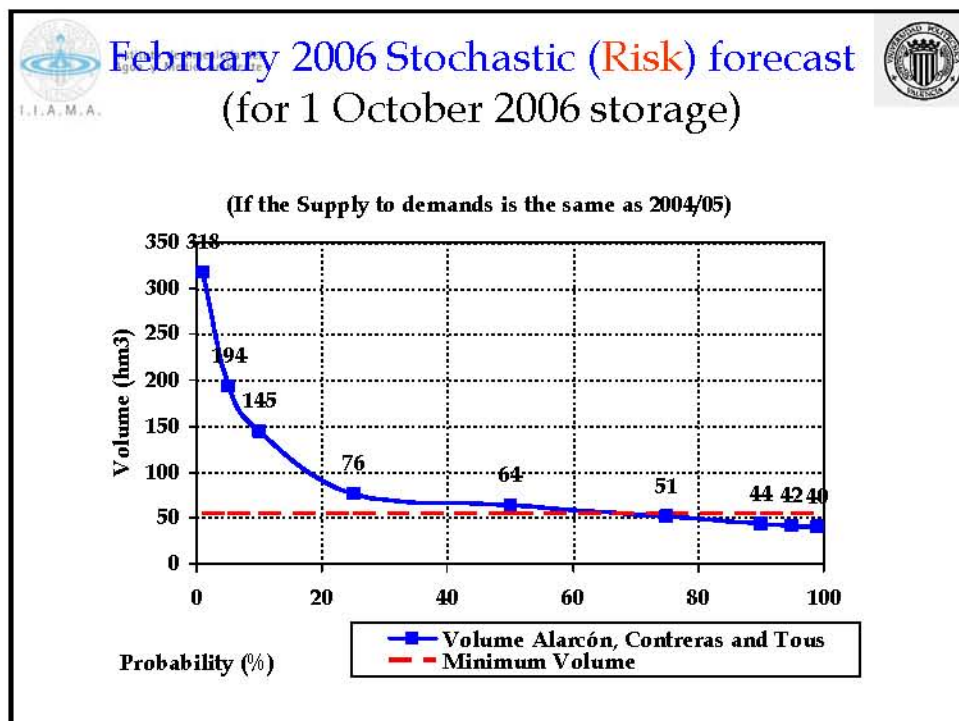
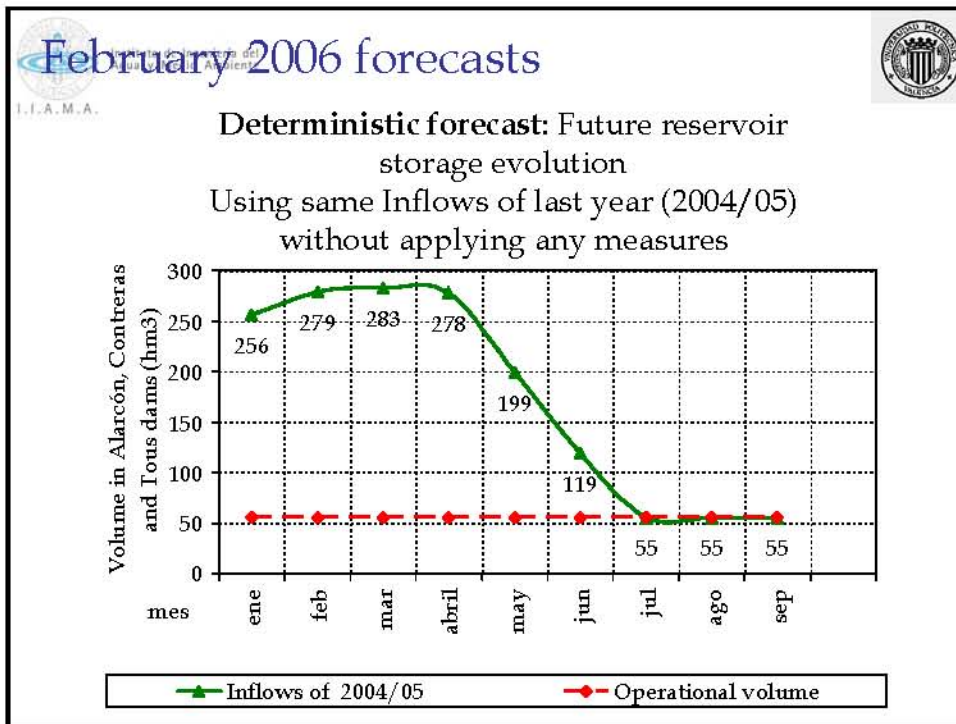


Drought indicators CHI
 (31 January 2006)

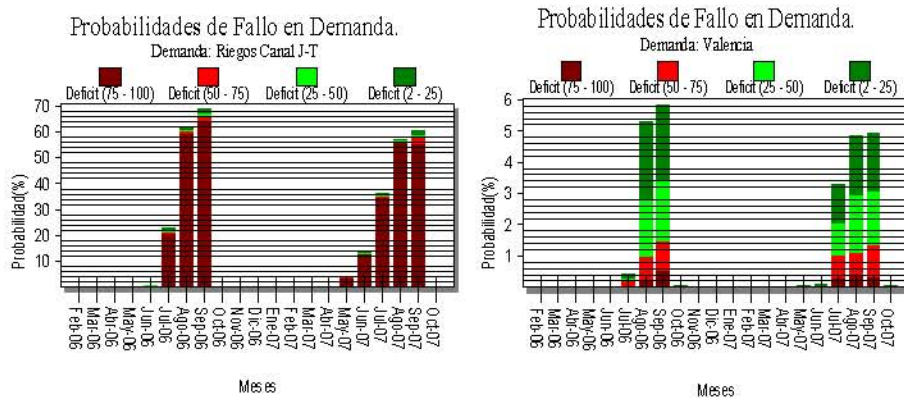
Júcar => emergency
 Marina Alta => alert



System	Valuation risk	State Index	State
Cenia-Maestrazgo	LOW	0.55	STABLE
Mijares-Plana de Castellón	LOW	0.51	STABLE
Palancia-Los Valles	LOW	0.52	STABLE
Turia	MEDIUM	0.38	INITIAL ALERT
Júcar	VERY HIGH	0.13	EMERGENCY
Serpis	MEDIUM	0.32	INITIAL ALERT
Marina Alta	HIGH	0.28	ALERT
Marina Baja	LOW	0.58	STABLE
Vinalopó-Alacantí	MEDIUM	0.49	INITIAL ALERT



Probability of failure in urban and agricultural areas



- Increase w. conveyance efficiency
- Increase Conjunctive surf&ground w. use + drought wells
- Increase Reuse of waste water
- Increase reuse of irrigation return flows
- Water rights purchase to preserve environmental flows
- Application of measures to save water: irrigation reduction, and alternative urban supply
- Conjunctive management of Turia and Jucar Basins
- Public education trough media (Newspapers, ...) in order to reduce urban consumption
- Intensive monitoring and surveillance, ...
- Other ...

Conveyance canal substituted by pressurized pipe

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- Savings of 100 MCM/year
- Part of an ongoing modernization plan

Fases de la Acción:

- **Red en alta:** Consiste en la conducción a presión que baja desde la salida del Tossal de la Escalera y discurre en paralelo al Canal Principal (Módulo de las Compuertas).
- **Mejora del canal principal:** Obras puestas a disposición al funcionamiento del canal y mejorar la sección.
- **Red de distribución a presión y cabezales de riego:** Conducciones a presión desde la red en alta hasta las cabezales de riego y sus conducciones.
- **Mejora de la red de distribución:**
- **Red de distribución hasta la parcela:** Dirección de una red desde el primer punto después del sistema de riego hasta cada parcela.
- **Cabezal y red de riego:** Consiste en el cabezal de cada parcela y su correspondiente red de riego.



+ Surface Water Allocation Proposal for 2005/2006

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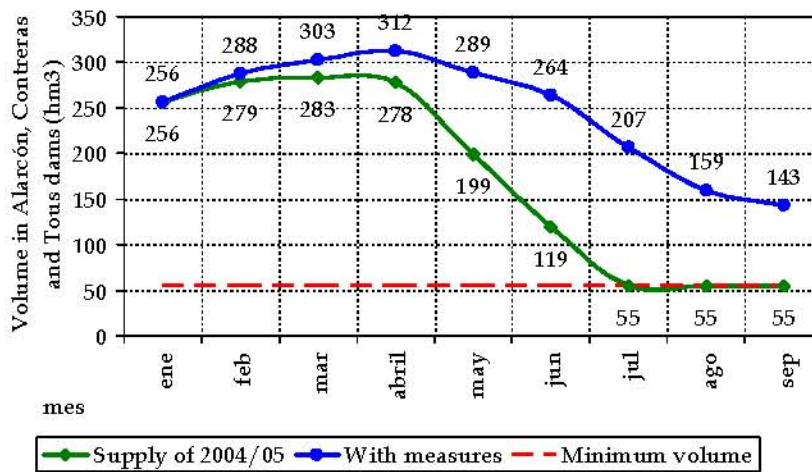


I. I. A. M. A.				
IRRIGATION	Supply	Supply	Proposal 2005/06	Reduction w.r. to 2004/05
	1994/95	2004/05	Surface water	Surface water
Regadíos canal Júcar Turia	42	46	16,1	65 %
Sustitución de bombeos y consolidación de MO	0	21	7,35	65 %
Riegos tradicionales Júcar (Ribera Alta)	179	316	158	50 %
Riegos tradicionales Júcar (Ribera Baja)	204	305	183	40 %
URBAN SUPPLY	Supply	Proposal 2005/06		
	2005/06	From Júcar River	Other sources	Reduction w.r. to 2004/05
Abastecimiento Albacete	15	10	5	33 %
Abastecimiento Valencia	126	70	56	44 %
Abastecimiento Sagunto	7	4	3	43 %
INDUSTRIAL USE				
Central N. Cofrentes	20	15	5	25 %

Effectiveness of the measures

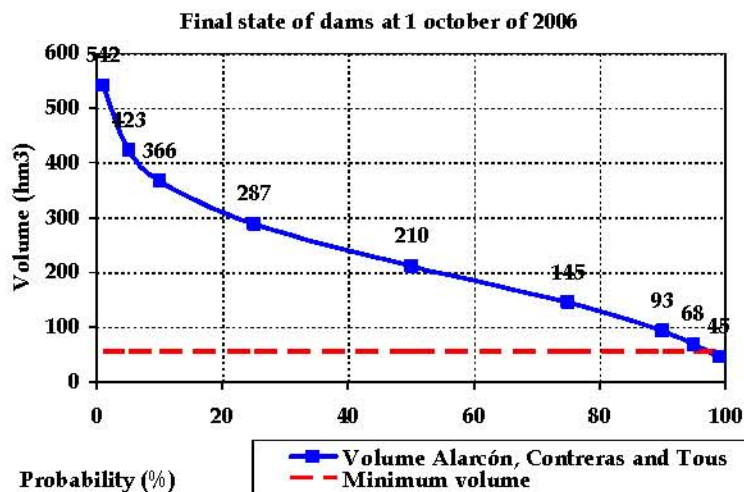
February forecasts (if measures are applied)

Deterministic forecast: Future volume reservoir evolution
Using same Inflows as last year (2004/05)

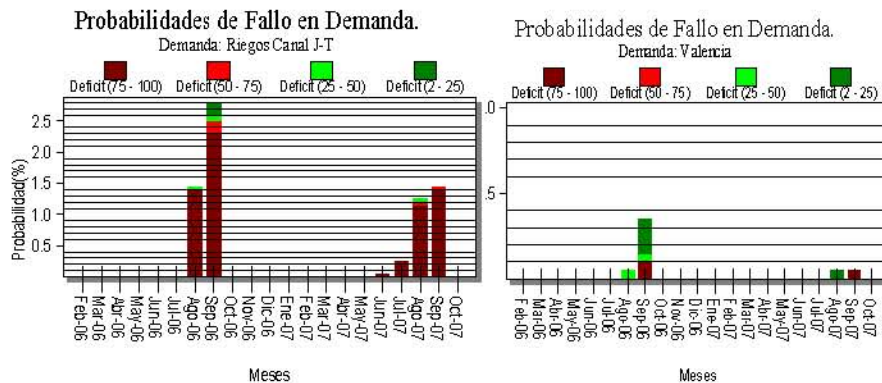


New February Stochastic forecast

for 1 October 2006 (if measures are applied)



Probability of failure in urban and agricultural areas



March 2006 Agreement for irrigation supply from S

IRRIGATION	Supply 1994/95	Supply 2004/05	Reduction w.r. to 2004/05	Proposal 2005/06
			Surface water	Surface water (Hm3)
Regadíos canal Júcar Turia	42	46	60 %	18,4
Asignación para sustitución de bombeos y consolidación de MO	0	21	60 %	8,4
Riegos tradicionales Júcar (Albacete) (*)	8,7	8,7	45 %	4,8
Riegos tradicionales Júcar (Ribera Alta y Baja)	383	621	43 %	354

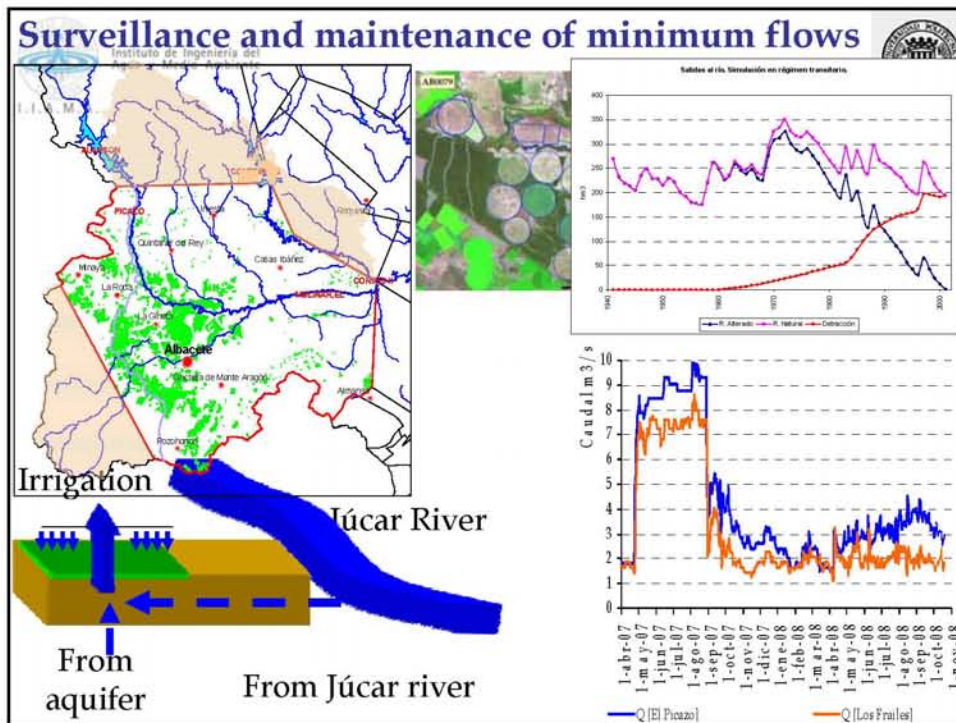
REGADIOS SUBTERRANEOS

Ahorro generalizado en las extracciones en el conjunto del acuífero de Mancha Oriental: 15% respecto a 406 hm³ (61 hm³). Posibilidad de materializar en tres años, con un mínimo del 5% en el primer año. **Aprobada la modificación del Plan de Explotación de la JCRMO en su Asamblea del 25 de marzo de 2006**

Ahorro en las extracciones en pozos con afección prácticamente inmediata al riego similar a las tomas superficiales: 45%.

TRAMO MEDIO DEL JÚCAR

Posibilidad de indemnización económica por reducciones adicionales



La Mancha Aquifer Use Reduction 2007-08

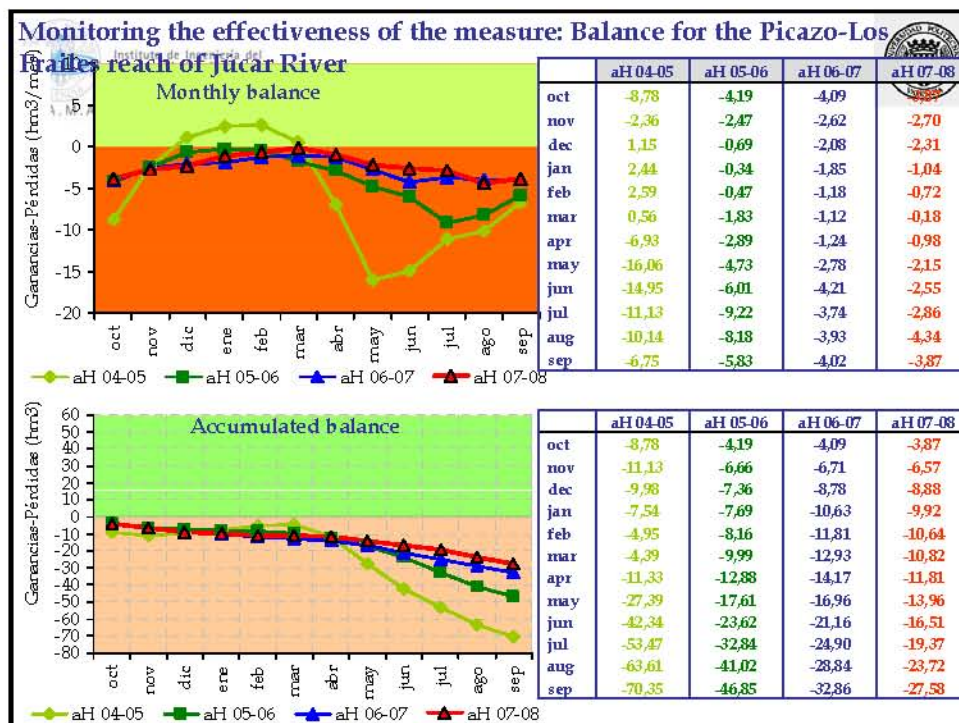
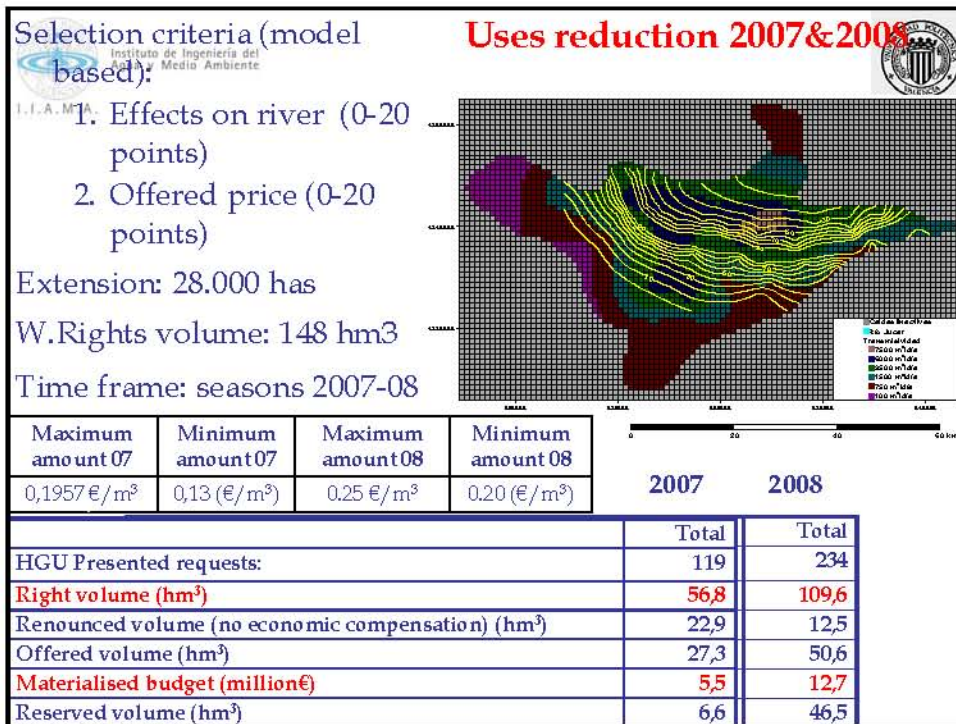
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1. **Public offer agreement for water rights acquisition in the middle section of the Júcar basin due to environmental reasons**

Objective: Reducing extractions in the middle section of the Júcar river, both in surface water and in the area of the aquifer with a greater effect on the river flow.

2007 Rights acquisition and **adaptation** through **reduction of irrigated surface**.

2008 Rights acquisition and **adaptation** by using less water-consuming crops (spring crops) (**Changes in crop patterns**)





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Surveillance middle section of Júcar river

Objective: flow maintenance downstream from Alarcón reservoir



Júcar river in summer 1995



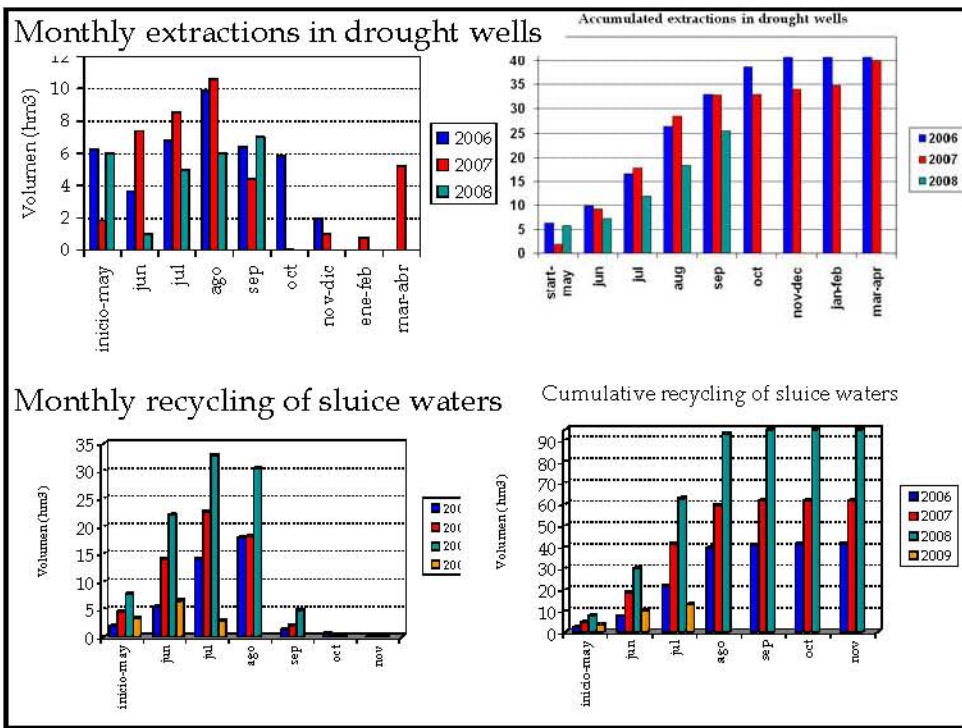
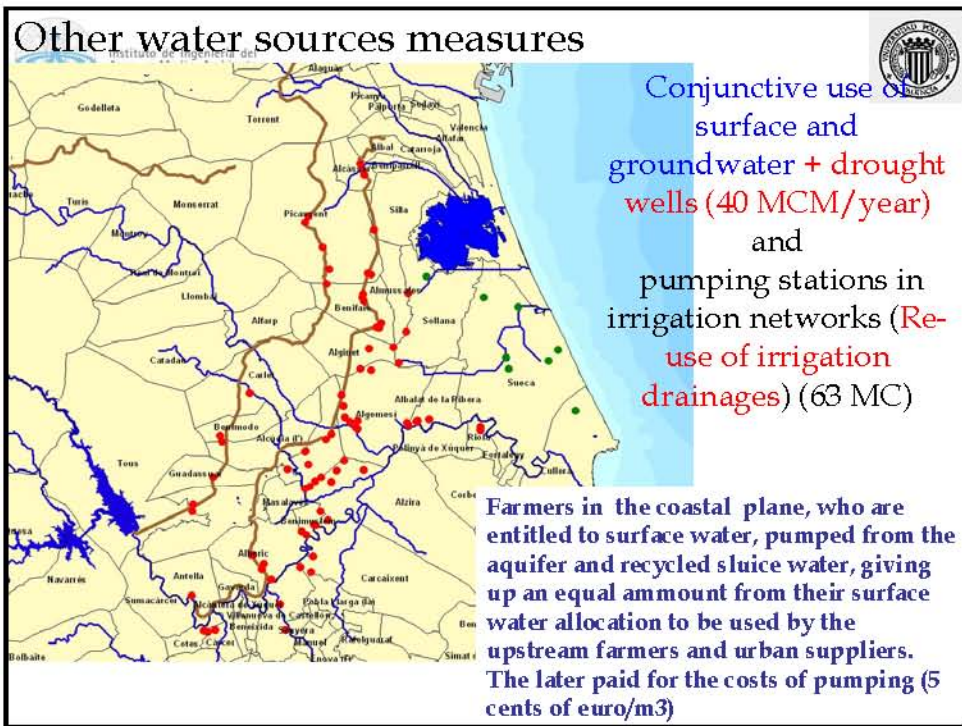
Júcar river in summers 2006 and 2007

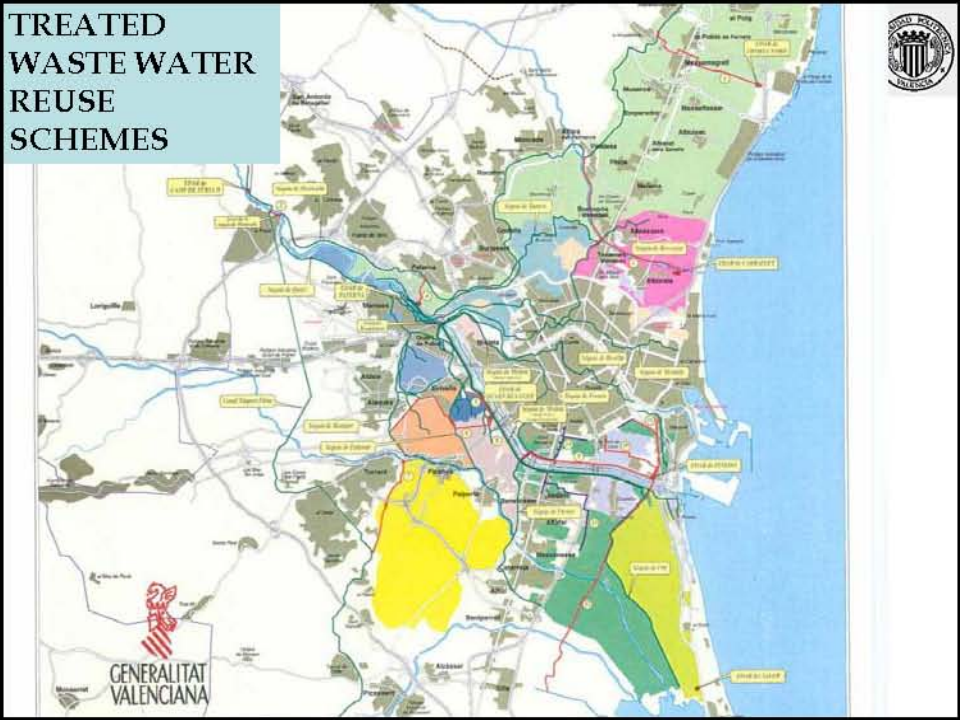
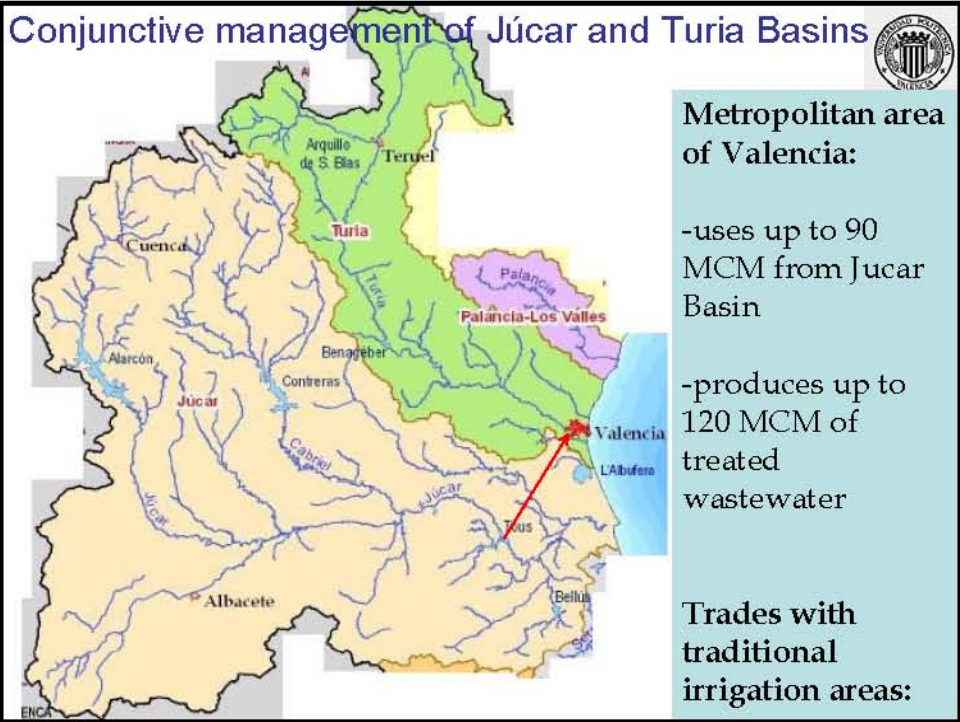
Strict control of water abstraction:

- Satelite & field control in MO aquifer
- Meters at main canals automatically meas.

Demand management and water savings (increased water use efficiency):

- Turns in traditional irrigated farms (every 15 days)
- Improvement in trad. Conveyance system







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DIRECT REUSE OF RECLAIMED (TREATED) WASTEWATER



Volumes of Direct re-use of treated wastewater during drought

EDAR	Pinedo II. Extension		Quart-Benatger	Carraixet	Paterna-Pte.del Jarro		TOTAL
UDA	Tradit.I. Vega de Valencia. Rest of Ditches	Del Oro Ditch	Tradit.I. Vega de Valencia. Rest of Ditches	Tradit.I. Vega de Valencia. Rest of Ditches	Tradit.I. Vega de Valencia. Rest of Ditches	Tradit.I. Vega de Valencia. Real Ac de Moncada	
User	Favara Ditch (B)	Del Oro Ditch (G)	Ditches of Andarella (B), Yirivella (B), Benager (B), Faitanar (B) y Favara (G)	Rascanya Ditch (B)	Formos Ditch (G)	Real de Moncada Ditch (B)	
	(Hm ³)	(Hm ³)	(Hm ³)	(Hm ³)	(Hm ³)	(Hm ³)	(Hm ³)
2005/06	6.015	22.156	0	0	0	0	28.171
2006/07	6.781	50.153	9.008	3.791	0.603	0.829	71.165
2007/08	9.946	66.857	12.782	3.444	0.214	0.913	94.157

Environmental measures Albufera Lake (Ramsar Wetland)

Monitoring network:

- Lake level
- Outflow in the 5 canals
- Inflows in some ditches



Special control & monitoring of Aquifers, and Springs
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Drought wells: flows, levels, and w.quality

W. Quality of Re-cycling in irrigation network

Transparency: Public information on CHJ web page
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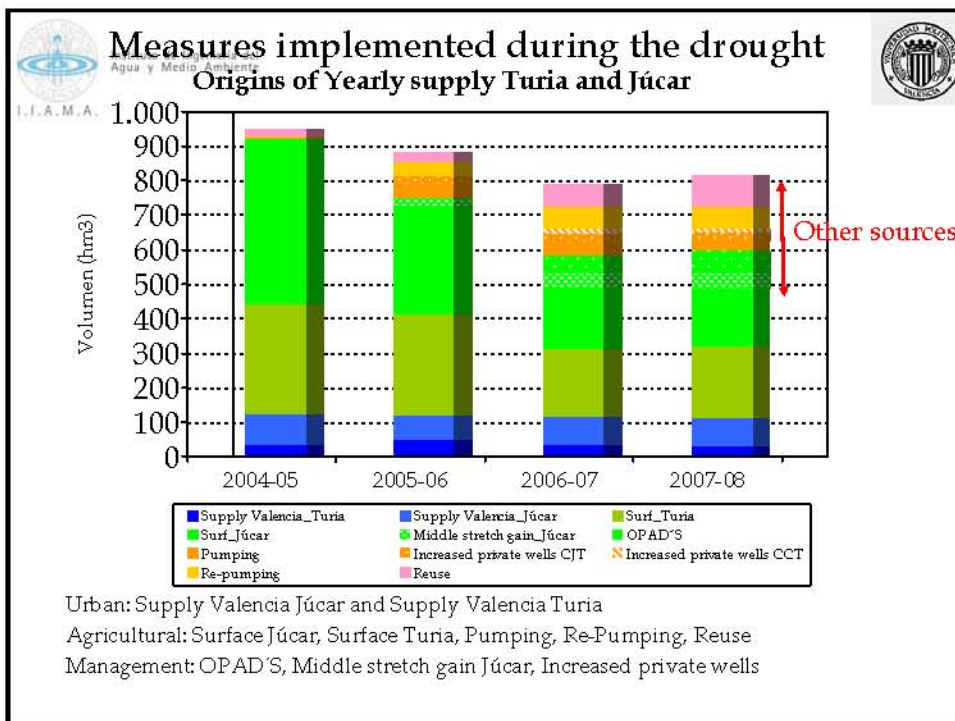
WWW.CHJ.ES

INFORME DE SEGUIMIENTO DEL INDICE DE ESTADO DE LA RED BASICA DE PREZONERIA EN EL AMBITO TERRITORIAL DE LA CONFEDERACION HIDROGRAFICA DEL JUCAR

Enero de 2009

COMUNICACION Funcionamiento Interzona

AGUA

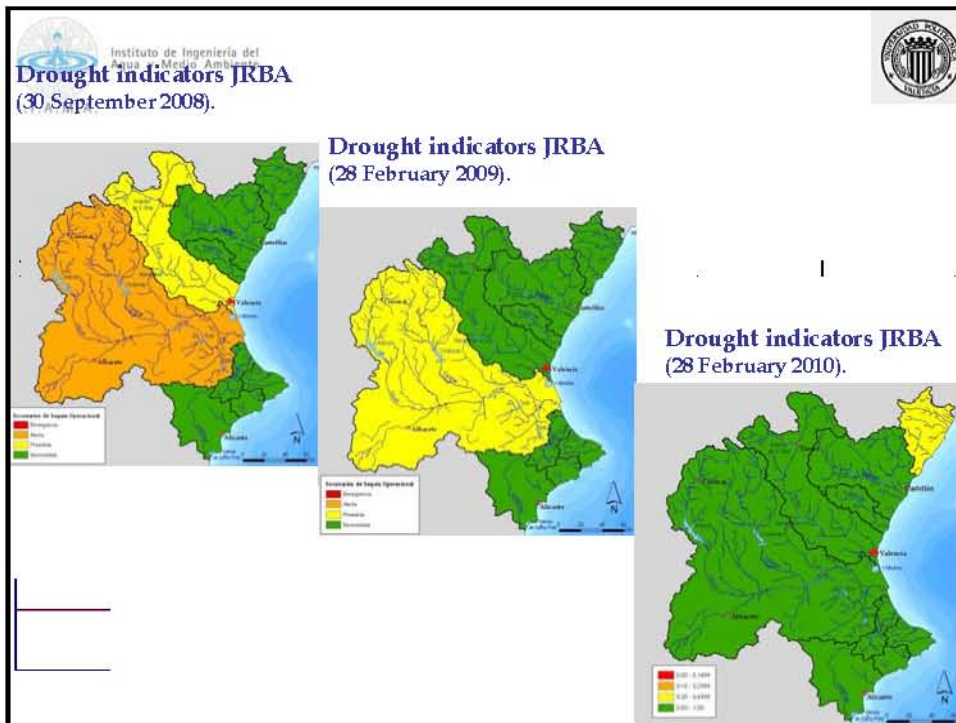


Emergency works

Main investments in:

- Improvement in the supply guarantee for urban areas and sources for alternative resource
- Improvement in drinking water treatment systems
- Improvement in the efficiency of irrigation systems

Emergency Works	Budget (thousand €)
Emergency Works 2005	19.285,0
Emergency Works 2006	35.286,0
Emergency Works 2007	15.350,0
Emergency Works 2008	4.940,0
Total	74.861,0






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Conclusions & Recommendations


DSS in Planning

- **DSS are essential** for the purpose of providing
 - Integration,
 - Transparency
 - easiness of use by PMA and
 - shared vision for conflict resolution.
- They are also very valuable for
 - sensitivity analysis
 - risk assessment
 - Trade-off assessment

	DSS in Planning	
I.I.A.M	DSS USE DURING NEGOTIATIONS PROVIDES MANY ADVANTAGES:	
u	Development of MODELS, SHARED by the technicians, stakeholders, and policy makers: SHARED VISION OF the SYSTEM	
u	OBJECTIVE FRAMEWORK AND REFERENCE that allows each group to evaluate the consequences of the alternatives that are proposed by them and by the others.	
u	TOOL FOR the RATIONAL ANALYSIS OF MANAGEMENT AND OPERATION POLICIES of resulting systems (CRUCIAL FOR REACHING AGREEMENTS AND TO AVOID FUTURE CONFRONTATIONS)	
u	OBJETIVITY OF TECHNICAL ASPECTS that allows negotiations to be developed IN SOCIAL AND POLITICAL TERMS THAT ALLOW EQUITABLE AGREEMENTS.	



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CONCLUSIONS

- Water **Scarce** Basins are usually also **drought** prone
 - We will never have 100% reliability.
 - Permanently prepared for droughts.
- New drought management policy
 - Planning and proactive vs. Emergency and reactive
 - Special Drought Plans
 - Efficient water management oriented to drought
 - Anticipation: Indicators must be useful to anticipate, and to manage drought (not only statistical figures) at basin or water resources system scale:
 - CHJ-OD Indicators + Risk assessment (MODELS)
- Drought = CONFLICT: participation, negotiation, transparency, tools and knowledge available to the stakeholders, ...
- Thrust atmosphere, cooperation, consensus
- Important role of DSS as a tool for drought risk estimation, planning and management, efficiency of measures, and as a common shared vision among the stakeholders.



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CONCLUSIONS (Cont.)

- 2005-2008 Drought was the worst in recorded history
- Permanent Drought Commission Plans of action:
 - Equilibrium
 - Environment protection measures
 - Control and management measures
 - Water conservation
 - Alternative resources generation
 - **EFFICIENT** resource allocation
- The most intensive drought in historical records was passed with:
 - Low environmental damage (reversible)
 - Low decrease in agricultural production (due to other circumstances, benefits were higher in some areas) (loses due to a simultaneous freezing in citric and fruits were higher)
 - No restrictions on urban uses
- **Science and Policy can go together.**
- Every drought is different:
 - SDP are guides
 - But drought management must rely on **adaptation** to each drought



Thank you for
your
attention!

