

The future of water reuse

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DEMOWARE
Water Reuse Conference
Innovation for a competitive water reuse sector
Barcelona, 13 and 14 June 2016



Escola Tècnica Superior d'Enginyers
de Camins, Canals i Ports de Barcelona

UNIVERSITAT POLITÈCNICA DE CATALUNYA



Five aspects...

- The relevance of water reuse for supply reliability and environmental stewardship
- The contexts that have promoted the two basic water reuse options:
 - non potable reuse (NPR) and
 - potable reuse (PR)
- The current trends in water reuse
- The advances of water reuse in Spain (and Europe)
- The challenges and opportunities in front of us

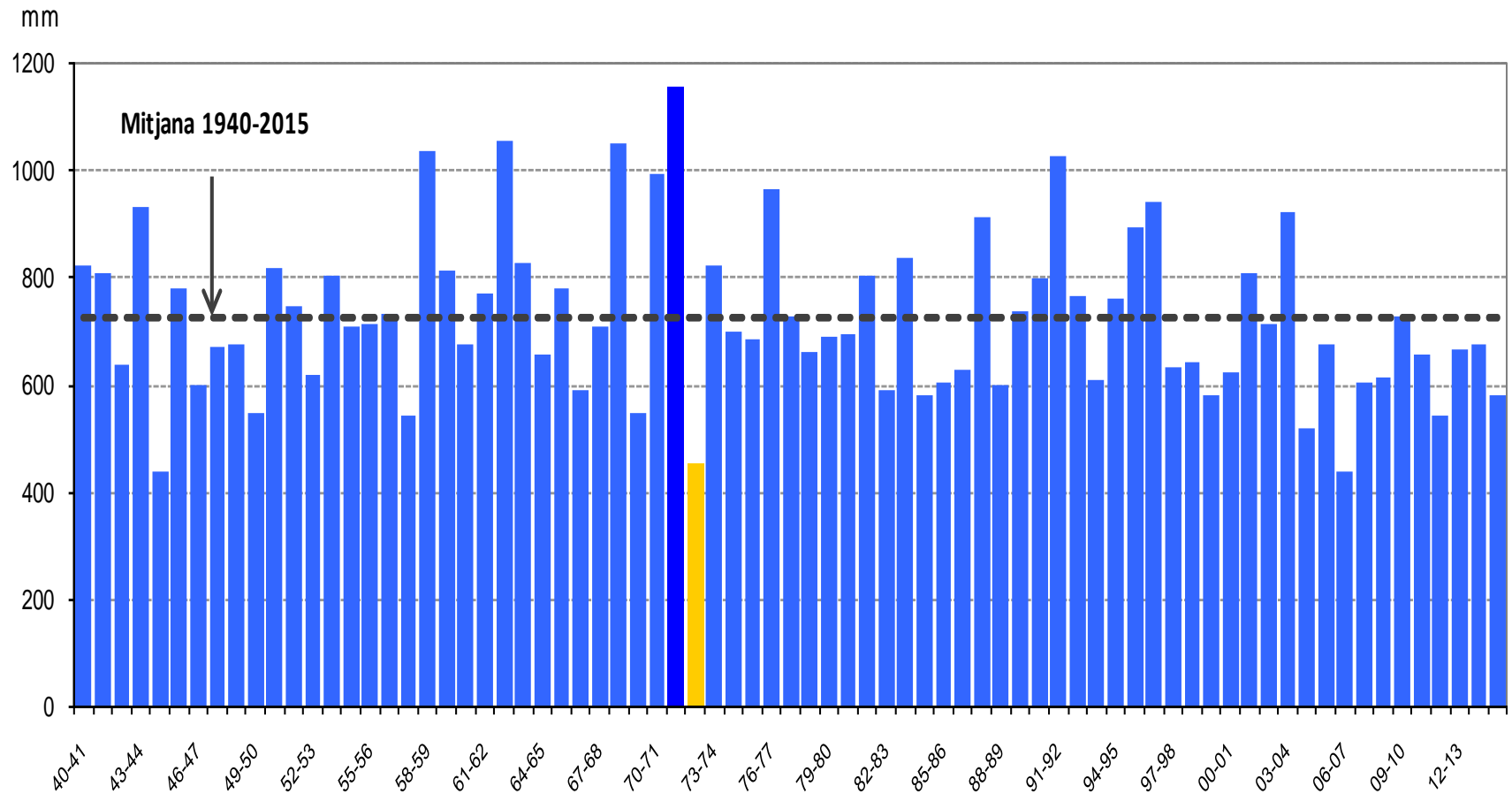
As a preliminary summary...

- Water reclamation and water reuse are two basic ***strategies for integrated management*** of water resources
- That have not reached its ***universal legitimation***
- That have been prompted ***by strict necessity***: droughts, chronic deficits and environmental enhancement
- They are based ***on drinking water*** production technologies
- With ***institutional collaboration*** as determining factor
- They have a ***tremendous potential*** for generating new resources, economic development and jobs
- They require wider ***vision and innovation***

Water perspectives...

- There is ***a finite*** amount of water resources (energy nexus) to care our natural environment and an increasing population (7,300 millions, at 150 p/min; 180,000 p/day...)
- Water consumption intensifies and concentrates in large urban areas, in an inevitable growth pattern
- The agriculture sector offers to provide food for all
- The natural environment has a recognized legal right (WFD)
- Climate change models anticipate:
 - larger rain ***irregularity***, both geographically and seasonally
 - a ***mean annual reduction*** of 5 % in our territories

Annual rain intensity in DCFC...



Integrated management...

- We have several strategies to satisfy water demands using available resources:
 - Water sources protection and improvement (sanitation)
 - **Conservation** (ahorro) and efficient use of water resources
 - Water **storage** (regulación): existing reservoirs, off-stream reservoirs and aquifers (*water banks*)
 - Exchange and transfers among water rights holders (*concesionarios*): Consorcios, Mancomunidades, trasvases, DCFC...
 - **Water reclamation and reuse**
 - Desalination of sea water and brackish water

...two basic drivers...

- **Provide new water sources** (*costal vs interior*)
 - during droughts, weather irregularities and chronic deficits
 - increasing *self-sufficiency, using local water sources*
- **Facilitate treated effluents management:**
 - offering alternative disposal options to the natural environment
 - promoting the possibility for “zero discharge”
- They are independent options, but can be consecutive options

... a really complex strategy...

- Water reuse has numerous dimensions, as it is:
 - a **technical (*excellence*) issue**
 - a public health issue
 - an economic and financial issue
 - a regulatory issue
 - an institutional management issue
 - an environmental issue
 - a land planning issue
 - an industrial issue
 - a public perception issue (culture, impure water...)
 - an ***integrated water resources management*** issue

... that needs a clear terminology

- **To reclaim:**
 - Adapt water quality to its use requirements
 - It is performed in a water reclamation plant
- **To reuse:**
 - Provide reclaimed water to users, by means of:
 - a (*dual*) distribution network
 - a storage facility (*regulación, logística*)
 - some user regulations
- Regardless of whether it is centralized or decentralized
- Recycled water (California, Australia); NeWater (Southeast Asia); Recycled sewage (United Kingdom)

with benefits and requirements

- Provides ***additional resources*** (costal vs. interior)
- It is a ***local water source***
- Expands ***self-sufficiency*** of water resources
- Improves ***supply reliability***, particularly in semi-arid zones

- Requires a new mentality: ***elaborate a product (with a cost)*** of great quality, instead of generating a residue
- A ***strict operation*** (similar to potable water supply)
- The ***political will*** to make it one basic element of integrated management of water resources

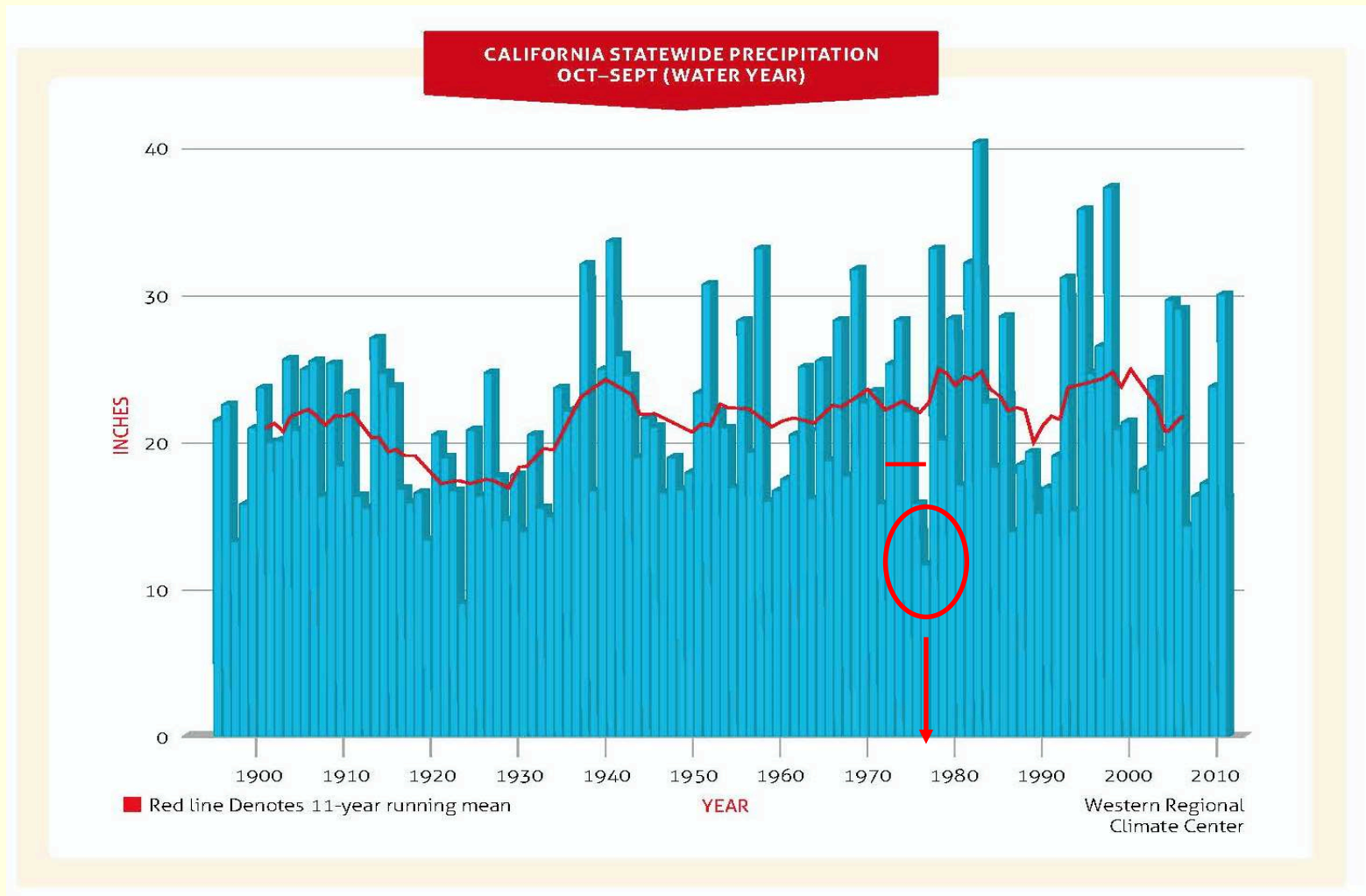
... with numerous applications....

- ***Non potable:***
 - Agriculture and landscape irrigation
 - Urban uses: toilets, fire fighting, street cleansing, car washing, dust control
 - Industrial uses: cooling, process, vehicle washing
 - Recreational uses: ornamental ponds or lakes
 - Environmental protection and enhancement: wetlands
- ***Potable:***
 - Groundwater recharge: infiltration and injection
 - Improving drinking water supplies
 - Augmentation of drinking water supplies

... with a diverse evolution...

- Non potable reuse:
 - basically from unrestricted irrigation
- Potable reuse:
 - starting from indirect potable reuse (IPR), using an ***environmental buffer***
 - Followed by direct potable reuse (DPR)
- Different historical circumstances and motivations
- Different models of promotion and regulatory approval

The 1976 y 1977 drought...



...resulted in 4 initiatives...

- Founding the *Office of Water Recycling de California*, 1978
 - Nominating Dr. Takashi Asano as scientific officer
- Changing *Title 22 of the **California Water Code***
 - offering the possibility to irrigate raw eaten food crops with reclaimed water
- Conducting the ***Monterey demonstration project***, 1980-85
- Editing the *Guidance Manual on Irrigation with Reclaimed Municipal Wastewater*, 1984
 - Translated to Spanish in 1990, UPC and GdC

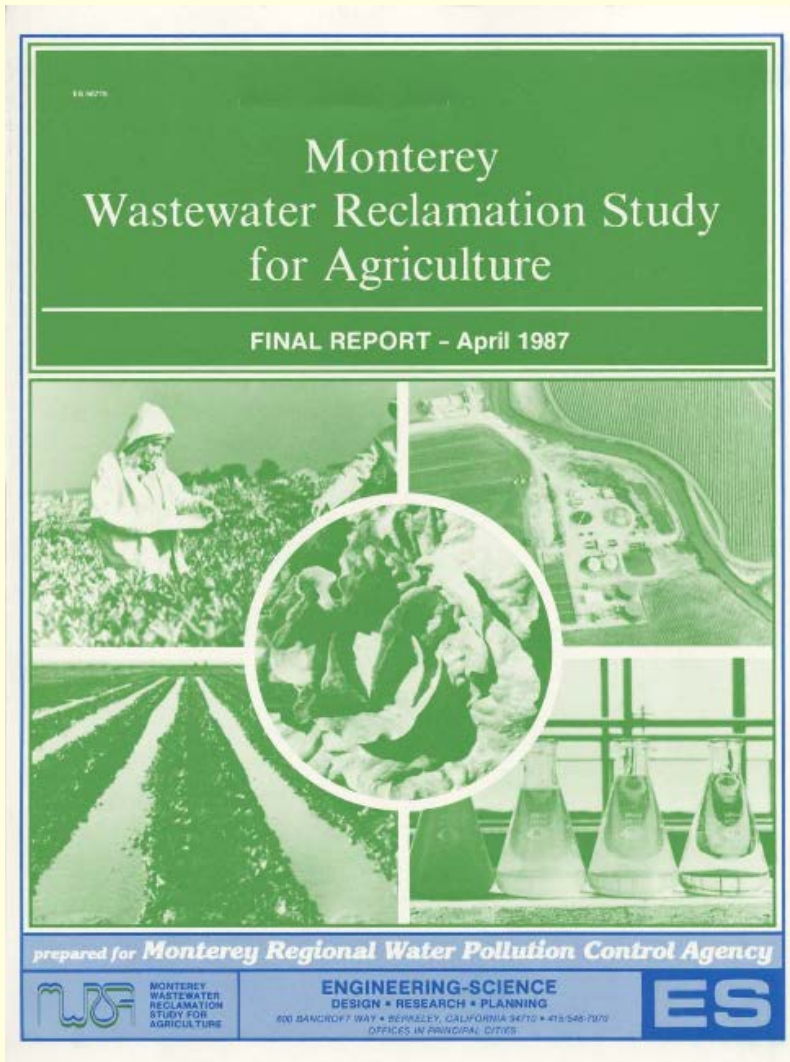
Title 22 of the Water Code...

- Introduced the possibility of *using reclaimed water* for unrestricted irrigation of
- ...*raw eaten food crops*
- Using a good biological secondary treated effluent...
- ... followed by a *physico-chemical reclamation* process.....
- consisting in a *drinking water production process*
- ...with similar requirements of reliability, performance , efficiency and cost
- Basically, preventing “*incidental dilution*”

The Monterey Project, 1980-85



... with a final report...



Duration:
5 years (1980-85)

Budget:
5 million USD

Institutional collaboration:
State Water Resources Control Board
Department of Health Services

Main participant:
University of California

and an institutional reference...



G. S. Pettygrove y T. Asano

...legitimated in Salinas Valley...



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California Farm Water Success Stories: Interviews with Innovative Growers and Water Managers

Innovative growers and water managers throughout California are finding sustainable ways to manage water, providing benefits both on and off the farm. Here are the *California Farm Water Success Stories* interviews.

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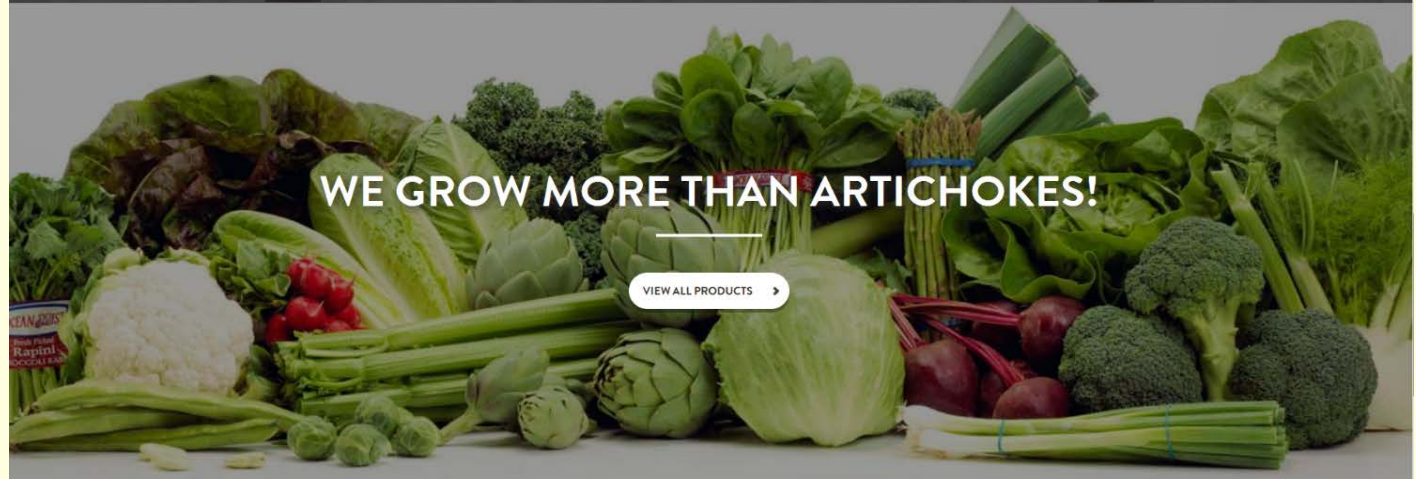


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...in landscaping in CCB, 1989...



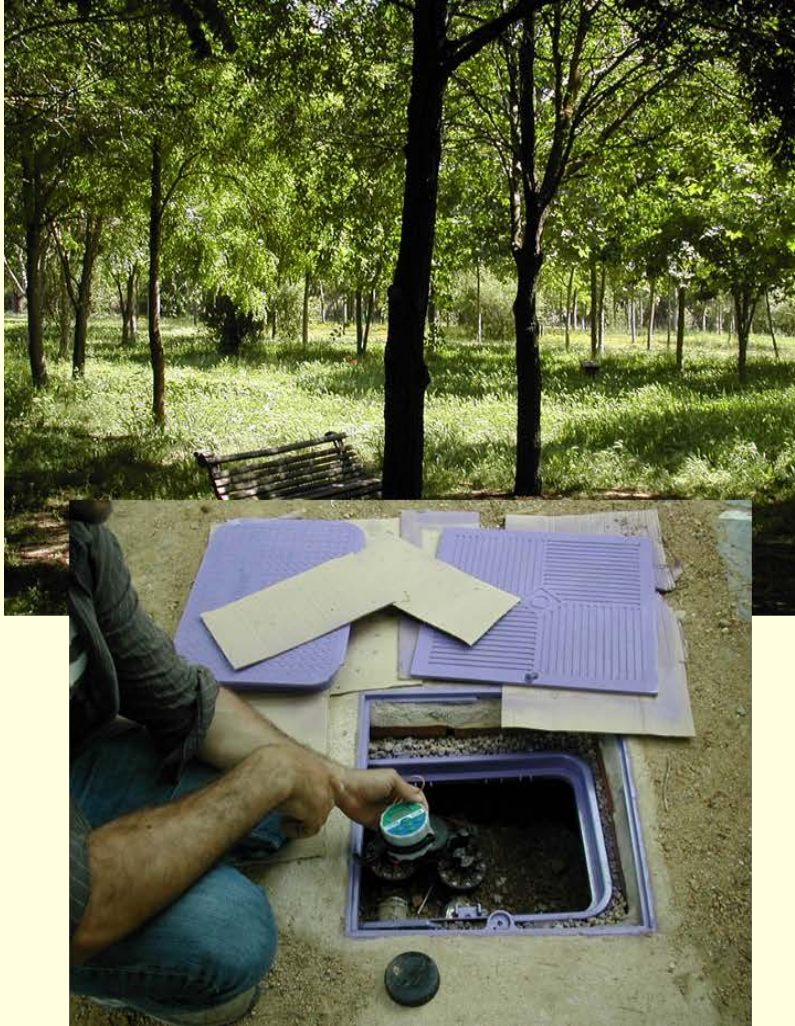
... Spanish “Title 22”, in 1994...



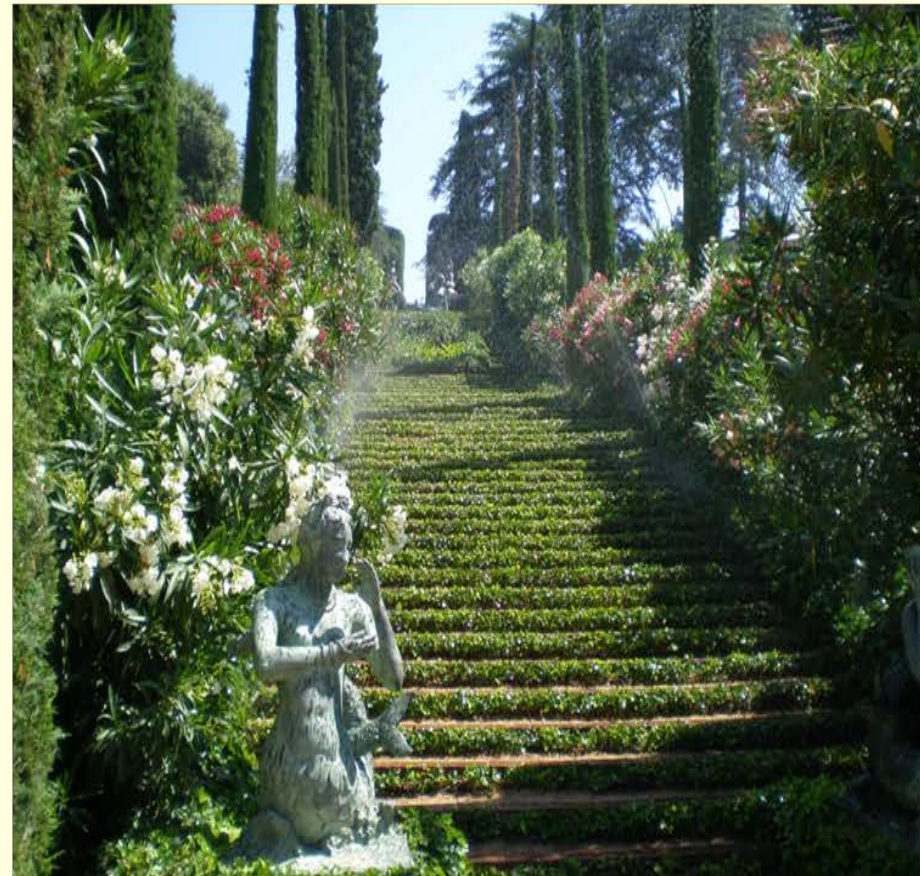
...in Port Aventura, 1995...



... urban use, Tossa de Mar, CCB



... in Lloret de Mar, 2007, CCB



landscape and cleaning, Madrid



The RD 1620/2007...

- 30 years after Title 22....motivated by **necessity**... and **opportunity**: the drought of 2006 and 2007
- Personal decision of Director General Jaime Palop
- That certainly needs complementary provisions...
- ... that **we have to develop gradually** (like others)
- Remembering that it involves a **certain economic cost**
- With an essential requirement for **institutional coordination**

... water rates for irrigation...

Núm. 227 – 27 de novembre de 2013

BOP
Butlletí Oficial de la Província de Girona



Pàg. 94

Núm. 12999

CONSORCI DE LA COSTA BRAVA

Anunci d'aprovació definitiva de la modificació d'una ordenança reguladora de preus públics

Al no haver-se presentat reclamacions durant el termini d'exposició al públic, i en compliment del mateix acord, queda automàticament elevat a definitiu l'acord de modificació del text de l'article 3 - categoria B de l'ordenança reguladora del preu públic per la prestació del servei de proveïment regular a usuaris d'aigua regenerada de les instal·lacions de regeneració del Consorci de la Costa Brava aprovat per la Junta General en la sessió realitzada el dia setze de setembre de 2013, el text íntegre de la qual es fa públic en compliment de l'article 17.4 del Reial decret legislatiu 2/2004, de 5 de març, pel qual s'aprova el Text refós de la Llei reguladora de les hisendes locals.

“Categoria B - Reg agrícola - Qualitat 2.1 del RD 1620/2007

Categoria	Volum anual m ³	Quota fixa mensual €	Quota variable €/m ³
B1 - Conreus intensius	Fins a 30,000	40	0,100
B2 - Comunitats de regants	Més de 30,000	80	0,015

Termes addicionals en la tarifa de la categoria B

- Ús espai públic (estacions bombament, instal·lació elements mecànics, etc.)*= 40 – 240 euros/ mes, segons superfície ocupada i/o afectació
- Ús estació transformadora d'energia elèctrica * = 40 – 240 euros/ mes
- Impulsió = Preu variable segons necessitats de bombament en cada cas. A expressar en €/m³.”

Exemption of disposal charges..

EDARs	Terciario (€/año)	Bombeos (€/año)	Total (€/año)
Pinedo II	1.123.584	14.029	1.137.613
Quart-Benàger	80.689	54.517	135.207
Cuenca del Carraixet	77.482	54.746	132.229
Paterna-Fuente del Jarro	361.107	92.956	454.062
Puebla de Farnals	96.765	66.917	163.683
TOTAL	1.739.628	283.166	2.022.794

Coste de analíticas RD 1620/2007: 33.000 €/año

Volumen regenerado: 60 hm³/año

Coste regeneración (EPSAR): $2.022.794 + 33.000 = 2.055.794$ €/año

Coste: 0,034 €/m³

¿Es posible que el titular del vertido dedique parte de su ahorro en CCV a financiar la regeneración?

Con un 50% del CCV el coste: 0,027 €/m³

EDARs	CCV * (€/año)
Pinedo II	-
Quart-Benàger	605.540
Cuenca del Carraixet	180.168
Paterna-Fuente del Jarro	40.038
Puebla de Farnals	-
TOTAL	825.746

*previsión CCV 2015

Abstraction fee from Turia 2016: 0,0014 €/m³

... the more expensive water is ...



BARRY BAKER

CO-OWNER, BAKER FARMING COMPANY

... big challenges and supports

- Fall of 2006, a national outbreak of *E. coli* in fresh spinach in the USA
 - 131 affected, 66 hospitalized, 1 dead
- Identified source: Salinas Valley
- Intervention of the *Food and Drug Administration* (FDA)
- ***Discarded*** prohibiting the use of reclaimed water
- Identified a ***cross-contamination from other farm sources***

WaterReuse risk assessment...

¿CUÁL ES EL RIESGO?

Comparación de la exposición a PFCEs a través del agua regenerada con respecto a sus usos convencionales

La gráfica muestra una comparación de las exposiciones típicas a tres Productos Farmacéuticos y de Cuidado Personal (PFCEs) – antidepresivo, ibuprofeno, hormona – con respecto a la exposición a esos mismos productos químicos a través de un agua regenerada, en el marco de los cuatro casos diferentes en los que una persona puede entrar en contacto con ellos. En cada caso de exposición – escolar, agricultor, jardinero y golfista – la gráfica muestra el número de años que cada una de esas personas debería participar en cada una de esas actividades antes de que alcanzara una dosis diaria individual a cada compuesto químico equivalente a una exposición convencional.

Número de años de exposición al agua regenerada necesarios para igualar la dosis convencional.



KEY: Cuatro casos concretos en los que las personas pueden entrar en contacto con un agua regenerada.



El escolar



El agricultor



El jardinero



El golfista

..detection and significance...

- Recent publication of “proof of concept” that fruits and vegetables uptake carbamazepine and metabolites when irrigated with reclaimed water
- Authors detected 0.1 ng/g (carrots and tomatoes) and nearly 100 ng/g (lettuce and parsley)
- WaterReuse Association has provided an assessment
- Assuming an acceptable daily intake of 0.34 $\mu\text{g}/\text{kg}\text{-day}$
- It will take 204 years for an “vegan” individual to accrue a lifetime acceptable intake
- It will take 2040 years for a non-vegan individual

Legal follow-up...



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Michigan E. coli O157:H7 Outbreak Linked to Bagged Lettuce, Again. Food Safety Attorney, William Marler, Gives History Lesson.

Posted on September 27, 2008 by [E. coli Lawyer](#)

This is a press release being distributed by Marler Clark:

Seattle— "E. coli O157:H7 outbreaks associated with lettuce or spinach, specifically the "pre-washed" and "ready-to-eat" varieties sold under various brand and trade names, **are by no means a new phenomenon**," according to food-safety attorney, William D. Marler, of Marler Clark. By way of illustration:

- in October 2003, thirteen residents of a California retirement home were sickened, and **two people died**, after eating E. coli-contaminated, pre-washed spinach;
- in September 2003, nearly forty patrons of a California restaurant chain fell ill after eating salads prepared with bagged, pre-washed lettuce; and
- in July 2002, over fifty young women fell ill with E. coli O157:H7 at a dance camp after eating "pre-washed" lettuce, leaving several hospitalized and one with life-long kidney damage.

And this is just a small sampling of the twenty or more E. coli O157:H7 outbreaks since 1995 in which spinach or lettuce was the source.

Several more outbreaks linked to contaminated leafy-produce, including most recently the **September 2005 Dole packaged lettuce outbreak**, are identified in the chart below, which is based on information gathered by the [Center for Science in the Public Interest](#):

Legal consequences...

The screenshot shows the Marler Clark law firm website. The navigation menu includes: HOME, FIRM PROFILE, PRACTICE AREAS, LAWYERS, NEWS & EVENTS (highlighted), MEDIA RELATIONS, FAQs, and CONTACT. The main banner features the firm's name "MARLER CLARK ATTORNEYS AT LAW L.L.P. P.S." and the tagline "The nation's foremost law firm with a practice dedicated to representing victims of food poisoning." Below the banner is a breadcrumb trail: Home » News & Events » Press Releases » Michigan E. coli O157:H7... and a search bar. The main article is titled "Michigan E. coli O157:H7 Outbreak Linked to Bagged Lettuce Again" and dated September 26, 2008. The article text discusses food safety attorney William Marler's perspective on E. coli outbreaks linked to lettuce and spinach. A sidebar on the right contains navigation links for Case News, Press Releases, Firm News, Events & Speaking Engagements, and Publications. At the bottom, there is a "BREAKING NEWS" section with two items: "E. coli O157:H7 - Washington State: At least 17 ill in Snohomish County, linked to Ixtapa Restaurant" and "E. coli O157:H7 - Vermont: Ten Illnesses traced to Vermont Livestock,..."

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Michigan E. coli O157:H7 Outbreak Linked to Bagged Lettuce Again

September 26 2008

Food Safety Attorney, William Marler, Gives History Lesson.

"E. coli O157:H7 outbreaks associated with lettuce or spinach, specifically the "pre-washed" and "ready-to-eat" varieties sold under various brand and trade names, are by no means a new phenomenon," according to food-safety attorney, William D. Marler, of Marler Clark. By way of illustration:

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» Case News
« Press Releases
» Firm News
» Events & Speaking Engagements
» Publications

BREAKING NEWS

- ! E. coli O157:H7 - Washington State: At least 17 ill in Snohomish County, linked to Ixtapa Restaurant
- ! E. coli O157:H7 - Vermont: Ten Illnesses traced to Vermont Livestock,

Internet 100%

... we never seem to learn...

“ Date Vehicle Etiology Reported Cases States/Provinces

Aug. 1993 Salad Bar E. coli O157:H7 53 1:WA
July 1995 Lettuce (leafy green; red; romaine) E. coli O157:H7 70 1:MT
Sept. 1995 Lettuce (romaine) E. coli O157:H7 20 1:ID
Sept. 1995 Lettuce (iceberg) E. coli O157:H7 30 1:ME
Oct. 1995 Lettuce (iceberg; unconfirmed) E. coli O157:H7 11 1:OH
May-June 1996 Lettuce (mesclun; red leaf) E. coli O157:H7 61 3:CT, IL, NY
May 1998 Salad E. coli O157:H7 2 1:CA
Feb.-Mar. 1999 Lettuce (iceberg) E. coli O157:H7 72 1:NE
July-Aug. 2002 Lettuce (romaine) E. coli O157:H7 29 2:WA, ID
Oct. 2003-May 2004 Lettuce (mixed salad) E. coli O157:H7 57 1:CA
Apr. 2004 Spinach E. coli O157:H7 16 1:CA
Sep. 2005 Lettuce (romaine) E. coli O157:H7 32 3:MN, WI, OR

The most recent major E. coli outbreak ties to leafy greens was the Dole Spinach outbreak of 2006. This included 205 illnesses due to E. coli O157:H7 reported the CDC. This number included 31 cases of HUS, 102 hospitalizations, and 3 deaths. The FDA maintained its conclusion that all the implicated spinach was traced back to Salinas Valley in California.

“We never seem to learn,” said Mr. Marler. In November 2005, the FDA elucidated its past efforts and present concerns in its “Letter to California Firms that Grow, Pack, Process, or Ship Fresh and Fresh-Cut Lettuce.” The letter begins:

RECENT NEWS

- » Michigan Environmental Health Association
- » North Dakota Environmental Health Association (NDEHA) Conference
- » Washington State the Latest Victim in Surge of E. coli Outbreaks

... yes, we have learned that...

- Success requires an integrated quality management within agriculture operations
- Using an excellent quality water
- With institutional and sector support
- Adapting Decrees and Orders that ***prohibit (?)***
- Adopting a systematic publicity of all the activities
- Promoting a “***quality brand name***”
- Because the risks of non compliance can have overwhelming.....

... economic risks...

CRISIS ALIMENTARIA

La 'crisis del pepino' provoca pérdidas "cuantiosísimas" a la agricultura española

La ministra de Medio Ambiente admite que lo que está ocurriendo afecta a la producción española.- Los agricultores almerienses calculan las pérdidas en más de seis millones de euros al día

CRISIS SANITARIA

Bruselas ofrece 210 millones de euros a los agricultores perjudicados por la 'crisis del pepino'

La compensación, que mejora en 60 millones la anterior propuesta, cubre el 50% de las pérdidas, según la Comisión.- España y otros ocho países exigieron ayer una cobertura de entre el 90% y el 100% de las pérdidas

≡ EL PAÍS 

SOCIEDAD

EDUCACIÓN SALUD CIENCIA MEDIO AMBIENTE IGUALDAD CONSUMO COMUNICACIÓN TECNOLOGÍA TV BLOGS TITULARES »

La UE cubrirá el 100% de las pérdidas causadas por la crisis del pepino

La Comisión eleva a 227 millones las ayudas a los agricultores afectados.- 71 de ellos serán para España, principal perjudicada

... 40 years after, 2010's...

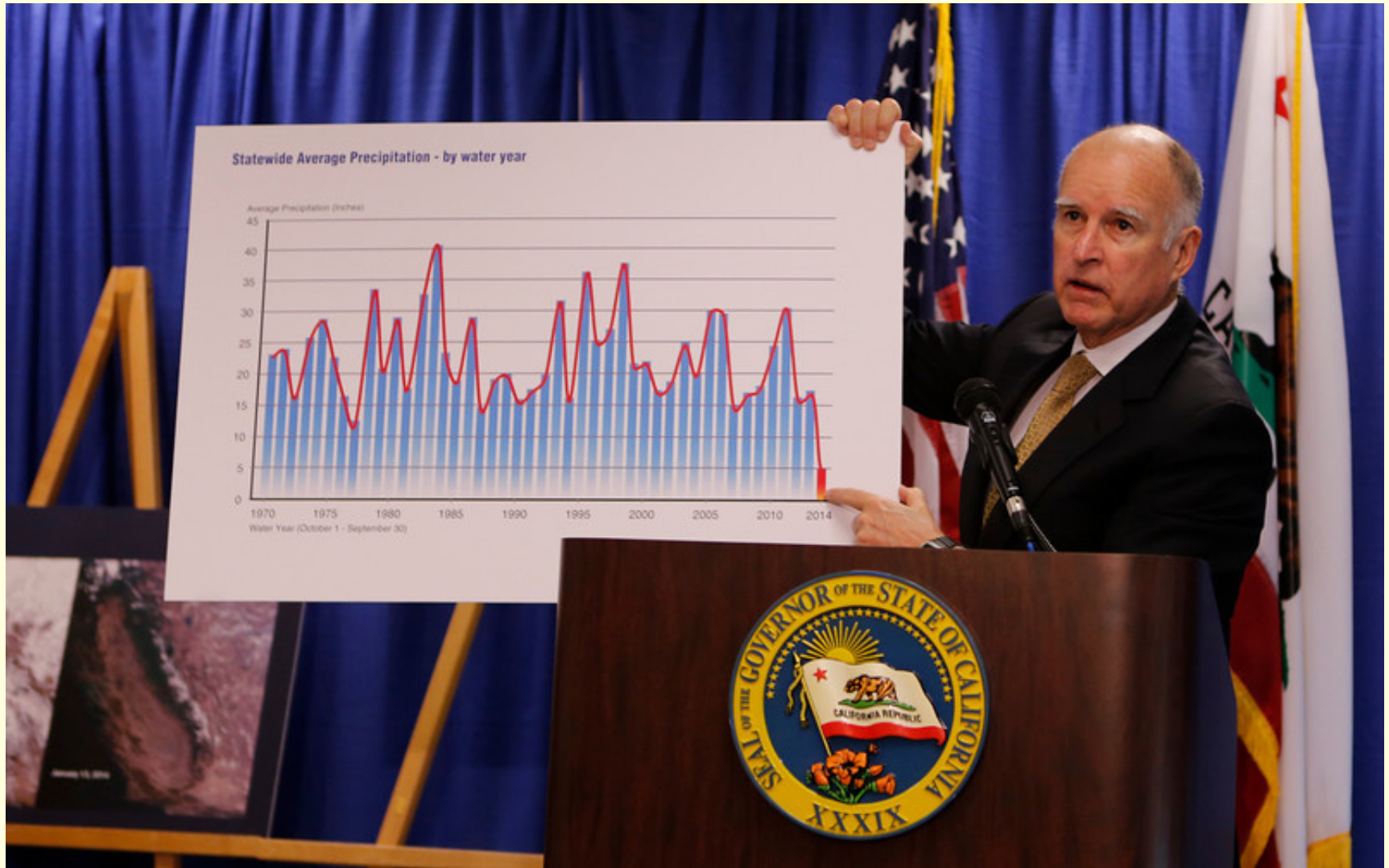
- Great progress in water purification technologies: microbiological and chemical quality
- The economic and energy costs of expanding water distributions networks **have become excessive**
- A new **strategy** has emerged:
 - diminish the investments in water distribution
 - increase the investments in advanced reclamation
- Producing high quality water (equal or better than potable)
- That can be distributed using **existing networks**....
-after obtaining its public legitimacy

... we knew that since 1994...

In Vitoria-Gasteiz:

- An investment of **3.25 M€** for the basic WRP, with capacity for 35,000 m³/d (400 L/s; **12.5 hm³**)
- Annual costs for O&M of **0.4 M€**, to produce 12.5 hm³ per year of water for unrestricted irrigation
- An investment of **16.2 M€** to build a dual distribution system to irrigate 10,000 ha, including water pumping
- A storage reservoir (off-stream) of 7 hm³ capacity, with an investment of **11.8 M€**

Drought emergency: 17/01/2014



Indirect potable reuse, 2008



380,000 m³/d=130 hm³/y (2015)

... purified water...

Table ES-1 2014 Average Purified Recycled Water Quality¹

Parameter Name	Units ¹	FPW ^{2,3}	Permit Limit
Electrical Conductivity	µmhos/cm	95 ⁴	900
Total Dissolved Solids	mg/L	54	500
pH	units	8.2 ⁴	6 – 9
Chloride	mg/L	7.5	55
Total Nitrogen	mg/L	1.8	5
Arsenic	µg/L	<1 ⁵	10
N-nitrosodimethylamine (NDMA)	ng/L	1.8 ⁶	N/A
1,4-Dioxane	µg/L	<1 ⁵	N/A
Total Organic Carbon (unfiltered)	mg/L	0.16	0.5 ⁷
Total Coliform (Colilert Method)	MPN/100 mL	<1 ⁵	2.2

¹ See Acronyms list for units abbreviations

...superior to potable water?...



... I can't believe ! ...



<http://www.cbsnews.com/news/depleting-the-water/>

Main economic features...

Project Funding and Timing



- ▶ **Capital Cost: approximately \$481 million**
 - ▶ Split equally between OCWD and OCSD
- ▶ **Expandable to 130,000 afy**
- ▶ **Costs comparable to imported water**
 - ▶ Project received \$92 million in state and federal grants, and \$4 million per year (21 year) operation and maintenance subsidy from Metropolitan Water District
 - ▶ Costs \$480 per acre-ft (\$850 per acre-ft without subsidies)
- ▶ **Operational since January 2008**



- 130 hm³/y (up to 160 hm³/y)
- 380,000 m³/d (335 d/y)
- 3.8 \$ y/m³
- 0.70 \$/m³
- 0.40 \$/m³ (subsidized)

... approaches have changed...

- The California DWR has opted for promoting demonstration and construction projects, using 725 M\$ since 2014
- In 2012, the WaterReuse Foundation and the WaterReuse Association launched the *California Direct Potable Reuse Initiative (2009)*
- Up to 2014, la WRF had sponsored 26 research projects on DPR worth 11.5 M\$
- 6 M\$ were received during 2015

... the *DPR Initiative*...

- The DPR Initiative has promoted that Congress form:
 - an Expert Panel (12 members)
 - an Advisory Group (14 members)
 - Coordinated by the National Water Research Institute (NWRI)
- The Expert Panel has to elaborate 3 documents
 - “*Regulations for groundwater replenishment using recycled water*”, approved in June 2014
 - “*Regulations regarding surface water augmentation with recycled water*”, to be presented by December 2016
 - A report to Congress about the “*feasibility of developing uniform water recycling criteria for direct potable reuse*”, to be presented by December 2016.

... with two recent changes...



- July 2014, California did incorporate the Drinking Water Program into the State Water Resources Control Board
- April 2016, a new regulation has been proposed to allow restricted distribution of bottled reclaimed water for promotion and education purposes

advanced reclamation in AMB...



Tarragona: industrial uses

Phase I: 7 hm³/y (2012)

In 2014: 2 hm³/y

Phase II: 10 hm³/y

Phase III: 20 hm³/y



...a quality ..of *potable* water

...reclaimed water...

Table 5 | Reclaimed water quality at the outlet of Camp de Tarragona AWRP and in the water distribution network to the Camp de Tarragona industrial park

<i>Legionella</i> spp. (cfu/L) ^a	<i>Escherichia coli</i> (cfu/100 mL) ^a	TSS (mg/L)	Turbidity (NTU)	Helminth eggs (ova/10 L)
<80	<1	<2	<0.2 – 0.3 (<0.6 in	<1

^aDetection limit of the analytical method

Reclaimed water from the Camp de Tarragona AWRP has an average electrical conductivity of 20 $\mu\text{S}/\text{cm}$ and a TOC lower than 0.2 mg/L, which makes it perfectly suitable for

the number of water users during the second semester of 2014 and reach the 2 hm³/year production capacity established in the action program approved by the CWA.

An economic analysis made by the AITASA-Veolia operating company indicated a production cost of 0.5 €/m³ for advanced reclaimed water, during the 1-year guarantee

El Port de la Selva, CCB



Riera de Rubiés, 7.6 km y 14.5 km²

Recent droughts < 350 mm/y

Water supply: 305,000 m³/y

Sanitation: 185,000 m³/y

Demoware UE project , CCB



600 m³/d
90,000 m³/y (50%)

In summary...

- The main motivation for water reuse: intense droughts and environmental enhancement
- Water reclamation is becoming increasingly **more**:
 - reliable, efficient and economic (*it is not free*)
- Water reuse has reached a wide development and acceptance for ***non potable uses, since 1980***
- An opportunity is ***strongly emerging*** (by ***necessity***) for:
 - reclaiming water to an advanced level
 - using aquifers and reservoirs to storage and distribute
 - using existing distribution networks
- Its legitimacy has been achieved in only a few places

... an opportunity to advance...

- We have emblematic projects at an international level
- However, technical or economic excellence are not guarantee of success
- A pro-active attitude among professional associations is strongly required (*water resources and public health*)
- A change in attitude is required among professionals, academics, researchers, regulators and users
- With a renewed outreach effort: a **quality brand name**
- California, Namibia, Singapore and Australia are leaders
- ... we could solve our water supply while enhancing our technological, labor and companies development



asersa

Asociación Española de Reutilización Sostenible del Agua

¡Reutilicemos el agua!

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*"Impulsemos juntos
el uso eficiente de los
recursos hídricos"*



La Actualidad del Sector



La recarga del acuífero de El Port de



Contaminantes emergentes:



Agricultura urbana con agua



Thank you
for your attention !