Study Tour 2008: Final Report

**United Arab Emirates (Dubai) - Israel - Spain**

# Sustainable water sources, innovations and applications

## Opportunities for Australia

October 20 - November 7, 2008

HAL

Know-how for Horticulture™

arris

**This study tour was developed by Arris Pty Ltd**

Authors:
Daryl Stevens, Jim Kelly and Jodie Hannaford.

Arris Pty Ltd
646A Bridge Road
Richmond, Vic 3121
PO Box 5143
Burnley, Vic 3121

Phone +61 3 9421 1701
Fax: +61 3 9421 1706

# CONTENTS

# I Introduction to Study Tour

## 1.1. Background

Local government and councils are under increased pressures from communities to improve and maintain public open spaces; providing amenities for general quality of life in the urban landscapes (parks, gardens and turf – amenity horticulture). As water resources become more challenged, individuals will have less lawn, increasing the reliance on public open spaces for sport and leisure activities, providing communities health and wellbeing benefits and minimisation of injuries from hard bare surfaces.

Similarly, many production horticulture operations are finding their water supplied restricted. This tour will help identify better ways to locate and manage alternate water supplies, maximise water use benefits and economic returns, while minimising environmental impacts.

During the tour there was a focus on the philosophy of reduce, reuse and recycle. This is used to identify irrigation systems and water sources that require less operational energy, less embodied energy, less use of materials and recycling waste materials.

## 1.2. Support


The tour is an extension to the Australian Coordinator for Recycled Water use in Horticulture (ACRWH) project (HAL Project HG06170) which focuses on facilitating the use of an alternative water source (recycled water) for urban and rural horticulture systems.

The delivery of research and development outcomes from this study tour (funded by HAL and managed by Arris Pty Ltd) is made possible by the Commonwealth Government's 50% investment in all Horticulture Australia's research and development initiatives.

## 1.3. Outline and Objectives

The study tour focuses on participants identifying Australian opportunities for the amenity and production horticulture industries by:

- Experiencing first hand international approaches to managing water sources and wastes and understanding management strategies and how barriers for adopting these methods were overcome;
- Understanding how some of the most 'water poor' countries have managed to combat pressure for more effective use of water using innovative, world leading technologies and methodologies;
- Understanding competitive challenges faced by international production horticulture industries and how they have been overcome;
- Exploring technology and application methodology used to combat water shortages and maximise quality and efficiency in horticulture;
- Identifying opportunities for Australian research and development projects and exploring infrastructure opportunities for the future; and
- Identifying marketing opportunities appropriate for consideration by the horticulture industry.

Participants of this study tour include:

- Industry leaders in horticulture;
- Industry leaders in water supply to horticulture (e.g. water authorities);
- Companies responsible for the infrastructure, reticulation and delivery of water supplies;
- Key researchers for both the water and horticultural industries; and
- Government employees responsible for water resources in States/territories of Australia (DPI, EPA).

The study tour participants each have different points of focus with respect to their core business. By travelling together and visiting a range of study sites covering a variety of interests, a combined study tour stimulates new ideas and innovative ways of addressing issues at the end use, water supply chain, and catchment levels. Participants learn from the sites visited, but also learn more about each other's businesses and how to improve them by working as an integrated team and understanding all components of the systems they operate in and manage.

These participants represent leaders in horticulture and associated industries. When they return to Australia the international networks they have created will help inform business decisions and assist in identifying, securing and efficiently using water resources across a range of horticultural industries.

The impact from the tour will be far reaching both for participants who will reflect on their experience for several years to come, and individuals throughout the industry or with an interest in efficient use of water in agriculture.

Additional benefits of the joint study tour are:

- Cross pollination of ideas from participants from Australia and hosts/presenters at international study sites;
- Non-mainstream ideas being discussed openly in a forum stimulated by what you see, who you talk to and the information that you read; and
- Creation of networks and relationships within Australia and internationally that support the development of progressive, informed, efficient amenity and production horticulture industries.

### 1.4. Study Tour Focus

A range of alternative water sources:

- Desalination
- Cloud seeding
- Membrane technology
- Water disinfection
- Effluent reclamation via groundwater replenishing
- Reverse osmosis
- Stormwater – urban or rural
- Groundwater

A variety of water uses:

- Urban and amenity horticulture (e.g. landscapes, gardens, turf, playing fields, public spaces)
- Production horticulture (e.g. vegetables, stone fruit, olives, grapes, citrus)
- Dairy & broadacre crops
- Industrial (e.g. manufacturing, cooling)
- Some links to drinking quality from the above uses.

Considerations, ideas to explore within alternative water sources and uses as identified above:

- Impact on climate change and carbon management
- Improving commercial viability & understanding commercial implications
- Integrated agricultural solutions – resource efficiency
- Integration of energy production and water treatment – small scale, localised wastewater reclamation plants improving economics of sourcing and recycling
- Water, energy, waste – linkages & sustainability
- Selling sustainability – within horticulture industries, to general public, etc
- Managing public perception associated with alternative water sources – including value perceptions
- Controlled climate and greenhouse horticulture solutions
- On-site wastewater management and water recycling
- Recycled water quality, pricing, consistency – value equations
- Use of biomass for energy and soil amendments
- Management of alternative water source plants – contractual arrangements, private versus government funded, performance management, sustainability considerations, asset ownership, commercial considerations, demonstrating value, etc
- Community cooperation / collaboration to achieve water efficiencies & enable appropriate supply.

# II Detailed Programme Summary

| Date | Country | City / Town | Study | Description of study area |
|---|---|---|---|---|
| 20/10/2008 | Australia | | Travel day | |
| 21/10/2008 | United Arab Emirates | Dubai | International Centre for Biosaline Agriculture | This Dubai-based water technology research institute was established in 1996 by the Islamic Development Bank (IDB) and is also supported by other donors, including the Arab Fund for Economic and Social Development, the OPEC Fund for International Development (OFID) and the Municipality of Dubai. |
| 21/10/2008 | United Arab Emirates | Sharjah | Schlumberger Water Services – Aquifer Storage & Recovery | Site visit to ASR pilot test site in Sharjah.<br>Understand aquifer storage and recovery in arid environments.<br>A water resource management technique in which water is injected into carefully selected aquifers to be treated or safely stored underground until needed. |
| 22/10/2008 | United Arab Emirates | Dubai | Metito – Alternative solutions for sludge handling – using sludge to power wastewater plants | Modern trends in wastewater treatment, upgrading conventional systems, optimising sludge disposal methods.<br>Awarded the highly prestigious 'Desalination Company of the Year 2006' by the Global Water Intelligence magazine in recognition of the company's significant and valuable contribution to the industry worldwide. Visit to Plant at Palm Jumeirah. |
| 22/10/2008 | United Arab Emirates | Dubai | MASDAR – Middle East Centre for Sustainable Development (MECSD); eco aware building principles, LEED | Masdar City in Abu Dhabi will be the world's first zero-carbon, zero-waste and car-free city. It will be generated by photovoltaic panels, while cooling will be provided via concentrated solar power. Water will be provided through a solar-powered desalination plant and landscaping within the city, as well as crops grown outside the city, will be irrigated with greywater and treated wastewater produced by the city's water treatment plant. |
| 22/10/2008 | United Arab Emirates | Dubai | Dinner Guest Speaker: Francois Dao – Acciona | *Creating an ecologically aware organisation – driving energy efficiency*<br>- Exploring the latest developments in sustainability<br>- Adapting streamlined operations and maintenance processes<br>- Integrated water management<br>- Looking into latest treatment init. |
| 23/10/2008 | United Arab Emirates | Dubai | Sembcorp Desalination Plant – Fujeirah Independent Water and Power Company | Fujeirah is approximately 100 kms from Dubai (NE)<br>Hybrid plant – Water and Power<br>The two year old facility consists of a gas-fired power plant which has a net capacity of 535 megawatts and a hybrid seawater desalination plant employing a combination of multi-stage flash and reverse osmosis technology to produce 100 MIGD of water.<br>A further 225 megawatts of power generation capacity will be added to the facility.<br>Construction of the new plant, to be situated adjacent to the existing plant, will commence immediately and commercial operation is expected by the first quarter of 2009. Upon completion, the plant's total generation capacity will reach 760 megawatts. |
| 24/10/2008 | Dubai | Jerusalem | Travel day | |
| 24/10/2008 | Israel | Jerusalem | Dinner and night tour of Jerusalem | Arranged by Netafim. |
| 25/10/2008 | Israel | Jerusalem | Rest day | Sabbath in Israel. |
| 26/10/2008 | Israel | Bet Shemesh | Atlantium | UV Disinfection<br>Atlantium develops and provides innovative water disinfection solutions that help businesses and municipalities build, expand and operate water-intensive processes. Their field-proven solutions have taken UV water disinfection to levels never before attained. They do this through a cost effective, environmentally friendly process that delivers unprecedented microbe inactivation, at industrial and municipal water flow rates. |
| 26/10/2008 | Israel | Tel Aviv | Shafdan Reclamation Plant – Mekorot (Israel's National Water Company) | Water treatment: investigation and development of cutting-edge technologies; optimisation and upgrade of existing plants.<br>Shafdan reclamation plant – Israel's largest plant, handling over 113.1Mil cu.m of reclaimed water, ensuring the required effluent level, effluent reclamation by groundwater infiltration, and supplying the reclaimed water to agricultural consumers in the southern part of the country through the "Third Negev Pipeline." Mekorot handles the sewage treatment and purification process on behalf of municipalities, and takes the water for extra-purification and distribution for agriculture.<br>The Shafdan purification plant, which is responsible for the purification of wastewater from cities in the Dan region and its reuse for agricultural purposes, is one of the largest and most advanced of its kind in the world.<br>A tour of Shafdan includes a description of purification methods and transport to the Negev, as well as movies and demonstration facilities. |

| Date | Country | City / Town | Study | Description of study area |
|---|---|---|---|---|
| 26/10/2008 | Israel | Rosh Ha'ayin | Mekorot Hayarko Springs Centre at Rosh Ha'ayin | Continuous water supply: improvement of the reliability of the water supply through advanced control and optimisation technologies with more efficient infrastructures. Also looking at management systems for improved control and optimisation of all processes.<br>Yarkon Springs at Rosh Ha'ayin is Israel's primary water "intersection". At this location, the National Water Carrier arrives from the north of the country and is combined with water from springs located at Rosh Ha'ayin. From here, water flows to the Negev in two large pipelines and to the Dan region in another pipeline. Hear an explanation of Israel's national water supply system, including Israel's various aquifers, and a tour of the site's pumping stations. An introduction to cloud seeding will also be presented (movie) as it is not the season for cloud seeding. |
| 26/10/2008 | Israel | Emek Hefer | Biogas site in Emek Hefer | A new project for the treatment of agricultural sludge has recently been inaugurated in Emek Hefer. The facility will treat agricultural sludge, in general, and dairy farm waste, in particular, by means of anaerobic digestion which produces biogas.<br>The facility, which will produce both compost and electricity, is the largest one of its kind in Israel. It will treat the cow wastes of all of the dairy farms in the Regional Council of Emek Hefer and of adjacent regional councils (Menashe, Carmel and Lev Hasharon) which number some 12,000 cows. |
| 26/10/2008 | Israel | Caesarea for dinner – overnight in Haifa | Dinner Speaker – Grand Water Research Institute (GWRI) @ Technion – Prof Rafi Semiat | The mission of the Grand Water Research Institute is to advance by research and development the science, technology, engineering, and management of water, through inter-disciplinary research and development and dissemination of information, with emphasis on the issues and problems facing Israel's water sector.<br>Focus on planning and big picture considerations as well as current R&D. |
| 27/10/2008 | Israel | Haifa | Bahai Gardens in Haifa – Landscape irrigation | Bahai Gardens run on bore water that is treated with an RO plant and UV. The site is about 12 hectares and has 3 separate systems – drinking water, irrigation and fire protection lines. The reason for this is that they planned that in the future irrigation water will come from recycled water. Chosen as world heritage listed sites, the two shrines are noteworthy for the formal gardens that surround them, blending design elements from many cultures. In addition to Baha'i pilgrims, they attract hundreds of thousands of visitors and tourists every year. |
| 27/10/2008 | Israel | Lower Galilee region | Eshkol site of the national water carrier in the Lower Galilee region | Water quality: improvement of water quality through the development/investigation of cutting-edge disinfection and treatment methods; R&D to support the deployment of the National Filtration plant; development of continuous water monitoring systems.<br>At this site, located in the Beit Netofa Valley (in the lower Galilee), water, coming from the Sea of Galilee (by open canals, pipes and reservoirs) is treated before being supplied to customers. The site is divided to 2 reservoirs: a settling reservoir and an operating reservoir. In the settling reservoir water goes through a series of treatments, and in the operating reservoir water entry to the National Carrier pipe is regulated according to the various needs. Then, the cleaned water is carried south to regional water supply systems around Israel and from there supplied to customers from the urban, industry and agricultural sectors. |
| | | | | Some years ago due to more strict standards of water purification set by the Ministry of Health; Mekorot decided to use filtration as the most effective means to ensure the required turbidity level and built the central filtration plant in the Eshkol site. The Central Filtration Plant in the Eshkol site is one of the world's most complex water filtration facilities. With a capital cost of $100 million plant and annual filtering capacity of more than 500 million cu. m., the plant integrates advanced technologies, engineering methods, and state-of-the-art operating procedures. Its automated control system ensures reliable, fast, and safe filtering of water at low cost. |
| 27/10/2008 | Israel | Beit Zera | Arkal – in Kibbutz Beit Zera | Arkal water filtration solutions have been successfully applied in over 90% of the world's agricultural/landscape micro-irrigation markets.<br>Arkal also has a number of water treatment solutions for a variety of applications: potable water systems, tertiary wastewater systems, industrial and commercial systems, RO systems. |
| 28/10/2008 | Israel | Sea of Galilee | Sapir Station Centre at the Sea of Galilee | This centre is located at the site of the first pumping station of the National Water Carrier. Here, deep inside the earth, three huge pumps lift water from the Sea of Galilee 209 metres (640 feet) below sea level to a height of 50 metres above sea level. A visit to the site includes a guided tour of the pumping tunnel, explanation of the pumps' sophisticated operation, and a movie explaining the construction of the National Water Carrier and Mekorot's system which supplies water throughout Israel. |

| | | | | |
|---|---|---|---|---|
| 28/10/2008 | Israel | Yiftach | Kibbutz Yiftach<br>Netafim – drip irrigation and irrigation technologies | Visit agricultural projects and fields using re-used water in the area.<br>See Orchard training centre.<br>Netafim made history in 1965 with its unique concept drip-irrigation and today they are the world's largest drip-irrigation manufacturer. Netafim has over $US250Mil in sales with 30 billion emitters in operation and an annual additional three billion emitters. Netafim is recognised as the global leader in the field of innovative-based solutions and water technologies whilst protecting the surrounding environment. |
| 29/10/2008 | Israel | Dead Sea | Nahal Og Reservoir – Wastewater treatment plant and palm plantations | The Nahal Og reservoir located in the plains of Jericho is part of a chain of reservoirs that have been rightfully described as "the lowest reservoirs on Earth." It was established before the sources of funding were obtained in order to irrigate agricultural areas in the northern Dead Sea using purified wastewater. The water in the reservoir comes from Ma'aleh Adumim in east Jerusalem, Anatot, and the Mishor Adumim industrial area. The Naama reservoir, presently being constructed to the north, with a capacity of 700,000 cubic metres, will absorb some of the water piped to the Og reservoir, which has a capacity of "only" 1.5 million cubic metres. |
| 29/10/2008 | Israel | Dead Sea | Hotel Wastewater Treatment Plant | This wastewater treatment plant was built and maintained by Mekorot and belongs to the hotels. The plant is now managed and maintained by the Regional Council of Tamar. Hotels in the Dead Sea area deliver their wastewater to the plant where it is cleaned by activated sludge to a level where it can then be reused to irrigate the hotels landscaped areas. |
| 29/10/2008 | Israel | Dead Sea | Salt works – Dead Sea Works | The Dead Sea is a salt lake between Israel and the West Bank to the west, and Jordan to the east. It is 420 metres below sea level, and its shores are the lowest point on the surface of the Earth on dry land. The Dead Sea is 330 m deep, the deepest hypersaline lake in the world. It is also the world's second saltiest body of water, after Lake Asal in Djibouti, with 30 percent salinity. It is 8.6 times saltier than the ocean. Experts say that it is nine times saltier than the Mediterranean Sea (31.5% salt versus 3.5% for the Mediterranean). This salinity makes for a harsh environment where animals cannot flourish. The Dead Sea is 67 kilometres long and 18 kilometres wide at its widest point. It lies in the Jordan Rift Valley, and its main tributary is the Jordan River.<br>In 1952 Dead Sea Works Ltd. (DSW) was established as a State-owned company to extract potash and other minerals from the Dead Sea. |
| 30/10/2008 | Israel | | Netafim Kibbutz Hatzerim | Netafim's new technology training centre at Kibbutz Hatzerim.<br>This unique centre takes visitors on an exciting journey through the history of drip irrigation and provides a vivid introduction to Netafim's products, with the emphasis on making the perfect match between them and each culture and growing method. Here you will see Jojoba irrigated with treated water, the drip irrigation training centre and Netafim factory. |
| 30/10/2008 | Israel | Ashkelon | Ashkelon Desalination Plant | The Ashkelon seawater reverse osmosis (SWRO) plant – the largest in the world – achieved two notable successes in 2006. In March it was voted 'Desalination Plant of the Year' in the Global Water Awards, subsequently passing a major project milestone in October 2006, when, little more than a year after it commenced initial production, it successfully delivered its first 100 million m3 of water. |
| 30/10/2008 | Israel | Ashkelon | City of Ashkelon Water Savings through subsurface drip irrigation | Economical, efficient irrigation solutions for urban areas.<br>The city of Ashkelon has adopted Netafim's irrigation methods and uses UniTechline™AS as subsurface drip irrigation (SSDI) in lawns and gardens all over the city, including extensively in traffic islands. Since the transition to irrigation with SSDI, which began in the early 1990s, there has been a 30% saving of water, compared with similar areas irrigated using traditional methods (sprinklers). Mr. Levi also noted that with the upgrading of the control system and the transition to the use of a Motorola manufactured central control system, a further 25% has been saved, relative to the period in which control systems were adjusted manually or locally. The current system provides the city's irrigation manager with a control room, from where he can regulate thousands of valves irrigating city landscaping, change the volumes of water used by the entire city at the touch of a button and receive warnings in case of faults in the system. |
| 30/10/2008 | Israel | Telaviv | Free night | Early start for Spain the next morning. |
| 31/10/2008 | Israel to Spain | | Travel morning | |

| | | | | |
|---|---|---|---|---|
| 31/10/2008 | Spain | Madrid | Fenacore: Farmers Federation of Irrigators | 1. Presentation providing overview of Fenacore and the various projects they look after. The National Federation of Irrigators Communities of Spain (Fenacore) is a non-profit association and independent politically, with more than half a century of existence, which brings together entities (irrigators' communities, union's irrigation, etc.). Devoted to the administration of water for irrigation, both surface and underground. Areas of interest: • Tackling drought and saving water • Increase water and energy efficiencies • Irrigation focus • Pricing • Environmental implications • Biofuels<br>2. Visit to CoreNet Project – Digital Water Management managed/ endorsed by Fenacore. |
| 1/11/2008 | Spain | Madrid | Rest day | Public holiday – All Saints Day. |
| 2/11/2008 | Spain | Alicante Arrive in Alicante 9:00am | Desalination Plants in Alicante (Operating) & Torrevieja (under construction) | Leave from airport to visit operating desalination plant demonstrating ERI technology in Alicante (arrangements supported by ERI).<br>Energy Recovery, Inc. (ERI) is a leading manufacturer of energy recovery devices, which by drastically reducing energy consumption is helping make desalination affordable and enabling the rapid expansion of desalination plants worldwide. |
| 3/11/2008 | Spain | Alicante | Overview of Alicante Region | The city of Alicante reuses water from the towns' treatment system to irrigate all of the cities parks, medium strips and open park areas. Participants will be shown various sites from the treatment system to the landscape applications; this will include the botanical gardens, golf courses. The group will visit the municipality to look over the infrastructure that was started in 1990. |
| 3/11/2008 | Spain | Valencia | | Overnight in Valencia en route to Barcelona. |
| 4/11/2008 | Spain | Barcelona | Early departure for Barcelona | |
| 4/11/2008 | Spain | Barcelona | ATLL (Aigues TER LLOBREGAT) | Overview of water issues and management in Spain & meet with Barcelona's local water authorities.<br>Visit innovative urban source management / applications.<br>Barcelona's local water authority – Aigues Ter LLobregat (ATLL) is a public company owned by Generalitat de Catalunya (Autonomous government of Catalonia region) and was created in 1990. It is responsible for planning, construction, improvement, management and operation of all networks of drinking water supply in terms of water treatment, pipe distribution system, storage and supply.<br>ATLL supplies water to more than 100 municipalities that represents water supply for more than 4 million people in around 1,800 $km^2$.<br>The global network distribution system is up to date around 50, kms, 141 storage tanks, 54 pumping stations and 202 outlet points of supply.<br>ATLL owns 2 main drinking water plants, one in north Barcelona and the second one in south Barcelona. ATLL is building the Barcelona desalination plant to ensure water supply at mentioned municipalities. |
| 4/11/2008 | Spain | Barcelona | Dinner – last night of tour | Evening activity to be arranged. |
| 5/11/2008 | | | Travel day | |
| 7/11/2008 | | | Arrive Australia | End of tour. |

# 1 Day 1 – Monday 20th October, Australia – Melbourne

## *1.1 Destination: Dubai*

**Focus: Depart Melbourne and arrive in Dubai**

# 2 Day 2 – Tuesday 21st October, UAE – Dubai

## *2.1 Destination: International Centre for Biosaline Agriculture (ICBA)*

**Focus: Research and development innovation**


### 2.1.2 Contact Information:

www.biosaline.org

**Site Address:**

Dubai – Al-Ain Road, Al-Ruwayyah

**Organised by:**

Ghazi Jawad Al Jabri

Communications Coordinator, ICBA

Email: g.al-jabri@biosaline.org.ae

Phone: + 971 4 336 1100

**Site Contacts:**

**Prof Dr Faisal K Taha**
*Director of Technical Programs*

PO Box 14660
Dubai, UAE

Phone +971 4 336 1100
ext 201
Fax +971 4 336 1155
Email f.taha@biosaline.org.ae

International Center for Biosaline Agriculture
www.biosaline.org

**Dr. Shoaib Ismail**
*Halophyte Agronomist*

P.O. Box 14660
Dubai, UAE

Tel: +971 (4) 3361100
Fax: +971 (4) 3361155
E-mail: s.ismail@biosaline.org.ae

Biosaline Agriculture Center

**Ghazi Jawad Al-Jabri**
*Master in International Business*
*Communications Co-ordinator*

PO Box 14660
Dubai, UAE

Tel +971 4 336 1100
ext 212
Fax +971 4 336 1155
Email g.al-jabri@biosaline.org.ae

International Center for Biosaline Agriculture
www.biosaline.org

### 2.1.3 Background

The Middle East and the GCC in particular are highly dependent on desalinated water (used mostly for human consumption) and, consequently, are world leaders in desalination technology. The Middle East has 60 per cent of the world's desalination capacity, and in 2006 the GCC spent $4 billion on desalination technology. This is forecast to increase to $8 billion by 2012, says Shawki Barghouti, director general of the International Centre for Biosaline Agriculture (ICBA).

This Dubai-based water technology research institute was established in 1996 by the Islamic Development Bank (IDB) and is also supported by other donors, including the Arab Fund for

Economic and Social Development, the OPEC Fund for International Development (OFID) and the Municipality of Dubai.

Office & laboratory facilities are located near Al Ruwayyah, 25kms south of central Dubai.

This is also the location for an R&D station – 100 hectares – 35 of which are under irrigation.

Experimentation is done with two sources of water: low salinity (2,000 ppm) & high salinity (20,000 ppm).

Computer controlled irrigation systems – a range of systems are in use including sprinkler, drip, bubbler, travelling irrigator systems.

ICBA has greenhouse & shade house facilities as well as a gene bank.

**Key programs of interest include:**

- Optimising management practices for maximum production of 3 Atriplex species under high salinity levels
- Optimising management practices for maximum production of 2 salt tolerant grasses
- Biosaline Agroforestry – remediation of saline wastelands through production of renewable energy, biomaterials and fodder
- Agroforestry trial using Acacia ampliceps, Sporobolus arabicus and Paspalum vaginatum at different salinity levels
- Development of salt tolerant forages for sheep and goat production
- Evaluation of salinity tolerance and yield in barley varieties and accessions (also for pearl millet & sorghum varieties – fodder beet & fodder rape/Brassica varieties)
- Response of 2 prominent grasses to water salinity
- Feasibility study for biosaline agriculture in UAE
- Utilisation of biosaline agriculture by the national prawn company

**Other areas of interest include:**

ICBA to host Arab Water Academy – what is its charter, focus, etc?

This academy is to be located in Abu Dhabi which is approximately 150 kms from Dubai – How will this work?

**Main researchers of interest are:**

- Dr Abdullah Dakheel (Field and forage Crops scientist); and
- Dr Shoaib Ismail (Halophyte Agronomist).

## 2.1.4 Site Visit

**International Centre for Biosaline Agriculture**

- The first phase of their development was to transfer issues of a scientific plan to a business plan
- The research centre consists of approximately 100 ha
- Managing 7-8 major projects including research into:
    - Date palms
    - Fodder irrigation with saline water for sheep and goats
        - 35-40 t/ha dry matter production
- Abu Dhabi has ≈ 70% of the regions agricultural production
    - Currently developing a water management plan
- ACBA has an innovative approach to research in international research
    - Dubai scientists do most of the coordination of research projects
    - Partner scientists do the work
    - Large private investment is core to their success
    - Capacity building
        - 788 people in 44 countries

**Saudi Arabia project**

- Worlds largest saline prawn farms
- Nutrients in wastewater a problem for delivery back to the sea
- Irrigation of salt tolerant plants to use water and nutrients

**Polluted saline water from oil production**

- ICBA developed a saline reed bed system to polish water before release to the environment

**Irrigation of commercial crops with saline water**

- Core to the successful irrigation of saline tolerant crops is sand soil that will not accumulate sodium and suffer from sodicity – dispersion
- Distichlis Spicata, a fodder grass that will produce 30 – 40 t/ha dry matter when irrigated with saline water up to seawater
- Date Palm irrigated with saline water ≈ 50% seawater (15,000 – 17,000 ppm)
- Sorghum and Millet irrigated with water to 10,000 ppm
- Saline environments are inherently low producing
    - Heavy cost of drainage is prohibitive
    - Soil profile needs to be very deep so salt can be leached below the root zone

**Questions**

- How do you control transpiration?
  We don't – we use 30 t/ha of compost to hold water and nutrient
- How many staff at ICBA?
  Approximately 40 staff including 7 scientists
- Annual rainfall?

115 mm p.a. although for the last three to four years 50 – 75 mm p.a.

- What irrigation rate is used with saline water?
  1 – 1.2 x crop factor, depends on salinity
- What leaching fraction is used?
  It has been sustainable for 8 years
- Do you have a shallow water table?
  No, but in some regions water table water is 5 – 15 dS/m

**Opportunity for residential development**

- ICBA has not developed relationships with developers
- Treated wastewater could provide options for open space irrigation
- There are cultural/mental blockages for the use of wastewater for food production
- Public could be more favourable for the use of wastewater for gardens
- New thinking is to use wastewater for the replenishment of groundwater
- A few years ago people would not walk on grass irrigated with wastewater

**Water pricing**

- Water is free to locals
- 50 – 70 cents per $m^3$ for expats
- Water is free to farmers but the Water Master Plan is looking at pricing
- What is the pressure to improve water use efficiency?
  - Growers are allowed access to water 3 – 4 hours per day
  - Overuse of water has seen mining of aquifers
  - Large fines from the government for exceeding the 3 – 4 hours per day irrigation
- Aquifer recharge is from the Ohmar Mountains
- Have built 100 artificial dams for water recapture and groundwater replenishment
- Recycled water could play an important role in the future

**Dubai**

- ≈ 5 million people
  - 1 M locals
  - 4 M expats
- Rainfall has decreased over recent years
  - Climate change?????
    - Gut feel is yes!
  - The nature of rainfall is changing
- Q. Has energy usage been considered for desalinisation of seawater?
  - Carbon emissions are receiving increased interest – global warming
- Land is changing use from desert to concrete jungle
  - Temperature increase 2-3 per annum
- Q. Do you grow a lot of eucalypts?
  - Problem with construction and infrastructure
  - They have shown to be very good at controlling rising groundwater
  - They are now banned in the United Emirates

**Germplasm – international seed bank for saline plants**

- Collected salt tolerant plants for around the world
- 100gm or 100 seed whichever is greatest
- Have barley varieties from Western Australia

**Shade house visit**

- Shade house is used for the propagation of salt tolerant plants

- Often irrigated with “good” quality water as many plants may grow under saline conditions but they may not produce seeds

**Date Palms**

- Evaluation of commercial crops
    - As salt↑ yield↓
- Trialing 10 different germplasm
- Irrigated with saline water to assess quantity and quality
- Highest salt tolerance 10 dS/m – can go higher but becomes economically unviable
- 5-6 years for commercial production – from tissue culture
- 9 years to commercial production from seed; use probes to measure moisture and salinity at depth

**Sorghum and Millet**

- Reassessing germplasm for salt tolerance
- Production for food and feed

**Site Summary**

- Water is cheap! 50 to 75 cents/KL for domestic and free for farmers
- Source of irrigation water is 82% groundwater, 10 – 12% treated wastewater and 3 – 4% rainfall
- They are mining groundwater and the depth for access is ranging from 100 to 300 ft and dropping
- 5 Million people in UAE, 1.3 in Dubai and 1.6 in Abu Dhabi
- Since 2004 rainfall seems to be getting less and less – they suspect due to climate change
- 700 to 800 ML of SWRO water is produced daily in UAE
- For calculating carbon offsets from SWRO the general rule is 10 – 15 barrels of water = 1 barrel of oil
- Recycled water is the next frontier in UAE, however, there is a cultural barrier to overcome regarding the recycling of water from treated wastewater; the current preference is that the recycled water must go into the natural systems before it would be accepted for general use, especially on food crops

## *2.2 Destination: Schlumberger Water Services*

**Focus: Water source & management; aquifer storage and recovery**

### 2.2.2 Contact Information:

www.swstechnology.com

**Site Address:**

See map for details – provided below

ASR site – Dubai Hatta Rd – city of Nizwa

**Organised by:**

Rolf Herrmann

Principal Hydrogeologist / Technical Manager Middle East

Schlumberger Water Services SWS

Al Masaood Tower, Hamdan Street, 6th Floor

P.O. Box 21, Abu Dhabi, United Arab Emirates

Email: herrmann@abu-dhabi.oilfield.slb.com

Phone: +971 2 6101 347

Fax: +971 2 6101 277

Mobile: +971 50 666 0795+ 971

Arnaud Levannier
Hydrogeologist

Schlumberger Water Services
Dubai Convention Tower
P.O. Box 9261, Dubai, U.A.E.
Tel: +971-4 3067494
Fax: +971-4 3293196
Mobile +971-50 6550317
alevannier@dubai.oilfield.slb.com

Schlumberger

**Site Contacts:**

Rolf Herrmann (as above) & Arnaud Levannier – Project Manager for ASR site

## 2.2.3 Background

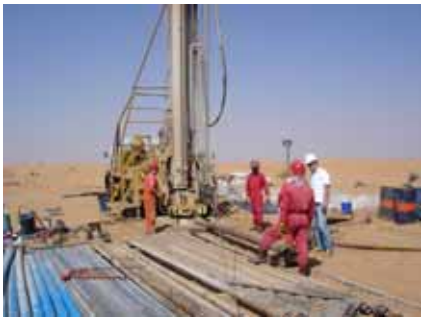
Site visit to ASR pilot test site in Sharjah – overview of history of groundwater supply; why ASR is required, how it is used, what is the process.

**Overview**

Aquifer Storage and Recovery (ASR) – also known as "Aquifer (or Artificial) Storage Recharge" – is a water resource management technique in which water is injected into carefully selected aquifers, to be treated or safely stored underground until needed.

**Environmental challenges**

Groundwater supply and water quality problems, coupled with the increasing demand for fresh water to supply urban growth, have amplified the need to manage sustainable water supplies in many parts of the world. ASR offers one method to attain a continuous, long-term supply of water; however, it requires exceptional management strategies and advanced characterisation technologies, combined with scientific expertise.



Water storage in natural aquifers is often attractive when compared with surface storage in reservoirs or tanks. Aquifer storage significantly reduces construction costs and limits environmental effects, such as evaporative loss of water, eutrophication, and reservoir-induced earthquakes, as well as the potential for catastrophic failure. Aquifer storage also places water closer to its users. Until recently, however, potential problems with ASR – such as accurate characterisation of the aquifer, water quality, required infrastructure, and unanticipated off-site effects – have limited its practical application.

**Advanced solutions**

Today, Schlumberger Water Services fields a multitalented team that combines advanced Schlumberger technologies to make ASR feasible on a wide scale. Schlumberger's geophysical characterisation expertise, combined with our professional-grade monitoring equipment and advanced data management, uniquely position us to make your ASR project a reality. We can help you to understand the subsurface environment and deploy the best technologies for collecting and managing hydrogeologic data.

To effectively assess hydrogeologic conditions and monitor groundwater, the Water Services team combines field expertise with sophisticated technologies in five areas:

- Advanced hydrogeologic assessment

  Determining the hydraulic properties of an aquifer using tools such as CMR (Combinable Magnetic Resonance), FMI (Fullbore Formation MicroImager) and AquiferTest Pro software

- ASR well network planning

  Optimising the placement and number of monitoring and pumping wells by applying specialised technology such as HydroWork Flow numeric groundwater flow models, Petrel, and ECLIPSE reservoir simulation software

- ASR system deployment

  Assessing and installing well technologies for long-term monitoring through Westbay multilevel well systems and Diver data loggers

- Long-term data collection and analysis

  Providing on-time, cost-effective data collection and advanced aqueous geochemical analysis and mapping of the ASR system

- Performance and compliance reporting

Automated reporting of ASR performance and compliance with regulatory guidelines, using HydroGeo Analyst and other software

**Case Study – Abu Dhabi, UAE**

www.slb.com/media/services/additional/water/integrated_projects/asr_abudhabi.pdf or DVD of photos and appropriate day under the info subdirectory.

## 2.2.4 Site Visit

Aquifer water is 1,900 mg/L TDS. The SWRO water will be 400 mg/L TDS and they need to operate to 450 mg/L TDS. So there is not much room for mixing with the aquifer water.
When fully operational, SWRO water will be pumped in 4 kms from the sea and injected into the aquifer.

The aquifer fall is approximately 4 m in 1,000 m, there is approximately 50 m of sand over 1,000 m of clay and the SWRO water is allowed to infiltrate under gravity into the 50 m of sand (i.e. injecting into the superficial aquifer). In the 50 m there is a range of sand sizes up to coarse gravel.

# 3 Day 3 – Wednesday 22nd October, UAE – Dubai

## *3.1 Destination: Metito*

**Focus: Innovation – Alternative solutions for SWTP sludge handling**

### 3.1.2 Contact Information:

www.metito.com

**Site Address:**

HQ for Metito

Techno Park, Dubai

Palm Jumeirah Sewage Treatment Plant

**Organised by:**

Mahmoud Kabeel

Plant Sales Manager – Dubai, Northern Emirates & Oman

Metito Overseas Ltd

PO Box 22701

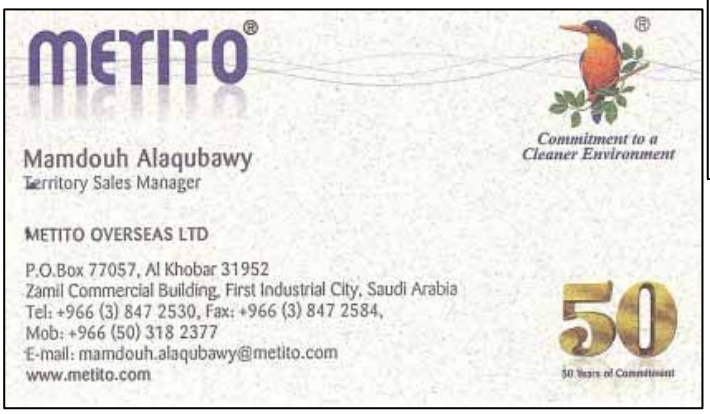
Email: mahmoud.kabeel@metito.com

Phone: + 971 6 556 1818

Fax: +971 6 556 4777

**Site Contacts:**





### 3.1.3 Background

Metito, founded in 1958, is a shining example of a Middle Eastern company that has grown to be a world leader in its field. Metito operates locally in 14 countries of the Arab and Islamic World, and supplies its plants internationally to locations as far apart as Argentina and Australia from its base in the United Arab Emirates. Some of the company's notable achievements for 2006-07 in UAE include wastewater treatment plants for the Dubai Investments Park and Palm Jumeirah as well as different projects in Abu Dhabi for ADSSC and Abu Dhabi Sewerage Services Company.

Metito is the first major international company to locate in Techno Park, Dubai that will focus on research and technological development in the areas of water desalination and environmental resources. This global headquarters will house a total of 500 engineers, scientists, technicians and executives.

“As a company committed to technological excellence and preserving the environment Techno Park is the perfect location for Metito. Over 50 per cent of the world’s desalination projects are in the Gulf region and it is estimated that demand for desalted water in the UAE will double by 2010. The Arab World is also forecast to invest over $30 billion dollars in desalination projects by the year 2025.”

Metito also intends to showcase its technological expertise on-site by constructing a water treatment and wastewater treatment desalination plant that will enable the company to become totally self sufficient in water. The plant will recycle the wastewater and become a showcase of how the company’s leading edge technology operates in practice.

Managing Director Fady Juez adds: “We have been recognised as a leader in our field for many years and creating this demonstration plant will allow other companies and interested parties to see our expertise at first hand. Techno Park, Dubai will give us the opportunity to grow our business and is a perfect location from which to operate our increasing global business.”

Metito has also been awarded the highly prestigious 'Desalination Company of the Year 2006' by the Global Water Intelligence magazine in recognition of the company's significant and valuable contribution to the industry worldwide.

**Metito Products & Technologies**

The Metito group offers a comprehensive range of products for: Process Water Treatment for Industry, Water Desalination by Reverse Osmosis, Sewage Treatment, Industrial Effluent Treatment, Water Disinfection, Water Treatment for Sports and Leisure, PLC Control, SCADA and Telemetry Systems for these processes, Specialty Chemicals and Concessions in water and Wastewater Treatment. Its clients include municipalities, oil and petrochemical companies, industries (food & beverage, textile, paper & pulp to name a few), tourism sector and various government departments and agencies.

Metito provides and utilises the following technologies in their water and wastewater treatment systems:

- Membrane Separation (MF/UF/NF/RO)
- Membrane Bio-Reactor (MBR)
- Two Bed and Single Bed Ion Exchange
- Electro-Deionisation (EDI)
- Activated Sludge and its variations
- Rotating Biological Contactor (RBC)
- Chlorination / Ozonation / Ultra-Violet (UV) Disinfection
- Vacuum sewage technology (www.flovac.com)

Metito sewage treatment plants cater for a wide spectrum of applications requiring aerobic, anaerobic or anoxic treatment processes. Metito utilises various biological systems that are variations of the well-known activated sludge process. These include:

- High Rate Activated Sludge
- Contact Stabilisation
- Extended Aeration XXX large gap
- Oxidation Ditches
- Conventional Activated Sludge
- Aerated Lagoons
- RBC or Rotating Biological Contactor

Metito further uses alternative treatment technologies that are more suitable for specific applications. Such technologies include:

- Membrane Bio-reactors (MBR)
- Trickling Filters

**Sewage Treatment Plants**

Metito has implemented many municipal scale sewage treatment plants on a supply and supervision basis, and on a turnkey basis. These plants cater for medium size communities and large cities.

Metito's range of package sewage treatment plants are either factory-built sectional-steel units, or site-assembled panel tank systems. This range of Metito plants is built to cater for population equivalents ranging from 100 to 5,000, and is ideal for smaller communities, temporary construction facilities, hotels and resorts, commercial ships, hospitals and schools.

## 3.1.4 Innovative Technology Partnerships

**Link:** www.zawya.com/story.cfm/sidZAWYA20071204124734

04 December 2007

Flovac Middle East provides environmental, construction and operational benefits to the local wastewater industry

Dubai, UAE – Metito, the international desalination, water, and wastewater treatment specialist, today launched Flovac Middle East with Flovac Vacuum Systems Ltd, an Australian wastewater infrastructure firm. With Metito being the leading shareholder, Flovac Middle East will offer efficient and holistic wastewater solutions to clients in the Gulf region using environmentally friendly and cost effective vacuum sewerage technology. This can lead to up to 50% reduction in construction time and 20% savings on infrastructure capital costs to developers and municipalities.

Flovac uses a vacuum system which has been globally developed and tested for over 25 years. This technology is based on the principle of collecting wastewater by gravity into centrally located manholes that are fitted with a vacuum valve, with each of these vacuum valve pits serving up to 8 individual properties. The wastewater collected is then transported via vacuum from the valve pits to a pumping station which then forwards it to a treatment plant/discharge point using conventional gravity.

When compared with traditional gravity sewerage schemes, Flovac vacuum technology offers many environmental, construction and operational benefits such as elimination of groundwater infiltration/sewerage ex-filtration, simplified retro-fitting of existing communities, fewer pumping stations and more efficient operation and maintenance.

Mutaz Ghandour, CEO of Metito said, "We welcome this partnership with Flovac Vacuum Systems to launch Flovac Middle East. This agreement will complement the strong reputations and long-term plans of both companies. The application of this technology in the Middle East has numerous advantages, all of which will combine to make the solutions offered by Flovac Middle East ideal for contractors, developers and wastewater authorities alike."

Mr John Radinoff, Managing Director of Flovac Vacuum Systems said, "Our vacuum sewerage technology has already been successfully implemented for the last six years on several projects in the UAE and across the Arabian Gulf. Currently we have projects underway at Dubai Festival, Dubai Festival City and Jumeirah Golf Estates and we are working with developers on numerous other projects across the region."

John added, "Flovac Vacuum Systems Ltd is a family company and this new partnership marks the 14th Flovac office worldwide and also our 25th year of involvement in the vacuum sewerage industry. Our partnership with Metito, also a family based company, provides great synergies on many levels and together I am sure that we will produce an excellent "one stop shop" team focussing on providing best practice wastewater collection and treatment in the Middle East".

From Metito Website: **Metito completes work on Palm Jumeirah plant**

Metito, the international desalination, water and wastewater treatment specialist, has completed work on an advanced, international-standard Reverse Osmosis polishing plant that will process 18,000 cubic metres of treated sewage effluent everyday and will drastically reduce water requirements of the Palm Jumeirah cooling system. The scope of work of the project included design, fabrication, shop testing, delivery, site installation, testing, commissioning the plant situated on Palm Jumeirah Trunk.

For more information about Palm Jumeirah see:

http://guide.theemiratesnetwork.com/living/dubai/the_palm_islands.php

### 3.1.5 Site Visit

**Metito**

- Founded in 1958
- Over 1,000 projects worldwide
- 16 plants on BOO (built own operate) or BOT (built operate transfer)
- 15 offices worldwide
- Has over 1,000 MBR plants worldwide
- MBR
  - < 3 mg/L bod
  - < 1 mg/L TSS
  - < 1 mg/L $NH_3$
  - < 2.2 coliforms/100 ml
- Small footprint seen as a big advantage

**Background**

1 Billion people lack access to clean drinking water
2 Billion people lack access to sanitation

Conventional technology

| Seawater | Wastewater | Greywater |
|---|---|---|
| ↓ | ↓ | ↓ |
| Desalination | Recycling (treatment) | Simple treatment |
| ↓ | ↓ | ↓ |
| Clean water | Clean water | Limited use |

**Wastewater options**

- Direct potable
- Indirect potable
- Agricultural
- Industrial

Benefits of recycling

**Environmental** **Economic** **Social**

**Three Projects**

Palm Island

- Recycle 10 ML per day

Emaar

- 3 ML per day
- Upgrade to 10 ML per day

Dubai Investment Park

- 100 kL per day (1999)
- Potential to increase to 40 ML per day

Problems in Dubai

- Water and wastewater infrastructure is not in place
- Wastewater is not well done
- WWTP are operating at 2.5 x capacity

**Saudi Arabia**

- Don't want to use RCW for crop or food production (cultural issues)
- There is a cognitive barrier to the use of RCW
- They are moving forward for RCW → agricultural crops → potable (perhaps in future?)
- Water is fairly cheap
  - ≈ $2.00 US per $m^3$
- Very low reuse
- Very low rainfall
- In the GGC companies are not very strategic in forward planning
- Wants to be self-sufficient
  - 1 L of milk requires 1000 L of water (in $50^{o}$ degree heat it doesn't make sense)
  - Looking for partnerships with Northern Africa

**Dubai**

- Tourism is seen as the big future (Dubai has small oil reserves)
- Oil has underpinned economic growth
- Very business orientated
- Population is double digit

- Growth in Dubai has been underpinned by debt
    - Problems will arise in the future servicing debt associated with growth
- Growth requires water
    - Management of wastewater
    - A lot of localised WWTPs (500k people)
- Wastewater treatment is not seen as a priority
- Water is manager by Water and Power (water and power are not separated as utilities)
- Developers do their own wastewater treatment systems
    - They recycle and charge what they want
- Locals drink mostly bottled water
- Although there is an Emirates there is a lot of competition between the emirate partners
- There is not much industry in Dubai, mainly warehouses
- Locals would not like to work in factories

It is interesting to note that a recent press release indicated….
'...for several weeks some of Dubai's fabled beaches have been covered with the stinking contents of septic tanks as the fast growing city suffers the consequences of frantic and poorly controlled development. While new apartment blocks are rising everywhere, infrastructure is lagging. Dubai still has no main drainage system. Tankers collect septic tank wastes to transport to the emirate's only sewage treatment works at Al-Awir, out in open desert.

**Palm Island Development (Jumeirah)**

- MBR plant 11 m below sea level
- There are 3 island developments
- The developments are changing the tides causing beach erosion
- Site restrictions
    - Aesthetics are an important consideration
    - No odour or noise
    - Minimal sludge production
    - Low maintenance requirements
    - 18 ML/day
- MBR
    - Easy to maintain
    - Low footprint
    - Proven performance
    - High level of acceptance of the technology
- Sewage lines are vacuum
- Regional body sets treatment standards
- Problem with sludge – sent to land fill
    - Regulators are unhappy with this
        - Although unhappy they offer no solution
- Water goes to polishing plant then used for landscape irrigation
- Everything has an inbuilt redundancy to ensure plant is failsafe
- Water use per head
    - 250 L/day/person
    - 120 L/day/person in the labour camps

**Reverse Osmosis**

- Problem with RO and its carbon footprint new technology improving energy efficiency therefore reducing pressure
- RO coming to the end of efficiency gains
- 4 kWhr/$m^3$ of water

- Pressure exchanges reducing power consumption from 12 → 6 kWhr/$m^3$ of water
- Treatment cost $4 DMR /$m^3$ ($250 US)
- RO discharge is a major problem
- 2 out of 3 reject water (33% efficiency)
- Pressure 11 bar for RO of effluent water – 60 bar for RO of seawater

**Vacuum Sewers**

Salinity was 7000 mg/L TDS in sewage water peaking at 20,000 mg/L TDS due to ingress from seawater. They used sampling from across the sewer to identify ingresses and fix them. The treated wastewater from the sewerage water is now consistently 900 mg/L TDS.

There is little agriculture in Dubai so little sewage water is recycled for agriculture. Most agriculture is currently undertaken in Abu Dhabi. Biosolids are disposed of in landfill.

Normal business logic doesn't seem to apply in Dubai.

## *3.2 Destination: Masdar*

**Focus: Technology and environmental applications for sustainable cities**

### 3.2.2 Contact Information:

www.masdar.ae

**Site Address:**

Next to Abu Dhabi airport

**Organised by:**

Mohammed Kharroubi

ASDA'A Public Relations

Tel: +971 4 3344550

Fax: +971 4 3344556

GSM: +971 50 4289678

www.asdaa.com

Email: m.kharroubi@asdaa.com


**Site Contacts:**

Charlie Clifton – Associate Business Development and Property Development Unit; and

Gordon Falconer – Department Manager Real Estate Strategy and Development

They can be reached through Hiba Kareem

Email: hkareem@masdar.ae

Tel: +971 2 513 3333 | Dir: +971 2 513 3102

### 3.2.3 Background

In April 2006, Abu Dhabi took a bold and historic decision to embrace renewable and sustainable energy technologies.


Masdar City in Abu Dhabi will be the world's first zero-carbon, zero-waste and car-free city. It will be generated by photovoltaic panels, while cooling will be provided via concentrated solar power. Water will be provided through a solar-powered desalination plant and landscaping within the city, as well as crops grown outside the city, will be irrigated with greywater and treated wastewater produced by the city's water treatment plant.

As the first major hydrocarbon-producing nation to take such a step, it has established its leadership position by launching Masdar, a global cooperative platform for open engagement in the search for solutions to some of mankind's most pressing issues: energy security, climate change and truly sustainable human development.

In addition to full-time residents, Masdar City will seek to attract and encourage collaboration between experts in sustainable transportation, waste management, water and wastewater conservation, green construction, buildings and industrial materials, recycling, biodiversity, climate change, renewable energy and green financial institutions. Masdar will maximise the benefits of sustainable technologies, such as photovoltaic cells and concentrated solar power, through an integrated planning and design approach.

By implementing these technologies, Masdar City will save the equivalent of more than US $2 billion in oil over the next 25 years, based on today's energy prices. The city will also create more than 70,000 jobs and will add more than two percent to Abu Dhabi's annual GDP.

"We are creating a city where residents and commuters will live the highest quality of life with the lowest environmental footprint," said Dr. Al Jaber. "Masdar City will become the world's hub for future energy. By taking sustainable development and living to a new level, it will lead the world in understanding how all future cities should be built."

In addition, the city will achieve unprecedented levels of demand reduction. Highlights include:

• 75 percent reduction in installed power capacity; Masdar City will require approximately 200 MW of installed clean power versus more than 800 MW of installed capacity to power a similar city based on conventional design

• Water needs to be cut by more than half; Masdar City will require around 8,000 m3 per day of desalinated water versus more than 20,000 m3 per day for traditional cities

• Landfill area severely diminished; a city of this size would have required millions of square metres of landfill area; Masdar City will need virtually no landfill area.

The first step in the city's seven-phase plan is the development of the Masdar Institute of Science and Technology (MIST), the world's first graduate university dedicated to renewable energy. Developed in collaboration with MIT and scheduled to open in 2009, MIST will maintain a body of students and professors focused on developing the next generation of solutions to the world's growing dependence on fossil fuels.

The six-square kilometre district is designed by renowned architecture firm Foster + Partners and set to be completed in 2016 in conjunction with Abu Dhabi's 2030 Development Plan. It will eventually grow to 1,500 businesses and 50,000 residents and will be home to international businesses and top minds in the field of sustainable and alternative energy. Of this, 30 percent will be zoned for housing; 24 percent for the business and research district; 13 percent for commercial purposes, including light manufacturing; 6 percent for the MIST; 19 percent for service and transportation; and 8 percent for civic and cultural pursuits.

Masdar City is one of the flagship projects of the One Planet Living™ programme – a global initiative launched by WWF.

For more information see:

www.masdaruae.com/text/broc-coll.aspx or DVD of photos and appropriate day under the info subdirectory.

### 3.2.4 Site Visit

**Futuristic city with a low carbon footprint**

- The city will be car free
- It will be built 7metres off the ground to improve cooling efficiency
- The city will have manufacturing producing green technologies
- Abu Dhabi Government initiative
    - Global hub for green technologies

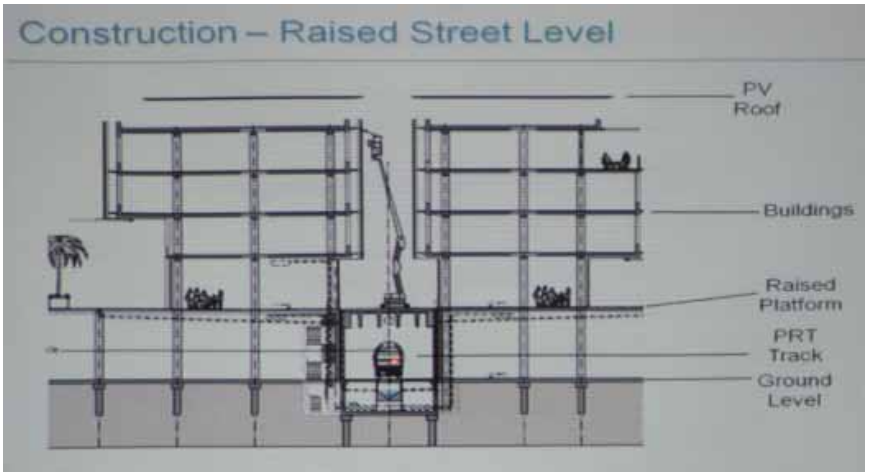
    - Car free – carbon neutral (use personal rapid transport (PRT) for inner city transport)
    - Carbon free energy (renewable) – purchase stake in wind energy
- Masdar Institute
    - Independent – not-for-profit
- Look for world future energy summit
- 50% of GGC <20 year old
- UAE is the most stable of the Arab countries. It is the centre for:
    - Tourism
    - Construction
    - Banking
    - In the UAE non oil GDP is growing at 105% per annum

**Project**

- Building
    - State of the art manufacturing
    - Renewable energy
    - Innovative transport
    - Recycling energy
    - Research institute
- City of 60,000 residents with a further 40,000 commuters
- $24 B over 8 years
- Will be a fully functional city with hospitals, cinemas, etc
- Inner city transport
    - PRT (known technology – in use at Heathrow Airport); nobody will be more than 100 m from a PRT pick up point
    - The PRT system will be backed up with a light railway system
    - Conventional cars will be left at the edge of the city
- Energy will be 53% photovoltaic
    - Concentrated solar
    - Evacuated thermal
    - Wind generation
    - The demand on E will be less
    - Energy form waste (< 2% of waste to landfill (zero waste) – will burn carbonaceous material)
- Will use LED lighting – 70,000 hr life time
- 2,500 feet$^2$ accommodation will cost $5,000,000

**Site Summary**

Masdar is not just about technical advances and knowledge. It is about advancing how we do business and manage systems for change. Changing the way we think and design to meet future challenges and advances, make these transitions easier.



## *3.3 Dinner Guest Speaker: Francois Dao – Acciona*

**Focus: Creating an ecologically aware organisation – driving energy efficiency**

### 3.3.2 Contact Information:

www.acciona.es

**Site Address:**

Landmark Hotel

Al Nasser Square (opposite HSBC Bank), Deira

Dubai, United Arab Emirates

**Organised by:**

Nirmala Gracias

Branch Office Manager

ACCIONA AGUA Middle East

Office 1213, Grosvenor House Commercial Tower

P.O. Box 118820

Sheikh Zayed Road, Dubai, UAE

Email: nirmala.gracias@acciona.ae

Tel: 04 329 7880

Fax: 04 329 7881

**Site Contacts:**

Francois Dao, Business Development Director, ACCIONA

Email: francois.dao@acciona.com

Tel: +971 (0)50 552 4473.

### 3.3.3 Background

*'Creating an ecologically aware organisation – driving energy efficiency'*

This presentation was recently delivered in the Middle East Wastewater Treatment & Reuse conference held on the 10th – 11th December 2007 and provides a good introduction to the site visit to Fujairah Independent Water and Power Company (FIWPP) on Thursday.

Topics covered include:

- Exploring the latest developments in sustainability
- Adapting streamlined operations and maintenance processes
- Integrated water management
- Looking into latest treatment initiatives for your organisation
- Implementing recycling processes.

**About Acciona**

Acciona is a leading Spanish multi-national company, specialising in water treatment and reverse osmosis desalination, development, operation and management of renewable energies, the construction and management of infrastructures, eco-friendly real estate, transportation and logistical services, and is a provider of urban and environmental services.

Acciona Agua focuses on the treatment of water and reverse osmosis desalination, a technology in which it is the world leader. It offers a full range of services in the integral water cycle and its scope of activity includes the project design and construction of desalination plants and wastewater treatment plants, operation and maintenance, the supply of drinking water and sanitation of cities.

Acciona Agua constructs, manages and runs plants and services which meet the supply needs of a population of more than 50 million people in 20 countries around the world.

The mission of Acciona Agua is to be a leading provider of global solutions contributing to sustainable development in the water sector through innovations in the design, execution and operation of plants for the treatment, purification and desalination of water. This is demonstrated by the awarding of the contracts for three of the largest desalination plants in the world: Tampa (Florida) and Carlsbad (California) in the US, and Torrevieja in Alicante, Spain.

Acciona Agua has earned the trust and confidence of a wide variety of clients, both private and public, at regional, national and international levels, as a result of its ongoing commitment to providing the optimum solutions and service excellence to the client.

Core business activities are:

- Design, construction and commissioning
- Operation and maintenance
- Integrated water resources management

in the following sectors:

- Reverse osmosis desalination
- Drinking Water
- Wastewater
- Reuse

**Acciona Agua chosen to design desalination plant in Perth, Australia**

www.acciona.es/press-/news/acciona-agua-chosen-to-design-desalination-plant-in-perth-australia.aspx?page=2

Following an international tender involving seven bidders, the consortium comprising Acciona Agua and its partner, United Utilities Australia, has been short listed, with another finalist, for the contract to build and operate a desalination plant in Perth, Australia

Approximate total revenue for the construction and 25-year operation of the plant is between 300-400 million euros; it will supply water to 400,000 people.

Madrid, 22 February 2008. Acciona Agua and its partner, United Utilities Australia, comprise one of the two consortiums selected by Water Corporation to design the final plans to build and operate the Southern Seawater Desalination Plant (SSDP) in Perth, Australia. The two consortia will sign a contract to design the plant over the next six months, and will then bid for the tender for the construction and 25-year operation of the plant, whose total expected revenue will be between 300 and 400 million euro.

The consortium comprising Acciona Agua and its partner United Utilities Australia was selected, along with another finalist, in the international tender in which seven leading groups in the sector participated.

The plant, powered by renewable energy, will have a production capacity of 140,000 m3/day in Phase I, with a possible extension up to 280,000 m3/day in Phase 2. Located in southern Perth, Western Australia, the plant will supply 400,000 people. The project was announced last spring by Water Corporation, and expected revenue totals between 300 and 400 million euro.

According to Jim Gill, CEO of Water Corporation, this tender means "we will be working with two of the world's leading desalination companies. Both have demonstrated their capability in building and operating desalination plants in Europe, the United States and North Africa".

Entrance into the Australian market is part of Acciona Agua's strategy to raise its international exposure. United Utilities (UK), already operating in Australia with a well-positioned subsidiary in the water treatment and management sector, and Acciona Agua reached an agreement last July to undertake desalination projects together.

In addition to the venture in Perth, Acciona Agua and United Utilities Australia will bid for a desalination project in Melbourne, where they have joined forces with the construction companies McConnell-Dowell and Abi Group, and the financial partner, Plenary Group. The plant will have an approximate capacity of 400 million litres/day, enough to supply 1.35 million people. The Melbourne plant will also be powered by renewable energy; because of its size, the State of Victoria has not yet decided how it will be financed, although it will foreseeably be a PFI. Acciona Agua Australia Pty Ltd has offices in Perth and Melbourne.

United Utilities Australia has been operating for more than 15 years in the Australian water treatment market, where it owns and operates drinking water and wastewater treatment plants in New South Wales, Victoria and South Australia.

In the increasingly globalised water treatment business, Acciona Agua, now operating on five continents, has attained a leading position by offering comprehensive water management services, including the design, construction and operation of drinking water, sewage treatment and desalination plants. The projects and contracts executed by the company contribute to treating, processing, reusing, desalinating and managing water for over 50 million people.

**Acciona Agua, Desalination Company of the Year**

www.globalwaterawards.com/2007/

- The Plants of Torrevieja and Cartagena (Phase I & II) have been awarded with a Silver Prize

Acciona Agua has been elected Desalination Company of the Year in the Annual Ceremony of the Global Water Intelligence, celebrated yesterday in Barcelona. In this category it was rewarded the desalination plant supplier which has made the greatest overall contribution to the desalination industry during 2006. Acciona Agua was competing with the companies SIDEM (Veolia Water Solutions & Technologies' specialist multi-effect distillation arm), IDE (a joint venture between Delek Group and Israel Chemicals Ltd, this company is Israel's largest desalination specialist) and CH2M Hill, a US-based employee-owned international engineering company.

Also, for the Category Desalination Deal of the Year, the Torrevieja Plant has won the Silver Prize. This category awarded the deal signed during 2006 which represents the most significant step forward for the industry in terms of financial innovation or in meeting the demands in challenging circumstance. The Plant of Torrevieja is a 15-year DBO contract for a 240,000m³/d desalination facility in Alicante, Spain. Torrevieja is the largest seawater desalination plant in Spain's Acuamed program. This project keeps Acciona's corporate commitment to sustainability. The proposal includes a bioclimatic regulation system, 585 solar panels to reduce power demand from the grid, the latest technologies to reduce energy consumption and non-energy costs capped at €0.06/m3.

For the Category Desalination Plant of the Year, the Plant of Cartagena (Phase I & II) has won the Silver Prize as well. This prize represents the most impressive technical achievement in the

industry for the desalination plant, commissioned in 2006. The plants of Cartagena are two 65,000m³/d seawater reverse osmosis plants in Murcia (Spain) built on a 15-year design-build-finance-operate basis; the Phase I plant was constructed by a consortium of Acciona Agua and Befesa. Phase II was constructed by a consortium of Acciona Agua and Degrémont.

Voting has been done among more than 600 subscribers of the GWI in the world. In the Award Ceremony in Barcelona, there were representatives of the best Companies in the water sector both nationally and internationally. The Prizes were gathered by Luis Castilla, General Manager of Acciona Agua.

### 3.3.4 Additional information

See PowerPoint and PDF version of presentation on the DVD provided under the appropriate day in the info subdirectory.

# 4 Day 4 – Thursday 23rd October, UAE – Dubai

## *4.1 Destination: Fujairah Independent Water and Power Company (FIWPP)*

**Focus: Hybrid plant – desalination and power generation**

### 4.1.2 Contact Information:

www.sembcorp.com.sg

**Site Address:**

Ras Al Qidfa, Fujairah

**Organised by:**

Harris Kodiyerikkandy

Executive Assistant - EMD's Office

Emirates Sembcorp Water & Power Company

Fujairah Independent Water & Power Plant (FIWPP)

Post Box No. 3020 – Ras Al Qidfa – Fujairah

United Arab Emirates

Phone: +9719 2088809

Fax: +9719 2381887

Email: harris.k@emsembcorp.com

**Site Contacts:**

Executive Managing Director – Mr Lai Saw Chong

Phone: +9719 2088991

O&M General Manager – Mr Hahabir Kumar Sharma

Phone: +9719 2088900




### 4.1.3 Background

**Note: no filming, cameras, phones, electronic equipment, etc were allowed – high security**.

**Hybrid plant – water and power**

The two year old facility consists of a gas-fired power plant which has a net capacity of 535 megawatts and a hybrid seawater desalination plant employing a combination of multi-stage flash and reverse osmosis technology to produce 100 MIGD of water.

A further 225 megawatts of power generation capacity will be added to the facility.

Construction of the new plant, to be situated adjacent to the existing plant, will commence immediately and commercial operation is expected by the first quarter of 2009. Upon completion, the plant's total generation capacity will reach 760 megawatts.

The Fujairah F2 IWPP represents one of the largest Greenfield power and water plants to have been built in the region over the past few years and the largest project financing undertaken in the Emirate of Fujairah.

Short-listed for Global Water Awards 2008, this is the first major RO-MSF hybrid plant in the region. With the RO portion finally meeting its “net dependable capacity test” before financial close, the deal should be seen as a vote of confidence in this approach to optimising power and water projects.

**Power Engineering International, August 2004**

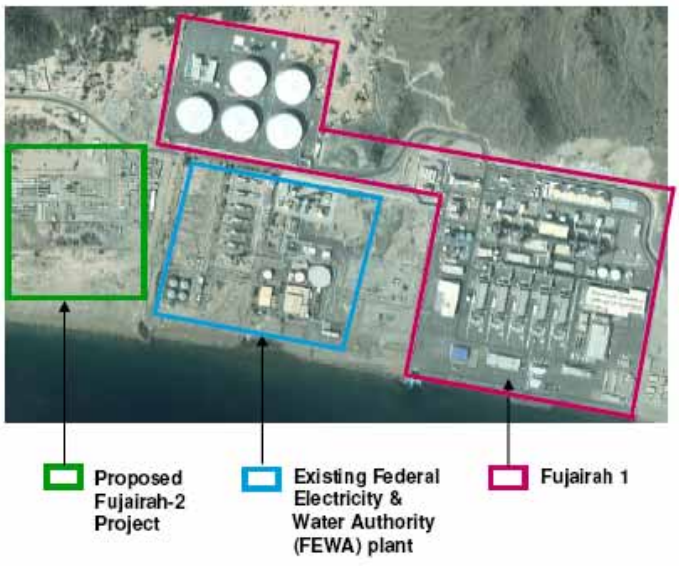
Desalination a first in Fujairah

http://pepei.pennnet.com/display_article/210764/17/ARTCL/none/none/1/Desalination:-A-first-in-Fujairah/

**Unique design**

The Fujairah project is unique in the Middle East in that it uses a combination of two different desalination technologies. It will produce 284 million l/day (62.5 MIGD) of water using multi-stage flash (MSF) technology and 171 million l/day (37.5 MIGD) using reverse osmosis (RO) technology. It is also one of the largest plants in the world to use this combination of technologies.

This hybrid desalination system is designed to provide significant operational savings by reducing fuel consumption by up to 25 per cent compared with a similar-sized plant based only on MSF technology. Other key criteria influencing the design of the desalination plant were feed water quality, product water requirements and compatibility with the cogeneration of electricity.




The water production system at the Fujairah desalination plant is comprised of five Doosan MSF units producing 57 million l/day (12.5 MIGD) each and one RO unit with a design capacity of 171 million l/day (37.5 MIGD). The RO unit was supplied by Ondeo Degremont. For drinking water supply, distillate from the MSF units and desalinated water from the RO plant are mixed in a distillate header and treated in a re-mineralisation unit before passing into the potable water storage tanks. Prior to export to the water transmission line, potable water is stored in five potable water tanks, each with a capacity of 91 million l (20 million gallons).

The five MSF evaporators (MSFE) each produce 57 million l of distillate per day (12.5 MIGD) containing less than 25 parts per million (ppm) dissolved solids with a performance ratio of 8.0 kg distillate per 2326 kJ at 109°C top brine temperature. These units were built at Doosan's Changwon facility in Korea and transported to Fujairah by sea. The first of the five MSF evaporators arrived at the project site in April 2002.

Doosan was also responsible for constructing the power island, consisting of four gas turbines, two heat recovery steam generators (HRSGs) and two steam turbines in a combined cycle configuration. The output of the power plant is 656 MW, of which 120 MW is required for the desalination process and 36 MW for the transmission system. The remaining 500 MW is exported to the grid.

The four gas turbines are GE Frame 9E units (model PG9171E) fitted with diverter dampers in order to enable the plant to operate in either combined cycle or open cycle mode. They are dual fuel units which use natural gas as the primary fuel and distillate oil as the back-up fuel. The 9E gas turbine has a design output of 126 MW and is capable of achieving more than 52 per cent efficiency in combined cycle.

The 9E units at Fujairah are fitted with a dry low NOx combustion system, while water injection is used to reduce NOx emissions when firing diesel fuel. The gross output of the four units is 424 MW when using evaporative coolers at an ambient temperature of 46°C and relative humidity of 40 per cent.

**Saving time**

The four HRSG units were supplied by Doosan. They are single pressure units with a horizontal design and are equipped for supplementary firing. The two steam turbines are back pressure units supplied by Siemens.

Like the MSF evaporators, the four HRSGs were fully assembled at Doosan's Changwon plant before being shipped to the site. This enabled Doosan to shorten the project time by 12 months as it would usually take the company 24 months for the shipping, disassemble and reassemble processes.

Civil work for the project was carried out by Six Constructions Arabian Construction Company, while switchgear was supplied by Hyundai.

In April 2003, UWEC signed a $37 million contract with Sogex Oman for the operation and maintenance of the power and desalination plant and the water transmission pipeline. The contract entails the operation and maintenance of the entire facility for a five year term. According to UOG, Sogex's bid for the contract was 40 per cent lower than any of the other bids it received.

**Transmission links**

Al Jaber and Technip are responsible for the project's water transmission package, which involves the construction of a 179 km dual pipeline to Sweihan, an 18 km spur to Al Dhaid in Sharjah, as well as pumping stations, water storage tanks and associated facilities. UWEC will supply water to the Federal Electricity and Water Authority (FEWA), which will distribute water to towns including Fujairah, Ajman, Umm al Quwain, Bathna, Dafta and Masafi Al Fujairah. The pipeline will have the capacity to pump 818 million l/day (180 MIGD) of water from the plant to Sweihan.


A 400 kV transmission line has also been constructed to evacuate electricity from the Fujairah power plant at Qidfa to the FEWA power grid. In the long term, UWEC will be able to export the power to the planned Emirates National Grid, which will also be connected to the GCC grid – a region-wide power network which will eventually interconnect the UAE with Oman, Kuwait, Saudi Arabia, Bahrain and Qatar.

**Building for the future**

According to Doosan, Fujairah was due to achieve Commercial Operation Certification in June 2004. By May 31, the plant had produced 646 million l (142 million gallons) of water and 85,193 MWh of power. The production of power and water was scheduled to be gradually increased in stages until design capacity was reached.

UWEC is now expected to privatise the Fujairah plant and is already developing a second project at Qidfa. This power and desalination plant will have a capacity of up to 1,000 MW and 455 million l/day (100 MIGD). UWEC received prequalification documents from 14 international, regional and local companies for the turnkey EPC contract, which was due to be awarded by mid-2004.

Germany's Fitchner is undertaking the project management consultancy contract for the project, which is expected to be commissioned in 2006.

### 4.1.4 Additional information

- http://search.abb.com/library/Download.aspx?DocumentID=9AKK101130D3450&LanguageCode=en&DocumentPartID=&Action=Launch&IncludeExternalPublicLimited=True
- http://en.wikipedia.org/wiki/Fujairah_power_and_desalination_plant

### 4.1.5 Site Visit

- Abu Dhabi will require 450 ML per day
  - Desal will produce 100 ML per day
- Abu Dhabi Power and Water building a RO plant
  - Desal will produce 100 ML per day
  - Cost $1.7 B US
  - Project is privatised
  - Seawater → RO → potable water
    - Will also have heat exchange and thermal separation
- The site produces 610 MWhr
- The plant operates with Natural Gas (from Qatar)
  - Cost $1.8 $m^3$ from Dolphin Energy
  - Has oil backup (paid for on use)
- RO system

| | | | **1st pass** | | **2nd pass** |
|---|---|---|---|---|---|
| Seawater→ | Flocculation Sand filtration | → | RO High pressure 70 bar | → | RO Low pressure 10 bar |
| | | → | RO Seawater (seawater membranes) | → | RO 500 ppm (brackish membranes) |
| | | | ↓ 500 ppm | | ↓ 15 ppm |

- Membrane life is 4 years
- Energy efficiency 3.5 kWhr/$m^3$
- Quality assurance
  - ISO 17025 certified
  - Plan for ISO 9000, 14001, 18001
- Water is used for potable, industrial and agriculture
  - $1.8 $m^3$ wholesale price to Abu Dhabi Water and Power
- Plant finance
  - $1.4 Billion lending
  - $0.3 Billion company funds



# 5 Day 5 – Friday 24th October, UAE – Dubai to Israel

## *5.1 Travel day – Destination: Israel – Jerusalem (via Telaviv)*

**Dinner in Jerusalem**

### 5.1.2 Contact Information:

www.netafim.com.au

**Site Address:**

Dan Boutique Hotel, Jerusalem

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

Kibbutz Magal – D.N. Hefer
38845

Tel: +972-4-6287499

Fax: +972-4-6287713

Mobile: +972-52-5017499

Email: ortal.erez@netafim.com

**Site Contacts:**

Tour Guide: Gadi Bar-Shalom

Tel: 050 576 9933


### 5.1.3 Background

To be met at the airport in Telaviv and transported by bus to Jerusalem for a night tour of the city and dinner.

# 6 Day 6 – Saturday 25th October, Israel – Jerusalem

## *6.1 Rest day*

# 7 Day 7 – Sunday 26th October, Israel

## *7.1 Destination: Atlantium*

**Focus: Water management technology: UV disinfection**

### 7.1.2 Contact Information:

www.atlantium.com

**Site Address:**

Israel Headquarters

Atlantium Technologies Ltd.

Har Tuv Industrial Park

POB 11071

Israel 99100

Tel: +972 2 992 5001

Fax: +972 2 992 5005

Email: sales@atlantium.com

info@atlantium.com

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2


**Site Contacts:**

Aion Tish

Product Marketing Manager

Tel: 02 992 5001

Mobile: 054 237 7115

### 7.1.3 Background

Atlantium develops and provides innovative water disinfection solutions that help businesses and municipalities build, expand and operate water-intensive processes. Their field-proven solutions have taken UV water disinfection to levels never before attained. They do this through a cost effective, environmentally friendly process that delivers unprecedented microbe inactivation, at industrial and municipal water flow rates.

Atlantium Technologies has re-invented ultraviolet-based water disinfection. By leveraging the mechanics of Total Internal Reflection, Atlantium has created Hydro-Optic Disinfection™, the most efficient UV microbe inactivation technology available anywhere. Atlantium's environmentally-friendly systems attain unprecedented levels of disinfection, helping industry and drinking water suppliers worldwide to provide healthier, safer products.

**About Atlantium**

Founded in 2003 with the technology and will to make a significant contribution to the environment by providing safe water disinfection solutions, Atlantium is today a growing company with global sales. Water-dependent industries such as food & beverage, dairy and aquaculture as well as municipalities use Atlantium systems to meet their growing needs for superior water. The

company enjoys an international customer base, with installations in Europe, the United States, Latin America, the Middle East, Asia and Australia.

Atlantium is made up of an interdisciplinary team of professionals who believe that promoting a highly effective, ecologically-sound water disinfection solution is a mission – not just a career.

Atlantium's unequalled innovation for water treatment technology combines ultraviolet (UV) disinfection with advanced hydraulic and fibre-optic principles.

Atlantium solutions have impacted businesses with measurable results that impact production, efficiency, operating and maintenance procedures and costs and more, leading customers to show especially quick ROI. The system reduces maintenance costs and downtime and increases reliability through automated online monitoring. These significant achievements are the fruit of high-performance disinfection solutions that Atlantium's in-house market-sector experts tailor to meet customer needs.

Atlantium's Hydro-Optic Disinfection system is field-proven and validated according to the stringent U.S. Environmental Protection Agency protocols.

**Technology Overview**

Atlantium technology is transforming the water disinfection landscape with an ultraviolet (UV) based system that reaches levels of disinfection never before attained.

While UV light's natural disinfection properties have been widely recognised and definitely provide an environmentally-friendly non-chemical solution with no disinfection by-products (DBPs), UV reactor manufacturers have struggled to deliver these benefits reliably over time.

### Atlantium's Hydro-Optic Disinfection™ system

Atlantium's revolutionary invention, the Hydro Optic Disinfection™ system, overcomes three obstacles encountered in the use of conventional reactors: performance; reliability; dose management and monitoring. The system's technology and configuration enable attainment of levels of microbial inactivation not achievable or validated before. Equipped with real-time monitoring and control, its dose delivery is sustained throughout disinfection, as demonstrated by unparalleled results. This has paved the way for use of the Hydro-Optic Disinfection system in a range of applications which previously were considered inappropriate for UV-based disinfection.

RZ104-12: one of the RZ series, modular systems that combines high disinfection effectiveness with high cost-effectiveness

R2000L: earned EPA+ recognized validation

### Revolutionary system design leads to unparalleled performance

Atlantium was able to break the performance barrier by integrating optic and hydraulic principles in unique ways. The core of Atlantium's Hydro-Optic Disinfection system is a large quartz tube that effectively traps UV light rays. Long effective paths of UV light propagation, coupled with carefully designed patterns of water flow within the Hydro-Optic Disinfection chamber ensure that all micro-organisms are exposed to the same UV dose, the key to reliable, effective inactivation. The system's protected disinfection chambers with nothing impeding the flow of water and light also contribute to achieving high rates of microbial disinfection.

The Hydro-Optic Disinfection system is built to deliver a wide range of doses – from low to very high – achieving microbial inactivation of an extremely broad array of micro-organisms, including

those that have resisted traditional chemical, thermal and other UV treatments. The control system allows the required dose to be set as well as monitored/tracked, so that it is reliably maintained as water and flow conditions change.

## How optic and hydraulic principles work in the Hydro-Optic Disinfection system

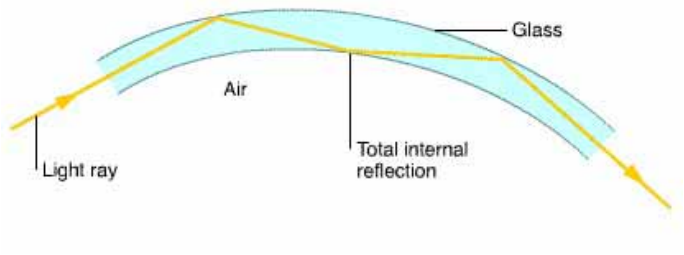
*Uniform Dose Distribution*

Inactivating water-borne micro-organisms at consistently high log reduction levels using ultraviolet (UV) disinfection necessitates distribution of the UV light so that all microbes are exposed to a uniform dose. Achieving this aim requires a system design and structure that promotes optimal synchronisation of UV light and hydraulic flow patterns along with unimpeded water flow in the disinfection zone. This configuration ensures microbes cannot avoid being confronted by the UV dose and, as a result, are inactivated.

Atlantium's invention, the Hydro-Optic Disinfection™ system, has achieved the goal of uniform dose distribution as verified by third parties. The system was built to effectively lengthen the path of UV light within the disinfection tube. The combined effect of long paths and optimal water flow ensures microbes are confronted by the required inactivation dose wherever they are located within the disinfection chamber.

*Performance: Total Internal Reflection – lengthening the path of UV light*

Inspired by the physics of fibre-optics, Atlantium adapted the principle of Total Internal Reflection (the natural phenomenon that carries waves over long distances in quartz tubes surrounded by air) to water disinfection. Implementing the principle using a thick quartz tube surrounded by an air block, lengthens the effective path of the ultraviolet (UV) rays and raises levels of disinfection to degrees never before attained in traditional UV systems.




Principle of Total Internal Reflection: light travelling through a glass tube (www.bbc.co.uk)

Atlantium's Hydro-Optic Disinfection system forces UV light rays to repeatedly bounce back from the quartz tube wall at different angles throughout the entire water volume. The water flowing through the quartz tube acts as a waveguide for the UV light, ensuring that the disinfecting photons continually propagate throughout the entire volume of water. As UV rays continue to spread and uniformly fill the entire disinfection chamber, all microbes are efficiently inactivated wherever they are located.

*Hydraulics – controlling the water flow*

Atlantium has effectively engineered the Hydro-Optic Disinfection system so that water flows in a controlled, defined pattern into the system's disinfection tube. The water flow, synchronised to match the pattern of UV light distribution, runs unimpeded as there are no parts, baffles or brushes to block UV photons from hitting and inactivating micro-organisms or compromising the disinfection reaction in the chamber.

In realising these fundamentals of effective UV disinfection – lengthening the path, properly distributing the UV light and controlling the pattern of water flow – the Hydro-Optic Disinfection system achieves the goal of unprecedented uniform dose distribution, the key to ensuring microbial inactivation at the highest levels.

## How Atlantium's Hydro-Optic Disinfection system inactivates micro-organisms with high efficacy

*Microbiology*

Atlantium's revolutionary Hydro-Optic Disinfection™ system guarantees inactivation of an extremely broad range of micro-organisms including those that have resisted traditional chemical, thermal, and low-pressure ultraviolet (UV).

Atlantium's pathogen-specific solutions, delivered by systems using medium-pressure UV, assure users of disinfection success.

*UV light's germicidal effects on micro-organisms*

UV light's germicidal properties have been known to scientists for more than a century. Invisible to the eye, UV light inactivates micro-organisms in milliseconds by various modes of action: damaging DNA, RNA and enzymatic systems.

The type of damage to micro-organisms' DNA caused by low pressure lamps that deliver their UV dose at 254nm leads adjacent Thymine bases to bond with each other, making them incapable of reproduction.

Atlantium's wide spectrum medium pressure lamps, however, deliver UV that causes DNA-protein crosslinks, enzyme inactivation, as well as actual DNA breakage. This damage is less subject to repair and thus, leads to more highly effective microbial inactivation.

*Determining the correct UV dose for target micro-organisms*

Accurate determination of UV dose requirements and subsequent reliable delivery of the required dose ultimately establishes the real disinfection results.

Using the highest professional standards – methodologies recommended by the US Environmental Protection Agency – Atlantium can test field water samples to precisely determine dose requirements.

The EPA method utilises a Collimated Beam Apparatus (CBA); a testing instrument designed to accurately measure the UV dose delivered to a microbial suspension and understand the system's ability to inactivate the micro-organism. Following measurement, the same type of water and microbes used in the CBA are tested in the actual Hydro-Optic Disinfection system. All Atlantium's Hydro-Optic Disinfection models have been tested under a wide array of water conditions, UV doses and test micro-organisms to make sure it adjusts to fluctuating conditions of water flow and UV transmissivity.

*Diagnosing and meeting customer needs: A pathogen-specific solution*

Atlantium maintains its own microbiology division and laboratory which provides full support to Atlantium personnel. Once a disinfection solution that accurately corresponds to site conditions and customer requirements has been identified the prescribed system is calibrated to deliver the determined UV dose to inactivate the target micro-organisms under the site-specific conditions.

The microbiology division also performs special consulting services and in-depth site analysis and diagnosis where there is a need to troubleshoot microbial and water anomalies. Customer research programs have included viruses such as WSS and IVN, bacteria such as TAB, Bacilli Sporoform and Deinococcus radioduranda, moulds such as Aspergillus niger and others, and yeasts such as Saprolegnia and others – that may be found in industrial, municipal, aquaculture and agricultural settings.

The microbiology division is involved in multi-national studies on system performance against viruses and bio-films. The division's involvement in cutting edge research means that Atlantium customers are alerted to the latest developments in UV practices which can protect their sites from existing and new threats.

**Product Overview**

The Hydro-Optic Disinfection™ system represents a sea change for the ultraviolet (UV) water disinfection industry. Highly effective microbial disinfection demands the design and configuration of a system that looks and operates like no other.

The R-series Hydro-Optic Disinfection system was launched in 2005 and in 2008 Atlantium launched its RZ-series.

### Key operating principles lead to high microbial inactivation

Both series adapt the physics principle of Total Internal Reflection and are engineered to achieve uniform dose distribution – design changes that lead to unprecedented performance. These two fundamentals have resulted in demonstrated and validated attainment of high microbial inactivation levels.

Atlantium's PR-20 at a large dairy plant operating as a non-thermal pasteuriser, having replaced a conventional heat pasteuriser

### Real-time monitoring and control maintain required disinfection dose

The Hydro-Optic Disinfection system consistently delivers the required dose. It's Monitoring and Control software provides real-time, continuous reading of the water flow, continuous measurement of UV transmissivity and UV lamp intensity and adjusts the required disinfection dose as conditions change. This saves energy while still providing the required protection for the microbial challenges.

For the operator's convenience, an easy-to-use system always displays dose and other key operating parameters on the interface screen, showing the dose value that leads to disinfection.

Monitoring and Control records performance parameters and produces reports, enabling tracking and quality control and giving operators a full history and trending capabilities.

### Simple to maintain, protected lamps

All R and RZ models use custom-designed short (up to 30 cm/12 inch), medium pressure high intensity UV lamp(s), protected by thick quartz enclosures and isolated from the water.

### Quality assurance

Both the R-series and RZ-series are developed, manufactured and assembled under strict quality control procedures and meet ISO 9001 requirements. The systems comply with relevant international regulations.

**Product Advantages**

The Atlantium Advantage – Hydro-Optic Disinfection™ –safe, high quality water: consistently and cost-effectively

- Superior microbial inactivation resulting from uniform dose distribution (UDD) – Atlantium system's configuration ensures UV light rays travel throughout the entire volume of water delivering the same amount of UV dose to all micro-organisms in the water; the system's custom-made medium pressure high intensity UV lamps ensure damage to micro-organisms and their inactivation is complete.
- Environmentally-friendly; no disinfection by-products means safe disinfection processes with healthy results.
- Real-time monitoring and control – two-sensors-per-UV-lamp setup continuously measures both lamp intensity and water's UV transmissivity. Real-time data from these sensors, as well as real-time flow rate data from an external flow meter, constantly update the Monitoring and Control program. Required UV dose is automatically readjusted

according to real-time measurements. The user-friendly and intuitive interface can be accessed remotely.

- Low operating costs – real-time adjustment of UV dose assures the required dose is delivered under fluctuating conditions; ensures energy is expended only on the dose required – not more.
- Simple maintenance – Atlantium systems use custom-designed short (up to 30 cm/12 in) Quick Connect medium pressure UV lamps protected by thick quartz enclosures, isolated from the water with minimal risk of lamp breakage. Lamps are quick and simple to change – in 4 minutes – using Atlantium's Lamp Replacement Tool. No need to shut the system down.
- Simple integration – Atlantium's small footprint systems integrate easily into new or existing facilities.
- System performance validated according to EPA protocols – the R200 model has been validated by third parties according to stringent U.S. Environmental Protection Agency (EPA) guidelines. They are pre-approved for use by municipalities and drinking water suppliers governed by EPA rules.

### 7.1.4 Site Visit

**UV System**

- Traditional UV systems offer 1 to 3 log removal of pathogens, this system can obtain 5 log removal
- Main advantage is uniform prescribed dose with consistency due to the design
- In aquaculture a $75,000 machine can pay for itself in 12 months
- TIR provides uniform treatment of water
- UVT is a measure of waters ability to be treated by UV light
    - It is a function of turbidity, UVT >90 is highly desirable
- Has been tested for plant pathogens including: canker, pythium, fusarium and proven to be effective
- Has a system of sensors to measure the uniformity of dose
    - Stops over or under dosing
- UV has been used as an additional barrier/treatment rather than the primary treatment until TIR UV reactors
- Lamp life 5,000hr guaranteed for 200 days
- Price starts at $40-50k US
    - 4" – 100 $m^3$/hr
    - 6" – 200 $m^3$/hr
- "The simple truth is there are no systems like this one"
- Lowest running cost for UV disinfection
- Lamps are only 25 cm long

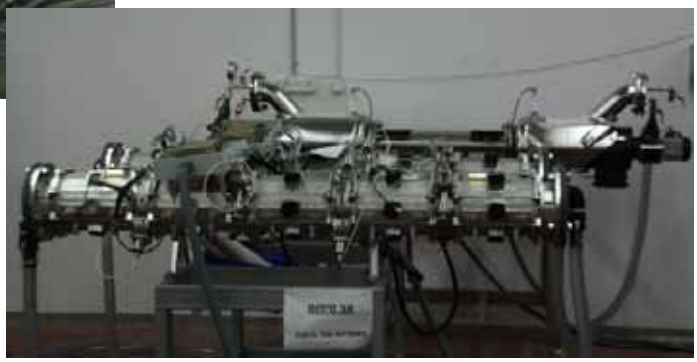
**Operation and Maintenance**

- The reactor does not have to be stopped to replace lamps
- Uses ultrasonic cleaning to prevent any deposits
- PQR – power to flow rate
    - TIR is better than 2 x normal reactors
- The RZE range can treat 71,000 $m^3$/hr
- All system changes must be validated by microbiological testing
    - Plate counts
- UV sterilisation does not kill bacteria but rather inactivates the bacteria
    - UV works on DNA/RNA → produces non-reproductive bacteria
- They use an alternate lab to validate their lab practice

**Laboratory testing of equipment**

The process is as follows:

| | |
|---|---|
| • Inject microbes into inflow stream<br>↓ | |
| • Inflow passes through a static mixer<br>  • Sample is taken to test homogeneity<br>↓ | This step ensures that the pathogen load is constant through treatment phase |
| • UV treatment<br>↓ | |
| • Outflow passes through a static mixer<br>  • Sample is taken to test homogeneity<br>↓ | This step ensures that the potential pathogen load is constant through outflow phase |
| • Outflow sampled for laboratory testing | |



## *7.2 Destination: Mekorot Shafdan Reclamation Plant*

**Focus: Wastewater treatment plant**

### 7.2.2 Contact Information:

www.mekorot.co.il/Eng/Activities/Pages/WastewaterTreatmentandReclamation.aspx

**Site Address:**

South of Rishon Letzion

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Gal (contact at Visitors Centre)

Phone: 03 9635 123

MEKOROT NATIONAL WATER CO. LTD.
Central District

**Tomer Kraitzer**
Operation & Process Eng.
Dan Region
Wastewater Treatment & Reclamation Plant

E-mail: tkraitzer@mekorot.co.il P.O. Box 56 Ramla 72100, ISRAEL
Tel: 972-3-9612757 Mobile: 972-57-7275776 Fax: 972-3-9635125

### 7.2.3 Background

**Mekorot Company Profile**

Mekorot, Israel's national water company, began operations as the "impossible dream" of Israel's pioneering leaders, a decade prior to the establishment of the State. Today, Mekorot is one of the world's most advanced water companies, a leader in water resources management, desalination, wastewater treatment and effluent reuse, rain enhancement, water quality, water security and water project engineering. Through continuous research, experimentation and field innovation, the company provides a reliable supply of high-quality water to a rapidly growing population, despite the region's limited freshwater resources, arid climate and difficult geopolitical realities.

Mekorot supplies 80% of Israel's drinking water and 70% of its entire water supply, operating 3,000 installations across the country.

Mekorot's uniqueness as a water utility lies in its unparalleled experience, know-how, technologies and innovative processes for the management, operation and treatment of all types of water resources: surface water, underground water, brackish water, seawater and effluents.

The supply of adequate quantities of high quality water has become a tremendous challenge in many regions of the world, a situation that unfortunately is expected to intensify. The skills, technologies, and know-how that Mekorot has accumulated over the decades have provided the company with deep insight regarding successful approaches to water challenges. Based on its experience and capabilities, Mekorot believes that it is possible to turn the global water shortage to an economical growth engine.

- Water resource management: Mekorot's expertise derives from decades of innovation in the face of severe challenges, including limited freshwater resources, climates ranging from semi-arid to desert, a rapidly growing population and difficult geopolitical realities. Mekorot has overcome these challenges through the development of cutting-edge processes that have succeeded in maximising the utilisation of Israel's water resources, automating its treatment and delivering it to domestic, industrial and agricultural users.
- Water supply: over a period of 70 years, Mekorot has implemented a range of novel systems and methods to supply water with high reliability and safety. Mekorot supplies water to approximately 5,000 intermediary water providers, including municipalities, regional associations, agricultural settlements and industrial consumers.

- Water quality and security: Mekorot has established a nationwide, state-of-the-art network of water quality laboratories and sophisticated monitoring programs. These services are available to partners on an outsourced basis.
- Desalination: one of the world's desalination pioneers, Mekorot today operates 31 desalination plants treating nearly a million cubic metres of seawater and brackish water every day. Its advanced R&D, experience and know-how have resulted in desalination plants with an impressive level of water economy and automation while reducing their energy consumption and membrane usage. These efficiencies have enabled Mekorot to achieve the world's lowest-cost desalination costs. Mekorot's desalination expertise ranges from plant design, construction and project management to operations, training and maintenance.
- Wastewater treatment and reclamation: the systems established by Mekorot have given Israel the world's highest water reclamation rate. The company's eight water purification plants treat 40% of all Israel's purified sewage water, and its nine reclamation plants enable 70% of the effluent to be reused for agriculture, freeing drinking water for domestic and industrial use.
- Flow catchment: Mekorot has developed innovative technologies for the capture of floodwater in desert regions.
- Rain enhancement: Mekorot's proprietary cloud seeding technologies and programs have succeeded in augmenting Israel's rainfall by approximately 13-18 % annually.
- Model-based operational planning: Mekorot has developed sophisticated mathematical models and SCADA (Supervisory Control and Data Acquisition) control systems that enable it to optimise the full range of its operations and planning activities. Its professional service personnel are available to adapt and implement these tools for partners.
- Advanced engineering and infrastructure capabilities: Mekorot's engineering subsidiary, Electro-Mechanical Services (EMS), is expert at carrying out major infrastructure projects such as Israel's flagship National Water Carrier and its state-of-the-art 5th Pipeline to Jerusalem. To share its expertise with companies around the world, Mekorot has established a professional services framework under which it provides planning, technological consultation, engineering, outsourced operation, maintenance, project management and implementation services. International partners that have benefited from these services include Siemens, FENTOS, CYII, Melbourne Water, Sydney Water, the Government of India, KIWA Research Institute and others.
- Entrepreneurship: to extend its technological leadership and continuously improve the quality of the water it provides, Mekorot actively promotes the development of innovative new water technologies. Through its WaTech™ initiative, Mekorot provides entrepreneurs in all water-related business areas with platforms for beta and commercial testing and supports them with a broad range of technological analysis and consultation services. It also assists them in their efforts to reach out to global markets, strategic partners and capital.
- Water treatment: investigation and development of cutting-edge technologies; optimisation and upgrade of existing plants.

**Facts & Figures – as at 31/12/2006**

Annual water supply

- 1.5 billion cubic metres (70% of national consumption and 80% of drinking water)
- Wastewater reuse: 60% of treated wastewater
- Sewage treatment: 40% of overall sewage

Customers

- 4,800 municipalities, local counsels, agricultural settlements, kibbutzim and regional associations, who in turn supply water to Israel's citizens, farmers and industries

Employees 2,150

Founded 1937

Ownership fully owned by the State of Israel

Financial information

- Sales – more than US$700 million per year
- Shareholders' equity – US$500 million
- Balance sheet total – more than US$3 billion

Physical plant

- Production and supply facilities: 3,000
- Control centres: 8
- Water pipes: 10,500 kilometres
- Desalination plants: 31

  a 100 million cu. m a year seawater desalination plant is under construction in Ashdod that will be operational in 2011

- Sewage treatment plants: 6
- Reused wastewater projects: 10
- Filtration plants: 8

  including a 500 million cu. m a year filtration plant at the company's Eshkol facility

- Pumping units: 1,822
- Pumping stations: 659
- Reservoirs: 91
- Wells: 1,042
- Tanks: 637 (500 cu.m and above)
- Reclamation projects: 10
- Water quality laboratories: 6

Water testing

- Water samples taken: 40,000 annually
- Laboratory analysis: 190,000 annually

**Shafdan Reclamation Plant**

Shafdan reclamation plant is Israel's largest plant, handling over 113.1Mil cu.m of reclaimed water, ensuring the required effluent level, effluent reclamation by groundwater infiltration, and supplying the reclaimed water to agricultural consumers in the southern part of the country through the "Third Negev Pipeline." Mekorot handles the sewage treatment and purification process on behalf of municipalities, and takes the water for extra-purification and distribution for agriculture.

The Shafdan purification plant, which is responsible for the purification of wastewater from cities in the Dan region and its reuse for agricultural purposes, is one of the largest and most advanced of its kind in the world. A tour of Shafdan includes a description of purification methods and transport to the Negev, as well as movies and demonstration facilities.

Mekorot's largest wastewater treatment plant is the Shafdan, a facility located in Israel's heavily populated Dan Region. It is one of the most complex wastewater treatment plants in Israel and the most advanced in the Middle East. Serving a population of two million persons in the Dan region, the plant treats 130 million cubic metres of wastewater annually. Mekorot operates both the facility and its pumping stations. Secondary effluent from the Shafdan plant is used to infiltrate fields in Rishon Letzion and Yavne. From these fields, the effluent is recharged into groundwater reservoirs (aquifers) where it undergoes natural physical, biological and chemical processes that improve its quality and storage ability.

The quality of the reclaimed water is very high, making it suitable for all forms of irrigation. Israeli produce grown using reclaimed water includes oranges, carrots, potatoes, lettuce, wheat and flowers.

Note: the most common problem associated with recharging using a spreading basin is clogging of the surface by fine-grain sediment suspended in the recharged water and/or by microbial growth. In Mekorot's Menashe and Shikma plants, this problem has been addressed by initially introducing the water into sedimentation basins to allow the suspended sediment to deposit and afterwards transferring the improved water to recharge ponds.

**Wastewater treatment and reclamation**

Mekorot constantly searches for solutions to increase Israel's water supply. One of these solutions is wastewater treatment and effluent reuse for agriculture. The company aims at improving reclaimed water quality, thereby broadening the applications for which it can be used.

Mekorot's treatment and reuse of wastewater improves Israel's water balance by allowing the replacement of fresh water with treated wastewater for the irrigation of crops, thereby saving limited fresh water sources for domestic use. The treated wastewater supplied by the company for agricultural use complies with strict health standards and contributes to preserving the environment by reducing ecological damage caused by untreated wastewater.

Mekorot is responsible for approximately 40% of the wastewater treated in Israel (approximately 200 million cubic metres a year), and for the reuse of 60% of the country's treated wastewater for agriculture. 350 million cubic metres of effluents were reused in Israel for agriculture in 2005 – 75% of total treated raw sewage. Despite its small size and limited resources, Israel has achieved the highest rate of water reclamation in the world.

Wastewater treatment typically comprises four stages: pre-treatment, followed by primary, secondary and tertiary treatments. The treatment methods include oxidation ponds, activated sludge and MBR (mechanical bio reactor).

92 percent of the wastewater in Israel is treated and around 75 percent is used for agricultural irrigation. According to Mekorot Chairman, Eli Ronen, this is the highest percentage of such utilisation in the world. Mekorot experts presented these figures on 6th September 2007 during a seminar the company arranged with the participation of leading researchers from academia and water and agriculture industries.

Table of water reuse rates in agriculture:

| Israel | Spain | Australia | Italy | Greece | Central Europe & USA |
|---|---|---|---|---|---|
| 75% | 12% | 9% | 8% | 5% | 1% |

Mekorot operates six wastewater treatment plants (WWTPs) with a daily flow of 460,000 cubic metres and an annual capacity of around 180 million cubic metres. Following biological treatment, the effluents are routed to one of nine effluent reclamation plants. These plants filter and disinfect the effluent before it is supplied for irrigation. The Shafdan effluents are inserted into the soil for tertiary treatment and to recharge the aquifer. Later, the water is pumped out and transported to the Negev. The total effluent supplied for agricultural purposes is 216 million cubic metres per year. Comprehensive water quality monitoring is carried out at all stages of the recharging process

**Use of innovative technologies**

One of Mekorot's goals for the next decade is to increase its usage of all effluent water in order to prevent seepage into the environment of around 110 million cubic metres per year. To this end, Mekorot invests significantly in the development of cutting-edge technologies designed to increase the yield and reduce the cost of its treatment and reclamation processes. The technologies that Mekorot has deployed so far include:

- AS – activated sludge
- SBT – sequential batch treatment
- Aerobic and anaerobic sludge treatment
- Gas Bio-generation SAT – soil aquifer treatment
- Sand filtration
- UF – ultra filtration
- Net filtration
- Long storage reservoirs

Further, Mekorot continuously invests in new R&D in the areas of:

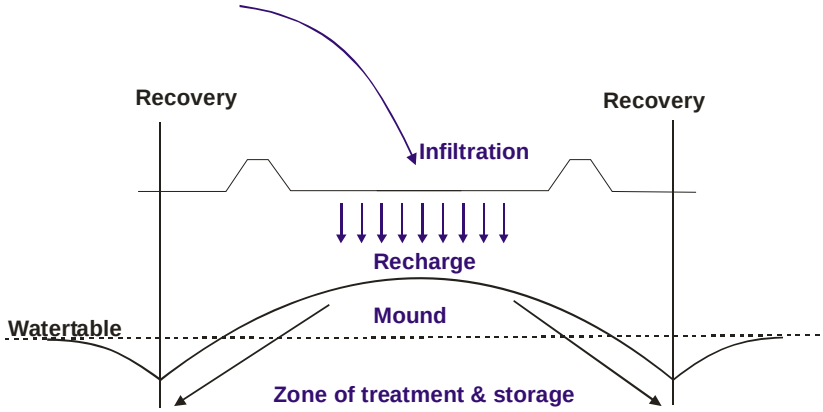
- effluent desalination
- membrane treatment
- alternative methods for chlorine disinfection

## 7.2.4 Site Visit

www.mekorot.co.il/Eng/Activities/Documents/Wastewater%20Treatment%20and%20Reclamation-%20WATEC%202007.pdf

Mekorot

- Started in the 1960's to manage water resources in Israel
- Treated wastewater from Israel's most populated regions – including Tel Aviv
- Treated wastewater is delivered to the southern agricultural district
- Inflow 380,000 $m^3$/day
- WWTP – mechanical filtration – biological activated sludge system
- Owned by the Dan region association of towns – operated by Mekorot
- Secondary treated effluent – good for restricted irrigation
- Water distributed to rapid infiltration basins for groundwater recharge




- Program of recharge
  - Day 1. fill RIB
  - Day 2. allow water to infiltrate
  - Day 3. RIB allowed to dry
- Oldest site is 30 years old
  - Reduction in infiltration is 0.5% p.a.
- 130 recovery wells
- Crops irrigated by Shafdan water
  - Oranges
  - Carrots
  - Potatoes
  - Lettuce
  - Flowers
  - Wheat
  - All crops unrestricted irrigation
- Cost of production

| | **Shekels / $m^3$** | |
|---|---|---|
| Energy | 0.42 | 40% cost of electricity |
| O & M | 0.23 | |
| Financing | 0.52 | |
| Payment Eff | 0.19 | |
| **Total** | **$1.33 (ILS)** | **$0.53 (AUD)** |

## *7.3 Destination: Mekorot Yarkon Springs Centre at Rosh Ha'ayin*

**Focus: Water supply management**

### 7.3.2 Contact Information:

www.mekorot.co.il/Eng/Mekorot/Pages/IsraelsWaterSupplySystem.aspx

**Site Address:**

Road 483, nr Kibbutz Giv'at Hashlosha

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Aliza (contact at Visitors Centre)

Phone: 03 9388 961

### 7.3.3 Background

**Yarkon Springs**

Yarkon Springs at Rosh Ha'ayin is Israel's primary water "intersection". At this location, the National Water Carrier arrives from the north of the country and is combined with water from springs located at Rosh Ha'ayin. From here, water flows to the Negev in two large pipelines and to the Dan region in another pipeline. The Visitors Centre offers an explanation of Israel's national water supply system, including Israel's various aquifers and a tour of the site's pumping stations.

**Israel's Water Supply System**

For 70 years, Mekorot's National Water System has been bringing high-quality water to Israel's growing population in the face of significant geographical, climatic and geopolitical challenges. Mekorot's innovations continually improve its utilisation of scarce water resources improving water quality and delivery reliability while minimising water loss and operational costs.

**Components of Mekorot's Water Supply System**

- Nationwide, flexible systems of conduits and controls that unifies and enables mobility between Israel's main water basins (the Sea of Galilee, Mountain Aquifer, Coastal Aquifer, local rivers, desalinated water and reclaimed water)
- "Smart" systems to automate operations while allowing remote control of all facilities
- Centralised monitoring and planning systems to facilitate a "top-down" approach to planning, operation and development

Internally-developed modelling and management tools, including:

- Mathematical models for optimisation of complex operations including:
- management of water supply to Jerusalem and the Jordan Valley
- management of the central filtration system
- optimisation of water supply to desalination plants
- remote control pump specification tests
- optimal real-time models for operation of pumping stations

Decision support systems including:

- mathematical models for planning of water systems
- forecasting of Sea of Galilee levels
- hydrological models for optimal operations
- forecasting of weather and water demand
- hydrological research
- usage of SCADA control systems

Mekorot designed these tools and systems to address the challenges of its environment:

- Chronic water shortages and continuously rising demand
- Complex structure of local aquifers
- Multiple types of water resources
- Distance of water sources from demand centres
- Complex security issues

### Israel's sources of potable water

- Surface water: (from Sea of Galilee-Lake Kineret), approximately 30% of Israel's drinking water supply, 242 million cubic metres in 2006
- Groundwater: (coastal aquifer along the length of Israel's coastline; mountain aquifer inland; ~2,800 wells): approximately 36% of the drinking water delivered by Mekorot; ~700M cu. pumped per day; pumping strictly controlled to prevent contamination by ingress of sea-water; recovery is carried out via 150 recharge wells
- Natural springs: 34% of the drinking water supply
- Desalination: 31 plants with treatment capacity of about 1 million cu.m per day
- Reservoirs: Mekorot maintains a number of reservoirs for floodwater collection and aquifer recharge; most of these are located in the south of the country

### Districts

Mekorot's water supply system is divided into northern, central and southern regions and Jordan District. A mechanical equipment unit serves all districts, constructing water infrastructure and other capital projects throughout the country. The Jordan District is responsible for the operation of the National Water Carrier.

### The National Water Carrier: Mekorot's Flagship Infrastructure Project

The National Water Carrier (NWC) is a visionary infrastructure project that Mekorot constructed over a two-decade period in the 1950s and 1960s, with construction completed in 1964. A single water network linking most of the regional water projects throughout the country, the NWC is able to convey 450 million cu.m of water per year. The NWC was intended originally to supply irrigation water to the central and southern regions of Israel, but since the early 1990s has been supplying more than half of the country's drinking water.

The concept behind the NWC was to combine Israel's three fresh water sources: the Sea of Galilee and its catchment basin, the Mountain aquifer and the Coastal aquifer to provide water to Israel's arid southern region. In practice, the Sea of Galilee has become the new primary natural reservoir and provides water to Israel's dense population centres as well as to the south. In

addition, the NWC water is used to recharge aquifers and groundwater to reduce the significant loss of water through evaporation of its surface reservoirs.

The Sea of Galilee is a lake that covers 168 square kilometres and contains 4 billion cu.m of water. It receives the majority of its water – approximately 520 million cu.m. – from the Jordan River, which itself receives water from three major tributaries: the Dan, which contributes 250 million cu.m per year; the Snir (Hatsbani), which contributes 150 million cu.m per year; and the Hermon (Banias), which contributes 120 million cu.m per year. Total inflow from the lake's catchment basin is approximately 850 million cu.m per year. Some 300 million cu.m of water evaporates from the lake each year and the remainder is available for pumping. Of this amount, approximately 400 million cu.m. per year is pumped into the NWC.

The route of the NWC covers mountains, streams and rocky terrain, challenges that were overcome by digging tunnels and constructing inverted siphons. For 35 kilometres of its route, the water travels through open canals. Among the solutions used to convey water from one region to another are advanced pumps and mechanised devices and sophisticated control centres.

Water enters the NWC through a pipeline submerged in the northern part of the lake and flows to a pumping station. The pumping station, located in a mountain cavern, contains 30,000 hp pumps that force the water into pressure pipes. The pressure pipes raise the water from 213 below sea level to 44 metres above sea level. Construction and excavation of the giant station was one of the most complex tasks of the NWC project.

The water is discharged into the 17 kilometre Jordan Canal and from there into the Tsalmon Canal, an operational reservoir with a capacity of 1 million cu.m. The Tsalmon Pumping Station lifts water another 115 metres into the 17 kilometre Beit Netofa canal, bringing it to the Eshkol reservoirs, which contains sludge removal, chlorination and water testing facilities. From this facility, water enters an 86 kilometre pipeline to the Yarkon-Negev system at Rosh Ha'ayin. Part of the route includes several tunnels that are remarkable engineering feats. Several additional pumping stations have also been constructed to increase the capacity of the NWC and enable additional sources of water to be conveyed by the NWC.

The Saline Carrier was built by Mekorot in the 1960s to 'catch' the flow of saline springs flowing into the Sea of Galilee in order to lower its salinity. Rather than allowing the saline water to enter the Sea of Galilee, the Saline Carrier carries it to the Jordan River at a point south of the lake, enabling it to flow into the Dead Sea. The Saline Carrier is 22 kilometres in length and conveys 22 million cu.m per year. Its usage has cut the salinity of the lake in half.

Additional steps taken to lower the NWC's salinity include diluting of the water in the carrier with well water, together with maintenance of an optimum level of the lake.

Significant energy is required to operate the NWC, primarily to lift the water from 209-213 metres below sea level to an elevation of 150 metres above sea level. In fact, the NWC consumes approximately 100 megawatts per hour, or 4% of all electricity produced in Israel. Savings in electrical consumption have been achieved by employing innovative technologies and by operating during minimum electricity tariff hours.

To increase irrigation water available for the Negev, Mekorot established the Third Pipeline. The water for this pipeline is created through the treatment of effluents at the Dan Region treatment plant. The Third Pipeline carries 110 million cu.m of water per year.

## Continuing to innovate

Mekorot continues to innovate with the goal of continually improving Israel's water services. Major building projects currently underway include:

- National filtration plant
- Seawater desalination facility in Ashdod
- Brackish water desalination facilities in Lahat and Atlit
- Enhancing of water system security
- Preparing for integration of water from the seawater desalination plants
- Expansion of the Shafdan and other wastewater reclamation plants
- Development of the Fifth Pipeline to Jerusalem
- Connection of local authorities to the national grid

www.mekorot.co.il/Eng/Mekorot/Pages/MekorotsSiteMap.aspx

### 7.3.4 Site Visit

In Israel the water supply is considered as number one priority, food and national security the second priority and the environment third on the list.

**Mekorot**

- In Israel all water belongs to the country
- There has been 12,000 kms of pipe laid since 1971
- Water sources
    - Rainfall
    - Sea of Galilee
    - Mountain aquifers
    - Coastal aquifers
    - Total 300 x $10^6$ $m^3$/yr
- Since 1964 most of the water from the River Jordan – Sea of Galilee system has been piped south for potable, industrial and agricultural uses
    - Sea of Galilee had a defined low level of -209m
    - The new low level was extended to -213m
    - Currently it is well below the -213m level
- The major concern is that if the Sea of Galilee gets too low then salts and minerals will become a problem
- The first spring water into the Sea of Galilee (inflow) is very saline, this water is channeled past the Sea of Galilee to the Dead Sea to keep the Sea of Galilee "fresh"

**Infrastructure**

- Pump 220M $m^3$ into the system from natural springs
- There are 3 main pipe systems:
    - 1 to Tel Aviv
    - 2 north – south pipelines
        - The longest is 350kms
    - Water supply is -200m therefore requires a lot of energy to pump to customers
- Most population along the coastal strip
- In Israel there is a problem with water pollution and overuse is causing saltwater intrusion of aquifers

- Another significant issue with water management in Israel is security
    - Water is constantly monitored
    - Major water resources close to Syrian and Jordanian borders
- In the past, agriculture uses 60% of Israel's water resources – today it accounts for 45% (including recycling)
- Today there are water education programs for children

**Desalination**

- Desalination is becoming an increasingly important part of the total water resources of Israel
    - Hadron – 35M $m^3$ (could be increased to 100)
    - Ashkelon – 100M $m^3$
- Desalinated water is added to the water system
- Mekorot manages 80% of water nationally
- 20% by local municipality – but pay tariff to the government
    - Based mainly on localised bore fields

## *7.4 Destination: Biogas site in Emek Hefer with Eli Katz*

**Focus: Technology – alternative energy sources**

### 7.4.2 Contact Information:

www.foeme.org

**Site Address:**

Friends of the Earth – Middle East

Nahalat Binyamin 85

Tel Aviv 66102, Israel

Tel: +972 3 560 5383

Fax: +972 3 560 4693

Email: info@foeme.org

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Eli Katz – Netafim

Phone: 052 5017 964

### 7.4.3 Background

This plant accepts solids from dairies. Nearby there is another plant which processes citrus factory waste.

**Emek Hefer biogas project**

www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=Articals^l4799&enZone=Agricultural_Proj_cdm

Updated: 27/02/2007

Emek Hefer is an agricultural region located in the centre of Israel, midway between Haifa and Tel Aviv. The population largely resides on moshavim, kibbutzim and communal settlements.

The purpose of the CDM project is to install and operate a combined heat and power (CHP) plant at the existing biogas reactor in the region, which is operated on cow manure. The existing biogas reactor handles manure in three phases (pre-treatment, anaerobic digester, effluent and sludge treatment). It currently treats some 600 tons of cow manure which is then delivered to the biogas reactor which generates 880 Nm3/h of biogas. The biogas is currently used in a boiler for heating the process water and the remainder is flared.

The project activity consists of the construction and operation of three biogas CHP components with an installed capacity of about 3.2 MW. In addition, the residual heat will be used to produce an additional 1.2 MW of electricity.

Within the framework of the CDM project, the collected methane will be used to produce electricity which will be fed to the national grid for sale to specific customers. The project activity will thus contribute to the reduction of greenhouse gas emissions because it will generate power from a non-fossil fuel, thus avoiding greenhouse gas emissions from mostly fossil fuel fired power sources connected to the national grid.

Madei Taas Ltd established the power plant and biogas treatment system while the project was set up and operated in cooperation with Hefer Ecology. The anticipated lifetime of the project is 10 years and it is expected to generate 19,437 CERs per year.

The project is a small-scale project and is based on the SSC-I-D methodology – see:

http://cdm.unfccc.int/methodologies/DB/CB0S9DLO3KV3MABOD3GF1Q5ILPW189/view.html

**Treatment facility for agricultural sludge in Emek Hefer**

www.environment.gov.il/bin/en.jsp?enPage=bulletin&enDisplay=view&enDispWhat=object&enDispWho=News%5EI1187&enZone=october_bulletin&enInfolet=ViewNews.jsp&enVersion=0&0

A new project for the treatment of agricultural sludge has recently been inaugurated in Emek Hefer. The facility will treat agricultural sludge, in general, and dairy farm waste, in particular, by means of anaerobic digestion which produces biogas.

The facility, which will produce both compost and electricity, is the largest one of its kind in Israel. It will treat the cow wastes of all of the dairy farms in the Regional Council of Emek Hefer and of adjacent regional councils (Menashe, Carmel and Lev Hasharon) which number some 12,000 cows.

**The Emek Hefer Ecological Centre: agricultural sludge treatment centre and reservoir**

www.foeme.org/docs/Brochure_Emek_Hefer_English.pdf

Everyday the Agricultural Sludge Treatment Centre treats 750 tons of cattle mire derived from 150 dairy barns in the area. The Centre creates 13.5 cubic metres of biogas a day, providing 1.9 megawatts of electricity a year. This is the largest plant in the Middle East and the first of its kind in Israel.

The northern reservoir is one of 8 water reservoirs established in Emek Hefer to provide affordable treated wastewater for agriculture. This enterprise supplies 20 million cubic metres of water for agricultural purposes and is one of the largest in Israel.

General information

The Emek Hefer Regional Council extends over 140,000 dunams, from the coastline in the west to the Shomron Mountains in the east. The Council is comprised of 44 small communities (moshavim, kibbutzim and villages), with a total population of 35,000 people. 90% of Emek Hefer's land is presently in use. The Council is only 16 kms wide and national infrastructure lines including major roads, train tracks, waterways, gas, sewage and electric lines pass through the district.

The rehabilitated Alexander Stream flows through the centre of the Council creating a scenic tributary that attracts visitors and animals. However, current pollution sources on both sides of the Green Line still threaten the stream's waters and the ecological system that it supports.

The Emek Hefer Neighbourhood Path provides a glimpse into the community's local water sources and its efforts to deal with waste management and sewage. In addition, the tour highlights the mutual dependency of the area's transboundary water sources.

The path brings us to several "green" initiatives, as well as areas of unresolved conflicts, and seeks to underline the connection between a healthy environment and neighbourly relations.

The tour focuses on eastern Emek Hefer, starting with an overlook near the Green Line and passing through two different kinds of wastewater treatment facilities; one conventional, the other a "constructed wetland." From there the tour takes us to the "Emek Hefer Ecological Centre" where we will learn about treatment projects for water, agricultural sludge and cattle mire that turn these waste products into useful materials. The tour ends at an open green area that used to be a swamp, but today is a protected natural and scenic area.

See also:

www.foeme.org/index_images/dinamicas/publications/publ69_1.pdf

### 7.4.4 Site Visit

**Biogas**

- The management of dairy effluent was becoming an increasing problem
  - Manure is collected from dairies for a radius of 60kms
  - There are 10,000 cows in this region
  - Farmers pay $10 per head per annum for the removal of effluent
  - 600 – 700 $m^3$ of manure annually
  - Manure is 85% liquid
- On collection of the manure it is stored in an underground tank
  - It is agitated so it is homogeneous
  - Then pasteurised

**Process**

- Digesters – for 20-21 days
- Anaerobic digestion – produces gas
- Gas is cooled to remove $H_20$ and $H_2S$
- Produce electricity from the gas, 2 MWhr
- Gas is stored during the night for power generation during the day
  - This is because of increased electricity pricing during the day
- Biosolid and water residue are separated
  - Biosolid used as a compost (free of the restrictions of human biosolid use)
  - Liquid is used as a fluid fertiliser
  - Liquid irrigation used over summer and not winter to reduce nutrient leaching
- To make the gas economic it needs to be used close to the site of production
- A contractor removes biosolid which is composted with green waste
- Plant cost $4 M

## *7.5 Dinner Guest Speaker: Professor Rafi Semiat – Head of the Grand Water Research Institute (GWRI) @ Technion*

**Focus: Overview of challenges facing Israel and how they are being addressed**

### 7.5.2 Contact Information:

www.gwri.technion.co.il

**Site Address:**

Dinner location in Caesarea Port – Pundak Hatzalbanim

Ph: 04 636 1931 or 04 636 1679

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2


**Site Contacts:**

Professor Raphael Semiat

Director of the Grand Water Research Institute

Head of Rabin Desalination Laboratory

Ph.D. 1978, Technion-Israel Institute of Technology.

Phone: 04-8292009

Fax: 04-8295672

Email: cesemiat@technion.ac.il or cesemiat@gmail.com


### 7.5.3 Background

The mission of the Grand Water Research Institute is to advance by research and development the science, technology, engineering, and management of water, through interdisciplinary research and development and dissemination of information, with emphasis on the issues and problems facing Israel's water sector.

Rami is going to provide an insight into the global picture and current R&D as well as planning and big picture considerations for Israel.

**GWRI Background**

Located at the Technion – Israel Institute of Technology, the GWRI operates with a broad national perspective and remains Israel's leading institute of water research. It fosters interdisciplinary work and encourages collaboration of Israeli researchers from all universities and agencies. The GWRI also seeks to establish collaborative projects with other countries, particularly with Israel's neighbours in the Middle East.

The GWRI was established in 1993. It has currently 66 members: 37 professors in 7 academic departments of the Technion and 6 professors from other Israeli universities. The Institute is managed by Director Prof. Semiat Raphael, under the guidance of a Management Committee, whose members are the Vice President for Research of the Technion, the Deans of Civil & Environmental Engineering, Chemical Engineering, and Food Engineering & Biotechnology, two elected researchers, and the Director. An International Science Advisory Committee (ISAC) advises the GWRI on its research policy and programs. Its members are prominent water experts, from Israel and from abroad. The GWRI also has a Research Committee and a Committee for Equipment.

The GWRI is supported by funds from the American Technion Society and a philanthropic foundation located in Israel. An agreement was reached in May 2001 with Stephen and Nancy Grand from Detroit through the ATS for a major naming gift and the Water Research Institute (WRI) was named The Stephen and Nancy Grand Water Research Institute (GWRI). The Technion carries the GWRI's indirect costs, including salaries of staff for that part of the time they devote to the research projects, some support staff, and the infrastructure provided for the research projects. The Technion also provides the GWRI with a special allocation for scholarships, post-docs, visiting scholars and for workshops and meetings.

The national perspective of the GWRI expresses itself in the participation of investigators from various disciplines, in different institutions, in its projects. The GWRI admits a certain number of professors from other Israeli universities as members, and among the Research Committee's five members there are two from outside the Technion.

Another national dimension of the GWRI is its contacts with the Water Commission, Mekorot Water Company, and other national agencies to consider the research needs as perceived by the managers and planners of Israel's water sector and to cooperate in meeting these needs.

The Technion – Israel Institute of Technology is one of the major technical universities of the Middle East and is widely recognised as a centre of excellence. Its academic departments and research institutes cover all engineering and science disciplines, including architecture and medicine.

Much of the expertise available in Israel on water resources, wastewater disposal and water production by desalination has been generated by Technion's staff. Technion's Grand Water Research Institute (GWRI) is an interdepartmental research institute, affiliating over 50 Technion professors from eight academic departments

**Background: Raphael Semiat**

Research Interests

- Process development
- Separation processes with special emphasis on heat and mass transfer phenomena in liquid-liquid and solid-liquid systems
- Water technologies: water desalination purification and waste treatment problems
- Application of electro-optical techniques in the study of such systems

Research Topics

- Water Technology: Desalination using evaporation and membrane processes. Problems of membranes fouling, pre and post treatment. Uses of membranes for water quality problems and waste treatment. Enhanced recovery with concentrate treatment.
- Separation processes: Membrane processes. Crystallisation. Nano crystallisation. Use of nano crystals for removal of organic matter from water. Modelling of liquid-liquid settlers. Improvement of extraction columns. Mechanisms of heat transfer enhancement.

- Optical measurements techniques: Use of Laser Doppler Velocimetry for two phase-flow. Development of Laser Grating Velocimetry technique for relatively large particles. Study of drops motion in printing heads. Shear induced migration in concentrated slurries.
- Industrial project: Desalination. Concentrate treatment. Water treatments. Double falling film evaporator for solution concentration. Crystallisation of aluminium chloride.

**Blumenstein Family Water Information Centre (GWRI-BFIC)**

The GWRI-BFIC is staffed by a Librarian and Information Specialist Mrs. Ella Offenberger and is managed by Prof. Raphael Semiat. The GWRI-BFIC has created a database on publications (research reports, field studies, theses etc.) with some 34,715 items. In addition to bibliographic information, it includes edited abstracts on the studies. Search tools are based on a thesaurus.

A "Who's Who in the Israeli Water Sector" listing individuals and organisations can be accessed through the GWRI-BFIC website. It currently lists some 1,242 individuals and 425 companies and is accessible through the GWRI-BFIC's website.

The GWRI-BFIC is connected to the international information super-highway and its database is available on the Internet. The GWRI-BFIC subscribes to international information services. Access to the GWRI-BFIC is via the web site: http://gwri-ic.technion.ac.il

Recent publications by the GWRI-BFIC include:

- Abstracts of research theses on wastewater treatment
- Proceedings of a workshop on state-of-the-art needs for information in the water sector in Israel
- Water and soil salinisation and possible solutions
- Pre-treatment & post treatment technologies in desalination
- The coastal aquifer management
- Environmental engineering, water & infrastructure
- Master plan for Israel's water sector
- Water Research Institute – research summaries 1994-1998
- Palestinian-Jordanian-Israeli Cooperative Project (PJIP) on wastewater treatment and re-use
- Palestinian-Jordanian-Israeli Cooperative Project – from raw sewage to valuable effluent wastewater treatment and re-use.

The GWRI-BFIC initiated the formation of the Israel Water Information Centres Association (IWICA), composed of libraries and information centres in academic, research and governmental institutes connected to water issues.

Waternet Project: The Norwegian government sponsors a regional electronic information system on water related issues – Waternet. It is based on several nodes in Israel, the Palestinian Authority and Jordan. GWRI-BFIC serves as the main node and professional leader in Waternet-Israel.

## 7.5.4 Additional information

See PowerPoint presentation on the DVD provided under the appropriate day in the info subdirectory.

# 8 Day 8 – Monday 27th October, Israel

## *8.1 Destination: Baha'i Gardens*

**Focus: Landscape irrigation**

### 8.1.2 Contact Information:

http://news.bahai.org/story/642

**Site Address:**

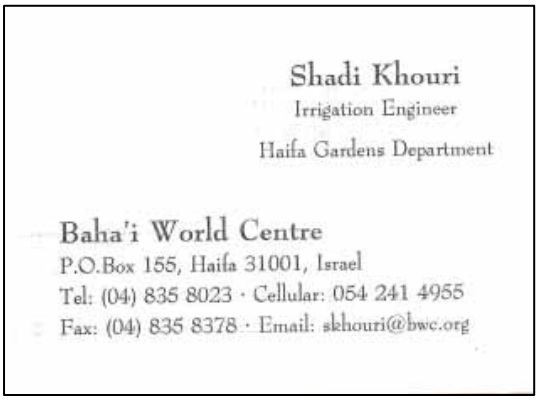
Haifa

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**




### 8.1.3 Background

Baha'i Gardens run on bore water that is treated with an RO plant and UV. The site is about 12 hectares and has 3 separate systems – drinking water, irrigation and fire protection lines. The reason for this is that they planned that in the future irrigation water will come from recycled water.

Chosen as world heritage listed sites, the two shrines are noteworthy for the formal gardens that surround them, blending design elements from many cultures. In addition to Baha'i pilgrims, they attract hundreds of thousands of visitors and tourists every year.

**The Bahá'í Shrine: the terraced gardens of the Shrine of the Báb**

www.tour-haifa.co.il/eng/modules/article/view.article.php/c12/58/p3

In 1987, gardening and construction works on the Carmel slopes had began with a purpose of beautifying and adorning the surroundings of the shrine of the Báb. The eighteen monumental terraced gardens connect the foot of the mountain with its crest, nine above and nine below the shrine. The gardens were designed by architect Fariburz Sahba, who won international acclaim for his design of the Bahá'í House of Worship in India, also known as the "Lotus Temple."

The gardens were designed as hanging gardens throughout the slopes of the Carmel to create an appropriate setting and access paths to the shrine, one of the most sacred places for Baha'is. The architect explains: "The shrine of the Báb is envisaged as precious gem, for which the terraces provide the setting, like a golden ring for a precious diamond. The terraces are designed as nine concentric circles appearing to emanate from the shrine of the Báb. All their lines and curves direct the eyes and feeling towards that central edifice. The geometry of parallel surfaces and lines have been employed to create the most agreeable and comforting setting for the spectator along the entire landscape. The combination of natural elements of light and water formed a major role in designing the gardens, in addition to other ornaments that enrich the landscape".

The gardens stretch uphill for a length of one kilometre reaching a height of 225 metres, and their landscape envelops the mountain reaching a width of 400 metres. Special attention was paid to conservation of the environment when planning the gardens and a highly advanced irrigation system was installed to help conserve water.

http://terraces.bahai.org/terraces.en.html

The gardens use a combination of ancient and modern gardening practices, from mulching and composting to computerised irrigation systems. The Terraces' irrigation system, which places high priority on water conservation, is an example of this blend of old and new. Sprinklers, sprayers and drippers cater to the water requirements of various plants and water in the fountains is recycled, while practices such as mulching, drought pruning in early summer and under-lawn drip irrigation allow for minimal evaporation. On the steeper slopes, which range from 30 to 60 degrees, drought-resistant groundcovers such as ivy, juniper, and lippia minimise erosion during the rains and preserve slope geometry with minimal maintenance.

Water

- Sprinklers, sprayers and drippers cater to water requirement of different plants
- Water in the fountains is recycled
- Kilometres of pipes have been laid for drainage of rainwater and prevention of waterlogging
- Fully automated, pressure reduced "back-flow preventer" devices in all irrigation supply lines allow for use of 'greywater' (effluent water recycled for irrigation purposes) and can inject fertiliser through the irrigation system
- Restricted water use practices include mulching, drought pruning in early summer and under-lawn drip irrigation for minimal evaporation

### 8.1.4 Site Visit

- Uses town water for water features and RO water for irrigation
- Estimate $1 USD per KL cost for RO production
- Pressure compensation of water delivery across the sight to ensure uniformity of irrigation
- Water requirement is approximately 550mm per year over the 32 ha site
- Surface drip irrigation is used on garden beds predominantly with spray on parts and subsurface drip irrigation on lawns
- Pulse irrigation is practiced 2-4 times a day and they think this achieves a water saving of 20% as leaching is restricted
- No trifluran injection to stop root growth into drippers is required as they irrigate so well that the roots don't come seeking water

## *8.2 Destination: Mekorot Eshkol Site – Central Filtration Plant*

**Focus: Water security – quality and monitoring systems & technology**

### 8.2.2 Contact Information:

www.mekorot.co.il

**Site Address:**

Located on Road 77,

Near Hamovil Junction

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Dr Ram Porat

Phone: 050 7332 823


### 8.2.3 Background

Water quality: improvement of water quality through the development/investigation of cutting-edge disinfection and treatment methods; R&D to support the deployment of the National Filtration plant; development of continuous water monitoring systems.

At this site, located in the Beit Netofa Valley (in the Lower Galilee), water coming from the Sea of Galilee (by open canals, pipes and reservoirs) is treated before being supplied to customers. The site is divided into 2 reservoirs: a settling reservoir and an operating reservoir. In the settling reservoir water goes through a series of treatments and in the operating reservoir water entry to the National Carrier pipe is regulated according to the various needs. Then, the cleaned water is carried south to regional water supply systems around Israel and from there supplied to customers from the urban, industry and agricultural sectors.

Some years ago due to more strict standards of water purification set by the Ministry of Health; Mekorot decided to use filtration as the most effective means to ensure the required turbidity level and built the Central Filtration Plant in the Eshkol site. The Central Filtration Plant in the Eshkol site is one of the world's most complex water filtration facilities. With a capital cost of $100 million for the plant and annual filtering capacity of more than 500 million cu. m, the plant integrates advanced technologies, engineering methods, and state-of-the-art operating procedures. Its automated control system ensures reliable, fast and safe filtering of water at low cost.

Mekorot has completed construction of the Central Filtration Plant at Eshkol at a total investment of NIS 550 million and launches a new era in the quality of Israel's drinking water:

- Water quality that is among the best in the world
- Improvement in the clarity and aestheticism of the water
- Reduction in the use of water treatment chemicals in the national water supply
- Improved treatment processes at water sources
- Environmentally friendly

- Proving a cheaper solution for Israel's water needs
- Capacity of the Central Filtration Plant: 75,000 cubic metres per hour * 1.7 million cubic metres per day * 450 million cubic metres per year

During the first stage of water treatment at the plant, untreated water from the Kinneret enters fast-mixing (coagulation) and slow-mixing (flocculation) chambers where water treatment chemicals are added, so that suspended particles will accrete into large particles. After a series of treatments, the turbidity level of the water emerging from the system is even lower than the standards mandated by the Ministry of Health. The filtered water is sent to pumping stations, which deliver it to customers.

In order to ensure reliable delivery of high-quality water, the plant has a state-of-the-art system of monitoring and supervision systems, which oversee the water quality and the treatment and operational processes. A central control room was built at the plant, which operates non-stop. The operational processes and monitoring systems are linked through computerised control systems to the control room. In addition to monitoring and gathering data, the system provides real-time warnings about any deviation from the operational or water quality requirements. The Central Filtration Plant is divided into two identical symmetrical modules, which operate independently. This improves the plant's reliability and enables parts of the plant to be shut down for maintenance without affecting regular operations.

### Thinking Green

Mekorot ascribes great importance to preserving nature and landscapes. During construction of the Central Filtration Plant, Mekorot showed great sensitivity to environmental issues and took care to prevent harm to the flora and fauna, including micro-organisms in the Yiftach-El River at the site. The rehabilitation effort included the replanting of 130 Tabor Pine trees located at the dig site of the central laboratory at Eshkol to the new river channel.

### About Eshkol

The route of Kinneret water to people's homes begins at the pumps at Sapir on the shore of the lake. Since the Kinneret lies 213 metres below sea level, it is necessary to raise the water to 44 metres above sea level. A pressure pipe pushes the water uphill and then to open channels, pipes and reservoirs to Eshkol in the Beit Netufa Valley for treatment before delivery to customers. Eshkol is divided into two reservoirs: a sedimentation reservoir and an operational reservoir. The water undergoes a series of treatments in the sedimentation reservoir, while the operational reservoir acts as a valve for the flow of water into the pipes of the National Water Carrier, on the basis of various needs. These pipes carry clean water southward to regional water systems across the country and from there to municipal water systems for urban, industrial and agricultural customers.

### Water quality and security

Mekorot pays special attention to water quality control and invests extensive resources to ensure the reliability of its water quality and supply. To this end, the company operates over 500 installations that disinfect and treat water, using a variety of environmentally-friendly chemicals and processes.

One example of Mekorot's focus on water quality is an ultra-modern filtration plant it recently designed and constructed at its Eshkol facility. Built at a cost of more than $100 million, the plant has an annual filtering capacity of more than 500 million cubic metres a year, is the largest of its kind in Israel and one of the largest in the world in terms of the amount of water it can process. It also ranks amongst the most efficient water purification facilities worldwide. The plant meets strict water quality targets matching those of western countries i.e. turbidity not exceeding 1.0 NTU (nephelometric turbidity units) and will ensure that Mekorot continues to deliver high quality water to Israel's residents.

Mekorot's water quality activities include:

- water sampling
- field testing
- carrying out of water quality surveys
- testing, monitoring and characterisation of water quality
- protection of water sources
- planning of water treatment strategies
- management of emergencies
- assessment of environmental risks
- laboratory testing quality control.

### A global leader

Mekorot has developed a variety of techniques and methods to streamline water treatment and testing in the field and the laboratory.

### Water treatment

Mekorot employs a variety of mechanical, chemical and biological means to treat water in Israel's National Water Carrier and the company's reservoirs.

- Water treatment and purification operations include sand filtration and membranal filtration facilities designed to eliminate microscopic particles
- Filtration processes involve the passing of water through huge sand filters to extract small particles from the water and carbon filters to improve the water's taste and neutralise the odour and taste of chlorine
- Mechanical treatments involve the use of fine screens to filter water before it is pumped from natural water sources and reservoirs
- Chemical treatments such as aluminium-sulphate are administered before water enters reservoirs to capture particles floating in the water and to remove chemical contaminants, such as sulphides, iron, nitrates and organic pollutants; disinfectants (chlor-dioxide and chloramines) are introduced to destroy bacteria; for this purpose, the company operates over 700 chlorination facilities and 80 fluoridation plant.

Mekorot also uses novel, proprietary biological treatments against "nuisance factors" such as algae, snails and microscopic organisms, which bring an undesirable odour, appearance or taste to the water. Using varieties of fish in a correct balance, the company decreases zooplankton and organic materials accumulating on the bottom of reservoirs.

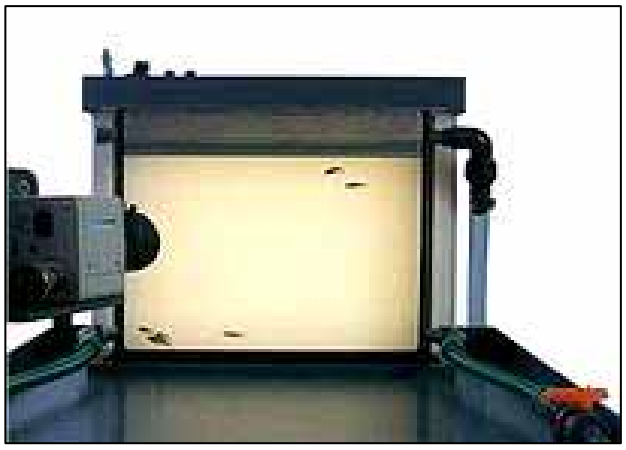
www.mekorot.co.il/Eng/Activities/Water%20Quality%20Security/Documents/Water%20Quality%20and%20Security%20-%20WATEC%202007.pdf

### 8.2.4 Site Visit

This site uses bio-sensing technology (fish) to alert for potential toxins in the water. The company where this technology came from is bbe Moldaenke (see www.bbe-moldaenke.de/)

Email for Ram is: Rporat@MEKOROT.CO.IL

Sea Bass and Daphnia have been used as the bio-sensor, however, Sea Bass were found to be lower maintenance and only gives 1-2 false alarms per month when set up correctly.



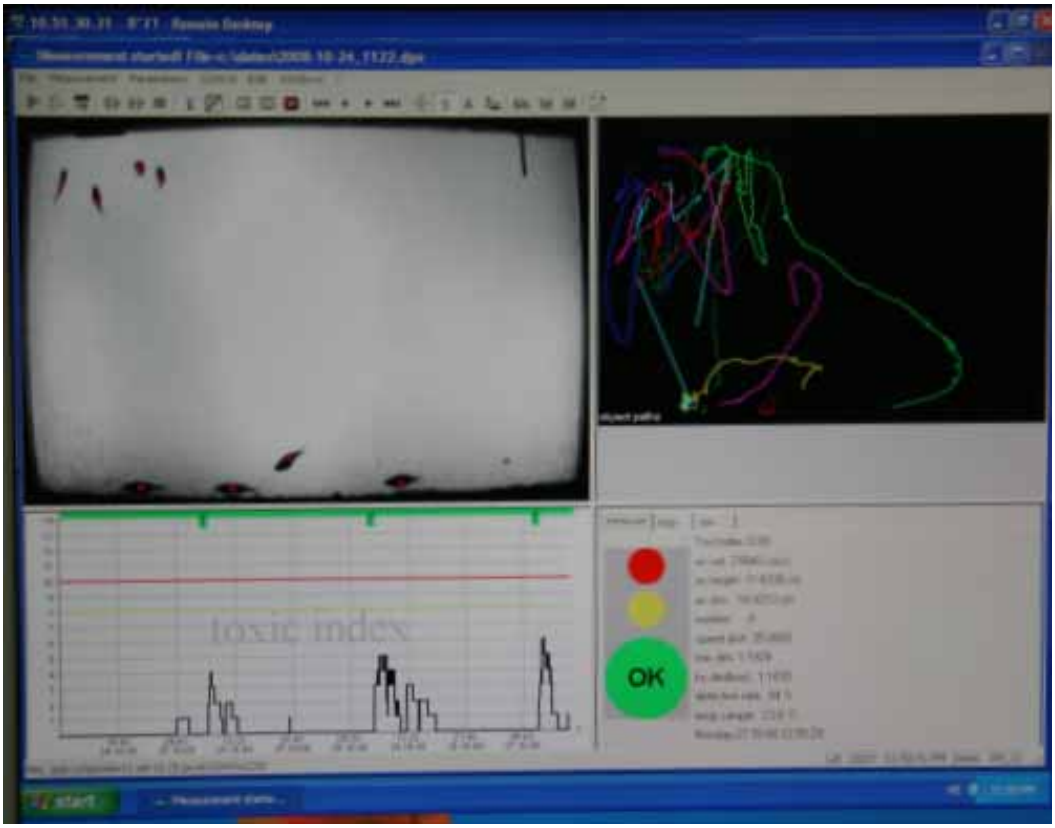



**Figure 1** **Sensing unit and computer screen of bio-monitoring system**

## *8.3 Destination: Arkal Filtration Ltd*

**Focus: Water filtration**

### 8.3.2 Contact Information:

www.arkal-filters.com

**Site Address:**

Arkal Filtration Systems

Kibbutz Bet Zera, Jordan Valley, Israel

Tel: (972)-4-6775140

Fax: (972)-4-6775476

Email: filters@arkal.com


**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Omry Levin – Arkal

Ph: 054 676 9215

### 8.3.3 Background

Arkal water filtration solutions have been successfully applied in over 90% of the world's agricultural/landscape micro-irrigation markets. They:

- Afford effective treatment of surface and seawater containing high quantities of biological materials
- Implement patented automatic Spin Klin filter technology, providing precise filtration from 400 to 20 microns
- Facilitate effective water conservation
- Prevent system failures and downtime in manufacturing, water treatment and irrigation systems
- Enable high quality pre-filtration solutions for MF, UF and RO membranes.

Arkal water treatment solutions:

- Provide integrated solutions in a variety of applications: potable water systems, tertiary wastewater systems, industrial and commercial systems, RO systems
- Remove iron, manganese and sulphides using advanced media
- Disinfect and oxidise using UV, ozone and chlorination.

Water is the most commonly used natural resource in industry today and is essential in optimising food production in an increasingly populous world. As the world's supply of clean water diminishes, Arkal is experiencing accelerated growth. Since clean water ensures quality-of-life, our vision is to facilitate this trend through dedicated professionalism.

Our main product lines include unique patented automatic Spin Klin filtration technology, manual disc filters and systems, automatic and semi-automatic screen filters, media filters and integrated water-treatment solutions.

Leading product applications include filtration and water treatment, micro-irrigation and membrane protection, wastewater and potable water treatment, cooling systems for industrial manufacturing process water and seawater filtration.

Arkal's filtration and integrated water treatment systems provide worldwide solutions in agricultural/landscape, industrial, municipal and commercial markets.

## Our team

Arkal's dedicated research and development team, sales and product engineers and expert support personnel use creativity and vision to design, market and service Arkal installations worldwide.

We promote in-house and on-location training seminars to introduce Arkal disc filtration technology and filtration systems to our international marketing, distributor and service partners. Our professionals, specialists in their respective fields, provide knowledge and solutions, convey technological updates, and develop and implement localised marketing plans.

## Dynamic clean-water technology solutions

Arkal's design and development plans encompass comprehensive clean-water solutions in accordance with customer requirements. Our technological leverage is based on the dynamic nature and use of the world's water supply.

At Arkal, we constantly identify and target existing and emerging markets and applications to successfully implement Arkal products and integrated system solutions.

Our dynamic solutions incorporate polymeric systems that feature modularity and flexibility. Arkal's long lifecycle, anti-corrosive products are produced from a wide range of superior materials, which are engineered and tested in-house to endure harsh conditions and meet British, French, American and other local certification standards, in addition to ISO 9001.

## Future benefits now

Innovative filtration and water-treatment improvements and upgrades are a constant on the Arkal solution-development agenda.

With over 30 years of technical expertise in providing engineered solutions, the company's proven technological solutions feature present and future customer benefits.

## Arkal installations

Systems afford cost-effective operation due to improved process performance and extended equipment lifetime, with minimal maintenance requirements.

- Optimise existing installations with modular add-on options
- Increase filtration efficiency: filtration range of 400 to 20 micron
- Facilitate reduction in wastewater volume and provide continuous filtration, even during backwash cycles
- Conserve space requirements

## Ongoing success

Our potential and success are embodied in our human resources.

Arkal's creative research and development team, sales and product engineers, and expert support personnel provide dedicated customer service for Arkal installations worldwide.

Since 1992, we have grown at an average annual rate of 15%.

Arkal's recently purchased US subsidiary, PEP Filters, is a leader in filtration for the HVAC segment and will provide a platform for additional North America market penetration.

The company's global team includes PEP Filters (USA), Arkal China, Arkal Singapore, Arkal Costa Rica. Among our distributors are PALL, Netafim, Regaber and Elga-Berkefeld.

Agriculture: micro-irrigation, membrane pre-filtration protection

Industry: process and cooling, laundries, aquaculture, injection moulding, pulp and paper, steel, power generation

More useful information and case studies:
www.arkal-filters.com/ind_full.html

Arkal in Australia

Aquaculture in Australia is a booming business and Arkal Filtration Systems is in the headlines. Netafim Australia supplied and commissioned an Arkal aquaculture filtration system to the new Fisheries Department research station at Hilary. This first-time event was hailed on the Investing in Aquaculture page of the local trade newspaper. The polymeric system including Arkal's automatic Spin Klin technology increases system efficiency and improves supply reliability to the research facility. The Netafim Australia site address is: www.netafim.com.au

## 8.3.4 Site Visit

**Arkal**

- Israel is 1/300 the size of Australia with 7 M people
- Water from Mt Galilee, Mt Hermon (Syria) and the Golan Heights
- In 1930 a desert landscape – converted using modern irrigation (all drip)

**Arkal Industries**

- Arkal Filtration
  - Agricultural
  - Industrial
- Arkal plastic products

**Filtration**

- Produce three types of filters
  - Disc filters
  - Screen filters
  - Media type filters

Note: "With water there is always politics".

**Arkal Laboratories**

- Commenced 14 years ago to provide specialist services including particle analysis in water
  - TSS total suspended solids
  - Solids that settle
  - Silt density index SDI
  - Turbidity ("clean water" < 1 NTU)
- Particle size analysis
  - Partial size distribution

    - Microscopic particle characterisation
- Filtration efficiency testing
    - Filter performance
    - Definition of filtration grades

** 20$\mu$m removal of all helminthes eggs (eggs > 30$\mu$m)*

- Basic chemical analysis
    - Temperature, pH, EC hardness
- Consult worldwide


# 9 Day 9 – Tuesday 28th October, Israel

## *9.1 Destination: Sapir Station Centre*

**Focus: Water management – pumping station**

### 9.1.2 Contact Information:

www.mekorot.il

**Site Address:**

Sea of Galilee

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Dudu Sapir

Phone: 050 7332 818

### 9.1.3 Background

This centre is located at the site of the first pumping station of the National Water Carrier. Here, deep inside the earth, three huge pumps lift water from the Sea of Galilee 209 metres (640 feet) below sea level to a height of 50 metres above sea level. A visit to the site includes a guided tour of the pumping tunnel, explanation of the pumps' sophisticated operation and a movie explaining the construction of the National Water Carrier and Mekorot's system which supplies water throughout Israel.

Sapir is also the location for a satellite quality analytical laboratory.

Mekorot performs high standard water quality testing and analyses designed to meet Israeli Ministry of Health and international requirements. Mekorot's tests performed in the field and laboratory continuously evaluate Israel's water supply for concentrations of chemicals, bacteria and other substances.

Mekorot's extensive water testing program is carried out under the supervision of Israel's Ministry of Health and the Israel Laboratory Accreditation Authority to ensure that its laboratories' activities comply with rigorous health regulations and ISO/IEC 17025 laboratory standards.

**Advanced laboratories**

Mekorot maintains a network of quality analytical laboratories. The Central Laboratory is located at Beit Netofa, 15 kilometres northwest of the city of Nazareth. Satellite laboratories operate in Rosh Ha'ayin, Ashkelon, Eilat, Atar Sapir adjacent to the Sea of Galilee, as well as the large wastewater treatment plant at Shafdan.

The company performs tests that evaluate water and wastewater according to approximately 200 chemical and physical parameters to determine the presence of a large variety of inorganic, organic, bacteriological and microscopic substances.

Mekorot's testing equipment is among the most modern and advanced in the world. Some of the equipment is managed automatically by state-of-the-art, internally-developed software, which performs continuous logical control of test results to increase the reliability.

**Comprehensive tests and studies**

A comprehensive battery of chemical tests to ensure public health is performed on water from all sources to determine the presence of any of over 200 restricted substances such as heavy metals, organic pollutants or pesticides.

Microbiological tests are conducted to verify the absence of coliform and other bacteria that would otherwise indicate contamination by sewage in the water system. The laboratory also monitors the presence of parasites (Giardia sp. and Cryptosporidium sp.) in raw water.

Wide-ranging studies are performed on a regular basis in order to resolve water quality problems that may occasionally arise and to introduce new technologies for laboratory and field testing.

## 9.1.4 Site Visit

**Summary**

- Rainfall distribution
  - >1000 mm in the north of Israel
  - < 100 mm in the south
- Total water consumption 1 B $m^3$
  - Agriculture approx 1 B $m^3$
  - Industry 119 M $m^3$
  - Potable 707 M $m^3$
  - Neighbours 100 M $m^3$
- Sea of Galilee 1/3 of total water use
- From the 1st of November no householder to use fresh water for irrigation
- Initially a channel system was proposed to move water from north to south but would be close to Syrian and Jordanian borders – problem for water security – so was not constructed
- Sea of Galilee catchment is 2730 $km^2$ – 25% of this watershed is in Lebanon
- The pump station to move water uses 2% of national electricity consumption
- Pump to 257 m head
- 1.7 M $m^3$ per day
- Water is pumped to the mountains then open channel approx 17 kms
- There are 4 pump units: 3 for pumping, 1 for backup (R&M)
  - Cannot use all 4 pumps as the channel will not handle all of the water
- Tzalmon pump station 115 head uses ½ power consumption
- Tzalmon water treatment
  - Pre chlorination
- Eshkol water treatment
  - Flocculation and sedimentation
  - Disinfection
    - $ClO_2$ and $NH_2Cl$
  - Biological treatment
- Water price $3.50 ILS (approx $1.00 US)
- Irrigation ½ potable water price
- Rainfall patterns
  - Each rainfall event is about the same size
  - Number of rainfall events down
- For the next ten years desalinisation is the major change in water supply
- Sea of Galilee
  - -209 m minimum surface level
  - Currently -251 m

**Cloud seeding**

- Was used and thought to increase rainfall by 2-15% but this is hard to measure
- Isn't used now as the climate has changed and clouds are now different than in the 70s when cloud seeding was thought to be successful
- A decrease in periods of rainfall and increase in time between rainfall events is making soil drier, and consequently, there is less runoff when it does rain as the soil soaks it up
- The dry in 1999 to 2001 led to a number of desalination plants being built

## 9.2 Destination: Upper Galilee Region and Kibbutz Yiftach

**Focus: Visit to water reservoir, see agricultural water use in upper Galilee region and visit Netafim Orchard Training Centre**

### 9.2.2 Contact Information:

www.netafim.com.au

**Site Address:**

D.N. Merom Hagalil

13840, ISRAEL

Phone: 972 4 6955518/7

Fax: 972 4 6904445

Email: ronir@netafim.com


**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Yoni Raz – Netafim (for lunch)

Ph: 054 501 5544


### 9.2.3 Background

Netafim made history in 1965 with its unique concept drip-irrigation and today they are the world's largest drip-irrigation manufacturer. Netafim has over $US250Mil in sales with 30 billion emitters in operation and an annual additional three billion emitters. Netafim is recognised as the global leader in the field of innovative-based solutions and water technologies whilst protecting the surrounding environment.

**Orchard Research and Training Centre at Kibbutz Yiftah**

Training

The Centre hosts growers from Israel and abroad for training irrigation competencies in general and drip in particular. Focus is placed on issues as irrigation system treatment, filtration, fertigation, subsurface drip irrigation (SDI), wastewater irrigation, irrigation control, etc. Training sessions may take a few hours or extend over a few days.


Research

In the Centre research studies and experiments are conducted on deciduous crop–related issues of interest to the Netafim customers.

The research studies are conducted partly by the Centre's agronomist and partly by the most advanced research institutions.

The Orchard Research & Training Centre's unique value is that it is not a scientific research station. It is "accommodated" in a "live" orchard on Kibbutz Yiftah, thus enabling Netafim direct contact with the customer's needs while ensuring that beyond the scientific conclusions each of the experiments conducted meets genuine economic standards.

Further information:

www.netafim.com/Business_Divisions/Crop_Management_Technology/

www.netafim.com/Crops/

www.netafim.com/Crops/Tree_Crops/Citrus/

www.netafim.com/Business_Divisions/Netafim_Greenhouse/

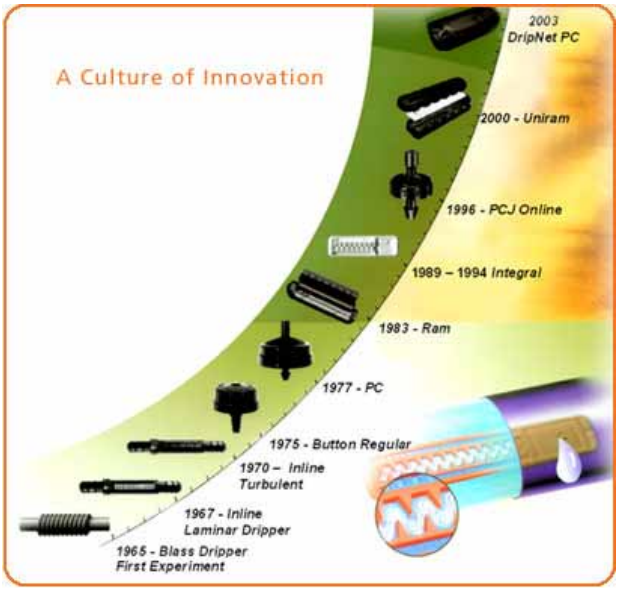
## 9.2.4 Site Visit

**Golan Heights**

- There has always been water but no electricity
- Water flows to the Sea of Galilee
- Use 10 M $m^3$
  - 3 diesel, 1500 hp, 300 rpm
    - Pumps 1800 $m^3$/hr
  - It was last used in 1979

**Irrigation**

- 20 M $m^3$ used for agricultural irrigation per year
- Farmers allocation cut to 40% due to the drought
- 8% of country power
  - 35% of Mekorot revenue
  - $14 M ILS power cost
- Piping colour coded
  - Red – irrigation
  - Blue – potable
- Standard for irrigation is 1 ppm of free chlorine
- Organic matter in water causing problems for chlorination
- Need chlorination to stop drip emitter clogging
- Water use
  - Almonds 300-400 mm
  - Orchards 700 mm
  - Apple 6-7 mm per day – typical during irrigation season




# 10 Day 10 – Wednesday 29th October, Israel

## *10.1 Destination: Nahal Og Reservoir*

**Focus: Water storage, wastewater treatment and reuse on date palm plantations**

### 10.1.2 Contact Information:

**Site Address:**

Dead Sea Area

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Dubi Segal (Netafim)

Phone: 050 7249 030


### 10.1.3 Background

www.jpost.com/servlet/Satellite?cid=1215331108811&pagename=JPost%2FJPArticle%2FPrinter

The Nahal Og reservoir located in the plains of Jericho is part of a chain of reservoirs that have been rightfully described as "the lowest reservoirs on Earth". It was established before the sources of funding were obtained in order to irrigate agricultural areas in the northern Dead Sea using purified wastewater. The water in the reservoir comes from Ma'aleh Adumim in east Jerusalem, Anatot and the Mishor Adumim Industrial area. The Naama reservoir, presently being constructed to the north with a capacity of 700,000 cubic metres, will absorb some of the water piped to the Og reservoir, which has a capacity of "only" 1.5 million cubic metres. The Naama reservoir water will be used to irrigate the lush date orchards in the central and south Jordan valley communities and both reservoirs will be added to three existing ones established below sea level in the northern and central Arava. The Arava reservoirs utilise only floodwaters from the mountains of the Negev that reach them intermittently or – like last winter – not at all.

www.kkl.org.il/kkl/english/main_subject/water%20in%20israel/word-water%20crisis.doc

**http://192.116.234.202/hanof/ProjectPool/ProjectPage.aspx?project_id=7807**

The Nahal Og 2 Recycled Water Reservoir is being built to increase storage potential of wastewater that can be used in crop irrigation. The reservoir stores treated effluents from nearby urban communities which are then used by farming communities in the Megillot Regional Council. The reservoir serves a double purpose: solving the environmental problem of water pollution and supporting local agriculture.

Description: The 1.5 million cubic metre Nahal Og 2 Recycled Water Reservoir, located about one kilometre away from the Nahal Og 1 reservoir (also built by KKL-JNF) will store treated wastewater from East Jerusalem, Ma'ale Adummim, and the Mishor Adummim industrial area. Nahal Og 2 was built by KKL-JNF jointly with the

Megillot Regional Council Water Association to increase the capacity of sewage drainage from the heavily populated areas east of the capital. After purification at an adjacent facility the water will be used to irrigate crops, including 425 acres (170 hectares) of dates and wheat for animal feed, belonging in the northern Dead Sea communities of Almog, Qalya, Mizpe Shalem and Bet Ha'Arava. An appropriate means of donor recognition is available.

Location: Near Kibbutz Qalya at the north-eastern corner of the Dead Sea.

Project Goals: To save fresh water in a very arid area; to respond to the growing water needs of Israel; to improve environmental quality in the areas of Jerusalem, Nahal Og and the Dead Sea area through sewage purification.

**Rationale of the Project**

Shortage of water is probably the most crucial environmental problem facing Israel today. It is aggravated by the deteriorating quality of existing water resources that are even now overused. One of the solutions to the water problem being developed in Israel is the use of recycled wastewater in agriculture, which both reduces pollution while providing an additional water source for irrigation. KKL-JNF is a leader in the field of unconventional solutions for the severe water problem in Israel and has built dozens of recycled wastewater (effluent) reservoirs. These reservoirs are actually the final stage in a complex process for purifying sewage so it can be reused for irrigation. Nahal Og is one of the largest wadis in the northern Judean Desert, draining the mountain ridges east of Jerusalem. The Nahal Og 2 Recycled Water Reservoir will provide a solution for two problems: sewage treatment and the high cost of water for irrigating fields in the agricultural communities.

**What Difference Your Contribution Can Make**

Israel has exploited virtually all of its renewable water sources. The future of its water supply depends on the country's ability to develop new sources of water, such as wastewater recycling. In contributing to the construction of the Nahal Og 2 reservoir for treated effluents, you will be helping the people of the northern Dead Sea area take a significant step toward solving a serious pollution problem. At the same time your donation will help save their agricultural ventures by providing a low-cost source of water. You will become a partner in developing some of the most advanced methods in the world for saving water and help keep Israel at the forefront of world agriculture.

**Research Articles**

**Impact of wastewater discharge on the channel morphology of ephemeral streams**

www3.interscience.wiley.com/journal/86513215/abstract?CRETRY=1&SRETRY=0

Abstract

The impact of wastewater flow on the channel bed morphology was evaluated in four ephemeral streams in Israel and the Palestinian Territories: Nahal Og, Nahal Kidron, Nahal Qeult and Nahal Hebron. Channel changes before, during and after the halting of wastewater flow were monitored. The wastewater flow causes a shift from a dry ephemeral channel with intermittent floods to a continuous flow pattern similar to that of humid areas. Within a few months, nutrient-rich wastewater flow leads to rapid development of vegetation along channel and bars. The colonisation of part of the active channel by vegetation increases flow resistance as well as bank and bed stability and limits sediment availability from bars and other sediment stores along the channels. In some cases the established vegetation covers the entire channel width and halts the

transport of bed material along the channel. During low and medium size flood events, bars remain stable and the vegetation intact. Extreme events destroy the vegetation and activate the bars. The wastewater flow results in the development of new small bars, which are usually destroyed by flood flows. Due to the vegetation establishment, the active channel width decreases by up to 700 per cent. The deposition of fine sediment and organic material changed the sediment texture within the stable bar surface and the whole bed surface texture in Nahal Hebron. The recovery of Nahal Og after the halting of the wastewater flow was relatively fast; within two flood seasons the channel almost returned to pre-wastewater characteristics. The results of the study could be used to indicate what would happen if wastewater flows were introduced along natural desert streams. Also, the results could be used to predict the consequences of vegetation removal as a result of human intervention within the active channel of humid streams. Copyright © 2001 John Wiley & Sons, Ltd.

**Presentation on the Israeli date palm plantation**

http://ressources.ciheam.org/om/pdf/a28/96605880.pdf

**Estimation of the impact of oil palm plantation establishment on greenhouse gas balance**

www.springerlink.com/content/j603663613284616/

**Journal Environment, Development and Sustainability**

Abstract

Estimates of emissions indicate that if tropical grassland is rehabilitated by oil palm plantations, carbon fixation in plantation biomass and soil organic matter not only neutralises emissions caused by grassland conversion, but also results in the net removal of about 135 Mg carbon dioxide per hectare from the atmosphere. In contrast, the emission from forest conversion clearly exceeds the potential carbon fixation of oil palm plantings. Forest conversion on mineral soils to promote continued oil palm mono cropping causes a net release of approximately 650 Mg carbon dioxide equivalents per hectare, while the emission from peat forest conversion is even higher due to the decomposition of drained peat and the resulting emission of carbon oxide and nitrous oxide. The conversion of one hectare of forest on peat releases over 1,300 Mg carbon dioxide equivalents during the first 25-year cycle of oil palm growth. Depending on the peat depth, continuous decomposition augments the emission with each additional cycle at a magnitude of 800 Mg carbon dioxide equivalents per hectare.

The creation of ‘flexibility mechanisms’ such as the clean development mechanism and emission trading in the Kyoto Protocol could incorporate plantations as carbon sinks in the effort to meet emission targets. Thus, for the oil palm industry, grassland rehabilitation is an option to preserve natural forest, avoid emissions and – if the sequestered carbon becomes tradable – an opportunity to generate additional revenue.

Keywords: Carbon sequestration – Emission – Greenhouse gas – Land rehabilitation – Savanna – Tropical forest – Kyoto Protocol

### 10.1.4 Site Visit

- 90 trees per ha
- Annual irrigation is approximately 20 ML/ha
- Irrigation water salinity = TDS 1200 mg/L (Government will soon be setting 800 mg/L TDS as maximum allowed. The use of RO seawater for drinking will mean that salinity of wastewater entering the plant will be lower and they should meet the 800 mg/L TDS guidelines)
- Chlorine is used to manage DOC (up to 400 mg/L) in water which is usually 10-20 mg/L; 1 mg/L residual chlorine is required at the most distance dripper
- Sometimes they chlorinate just for worker safety, as the risk to plants and foods is already low

## *10.2 Destination: Dead Sea Hotels Wastewater Treatment Plant*

### 10.2.1 Contact Information:

**Site Address:**

Dead Sea

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Avi Borovsky

Phone: 050 7249 030

### 10.2.2 Background

This wastewater treatment plant was built and maintained by Mekorot and belongs to the hotels. The plant is now managed and maintained by the Regional Council of Tamar. Hotels in the Dead Sea area deliver their wastewater to the plant where it is cleaned by activated sludge to a level where it can then be reused to irrigate the hotels landscaped areas.

### 10.2.3 Site Visit

## *10.3 Destination: Dead Sea Works*

**Focus: Operating salt works**

### 10.3.2 Contact Information:

**Site Address:**

Dead Sea

**Organised by:**

Ortal Erez– Marketing Dept. – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Ms Michal Lerner – 08 9977 501 or 08 9977 277

### 10.3.3 Background

**Background on the Dead Sea in General**

http://en.wikipedia.org/wiki/Dead_Sea_Works

The Dead Sea is a salt lake between Israel and the West Bank to the west and Jordan to the east. It is 420 metres below sea level and its shores are the lowest point on the surface of the Earth on dry land. The Dead Sea is 330 m deep, the deepest hyper saline lake in the world. It is also the world's second saltiest body of water, after Lake Asal in Djibouti, with 30 percent salinity. It is 8.6 times saltier than the ocean. Experts say that it is nine times saltier than the Mediterranean Sea (31.5% salt versus 3.5% for the Mediterranean). This salinity makes for a harsh environment where animals cannot flourish. The Dead Sea is 67 kilometres long and 18 kilometres wide at its widest point. It lies in the Jordan Rift Valley and its main tributary is the Jordan River.

The Dead Sea has attracted visitors from around the Mediterranean basin for thousands of years. Biblically, it was a place of refuge for King David. It was one of the world's first health resorts (for Herod the Great) and it has been the supplier of a wide variety of products, from balms for Egyptian mummification to potash for fertilisers.

From 70,000 to 12,000 years ago the lake level was 100 m (328 ft) to 250 m (820 ft) higher than its current level. This lake, called "Lake Lisan", fluctuated dramatically, rising to its highest level around 26,000 years ago, indicating very wet climate in the Near East. Sometime around 10,000 years ago the lake level dropped dramatically; probably to levels even lower than today. During the last several thousand years the lake has fluctuated approximately 400 m (1,310 ft) with some significant drops and rises. Current theories as to the cause of this dramatic drop in levels rule out volcanic activity; therefore it may have been a seismic event.

The Jordan River is the only major water source flowing into the Dead Sea, although there are small perennial springs under and around the Dead Sea, creating pools and quicksand pits along the edges. There are no outlet streams.

The northern part of the Dead Sea receives scarcely 100 mm of rain a year. The southern section barely 50 mm.

The Dead Sea zone's aridity is due to the rain shadow effect of the Judean Hills. The highlands east of the Dead Sea receive more rainfall than the Dead Sea itself.

The mineral content of the Dead Sea is very different from that of ocean water. The exact composition of the Dead Sea water varies mainly with season, depth and temperature. In the early 1980s the concentration of ionic species (in g/kg) of Dead Sea surface water was $Cl^-$ (181.4), $Br^-$ (4.2), $SO_4^{2-}$ (0.4), $HCO_3^-$ (0.2), $Ca^{2+}$ (14.1), $Na^+$ (32.5), $K^+$ (6.2) and $Mg^{2+}$ (35.2). The total salinity was 276 g/kg. These results show that w/w% composition of the salt, as anhydrous chlorides, was calcium chloride ($CaCl_2$) 14.4%, potassium chloride (KCl) 4.4%, magnesium chloride ($MgCl_2$) 50.8% and sodium chloride (common salt, NaCl) 30.4%. In comparison, the salt in the water of most oceans and seas is approximately 97% sodium chloride. The concentration of sulphate ions ($SO_4^{2-}$) is very low and the concentration of bromide ions (Br−) is the highest of all waters on Earth.

The salt concentration of the Dead Sea fluctuates around 31.5%. This is unusually high and results in a nominal density of 1.24 kg/L. Anyone can easily float in the Dead Sea because of natural buoyancy.

One of the most unusual features of the Dead Sea is its discharge of asphalt. From deep seeps, the Dead Sea constantly spits up small pebbles of the black substance. After earthquakes, chunks as large as houses have been found.

## Industry

In the early part of the 20th century, the Dead Sea began to attract interest from chemists who deduced that the Sea was a natural deposit of potash and bromine. The Palestine Potash Company was chartered in 1929 after its founder, Siberian Jewish engineer and pioneer of Lake Baikal exploitation Moses Novomeysky, worked for the charter ex for over ten years. The first plant was on the north shore of the Dead Sea at Kalia and produced potash, or potassium chloride, by solar evaporation of the brine.

Employing Arabs and Jews, it was an island of peace in turbulent times. The company quickly grew into what is thought to be the largest industrial site in the Middle East and in 1934 built a second plant on the southwest shore, in the Mount Sodom area, south of the 'Lashon' region of the Dead Sea. Palestine Potash Company supplied half of Britain's potash during World War II, but ultimately became a casualty of the 1948 Arab-Israeli War. Its remnants were nationalised and Dead Sea Works Ltd was established in 1952 in its stead as a State-owned company to extract potash and other minerals from the Dead Sea.

From the Dead Sea brine, Israel produces (2001) 1.77 million tons potash, 206,000 tons elemental bromine, 44,900 tons caustic soda, 25,000 tons magnesium metal and sodium chloride. On the Jordanian side of the Dead Sea, Arab Potash (APC), formed in 1956, produces 2.0 million tons of potash annually, as well as sodium chloride and bromine. Both companies use extensive salt evaporation pans that have essentially dyked the entire southern end of the Dead Sea for the purpose of producing carnallite, potassium magnesium chloride, which is then processed further to produce potassium chloride. The power plant on the Israeli side allows production of magnesium metal (by a subsidiary, Dead Sea Magnesium Ltd). The salt evaporation pans are visible from space.

Due to the popularity of the sea's therapeutic and healing properties, several companies have also shown interest in the manufacturing and supplying of Dead Sea salts as raw materials for body and skin care products.

### Dead Sea Works

http://b7prt05.iclfertilizers.com/irj/servlet/prt/portal/prtroot/com.sap.portal.navigation.portallauncher.anonymous?NavigationTarget=ROLES://portal_content/com.sapro.iclportal/roles/com.sapro.portal_user/Production_Marketing/com.sapro.Dead_Sea_Works/com.sapro.DSW_About_Us

ICL Fertilizers' history begins in the early 20th century with the first efforts to extract minerals from the Dead Sea in Israel's South. After Israel's independence in 1948, the extraction of minerals from the Dead Sea carried on with the establishment of Dead Sea Works Ltd as a State-owned

company in the early fifties. During the same period, several other State-owned companies were created to extract minerals from the Negev Desert and transform them into chemical products.

In 1952 Dead Sea Works Ltd (DSW), was established as a State-owned company to extract potash and other minerals from the Dead Sea.

Dead Sea Works, a business unit of ICL Fertilizers, is the world's fourth largest producer and supplier of potash products, as well as a broad range of chemical products, including magnesium chloride, anhydrous aluminium chloride, industrial salts, de-icers, bath salts, table salt and raw materials for the cosmetic industry.

Dead Sea Works serves customers in over 60 countries from our manufacturing and support operations in Israel and in Spain, through our wholly-owned subsidiary, Iberpotash.

Our Dead Sea facilities in Israel are a unique natural resource, situated at the lowest point on the planet, in a region of unspoiled beauty and splendour. Here, solar energy helps us responsibly extract pure potash and other minerals from the biggest solar evaporation pond array in the world.

Dead Sea Works shares the commitment of all of ICL Fertilizers' businesses to environmental responsibility and makes substantial investments in pursuit of ecological excellence, such as the widespread use of solar energy and preservation of the irreplaceable Dead Sea ecosystem.

**For Dead Sea, a slow and seemingly inexorable death**

By John Ward Anderson

www.washingtonpost.com/wp-dyn/content/article/2005/05/18/AR2005051802400_pf.html

Washington Post Foreign Service

Thursday, May 19, 2005; A01

EIN GEDI, When the Ein Gedi Spa opened in 1986 to pamper visitors with massages, mud wraps and therapeutic swims, customers walked just a few steps from the main building to take their salty dip in the Dead Sea.

Nineteen years later, the water level has dropped so drastically that the shoreline is three-quarters of a mile away. A red tractor hauls customers to the spa's beach and back in covered wagons.

"The sea is just running out and we keep running after it," said Boaz Ron, 44, manager of the resort. "In another 50 years, it could run out another kilometre".

It may sound redundant, but the Dead Sea, one of the world's cultural and ecological treasures, is dying. In the last 50 years, the water level has dropped more than 80 feet and the sea has shrunk by more than a third, largely because the Jordan River has gone dry. In the next two decades, the sea is expected to fall at least 60 more feet and experts say nothing will stop it.

The decline has been particularly rapid since the 1970s when the water began dropping three feet a year. That created a complex domino effect that is slowly destroying some of Israel's most cherished plant and wildlife reserves along the Dead Sea's shores, a key resting stop along the annual migration route for 500 million birds that fly between Europe and Africa. The receding waters have left huge mud flats with hundreds of sinkholes that threaten to collapse roads and buildings and have forced a development freeze on Israel's side of the sea, which lies on the border with Jordan.

"I'm looking at the reality, nothing will change in the next 20 to 40 years – the sinkholes will continue opening even more, the infrastructure will be destroyed from stream erosion, the water level will drop and affect the ecosystem," said Galit Cohen, head of environmental policy at Israel's Environmental Ministry. "The forecast for the future is very bad".

The main problem, experts agree, is that most of the water that once flowed into the sea – the saltiest large body of water in the world and, at 1,371 feet below sea level, the lowest point on Earth – is being diverted for drinking water and agriculture, so there is not enough to offset the high evaporation rate. In addition, Israeli and Jordanian industries on the south end of the sea are letting 180 million gallons of the mineral-rich water evaporate every day – about 66 billion gallons a year – to extract chemicals.

"The situation of the Dead Sea is something that happened because there's a water shortage and it's needed for other uses," Cohen said. "You can say, 'Don't think of anything else. Let the Dead Sea have the water,' but no one will listen. They'll say, 'So we won't have water in Tel Aviv or the Negev or where?'".

The best hope for a solution, some believe, is to pump salt water from the Red Sea to the Dead Sea via a proposed 120-mile Red-Dead Canal, a $5 billion project that the Jordanian government is pursuing with international donors. The World Bank will help fund a $20 million study of the idea.

But Israeli experts say similar proposals – including a Med-Dead canal to pump water from the Mediterranean – have been around for more than 30 years and are unlikely to work. According to Amos Bein of the Geological Survey of Israel, chemical and biological reactions produced by mixing Dead Sea water with seawater could change the blue colour of the Dead Sea to white or red or create deadly gasses.

In the end, he said, the sea will continue falling about three feet a year for the next 150 years or so until the water becomes so supersaturated with salt that evaporation effectively stops. At that point, according to Bein, the surface of the Dead Sea will be one-third smaller and about 434 feet lower than today.

"It's possible to see the half-full part of the glass," he said. "The Dead Sea will never dry up".

**A River of Sewage**

The Dead Sea covers about 250 square miles in a deep valley bordered by Israel, Jordan and the West Bank. But to understand why the sea is dying, begin about 60 miles north, at a spot just below the Sea of Galilee that today is the northernmost source of water for the lower Jordan River – an open drain that pumps out 720,000 gallons of raw sewage a day.

White foam flutters in small pools around rocks. Chunks of concrete, strips of plastic piping, bicycle tires and other litter clutter the shore. The stench of human waste fills the air. If the scene is not cautionary enough, a sign warns: "Danger! Don't enter or drink the water".

"This is the end of the Jordan River as far as clean water is concerned," Gidon Bromberg, head of the Tel Aviv office of Friends of the Earth Middle East, said as he walked around the site. "From here down to the Dead Sea, the Jordan River has been turned into a sewage canal – little more."

The Jordan – best known as the river where Christians believe Jesus was baptised – used to be the main source of water for the Dead Sea, delivering about 1.3 billion cubic metres of water every year, or about three-quarters of all the water that flowed into the sea.

Today, virtually every major spring and tributary that once flowed into the Jordan has been dammed or diverted for drinking water and crop irrigation by Israel, Jordan, Lebanon and Syria. The Jordan now delivers less than 100 million cubic metres of water a year to the Dead Sea, and as much as half of that is raw sewage, according to Bromberg and other environmentalists.

Months go by in the summer when parts of the river are dry. At Jesus's baptismal site, five miles north of where the Jordan trickles into the Dead Sea, pilgrims fill souvenir bottles with greenish-brown water.

"The irony is that today the Jordan is being kept alive by sewage," Bromberg said.

As the level of the Dead Sea falls, it affects everything around it. Underground pools of fresh water are retreating, pulling water away from plants in major wildlife areas bordering the Dead Sea. The fresh water is hitting pockets of salt deep underground and dissolving it, causing the earth above to collapse into giant sinkholes, which recently forced the closure of an army camp and a trailer park. As the shoreline shifts, rain runoff digs deep gorges in the newly exposed landscape and wipes out roads and any other infrastructure in its path.

"The real solution is that we need to be smarter and use our water in a wiser way," said Ariella Gotlieb, a biologist with Israel's parks authority who works at the Ein Gedi Nature Reserve, an oasis of dense tropical plants, hyenas, ibex, wolves and more than 200 species of birds. The reserve is one of several plant and wildlife sanctuaries threatened by changes in the local ecosystem.

Gotlieb and others said the traditional Zionist dream to "make the desert bloom" has to be updated to reflect the scarcity of resources in a more densely populated country. She pointed to the reserve's neighbour, Kibbutz Ein Gedi, and said it was no longer appropriate for residents there to use natural spring water to tend fruit groves and a botanical garden with more than 800 species of exotic plants in the middle of the desert. Of the 3 million cubic metres of water that flow from Ein Gedi's four springs, not a drop reaches the Dead Sea anymore, she said.

"The Dead Sea is receding because the Jordan River is dead – it has no relation to the botanical gardens," responded Meir Ron, a founder of the 550-resident kibbutz. He said the problem was a classic battle between man and nature.

"When I was born in Haifa in 1935, there were 600,000 people in Israel, and now there are more than 6 million," he said. "What can we do?"

**Chemical Extraction**

From Masada, the mountaintop citadel that was fortified by Herod the Great and became a Jewish cultural icon and a symbol of the struggles of modern Israel, the view is of mud flats stretching for miles into Jordan.

"Herod built Masada overlooking the Dead Sea, but he'd turn in his grave if he could see what we've done to it," said Bromberg, the Friends of the Earth environmentalist. "You don't have to be Jesus to walk across the Dead Sea anymore".

Below Masada, the southern edge of the sea is about 15 miles north of where it used to be. From here, pumps siphon water into a six-mile canal that carries it through the mud flats to a large complex of evaporation ponds. Though marketed by Israeli hotels as the "southern basin" of the Dead Sea, the area is operated entirely by the Dead Sea Works chemical company to harvest minerals from the water. Without the pumps, the basin would soon go dry.

The evaporation process leaves a seven-inch residue of salt that settles to the bottom of the main pond every year, creating the exact opposite problem that the northern Dead Sea is facing. As the bottom rises, the water level does too, and posh Israeli hotels along the shore are building huge sand dikes in a losing fight against the floodwater.

The Sheraton hotel has had to rebuild and raise its dike three times to hold back the adjacent pond, which is now well above the hotel's swimming pool and ground floor, according to Udi Sicherman, chairman of the Dead Sea Hotel Association. The solution, he said, is a $200 million proposal to build a huge wall inside the ponds, creating a massive lagoon in front of the hotels where the water level could be controlled.

The Dead Sea Works, one of the world's leading producers of potash for fertiliser, operates an 18-mile-long maze of evaporation ponds. Discoloured water that threatens to flood roads is held back by a network of dirt berms. The company's plant is a massive industrial complex surrounded by vast ponds and mountains of chemicals.

Environmentalists say that the Dead Sea Works evaporation ponds are responsible for 25 to 30 percent of the annual drop in the Dead Sea and that the company, which just had its State concession extended to 2030, is reaping a financial bonanza from the increased concentration of minerals in the water. "They are the only ones making good money. They want the water to decline," said the Environmental Ministry's Cohen.

Menachem Zinn, chief operating officer for Dead Sea Works, said the main cause of the sea's shrinkage was diversion of water from the Jordan River and other sources, not the company's

evaporation ponds. He said the Dead Sea Works and industries that serve it employ about 35,000 people. The company recently completed a $70 million project to upgrade its ecological standards, he said.

"We try to keep the environment the best we can and at the same time make 3.5 million tons of potash and give so many families the ability to live from it," he said. At the Ein Gedi Spa, where Boaz Ron is watching the Dead Sea and his business dry up together, the answer is simple.

"You have to put a limit on things. If you can't put the water in, you have to stop taking it out," he said. "You need to reach a balance with nature, or the Dead Sea will become the Dry Sea".

### 10.3.4 Site Visit

**Salt works**

- Rainfall 30 mm p.a.
- History
  - In the 19th century the British came to the Dea Sea (occupied Palestine)
  - Started the Palestine Potash Company
  - Two advantages
    - Hyper saline sea
    - High evaporation – > 42°C
  - Biggest solar energy industry in the world
  - Started at the North Lake
    - North lake very large (problem)
    - South lake smaller
    - North closed due to access problems
  - In 1940 potash became the first export of Palestine
  - In 1947 the north of the lake came back under Jordanian kingdom
  - Got water from Jordan
    - War stopped this supply of water
  - New plant
    - 1964 plant upgrade – started to make a profit
    - 1995 private company (ICL – Israel Chemical Limited)
      - Now publicly listed

**Dead Sea**

- Lowest place in the world
- Decreasing rainfall and increasing population, 10 x 1948 pop.
- 1960's Jordan stopped water supply – this lead to war
- 85% of inflow stopped
- Minerals harvested
  - Magnesium, NaCl, KCl, Br
- Third largest producer of potash in the world behind Canada and Russia
- ICL is major producer of fertilisers
  - Phosphate fertilisers made a loss in the last three years
- Bromine is the last to be extracted from hyper saline water

# 11 Day 11 – Thursday 30th October, Israel

## *11.1 Destination: Netafim Kibbutz Hatzerim*

**Focus: Drip irrigation, Technology Training Centre, Netafim factory and Jojoba plantations**

### 11.1.2 Contact Information:

www.netafim.co.il


**Site Address:**

D.N. Hanegev

85420

ISRAEL

Phone: 972 8 6473222

Fax: 972 8 6473028

Email: ronir@netafim.com

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Mrs Tali Shapira (Netafim)

Ph: 052 501 3560

### 11.1.3 Background

**Netafim's new technology training centre at Kibbutz Hatzerim**

This unique centre takes visitors on an exciting journey through the history of drip irrigation and provides a vivid introduction to Netafim's products, with the emphasis on making the perfect match between them and each culture and growing method.

**Agriculture Drip Products**

Since 1967, Netafim's R&D division has accumulated a depth of agronomic knowledge that enables it to respond to the specific irrigation needs of a field crop with exactly the right solution and the technological knowledge to develop drippers and sprayers for the most effective and accurate irrigation.

During the past 30 years of developing irrigation systems and products, Netafim has launched 10 generations of drippers and drip irrigation systems, from the very first generation of laminar flow dripper lines, to the latest generations of integrated, regulated drippers. Progress has been enormous, with each generation of drippers meeting the changing agricultural needs in the field.

Below are mentioned some of the different generations of drippers developed by Netafim, together with their main uses in crop field irrigation, surface drip irrigation, irrigation and subsurface drip irrigation systems.

- Turbulent flow dripper lines: irrigation with a very strong water flow that washes out every particle of dirt from the pipeline
- Regulated drippers: a unique patent enables drip irrigation in severely sloping conditions; also comprises an improved self-cleaning mechanism

- Integrated drippers: an extension of drippers soldered to the pipe's interior wall; used in fields in which the pipes are rolled up at the end of the season and re-laid at the start of the next irrigation season
- Integrated pipes: with extensions of regulated Ram drippers that are the world leaders in irrigation, and unregulated drippers soldered to pipes of varying wall thicknesses, like Tiran, Typhoon and Streamline.

During the last year, Netafim has launched the newest generation of regulated, integrated drippers, developed especially for the following sectors:

- Concealed drip irrigation
- Plantations with slopes
- Greenhouses (pulse irrigation)
- Anti-root penetration

Today, Netafim's R&D division continues to develop the drippers and dripper lines that will serve agricultural irrigation and meet its challenges in the years to come head-on!

**Jojoba plantation information**

Trial done in southern United States and Mexico. Grew in various soils.

Sensitive to cold beneath 5°C.

Perennial evergreen shrub. A bi-pollinated plant male and female flowers on separate shrubs. When propagation is with seeds, the ratio between male and female trees is 1:1. The fruits are borne on the female shrubs. When using suckers it is possible to achieve a given ratio between male and female shrubs and therefore uniformity in the plants. Nowadays, there is a trend towards merristial propagation of high yielding plants.

The desired ratio between male and female shrubs is 5-10% male plants, and all the rest female.

The onset of fruit bearing occurs at the age of 3 with yields of 5 tons per hectare.

### Distances

The distance between rows is 3.5 m and between plants in the final stage is 1.5 m. When propagation is from seed, they are sown every 0.3 m and after 2 ½ years thinned out to a situation of 10 female plants for every male plant. The main product is wax.

### Irrigation

The irrigation factor is 0.5. Two irrigations are performed weekly with a lateral per row every 1m. It is preferable to cease irrigation in October in order to put the shrub into a dormant state.

Fertilisation – 150-200 kgs compound nitrogen per hectare. Phosphorous and potassium should be applied according to soil tests.

### The Results of a trial in southern United States

| Treatments | Average for a Plant 5-8 Years | Average for a Plant 9 Years and More |
|---|---|---|
| **Without fertilisation and irrigation** | 408 grams | 428 grams |
| **Ultimate irrigation without fertilisation** | 805 grams | 1105 grams |
| **Partial irrigation and fertilisation** | 852 grams | 1605 grams |
| **Optimal irrigation and fertilisation** | 1357 grams | 2525 grams |

Advantages of irrigation

- Economical irrigation system equipment
- Irrigation and fertilisation in a moist strip; aeration via the dry strip
- Prevents weeds between rows
- Prevents spread of leaf diseases
- Harvest while irrigating

### 11.1.4 Site Visit

## *11.2 Destination: Ashkelon Seawater Desalination and Purification Plant*

**Focus: Mekorot's desalination and rain augmentation technologies, integration of desalinated water into the National Water Carrier, urban amenity irrigation**

### 11.2.2 Contact Information:

www.ide-tech.com

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Elisha Arad
Marketing Engineer,
IDE Technologies
Phone: 054 846 0801


### 11.2.3 Background

**Ashkelon – winner of world's largest and most advanced SWRO plant in 2006**

The Ashkelon seawater reverse osmosis (SWRO) plant – the largest in the world – achieved two notable successes in 2006. In March it was voted 'Desalination Plant of the Year' in the Global Water Awards, subsequently passing a major project milestone in October 2006, when, little more than a year after it commenced initial production, it successfully delivered its first 100 million m3 of water.

**Site details (dimensions, capacity, etc)**

www.ide-tech.com/AllProducts.asp?pID=1714&ID=1484

Project data

- Total desalination plant capacity: 100 Million m3/year
- Plant footprint dimensions: 300 x 250 (m x m)
- Capacity of 330,000 kilolitres / day
- Maximum specific electrical consumption: < 4 kWh/m3 (including feed and product water pumping)
- Feed water salinity: 40,750 ppm TDS
- Product water salinity: < 200 ppm TDS (potable water according to WHO recommendations)
- Feed water temperature: 15 – 300C
- Lowest product price of $0.53USD per kilolitre (lowest in the world in 2006)

**Brochure**

www.ide-tech.com/dwlfls/Ashkelon%20Flyer%202007.pdf

**News article**

www.ide-tech.com/News_item.asp?iid=6029&pid=1599&ppid=1489&z=2&p=1

IDE lead consortium's largest and most advanced seawater desalination facility of its kind began operation in Ashkelon.

The world's largest and most advanced seawater desalination plant of its type began operation in Ashkelon. As of December 2005 the plant operates in its full capacity and produces 100 million cubic metres of desalinated water, with the approval of the Ministry of Health, Water Commission, the Water Desalination Administration and the Ministry of Environment.

The Plant was constructed with an investment of over a billion NIS and is operated by VID Desalination Company Ltd (V.I.D.), a consortium lead by IDE Technologies Ltd which is equally owned by Israel Chemicals Ltd (ICL) of the Israel Corporation Ltd and by Delek Group.

The agreement with the State is based on the BOT principle, whereby the entrepreneurs finance and construct the desalination plants on the State's land which is made available to them. They operate the plant as a private business and sell the water to the government of Israel at a pre-defined price, over a period of 25 years (including the construction period). At the end of the contract period, the plant is handed over and becomes government property.

The Ashkelon desalination facility uses Reverse Osmosis technology, a modern process technology used in a variety of water desalination applications. The facility provides high-quality drinking water, while making use of advanced means of energy recovery. The price of water produced stands at approximately 2.6 NIS per cubic metre.

The plant's site is about 70,000 square metres. Its construction works included the supply and installation of all desalination equipment, civil works engineering, buildings and infrastructure, structures for the pumping of seawater, channelling to the desalination plant, brine outflow to the sea, product water treatment till the final quality of drinking water is achieved. All this in accordance with the parameters set out in Health Regulations. The drinking water is channelled to Mekorot's Reservoir located next to the Power Plant constructed for the independent production of electricity for the needs of the Desalination Facility.

Mr Avshalom Felber, General Manager of IDE Technologies Ltd, who also serves as VID's Chairman, said that "IDE's vast experience and know-how in the provision of quality desalinated water applications accumulated in over 350 different desalination plants and facilities, supplied to over 40 countries, has served as the basis for the construction of the Ashkelon Desalination Project".

General Manager of VID, Gustavo Kronenberg said that, "VID is pleased to be the first company to construct an innovative and technologically advanced desalination facility in Israel". According to Kronenberg, "there exists no world water deficiency, only the problem of excess salts, and VID has proved that it is possible to desalinate seawater in an economical and safe way". He added that "the desalination facility provides approximately 15% of the total household water consumption in Israel". According to him, "desalinating seawater is the most effective solution for the water shortage in Israel, and the Ashkelon Facility – the largest and most advanced of its kind in the world – will contribute to the Israeli water scheme and boost Israel's position as world leader in the field of desalination".

**Guidelines for selection of desalination technologies**

www.ide-tech.com/AllProducts.asp?id=1568&sid=1571&pid=1571

## *11.3 Destination: City of Ashkelon*

**Focus: Water savings through use of subsurface drip irrigation in urban setting**

### 11.3.2 Contact Information:

www.netafim.com

**Site Address:**

City Hall, Ashkelon

**Organised by:**

Ortal Erez – Marketing Dept – Netafim Ltd

See details 5.1.2

**Site Contacts:**

Gavri Gilhad (Netafim)

Ph: 052 501 4612

### 11.3.3 Background

**Economical, efficient irrigation solutions for urban areas**

The city of Ashkelon has adopted Netafim's irrigation methods and uses UniTechline™AS as subsurface drip irrigation (SSDI) in lawns and gardens all over the city, including extensively in traffic islands. Since the transition to irrigation with SSDI, which began in the early 1990s, there has been a 30% saving of water, compared with similar areas irrigated using traditional methods (sprinklers). Mr Levi also noted that with the upgrading of the control system and the transition to the use of a Motorola manufactured central control system, a further 25% has been saved, relative to the period in which control systems were adjusted manually or locally. The current system provides the city's irrigation manager with a control room, from where he can regulate thousands of valves irrigating city landscaping, change the volumes of water used by the entire city at the touch of a button and receive warnings in case of faults in the system.

### 11.3.4 Site Visit

## 12 Day 12 – Friday 31st October, Israel to Spain – Madrid

## *12.1 Destination: Fenacore (Farmers Federation of Irrigators)*

**Focus: Irrigation technology, irrigation education and best practice – including visit to Coronet Project (digital drip irrigation system)**

### 12.1.2 Contact Information:

www.fenacore.org

**Site Address:**

Fenacore (Farmers Federation of Irrigators)

(see below)

**Organised by:**

Mr David Hernández Gómez

Fenacore (Farmers Federation of irrigators)

Paseo de la Habana, 26

E- 28036 Madrid

Tel: + 34 91 563 63 18

Fax: +34 91 563 62 53

Email: dhernandez@fenacore.org


**Site Contacts:**

David Hernandez

### 12.1.3 Background

**Areas of interest**

- Tackling drought and saving water
- Increase water and energy efficiencies
- Irrigation focus
- Pricing
- Environmental implications
- Biofuels

**Overview on Fenacore**

www.fenacore.org/empresas/fenacore/documentos/ingles.doc

An apolitical association for the defence of the interests and rights of water.

The National Federation of Irrigators Communities of Spain (Fenacore) is a non-profit association and independent politically, with more than half a century of existence, which brings together entities (irrigators communities, unions irrigation, etc.). It is devoted to the administration of water for irrigation, both surface and underground.

Fenacore was created in 1955 with the need to establish and maintain a unit of performance criteria among all entities involved in water use for irrigation. At that time, the political regime was trying to control the country's public life and communities irrigators partnered to cope with this

intrusion. It is known that: "In monarchy, republic or dictatorship, there is always water" referring to their political independence.

In this sense, the fundamental objective of Fenacore is to apolitically defend the interests and rights of water, aligning the effort and work of all parties involved in Spanish irrigation and working closely with the various governments in designing water policies for the country.

Among its short-term projects is the upgrading of existing irrigators communities, as envisaged in the National Irrigation Plan, as well as sensitising the society of the importance of irrigation in achieving sustainable agriculture, being cost-effective and respecting the environment. Fenacore's priority is to modernise the existing irrigation rather than undertake the implementation of new irrigation: modernise rather than run.

At present, Fenacore has more than 300 federal entities, involving 700,000 irrigators and almost 2 million hectares, or more than 50% of national irrigation. They are integrated into Fenacore Irrigators Communities of all Spanish provinces (including the Balearic and Canary Islands), and inside it the largest in the country either by their size or because of its tradition.

This model of users' association in irrigator's communities, with great experience in Spain, is being widely disseminated by Fenacore in other countries (Iran, Poland, Romania, Bosnia, Armenia, Egypt, Turkey, etc.) so that their water resources can be distributed with the utmost rigour and fairness.

**An intensive counselling, educational and informative regime**

In order to defend the interests and rights of communities irrigators federated, Fenacore performs a wide range of activities which may include, mainly in the following lines of action: advice; and responding to queries (legal, technical, practical, etc). Also, Fenacore endorses the aspirations of the federated entities related to management improvement, modernisation of irrigation, etc.

**In collaboration.** Fenacore maintains close relations of cooperation with the Ministry of Agriculture since 1993 through "Partnership and Cooperation Agreements", currently with the General Directorate of Rural Development. These agreements have enabled the exchange of data and ideas on planning irrigation structures, upgrading and dissemination of irrigation techniques, knowledge of the real problems that affect the irrigation, etc.

**Teaching.** Fenacore participates in numerous seminars, conferences, etc. so it can defend the public interests of communities irrigators and the reality of Spanish irrigation. It also organises its own National Congress Irrigators Communities and technical seminars on topical issues in Spain and other countries.

Also, in collaboration with the Ministry of Agriculture, Fenacore is developing a policy of intensive training through courses aimed at farmers, irrigators; training programmes for professionals in the multi-year agri-food sector, and organising trips to exchange technical experiences with farmers and technicians of the office of the country visited.

Information is also available through the regular issuance of circulars on topical issues (legislation, rulings, technical reports, etc.). With the goal of having an organ of expression of one's own federated entities, Fenacore has launched this year its new bulletin, Intercuencas, on a quarterly basis.

Fenacore wanted to boost the modernisation of irrigators communities across new technologies, with the introduction of comprehensive management programme "Fenacore". This program allows for this process to be computerised (roll / census, land registry, administration, billing, accounting, registration, etc) which will achieve better and more modern management of the communities that contribute to a fairer and more efficient distribution of water for irrigation.

Also, at present, Fenacore works in the development of the project CoreNet, an intranet to provide more than 90,000 farmer-irrigators access to all information and services needed to improve their performance and competitiveness. Through this new site, users will be able to keep pace with the latest news, subsidies, regulations on water, recommendations, weather forecasts, etc.

Fenacore is fully integrated into the country's public life and is the only official representative of irrigation at a national level. Throughout this past century, Fenacore has worked in favour of irrigators with governments of different political signal, maintaining its political independence and with a constructive spirit, which has allowed it to become an important part of decision-making for water policies for the country.

In this sense, Fenacore is recognised by the Civil Service as a valid interlocutor on many occasions, including the drafting of the Water Act and its regulations, the development of the National Hydrological Plan (NHP), collaboration in the preparation of the Plan National Irrigation (NRP) and, recently, the bill Reform of the Water Act, the White Paper or the Water Framework Directive on Community water policy.

In addition, Fenacore is also, by Ministerial Order, an advisory body to the Ministry of the Environment, an ex officio member of the National Water Council by Royal Decree and was once a founding member of the Advisory Council on the Environment.

**Community Mediterranean Irrigators (EIC)**

In the international framework, Fenacore is a founding member of the Euro-Mediterranean Irrigators Community (EIC), a non-profit association that brings together European organisations involved in the administration of land and groundwater. At present, some of the EIC countries include Italy, Greece, France, Portugal, Spain, Tunisia, Morocco and Egypt.

The EIC acts as a stakeholder before the European Commission (Brussels), defending the interests of the irrigators of all member countries in water policy of the European Union, analysing and studying the implementation of the Water Framework Directive and its impact on irrigation Europe.

Similarly, the EIC maintains institutional relations with various international agencies such as FAO, the Global Water Partnership (GWP), the Mediterranean-Water Institute, etc.

**The Irrigators Communities: a review by its history**

The Communities Irrigators are ancient institutions with a long historical tradition, created from its origins to the proper distribution of water and irrigation organisation itself. The first period of the history of irrigation in Spain dates back to prehistory and the Old Age, although it is very difficult to specify its origin, different for different watersheds.

Similarly, the organisation of Irrigators Communities does not appear in our law Historic well defined, since it is governed by associations own rules of Romans and Arabs. The rules for distribution of water for irrigation were based on customary law, custom, habits that would end plasma in written ordinances.

At present, the legal framework within which rely Irrigators Communities is the current Water Act, which establishes the foundations of its structure, powers and responsibilities. The first Water Act dates from 1866 and the last, was enacted in August 1985 and has been recently renovated. In Spain, from historical times, the Communities Irrigators receive different names (Courts Water, Irrigation Unions, inherit, Water Board, Central Boards of users, etc).

At present, it is understood as communities irrigators those groups are owners of an irrigated area, which is compulsory by law to join the autonomous administration and common public waters, non-profit basis. These communities are characterised by having legal personality, corporations to be governed by public law and have the qualification of Public Administration.

The figure irrigators communities is reinforced by the administration itself as it not only recognises the communities in due course, but requires future users who use the water together to form community irrigators. Thus, most of Spanish irrigation is integrated into these groups, playing a key role in the proper use and water management to ensure water demand. The National Irrigation Plan-Horizon 2008, published by the Ministry of Agriculture, Fisheries and Food in 2001, already estimated the number of Irrigators Communities in Spain to be 7,196.

In Spain, between 80% (in the past) and 70% or less (nowadays) of water resources are used by the irrigation sector.

By legal force, water users, as well as users for any other public purpose that share the same outlet or concession, shall organise themselves into “users communities”. When the water is used only for irrigation, these communities are named “irrigators communities”. According to a catalogue published by the Ministry of Works (Ministerio de Obras Publicas presently Ministry of Environment), nowadays in Spain there are around 6,200 irrigators communities taken in the census.

What is an irrigators community? We could define it as the grouping of all the owners who own an irrigating area forced by law to join together, for the autonomous and common administration of the public waters, without intention of profit. Then we are talking about “a specific area, suitable for irrigation, enjoying a water concession to being irrigated”. This definition highlights that the water concession is linked to the land and not a grant to the landowner or “commoner”. Accordingly, when a “commoner” sells his field he transfers, along with the land, the relevant right to the water that cannot be sold separately, for it does not belong to him.

### Objectives of irrigators communities

Irrigators communities have the obligation to administrate collectively public, surface and underground waters they share. Their foremost task is the distribution and regulation of granted waters, binding to the norms sanctioned by Public Authority and elaborated by the users themselves.

The reason why irrigation water users shall gather in Irrigators Communities, by enforcement of the Law, is conditioned, on my view, by the existence of common properties and related equipment, such as:

- Water (generally with one or several common outlets)
- Transport and distribution hydraulic networks
- Right-of-ways caused by the works

which preferably should be managed, operated and financed in an associative form.

### Management improvements of irrigators communities

At this stage in time it seems necessary to gradually allow the users to take more decisions on the regulation and control of the water resources inside their corresponding hydrological basin granted by concession for irrigation, initiative which up until now has been taken in Spain by the Basin’s Agencies. But we have to advance more and more towards the responsibility between the water administration and the users.

To this purpose, the irrigators communities will have to assume their own responsibilities, although with the support of State agencies either in the scope of hydraulics or environment or in agricultural aspects.

Of all tasks that an Irrigation Community has to assume, the most important one is the fair and equitable distribution of water to each one of the irrigated plots. Henceforth the importance of a good and permanent agricultural management, made by experts on overall aspects of cropping techniques and, in particular, on two of them, related to a better knowledge of the relationship between soil-water and soil-water-plant, in a general way. The first one – the right water application to the plants, or use of the best suited irrigation method – and the second one – occurs due to special interest in the areas of water deficit conditions as it happens in Spain and other Mediterranean countries where the irrigations are usually rare due to a lack of water. It should be known which stages of the vegetative development of the crops are more affected by temporary water deficit conditions because of its effects on agricultural yields losses, with the final object to improve available water resources management, specially in regions as is the case of the Spanish Levante and many other parts of the world, where water resources are limited, both because of unfavourable climatic conditions, such as drought periods, and the increasing demand of water for other uses that might be priority, as it happens with the populations supplies.

The XXI Century Agricultural has to be characterised by being a pattern of supporting agricultural, based on two main principles: a/ “competitive” (the farmer has to use a production means and commercialisation channels which allow him to sell his products at competitive prices, in order to

make his living with his family from this activity) and b/ “non-aggressive for the environment” (he should protect the natural resources, meaning the soil and water, so that they can be used by future generations). The first consequence of this future agriculture is that the farmer will need almost permanent advice about which are the inputs in which his contribution to the crops could be reduced. For instance, cultivation, fertiliser, etc and which are the essential production factors to obtain competitive crops from a qualifying point of view more than a quantifying point of view.

In the light of this worldwide situation, irrigators communities are challenged to channel their members on the best way to make use of the available water volumes and teach them how to do so. This participation will, of course, be completed by a control on the water consumed by the farmers. This task will be successfully assumed provided that it is complemented by the appropriate flow measuring instruments and a good water pricing policy.

One task, which in reality is the responsibility of the State authorities since it should be accomplished before the creation of the Irrigators Community, is to inform the farmers on the benefits of being a part of the Users Community. Even though, once one Irrigators Community has been formed, no matter how small it may be, it is in its interest to gather into General Communities or General Board of Irrigators Communities, covering river sections or the whole river basin. This coordination would permit a better access to technical, juridical, financial, guard surveillance, etc services, out of their possibilities in other circumstances.

Furthermore, it would be advisable that the users of irrigation schemes elaborate within their community a pyramidal organic structure similar to that of the Spanish National Federation of irrigators communities, composed of the General Assembly, a Governing Board, and a Permanent Committee. This committee is composed of a representative of each hydrographical basin. And finally, the President who is no more than the legal representative of the bodies abovementioned.

**The efficiency in water use**

There is generally a high degree of consensus on measures that can be applied to achieve efficient water use in irrigation. The most important are:

• Introduction of new technologies for more efficient irrigation

• Creation of Advisory Services to irrigators (SAR)

• Training to irrigators in new technologies and environmental aspects

• Using tariffs binomial (volumes-surfaces) with penalties for excesses

• Placing control systems in high water

• Improved internal regulations (in rafts and / or their own channels)

• Improving the transmission and distribution networks

• Improved management systems in administrative irrigators communities

• Improving the operating systems of reservoirs with real-time evaluation of needs water crops.

These measures to improve efficiency in water use are, as can be seen, some of nuance and administrative management and other more technical nuance. All of them can be beneficial, enabling savings and energy efficiency if they were planned and implemented adequately, as explained in paragraphs later.

Reducing energy intensity is a priority objective for any economy and more so in Spain where energy intensity is increasing annually at a high rate.

**Energy efficiency**

The decrease in energy consumption is considered to be done through two aspects:
a decrease in water consumption due to a better understanding of the needs across the advisory services to irrigators and the restructuring or modernisation with changing irrigation system. It has more effect on irrigated land on which it is considering a change of the irrigation system (can pass efficiency of 0.4 to 0.75) and those with low percentage of lining their networks at present (can improve the efficiency of 0.4 to 0.6). However, in the case of upgrades involving a change of

irrigation system and water-saving, if it occurs, it may be offset by higher energy consumption for irrigation pressure, as they require half an installed power order of 2.0 kW per hectare.

For the correct alignment of the pumping system, both as a new irrigation modernisation, the following needs to be considered:

• Introduction of variable frequency for operation of pumps under variable

• Improving performance in the teams drive

• Automation systems for command, control and manoeuvre

• Possibility of construction of warehouses operating in certain cases

• Designing optimised energy networks

• Improving power factor

• Choosing the most appropriate fare.

Improving the energy efficiency of irrigation systems that depend on external inputs of energy involves investments that minimises, in principle, operating costs for farmers but, above all, has a positive effect on the environment as decreasing the need for energy production

The modernisation of irrigation has a roof to reach specific changes to irrigation systems automation, with monitoring the application of plant protection and paid, in some productive structures with improved processes re-parcelling. The direct consequences for the farmer are improving their working conditions, increased availability of time and improving their economic performance. The society as a whole will benefit from the environmental improvement resulting from the modernisation and, in particular, energy savings occurring in conjunction with traditional irrigation pumping.

Despite the difficulties, efforts must be made to carry out the modernisation works of traditional irrigation, preferably with change to pressure irrigation system which, together with technical assistance provided by the Advisory Service to irrigators, are the two basic elements to the effective management of available water resources. The proper design and use of the facilities may later provide a release of water for environmental purposes and, in particular, can help reduce the overexploitation of aquifers by saving water produced and, ultimately, saving energy by minor needs pumping.

**Water management in Spain goes digital**
www.treehugger.com/files/2007/11/water_management_digital.php

You can call it drip irrigation 2.0: a growing number of Spanish farmers have decided to sign onto an ambitious digital initiative linking up their fields to a national grid controlled from Madrid. Its main purpose, of course, would be to conserve water and costs – authorities estimate the new irrigation system could save 20% of the water Spain currently uses, or close to 1.3 trillion gallons every year.

Another benefit would be to simply overhaul a now dated infrastructure – in use since the 13th century when it was first introduced by the Moors. According to Juan Valero, secretary general of Fenacore, the Irrigation Farmers' Federation, 200,000 farmers have already signed up for the project. By 2010, he hopes to raise that number to 500,000, which would then represent the vast majority of Spain's irrigation farmers.

Fenacore is also encouraging farmers to lay down telecommunication cables alongside the new water conduits to allow regional and national officials to effectively monitor all aspects of the irrigation grid – where the water is going, how much is getting there and at what pressure it is. The farmers will be able to control all the action from their laptops and cell phones.

These developments come at a crucial time for Spain; years of debilitating droughts coupled with unsustainable levels of water use for irrigation (about 70% of all water resources) have convinced Spaniards of the need for change. Experts estimate that the nation loses more than 60% of its water before it reaches the tap, of which only a measly 1.5% is recycled. Though not bullet-proof (the technology will likely present some new problems in the short run), this new system should go a long way towards helping tackle Spain's water management crisis.

**Spanish farmers modernise water control**

www.usatoday.com/tech/products/2007-08-02-3496358447_x.htm

Valencia, Spain — The Moorish invaders who once ruled Spain brought with them a clever irrigation system that helped turn arid land into verdant fields. A millennium later it is still largely in use, and Spain remains one of Europe's breadbaskets.

But after years of chronic drought coupled with vastly increased water use, not to mention worrying climatic change, farm groups have realised it's high time for change.

Spain's Federation of Irrigators, known as Fenacore, is promoting an initiative to computerise Spain's irrigation system by 2010, connecting some 500,000 farmers to an irrigation network headquartered outside Madrid.

The scheme should allow valuable water to be monitored and controlled by computer, drop by precious drop.

"We're jumping from the 13th century to the 21st century," said Juan Valero, Fenacore's secretary general.

While computer-assisted irrigation is not new, Fenacore believes no other country is organising it at a national level. So far 200,000 farmers have signed up for the project, Valero said.

"The only way to manage water is to measure how much enters each channel and computer technology is the best way to do this," he said.

Farmers are being encouraged to move away from outdated, wasteful Moorish-style flood irrigation systems toward drip and dispersion irrigation. They are also asked to lay highly efficient telecommunication cables alongside main water conduits so that the irrigation grid can be monitored from a national computer centre.

"In almost half of Spain the irrigation technique used is flooding, which uses up to three or four times more water than is necessary," Environment Minister Cristina Narbona said recently.

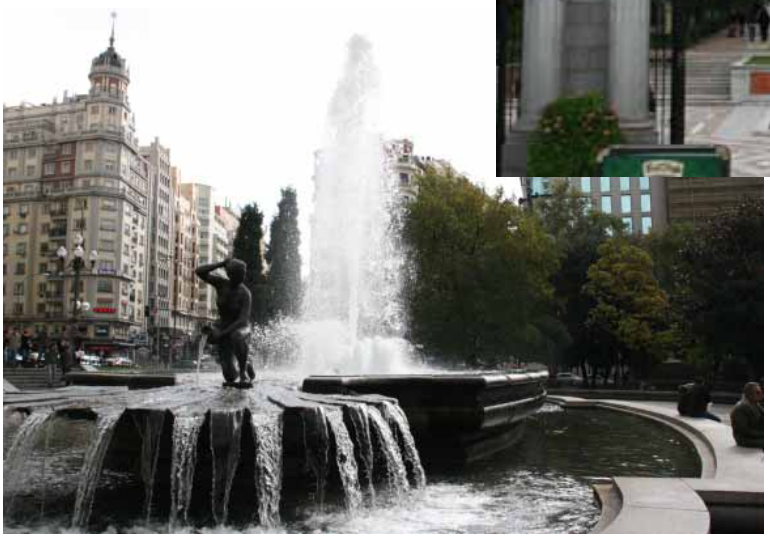
Fenacore estimates computerised irrigation will mean up to 20 percent water savings.

Water management is done by the River Basin Administration who report to the EPA.

# 13 Day 13 – Saturday 1st November, Spain – Madrid

## *13.1 Rest day*

**Focus: Public holiday in Spain for All Saints Day**



# 14 Day 14 – Sunday 2nd November Spain – Alicante

## *14.1 Destination: Torrevieja desalination plant under construction, Alicante desalination plant operating with ERI unit.*

**Focus: Water source, desalination**

### 14.1.2 Contact Information:

www.energyrecovery.com

**Site Address:**

1. Construction site of desalination plant in Torrevieja
2. Operating desalination plant in Alicante

**Organised by:**

Joan Galtes (see below) &

Borja Blanco

Vice President Large Projects Group

Email: bblanco@energy-recovery.com

Phone: + 34 91 503 0230

Mobile: +34 659 792 670


**Site Contacts:**

Joan Galtes

Technical Manager

Email: jgaltes@energy-recovery.com

Phone: + 34 91 503 0299

Mobile: +34 659 796 600

Audrey Bold

Vice President, Marketing

Email: abold@energyrecovery.com

Phone: +1 510 483 7370

## 14.1.3 Background

**Visit to operating desalination plant utilising ERI Technology & plant under construction**

**Company background**

**Ownership**

Energy Recovery, Inc. (ERI®) is a privately held company, incorporated and founded in the USA since 1994. The company is funded by several large investor groups who have provided over $22 Million in developing the PX Pressure Exchanger® (PX®) Technology. ERI has been profitable from commercial operations since December 2002.

**Company Data**

Energy Recovery, Inc. (ERI) is a leading manufacturer of energy recovery devices, which by drastically reducing energy consumption is helping make desalination affordable and enabling the rapid expansion of desalination plants worldwide.

The company's headquarters has research, development and manufacturing facilities in the San Francisco technology corridor as well as direct sales offices and technical support centres in key desalination hubs such as Madrid Spain, Dubai, UAE, Shanghai, China and Florida; including trained service representatives in Algeria, Australia, China, India, Mexico, Spain and Taiwan.

ERI's PX breakthrough technology is protected by six granted US patents and multiple overseas patents, plus numerous trademarks.

**Desalination capabilities**

ERI's PX Pressure Exchanger® technology (PX®) is a rotary positive displacement pump that recovers energy from the high pressure waste stream of SWRO systems at up to 98% efficiency with no downtime or scheduled maintenance. With over 6,000 PX devices installed or contracted in plants worldwide, PX technology is reducing the cost to produce over 5.2 million cubic metres (1.4 billion US gallons) a day of fresh water and saving customers an estimated 580 MW of energy, or $400 million a year in operating costs.

ERI has been developing and manufacturing the breakthrough engineered ceramic PX technology since 1994. To see how the PX actually works, you may visit www.energyrecovery.com

In 2005, due to rapid global acceptance of the PX-220, ERI became the world's largest manufacturer of energy recovery devices for SWRO desalination plants – with over 2,500 units operating successfully worldwide.

In 2002, the company introduced the large rotor model PX-220 and installed it in Veolia plants in the Caribbean, as well as 13 other sites worldwide, including two 10,000 m3/day lines in Cyprus Dhekelia.

**Market strategy**

The company's strategy is to provide the highest efficiency energy recovery devices for SWRO desalination. The company leads the market in providing the lowest lifecycle costs for producing potable water worldwide.

To address the demands of the company's growth in large markets (over 50,000 m3/day), ERI is well positioned with its AG Large Projects Group, managing projects such as the 200,000 m3/day HAMMA plant and 143,000 m3/day plant in Perth, Australia.
To target small to medium size projects (under 50,000 m3/day), the company's OEM Group

remains focused on providing competitive solutions over other ERDs available today. Always critical to the success of any solution is its emphasis on customer services and support. ERI's Service and Support Group enables the company's after market services including start-up support, field services professionals for commissioning, classroom and hands-on operator training.

**Projects**

- Hamma, Algeria: 200,000 m3/day (52.2 MGD)
- Barcelona, Spain: 200,000 m3/day (52.2 MGD)
- Al Shuiabah IWPP: 150,000 m3/d (39.6 MGD)
- Perth, Australia: 143,000 m3/day (37.5 MGD)
- Chennai, India: 100,000 m3/d (26.4 MGD)
- Los Cabos, Mexico: 36,000 m3/day (9.5 MGD)
- YuHuan, China: 36,000 m3/day (9.5 MGD)
- Ridgewood, Egypt: 9,000 m3/day (2.4 MGD)

**Key desalination staff**

Bill Anderson – VP, Service & Support/ Telephone: +1 (510) 483-7370

Audrey Bold – VP, Marketing/Telephone: +1 (510) 483-7370

Borja Blanco – GM/VP, Large Project Group/Telephone: +34 915030230

Dr Rick Stover – Sr. VP, Sales/CTO/1 (510) 483-7370

Hattie Wang – GM/VP, OEM Projects Group/Telephone: +1 (510) 483-7370

**Simple. Reliable. Efficient – lowest lifecycle costs**

ERI saves clients real money compared to older energy recovery technologies such as Pelton wheels, Francis turbines and turbo chargers. There is no commercially available energy recovery device (ERD) technology with higher overall efficiency. Among high efficiency technologies, ERI has been proven to have the lowest maintenance and highest reliability:

- Saving Clients Over $350 Million per year*
- Up to 98% Efficient
- Proven SWRO power consumption as low as 1.6 kWh/m³*
- Real power savings of over 500 MW worldwide*

**Experience and proven reliability**

ERI has 10 times more (in unit hours) operating experience than the next manufacturer of isobaric energy recovery devices.

- Millions in unit hours of proven reliability
- Over 6,000 units installed or contracted worldwide*
- More than 5,200,000 m³/day of capacity installed or under construction *
- More than 450 independent reference plants*

- Multiple 10,000 m³/day trains operating for more than 4 years*
- Standard 5 year warranty
- More than 32 trains worldwide with capacity of greater than 3,000 m³/day
- Standard off-the-shelf product line

**Simple design & ease of use**

PX® technology offers the simplest approach to isobaric energy recovery available today; only one moving part with no downtime or scheduled maintenance. Its ease of use with no artificial intelligence or adaptive control schemes as well as superior design features makes the PX device easy at start-up and shutdown.

- Reliable, one moving part – tough engineered ceramic
- No pulsation, valves, pistons or timers
- No over flush
- Zero scheduled maintenance
- Smallest footprint in isobaric ERDs
- Constant efficiency over entire operating range

**White Papers**

www.energyrecovery.com/news/pdf17_SWROwithIsobaricEnergyRecoveryDevices.php4

**Seawater reverse osmosis with isobaric energy recovery devices**

By Richard L. Stover, Energy Recovery Inc. (Received 21 March 2006; Accepted 28 March 2006)

Keywords: SWRO; desalination; pressure exchanger; energy recovery device

Presented at the EuroMed 2006 conference on Desalination Strategies in South Mediterranean Countries: Cooperation between Mediterranean Countries of Europe and the Southern Rim of the Mediterranean. Sponsored by the European Desalination Society and the University of Montpellier II, Montpellier, France, 21–25 May 2006.

0011-9164/07/$– See front matter © 2007 Published by Elsevier B.V. doi:10.1016/j.desal.2006.03.528

**Abstract**

The world increasingly depends on desalting seawater or brackish water for producing suitable and sustainable supplies of potable water for local populations, tourism, agriculture and industry. The energy cost component of desalinating seawater has historically been a large factor (up to 70%) of the total cost. There is a limit to the amount of available energy and an environmental consequence associated with every kilowatt consumed. Along with the older style centrifugal energy recovery devices (ERDs), there has been a recent proliferation of ERDs that employ positive displacement mechanisms. These “pressure-equalising” or isobaric ERDs transfer the energy from the membrane reject stream directly to the membrane feed stream.

This direct, positive displacement approach results in a net transfer efficiency of up to 97%. This efficiency advantage makes it possible to dramatically improve the performance of seawater reverse osmosis (SWRO) plants by reducing their energy consumption by as much as 60% compared to systems operating without energy recovery. In addition to energy savings, isobaric ERDs offer significant benefits to SWRO plant designers and operators. These include unlimited capacity, reduced high-pressure pump costs, high efficiency and operational flexibility. The PX pressure exchanger isobaric ERDs provide the additional benefits of maintenance-free operation, fail-safe operation, corrosion avoidance, low vibration, ease of control and long life. Although the author of this paper is directly associated with Energy Recovery, Inc., a leading company in isobaric ERD technology, the principles and theories presented in this paper are applicable to all devices that are based on the positive displacement, isobaric chamber approach.

www.energyrecovery.com/news/pdf_ThePerthSaltwaterDesalinationPlant.php

**Environmentally sound desalination at the Perth Seawater Desalination Plant**

Richard Stover[1], Gary Crisp[2]

1 Energy Recovery, Inc., San Leandro, California, USA, stover@energy-recovery.com

2 GHD Pty Ltd, Brisbane, Queensland, gary.crisp@ghd.com.au

**Abstract**

Water scarcity is recognised as a significant problem in Australia and throughout the world. Yet the demand for fresh water continues to grow, driven by the need for drinking water to satisfy the world's growing population, changing weather patterns, an increasing need for water for agriculture and industry and the concentration of populations in urban areas that lack sufficient fresh water resources. Water scarcity can be addressed, in part, through conservation efforts and better use of conventional resources. However, resource limits and the environmental impacts associated with increased use of surface water limit the viability of these options. At the same time, seawater reverse osmosis desalination has emerged as an affordable and environmentally preferable water resource.

The city of Perth recently increased its water supply capacity through the implementation of the Perth Seawater Desalination Plant (PSDP). This plant and others around the world incorporate low-energy membranes, high-efficiency pumps and isobaric energy recovery devices to reduce energy consumption. The cost of water production can be comparable to or less than that of new conventional sources of supply. The energy consumption of PSDP is carbon neutral, meaning that it is 100% offset with renewable energy. In addition, its brine discharge has been shown to have no adverse impact on the environment.

The authors discuss water scarcity and demand in an Australian context. The design and operation of the Perth plant are presented as a standard for seawater reverse osmosis plants and a model for sustainable water production from the sea.

## 14.1.4 Site Visit

**Alicante**

- Building new desalination plants (seawater RO)
  - 60% potable water
  - 40% agricultural use
- Some plants in the region have been built specifically for agricultural irrigation water

**AquaMed**

- Building 14 desalination plants
  - Totaling 240,000 kL/d
- Water for potable and agricultural use
- 21 kms of pipelines
- Alicante has always had a problem with water supply
- Government purchases water 30 c/$m^3$ (EUR) ex-plant
- Potable reuse not considered
- Effluent reuse for agriculture only
- Water quality
  - 300 ppm TDS summer
  - 150 ppm TDS winter
  - <1 ppm Boron

**The Plant**

- 400 $km^3$ concrete
- $3x10^6$ ton of reinforcing steel
- $1x10^6$ ton of structural steel

- 6 bar pressure in the pressurised filters
- 3.5kWhr/$m^3$
- 40% efficiency on first pass
- 90% efficiency on second pass

**Energy recovery**

- High pressure pump 40-45% of water, the rest comes from the energy recovery system
- Brine from RO is 68 bar; this energy is transferred to inflow seawater, 95-98% efficiency
- There is a trade of 3% increase in salinity of seawater
- Capital cost recovery in 2 years (this is dependent on the cost of power)
- Discharge brine, sweater is brought into shandy with brine stream to reduce salinity of outfall brine then discharged to ocean
- There has been a trend to increase recovery percentage but it reduces membrane life
- Now they set energy recovery to 40% to increase membrane life

Of the SWRO produced in Spain, 40% might go to agriculture and 60% is used for drinking.

Near the Torrevieja desalination plant are the “Salterns of Torrevieja’ the second larges salt water lagoons in the world (and certainly the largest in Europe). The flats have been used for salt production since Roman times and still provide salt for export world wide. The lagoons have been designated as national parks and attract more than 250 bird species including the pink flamingo.

# 15 Day 15 – Monday 3rd November, Spain – Alicante

## *15.1 Destination: Alicante and Surrounds*

**Focus: Wastewater treatment and urban irrigation**

### 15.1.2 Contact Information:

**Site Address:**

Alicante & Surrounds

**Organised by:**

Mordi Schwartz (+34 638 019 343) and

Ortal Erez – Marketing Dept – Netafim Ltd

Kibbutz Magal – D.N. Hefer 38845

Tel: +972-4-6287499

Fax: +972-4-6287713

Mobile: +972-52-5017499

Email: ortal.erez@netafim.com


**Site Contacts:**

Sonia Sampietro (LS Sales – North Spain) – cellular 686 703 476

Vicente Abadia – Local Dealer – cellular 609 655 560


### 15.1.3 Background

Alicante is renowned as being one of the largest cities to utilise recycled water to maintain urban green spaces.

The city of Alicante reuses water from the towns treatment system to irrigate all of the cities parks, medium strips and open park areas. Participants will be shown various sites from the treatment system to the landscape applications; this will include the botanical gardens and golf courses. The group will visit the municipality to look over the infrastructure that was started in 1990.

A story which illustrates the impact of water shortage in Spain:

www.guardian.co.uk/world/2005/jun/06/spain.gilestremlett

### 15.1.4 Site Visit

**Alicante Recycled Water**

- There are 2 storage tanks – buffer for treatment plant breakdowns

- Provides RCW to 2 golf courses 1 x 18 holes
  1 x 9 holes
- RCW, apart from municipal irrigation, it is used for agricultural irrigation
- RCW is free to the council
- In Spain there are no rules for irrigation with RCW
- In December there will be RCW water use and water quality guidelines
- Rainfall 300-350 mm/a
  - Rainfall concentrated in autumn
  - There are more droughts for longer periods
- Soil profile – there is a clay layer at 3 m
- Place high importance on sodium management in water
- They leach in winter to manage sodicity
- Salt – there is saline intrusion into sewer
  - Council has contracted a private company to renew sewers
- 2 WWTPs north and south of the city connected with 500mm pressurised pipeline
- Alicante population 700,000 in summer
  350,000 in winter
- 7GL of treated effluent used
- Vandalism of public assets a big problem in Spain
  - Is a high cost to Council
  - One of the drivers for subsurface irrigation is vandalism
- Telemetry is used to manage irrigation systems
- Purple pipe is not regulated
  - Use is up to Council
  - Alicante does use purple pipe

**Treatment plant**

- Treatment plant is built on top of a hill
  - This is due to the high cost of low lying land
- Controlled by radio in real time
- 10 sewer pump stations 2 – 6 pumps each
- 2 central sewage stations
- Monitoring
- Daily samples for inflow
- Sample each treatment process
  - 400 mg/L SS
  - 400-600 mg/L BOD
  - NTK 60 mg/L
  - Inflow Summer 45,000 m3 per day
    Winter 30,000 $m^3$ per day
- Plant capacity 60,000 $m^3$ per day
- Secondary treated effluent
  - 20 mg/L BOD
  - 20 mg/L SS
  - NTK 5mg/L
- Tertiary treated effluent
  - 10 mg/L BOD
  - 5 mg/L SS
  - Turbidity 2 NTU
  - Faecal coliforms 10 MP/100 ml
- Treatment solids to landfill – no industrial waste, therefore requires no special treatment
- Sand is a particular problem in the treatment plant
- Disinfection
  - I$^{st}$ treatment UV sterilisation – designed for agriculture – excess to sea

- 2nd treatment $Cl^-$ sterilisation – designed for city reuse – delivered to storage tanks

- 100% of sludge to agriculture
  - There are no limitations to what type of agriculture sludge can be used
  - Most sludge goes to broadacre agriculture and wine grapes

Challenge is planning for the future, integrating into a master plan allowing adaptive management to improve adoption of technology in the future.

**Managing Soil Salinity**

Some of the plants selected have not tolerated the level of salinity in the recycled water (eg: roses) and have suffered as a result of this.

Salts are also building up in the soils. This is yet to be addressed by the municipality.

The delegation was warmly welcomed to Alicante and an impromptu press conference was held in the Mayors office with regional media seeking feedback about their progress in relation to Australian advances.

# 16 Day 16 – Tuesday 4th November, Spain – Barcelona

## *16.1 Destination: ATLL (Aigues TER LLOBREGAT)*

**Focus: Overview of water issues and management in Spain to ensure consistent supply**

### 16.1.2 Contact Information:

**Site Address:**

Barcelona

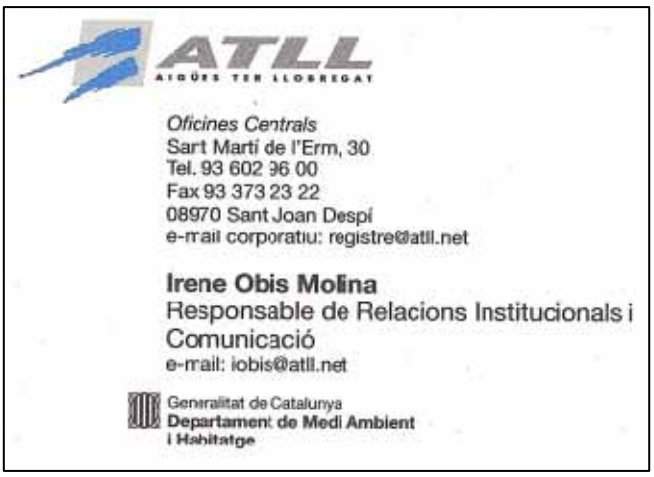
**Organised by:**

Joan Galtes

Technical Manager – Mega Projects Division ERI

Email: jgaltes@energyrecovery.com

Phone: + 34 659 796 600




**Site Contacts:**

Joan Compte (General Manager of ATLL)

Tomas Cazurra (VP of Public Works of ATLL)

Irene Obis Molina (PA to General Manager)

### 16.1.3 Background

Aigues Ter LLobregat (ATLL) is a public company owned by Generalitat de Catalunya (Autonomous government of Catalonia region) and was created in 1990. It is responsible for planning, construction, improvement, management and operation of all networks of drinking water supply in terms of water treatment, pipe distribution system, storage and supply.

ATLL supplies water to more than 100 municipalities, representing water supply for more than 4 million people in around 1800 $km^2$.

The global network distribution system is currently around 507 kms, 141 storage tanks, 54 pumping stations and 202 outlet points of supply.

ATLL owns 2 main drinking water plants, one in north Barcelona and the second in south Barcelona. ATLL is building the Barcelona desalination plant to ensure water supply at mentioned municipalities.

Due to the high industrial contents in the area, the drinking water plant that ATLL owns combines a wide range of technologies of treatment, from desalination plants to brackish RO systems, UF, electrodialysis up to conventional systems.

ATLL supply waters to municipalities where at the same time have their contracts with private entities that are the responsible for the supply of water to the end user.

Water Desalination Report – Volume 44 Number 37

**SWRO will provide drought relief**

Aigües Ter Llobregat (ATLL), the public water agency responsible for supplying water in the Barcelona region, said the Prat de Llobregat desalination project is on schedule for a May 2009 start-up. The 180,000 m3/d (47.5 MGD) SWRO will supply up to 20 percent of Barcelona's water and should remove the threat of water restrictions on the area's 4.5 million residents.

The twin, 1.8m (5.9 ft) diameter polyethylene intake pipes, extending 2.2 kms (1.4 mi) off the coast in 30m (100 ft) deep water, have been installed as work continues on the desalination plant itself. The €200 million ($270 million) plant is being built by a consortium of Degrémont, Agbar and Dragados for ATLL with 75 percent of the funding provided by the EU.

Other stories of interest….

www.independent.co.uk/news/world/europe/spains-drought-a-glimpse-of-our-future-833587.html

www.guardian.co.uk/world/2008/may/14/spain.water

## 16.1.4 Site Visit

**Barcelona**

- Water delivered to 5 Million people
- Wastewater treatment plant and desalination plant
    - They have tertiary treatment – the potential to use water for preventing saline intrusion
    - 2 treatment plants 4 & 8 M $m^3$/d

**Desalination**

- Reason for desal
    - Low flow reliability
    - Increased guarantee of water supply
    - Potable water high in salinity – use electrodialysis reversal plant
    - Salt mines high in catchment increases salt in water
- To connect the desal plant they are going to build a tunnel
- In the hills below Barcelona they have a reservoir where desal and river water will be mixed for distribution
- Combined mixing – electrodialysis river and desal water will improve water quality

**Desalination Plant**

- Peak power demand 35 MW
- 3.0 kW/$m^3$
- Conversion factor 45%
- Water intake 2.2 kms from coast – 6 kms from plant
    - This was required to get the best quality of water for plant – avoiding sediment and pollution from Llobregat river
- Water piped to Fontasa reservoir

**Process**

- DAFF open filtration pre-filtration
- Closed vessel filtration
- Cartridge filtration
- Then reverse osmosis
- RO plant 10 racks RO v

- ERI energy recovery
    - 50% energy reduction
- Outfall 3 kms long, depth 60 m, flow 15 $m^3/s$
- Mixing WWTP wastewater and RO brine – discharge at sea level salinity
- Investment $230 M (EUR)
    - Pipe
    - Plant
    - Project 75% co-financed by the European Union
- One water price across Barcelona – $0.35 (EUR) $/m^3$
- RO plant will supply 20% of potable water
- New water quality < 100 ppm salinity
- Water demand 125 L/person/day
- By 2010 they plan to build 3 more plants
- The current development will be completed by 2009

# 17 Day 17 – Wednesday 5th November, Spain – Barcelona to Australia

## *17.1 Destination: Australia*

Delegates returned to Australia or continued with their alternative travel arrangements.

# 18 Summary

The study tour 2008 has been completed successfully after visiting almost 30 sites in 3 countries. A total of 16 participants and two tour leaders:

- Studied differences in water resource management and use in three countries (UAE, Israel and Spain) which were similar to Australia in some ways (lack of water) and very different in other ways (drivers that influence management options);
- Spoke and formed relationships with world leaders in water management & supply strategies;
- Visited the three largest desalination plants in the world learning the intricate details of their development and operation;
- Learnt about efficient methods for recovering energy from desalination processes and innovative technology that can improve (reduce) operating costs significantly;
- Made contacts with irrigation companies that lead efficient water use methodologies in urban and rural industries across the world;
- Discovered innovative new technologies for treating, desalinating, delivering, irrigating and managing water supplies;
- Viewed some of the most productive and salt tolerant plants currently being breed in the world, and innovative methods for growing plants with salty water; and
- Made excellent contacts with a range of experts from Australia (other tour participants) and internationally.

Many participants have already contacted sites and people met on tour for more detailed information.

The above points are a summary of highlights from the tour. There were many additional benefits for participants and Australia. Over 10 gigabytes of photos, 200 gigabytes of digital video and 3 gigabytes of presentations were captured on tour. A tour report and release of this information will now be delivered across Australia over the next 3 months.

Some of the feedback from participants has been very supportive of the tour:

- 'I found the tour extremely beneficial and am still distilling all the thoughts and their relevance for how we do things';
- I have been able to bring back some great ideas and innovations to incorporate into our business
- 'It really was quite refreshing to see how well so many people with such a wide range of ages and interests got along';
- 'The exchange of information between parties was free and flowing and the information and questions were very informative';
- 'Jodie, Jim and Daryl, well done on a well managed and organised trip'.
- 'Some of the sites were quite impressive'; and
- 'I have done a number of media interviews on the tour here in Bendigo already'.

The primary purposes of the study tour were to:

1. Experience first hand international approaches to managing water sources and wastes and understanding management strategies and how barriers for adopting these methods were overcome;
2. Understand how some of the most 'water poor' countries have managed to combat pressure for more effective use of water using innovative, world leading technologies and methodologies;
3. Understand competitive challenges faced by international production horticulture industries and how they have been overcome;
4. Explore technology and application methodology used to combat water shortages and maximise quality and efficiency in horticulture;

5. Identify opportunities for Australian research and development projects and explore infrastructure opportunities for the future;
6. Identify marketing opportunities appropriate for consideration by the horticulture industry;
7. Increase the water industry's knowledge base and understanding so as to improve the diversity of water resources and volumes of water available for horticulture (urban and rural); and
8. Increase industry and the public's understanding of water supply management, delivery and use of a diversity of water sources.

The tour has achieved this and will add to these achievements as participants communicate their findings to organisations across Australia.

The tour exposed participants to a wide range of issues and technologies. The majority of irrigation in the countries visited was carried out using drippers, either above or below ground, because of their high water use efficiency under the very high evaporation rates experienced in the Israeli environment. All countries were using marginal water from a salinity perspective in some cases and using innovative ways to manage this salinity. These innovations included breeding of salt tolerant plants, pulse irrigations, high leach fractions and modification of plant species or varieties grown (both in rural and urban contexts).

Throughout the tour, participants were continually reminded of the importance of relevant targeted research, which is required to ensure the validation of new technologies and to ensure the sustainability of water resources. Several of the study tour participants have developed/strengthened research and water industry links with individuals and organisations in the UAE, Israel and Spain.

The contrasting practices in the three countries visited provided opportunities for water industry representatives, growers and legislators to become increasingly aware of the diversity of issues relating to water resource management and use. The over-riding response to water shortages in all countries has included desalination as a major part of water resource management strategies. Demand management and water use efficiency strengths varied between countries. In UAE there seems to be opportunities for much greater recycling of wastewaters. However, culture/perception was preventing this developing quickly in some cases, especially for food crops.

Communication of the findings from this study tour has been at several levels. The horticultural industry (urban and rural) will be educated through presentations, press, radio and television interviews prepared by the Tour Leaders (ongoing through HAL project HG06170) and tour participants. The water industry will be educated by several industry reports/presentations provided to State water authorities by participants.