

# Characterisation of recharge and receiving water in the Malta case study area

MARSOL - Water Quality Workshop

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Algarve, Portugal

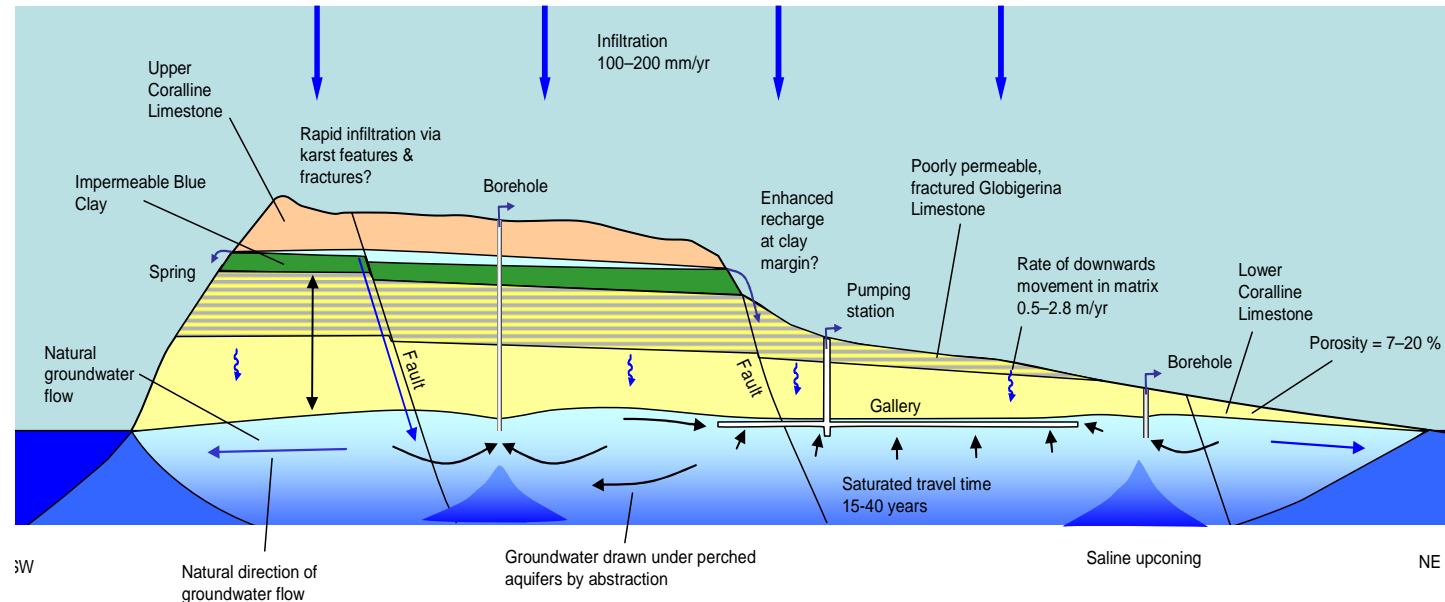
# Introduction

MARSOL WP10

DEMO Site 8: South Malta Coastal Aquifer

The overall objective of WP10 is the development of a seawater intrusion barrier in the southern region of the Malta Mean Sea Level Aquifer System

# Mean Sea Level Aquifer

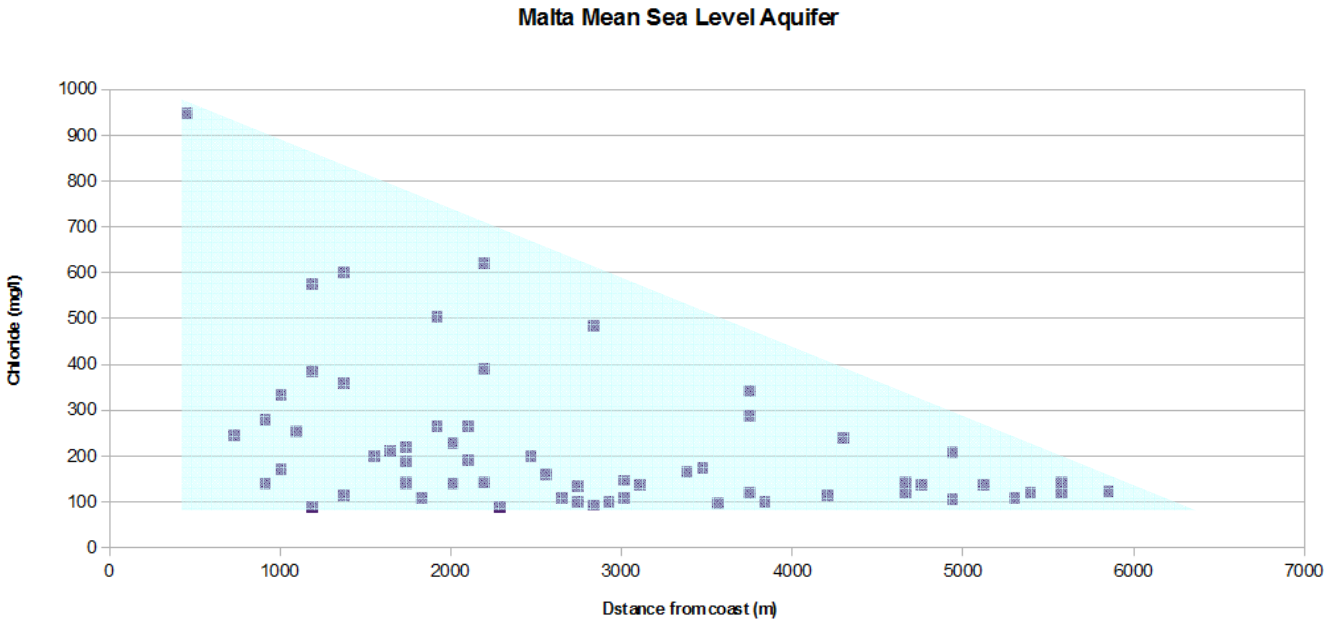


- Sustained in the Lower Coralline Limestone formation, which lies beneath the whole island (and locally in the Globigerina formation);
- In direct lateral and vertical contact with sea-water;
- Capped in certain areas by the impermeable Blue Clay formation and more extensively by less permeable strata of the Middle Globigerina Limestone (considered more as offering increased protection to the aquifer rather than confining it);

# Mean Sea Level Aquifer

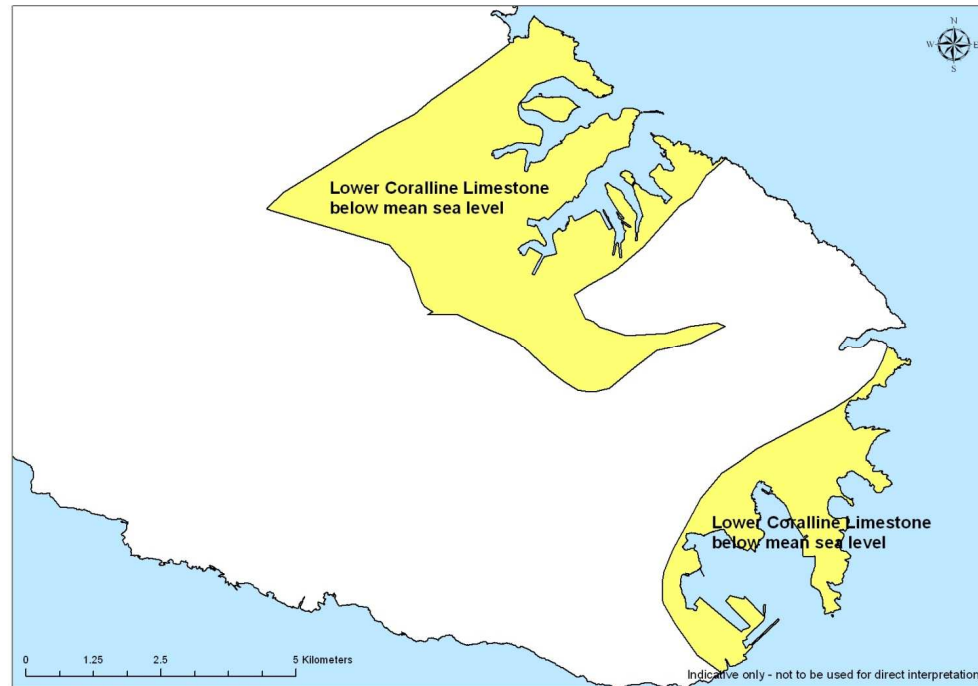
- Water table is controlled by abstraction and is presently up to only 3m above mean sea level;
- Abstraction leads to saline upconing and an increase in salinity;
- Low porosity implies that the rate of downward movement in the aquifer will be greater than in the perched aquifer, but the unsaturated travel time will be longer in the thicker parts of the aquifer;
- Limited detection of coliforms indicate that rapid transport from the surface to the aquifer is limited;
- Residence time in the saturated zone is in the range of 15-40 years;
- Low estimates of transmissivity from pumping tests suggests that movement in enlarged solution features is limited (primary permeability prevails);
- Region of the aquifer capped by the Blue Clay is recharged through different mechanisms (slow direct infiltration, preferential infiltration at edge of clay and rapid infiltration at faults/fractures)

# Mean Sea Level Aquifer



Increased variability in salinity content towards the coast.

# Regional Aquifer



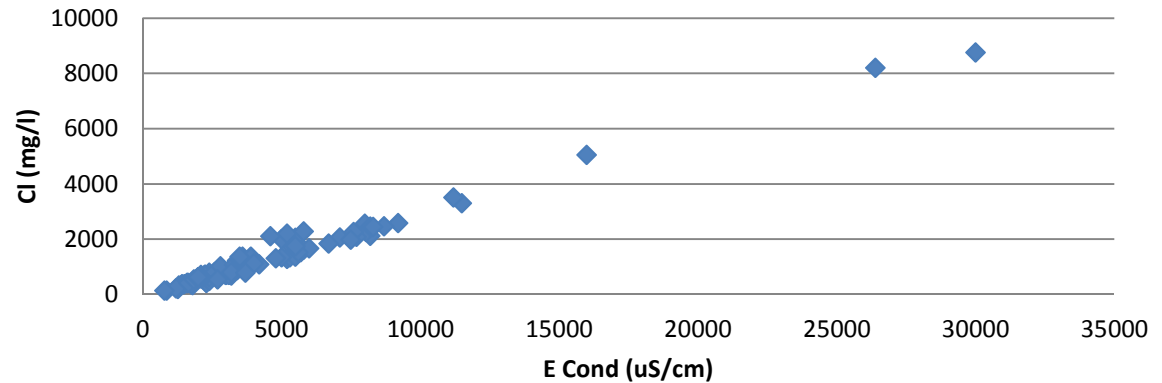
The Malta south region of the sea-level aquifer system therefore lies between these two depressions in the Lower Coralline Limestone and can thus be considered as a central SW to NE oriented 'corridor' of Lower Coralline Limestone bounded by the less permeable Globigerina Limestone Formation to the north and to the south, and the coastal region to the east.

# Characterisation

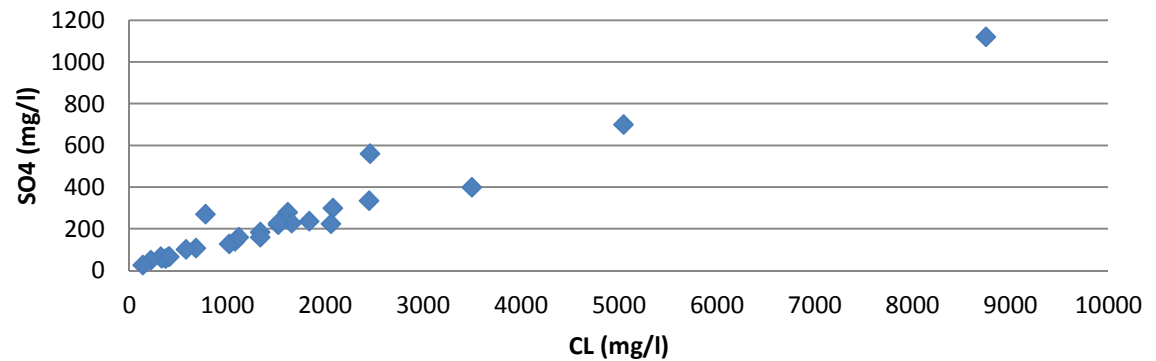
Excellent correlation between Sodium (Na) and Chloride (Cl) – the two major constituents of sea-water, as well as between Chloride (Cl) and Sulphate (SO<sub>4</sub>) – the third major constituent of sea-water.

Indicative of the influence of sea-water intrusion.

### ECond vs Cl



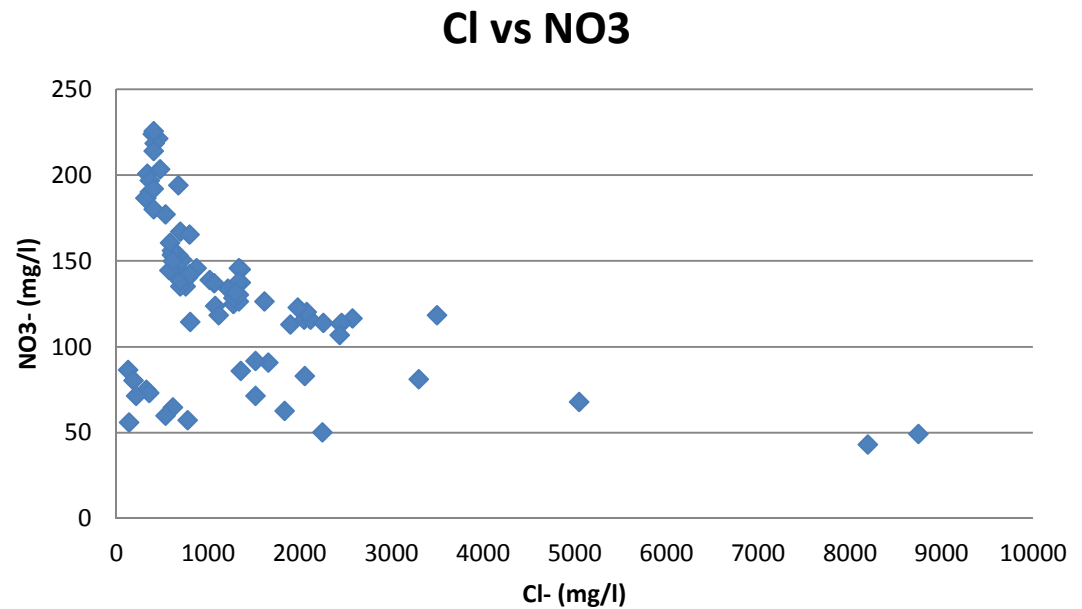
### Cl vs SO<sub>4</sub>



# Characterisation

Nitrate content decreases with increasing saline content in the groundwater body.

Indicative of mixing with non-nitrate containing intruding sea-water.



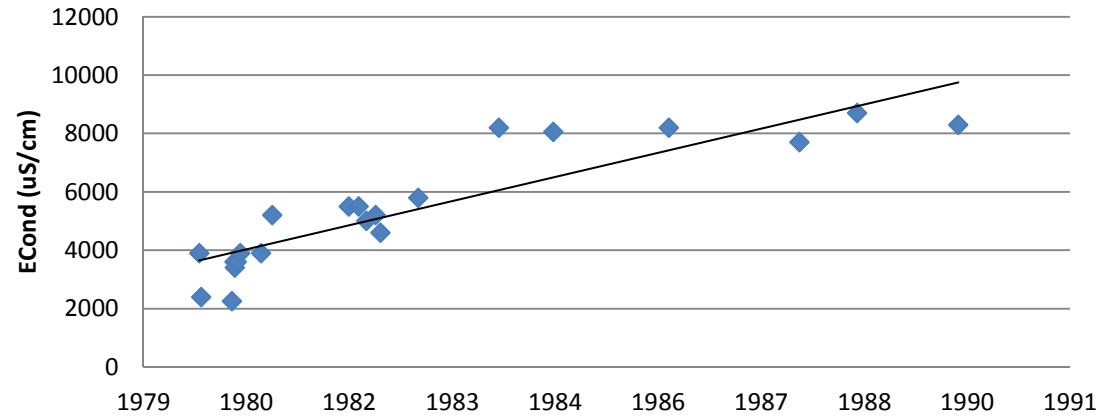


# Characterisation

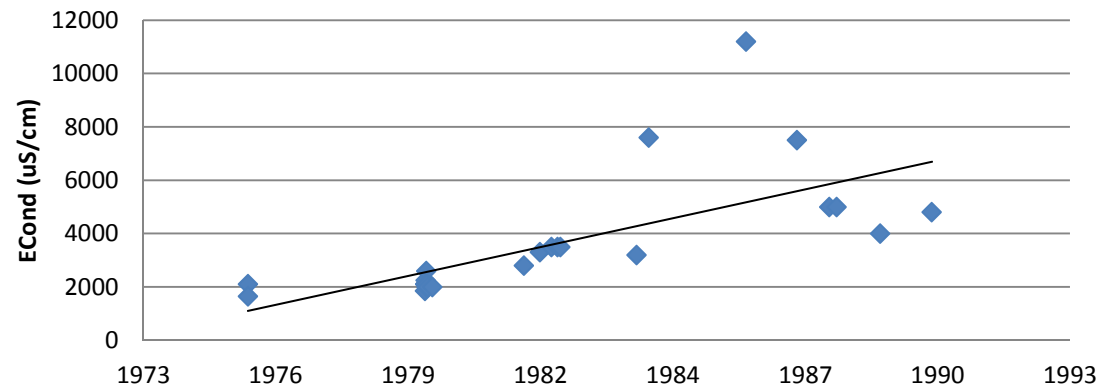
Under pumping conditions, significant increases in salinity were registered for public groundwater abstraction stations registered in this regional aquifer.

Abstraction for municipal purposes from all public groundwater stations in the regional aquifer was discontinued in the mid-1990's due to high salinity levels.

### San Klement BH



### Zabbar Road BH

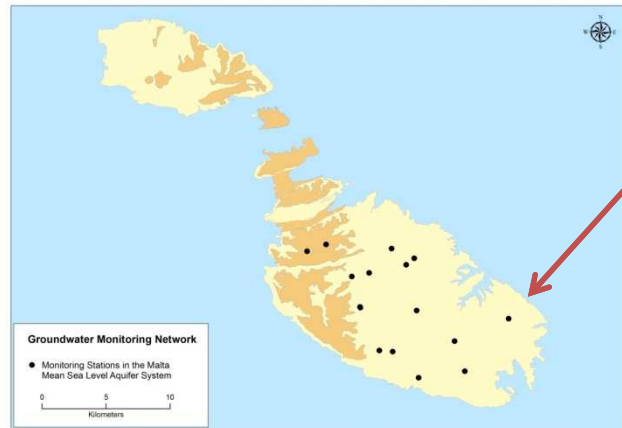


# Characterisation

## WFD Monitoring Network

Qualitative Analysis from 2009-2014.

### Zejtun Monitoring Station



Parameter	Unit	Lowest	Highest
Electrical Conductivity	uS/cm	6200	7800
Nitrate	mg/l	113	152
Chloride	mg/l	1635	2433
Sulphate	mg/l	200	338
Sodium	mg/l	890	1050
Boron	mg/l	0.45	0.575
Fluoride	mg/l	0.25	0.71
Arsenic	ug/l	ND	ND
Total Pesticides	ug/l	ND	ND

# Characterisation

## Trend Assessment

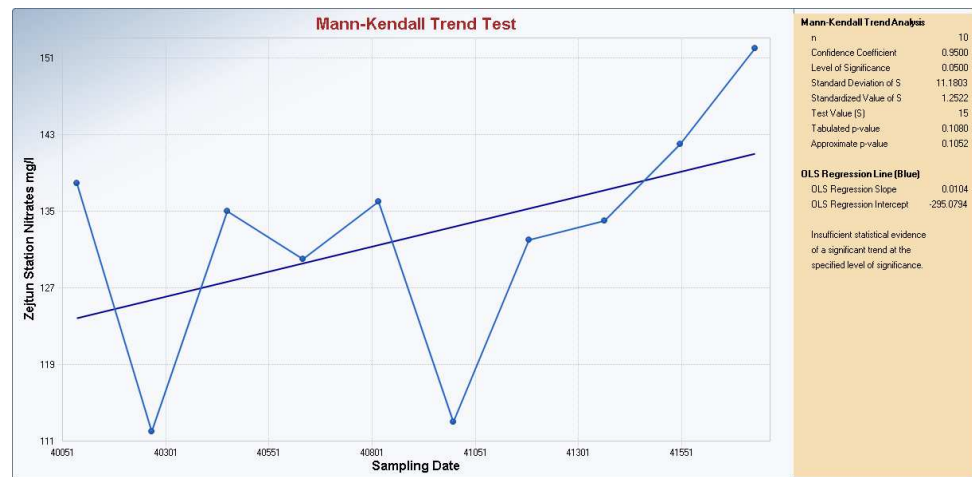
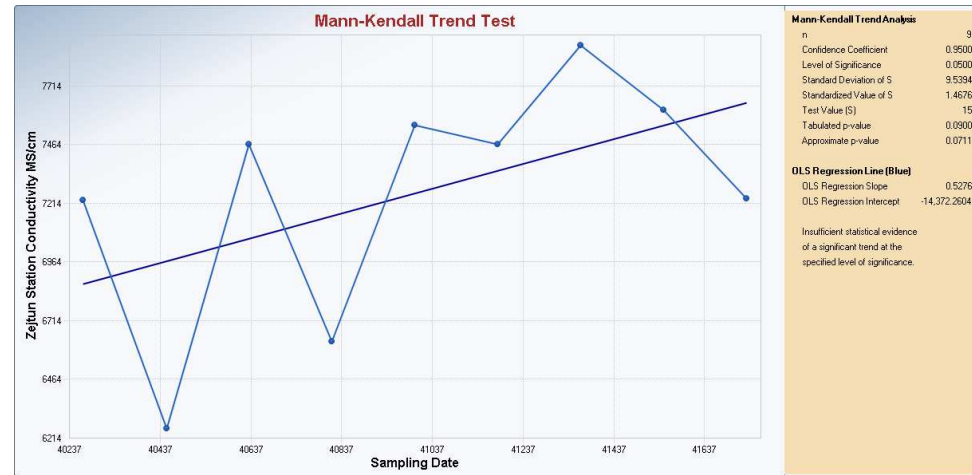
Mann Kendal Test at monitoring point level.

95% confidence level

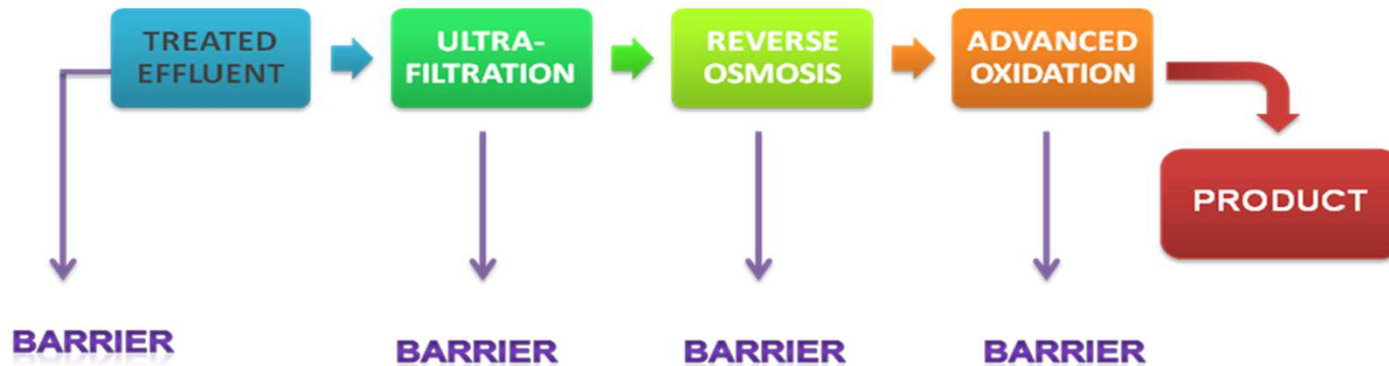
Zejtun Monitoring Station

No statistically significant trends were encountered for:

Electrical Conductivity  
Nitrate



# Treatment Process



A multi-barrier effluent polishing process has been developed by the Water Services Corporation (WSC) with the aim of achieving high quality levels in the final polished effluent produced in their wastewater treatment/polishing plants. This effluent treatment/polishing process in fact includes four treatment barriers, namely:

- (i) conventional wastewater treatment,
- (ii) ultra-filtration,
- (iii) reverse-osmosis, and
- (iv) advanced oxidation

which are applied to wastewater as part of the treatment and polishing process.

# Recharge Effluent

Expected quality (inorganic) of the recharge effluent, following Reverse Osmosis phase.

Will permit blending with UF treated water.

SOUTH - 3 years			
Temperature = 20°C			
Composition		Remineralized water	
NH4 (mg/l)	mg/l	1,21	
K (mg/l)	mg/l	3,02	
Na	mg/l	11,01	
Mg	mg/l	0,32	
Ca	mg/l	5,74	Hardness =1,43 °F
Sr	mg/l	0	
Ba	mg/l	0	
CO3	mg/l	0	
HCO3	mg/l	17,57	Alk = 1,44 °F
NO3	mg/l	4,94	
Cl	mg/l	18,91	
F	mg/l	0,02	
SO4	mg/l	0,2	
SiO2	mg/l	0,05	
Boron	mg/l	0	
CO2	mg/l	0,01	CO2 Dose =8,25
TDS	mg/l	63,00	
pH		8.7	

# Recharge Effluent

## Scan for Emerging Contaminants

**Pharmaceuticals:** *Etofibrate, Chloramphenicol, Clarithromycin, Dehydrato-Erythromycin, Erythromycin, Roxithromycin, Sulfadiazine, Sulfamethoxazole, Trimethoprim, Caffeine, Chloramphenicol, Atenolol, Betaxolol, Bisoprolol, Metoprolol, Pindolol, Propanolol, Sotalol, Acetylsalicylic acid, Bezafibrate, Diclofenac, Fenopropfen, Gemfibrozil, Ibuprofen, Indometacine, Ketopropfen, Naproxen, Carbamazepine, Diazepam, Fenofibrate, Pentoxifylline, Phenacetin, Phenazone.*

**Steroids:** *Estradiol, Estriol, Estrone, 16 $\alpha$ -Hydroxyestrone, Mestranol, 17 $\alpha$ -Ethinylestradiol beta-Sitosterol*

**Organic compounds used in Manufacturing:** *Bisphenol A, 4-Nonylphenol Isomer mixture, 4-tert.-Octylphenol, DEET, EDTA*

**Solvents, Plasticizers, Surfactants:** *Hexachlorbutadiene (HCBd), Tris(2-chloroethyl)phosphate, Tris(1,3-dichloro-2-propyl)phosphate, Tris(1-chloro-2-propyl)phosphate, TMDD*

**Pesticides/Herbicides:** *Atrazine, Parathion-methyl, Clofibric acid*

**Medical Imaging Agents:** *Amidotrizoic acid, Ioxaglinic acid, Iodipamide, Iohexol, Iomeprol, Iopamidol, Iopromide, Iothalamic acid, Ioxithalamic acid*

**Sweeteners:** *Acesulfame, Cyclamate, Saccharine*

# Recharge Effluent

30 parameters were not detected neither in the conventionally treated effluent and the RO product (polished effluent).

30 parameters were detected in the conventionally treated effluent but not detected in the RO product (polished effluent).

## Pharmaceuticals

Caffeine  
Clarithromycine  
Erythromycin  
Sulfadiazine  
Sulfamethoxazole  
Trimethoprim  
Atenolol  
Betaxolol  
Bisoprolol  
Metoprolol  
Propranolol  
Sotalol  
Bezafibrate  
Diclofenac  
Ibuprofen  
Ketoprofen  
Naproxen  
Carbamazepine  
Phenazone  
beta-Sitosterol

## Sweetners

Acesulfame  
Cyclamate  
Saccharine

## Medical Imaging Agents

Iohexol

## Solvents

Tris(1,3-dichloro-2-propyl)phosphate  
TMDD

## Organic Compounds

Bisphenol A  
4-tert.-Octylphenol  
DEET

# Recharge Effluent

Only 5 parameters detected following the Reverse Osmosis stage:

<u>Category</u>	<u>Compound</u>	<u>Concentration Before RO</u>	<u>Concentration after RO</u>
		<i>ug/L</i>	<i>ug/L</i>
Organic compounds used in manufacturing	4-Nonylphenol. Isomer mixture	0.38	0.08
	EDTA	218.5	1.2
Plasticizers	Tris(2-chloroethyl)phosphate	0.26	0.01
	Tris(1-chlor-2-propyl)phosphate	1.8	0.02
Medical Imaging Agents	Amidotrizoic acid	0.7	0.01



# Future Work

Capacity building at Water Services Corporation Laboratories will enable focused monitoring on the quality of the recharge effluent to be undertaken.



ICP-MS with auto-sampler for metal analysis in water.

GC-MS/MS with auto-sampler for organic analysis in water.

Thank-you