FREEWAT
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EU HORIZON 2020 Project

OPTIMISING THE MANAGEMENT OF THE GOZO MEAN SEA LEVEL AQUIFER (MALTA)

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Introduction

The Gozo Mean Sea Level Aquifer

- Underlies almost the whole island, except in the south-eastern region of the island;
- Sustained primarily in the Lower Coralline Limestone and the Globigerina Limestone where this occurs at sea-level;
- Is in direct lateral and vertical contact with sea-water, and the bulk of its storage capacity occurs below sea-level; and
- Has significant importance for the water supply of the island

Gozo:

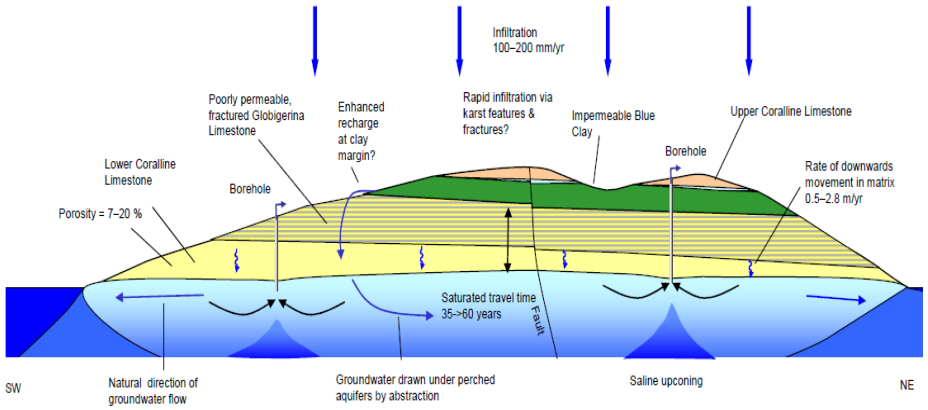
Elongated Carbonate Island

14km - length

7.25km - width

67km^2 - surface area

60km^2 - gw body extent



Management Tool

Numerical Model

A tool which:

- *can increase the conceptual understanding of the groundwater body and support the implementation of the EU's Water Framework Directive;*
- *can facilitate the assessment of the aquifer system's quantitative status conditions (a requirement of the EU's Water Framework Directive);*
- *can permit the development of future groundwater exploitation scenarios and the evaluation of their impact on the long-term quantitative status of the aquifer system; and*
- *can enable a reliable evaluation of the long-term impacts on the aquifer system arising due to climate change.*

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WFD Objectives

Malta's 2nd River Basin Management Plan

sets the objective for the achievement of good quantitative status in the Gozo Mean Sea Level aquifer system by 2021.

Good groundwater quantitative status is defined under Annex V to the Directive as "the level of groundwater in the groundwater body is such that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction."

Metrics for determining good quantitative status:

- *Water Balance*
- *Piezometric Head*

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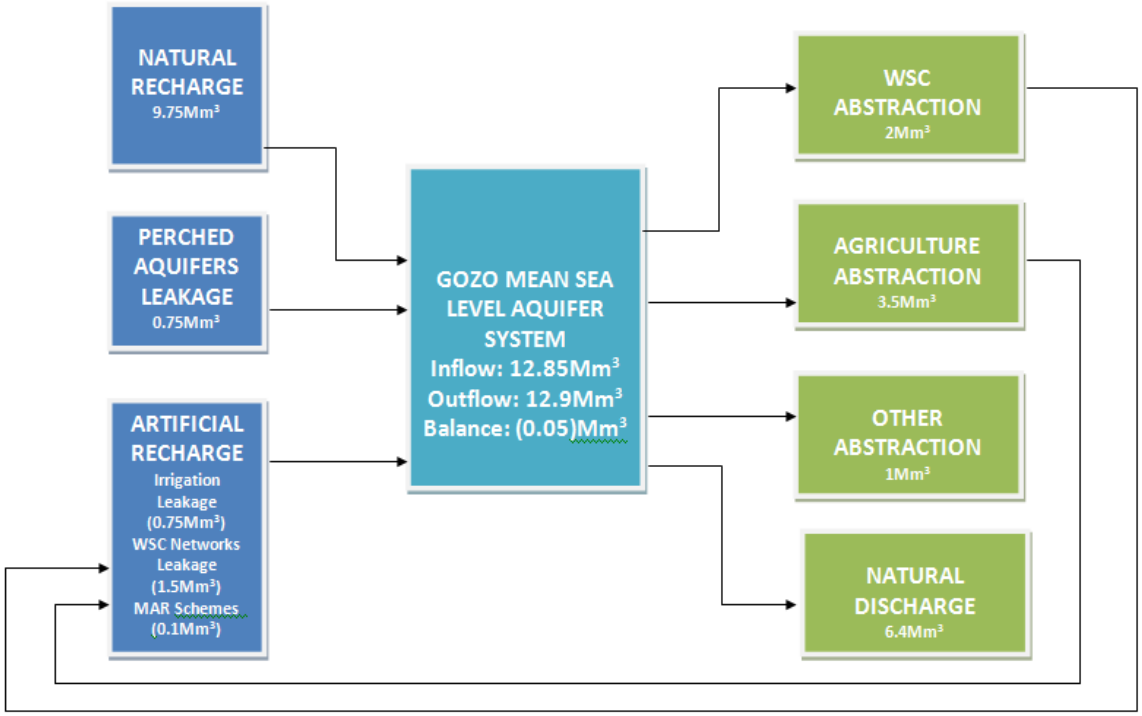
WFD Objectives (2)

Water Balance:

Malta's 2nd River Basin Management Plan (2016)



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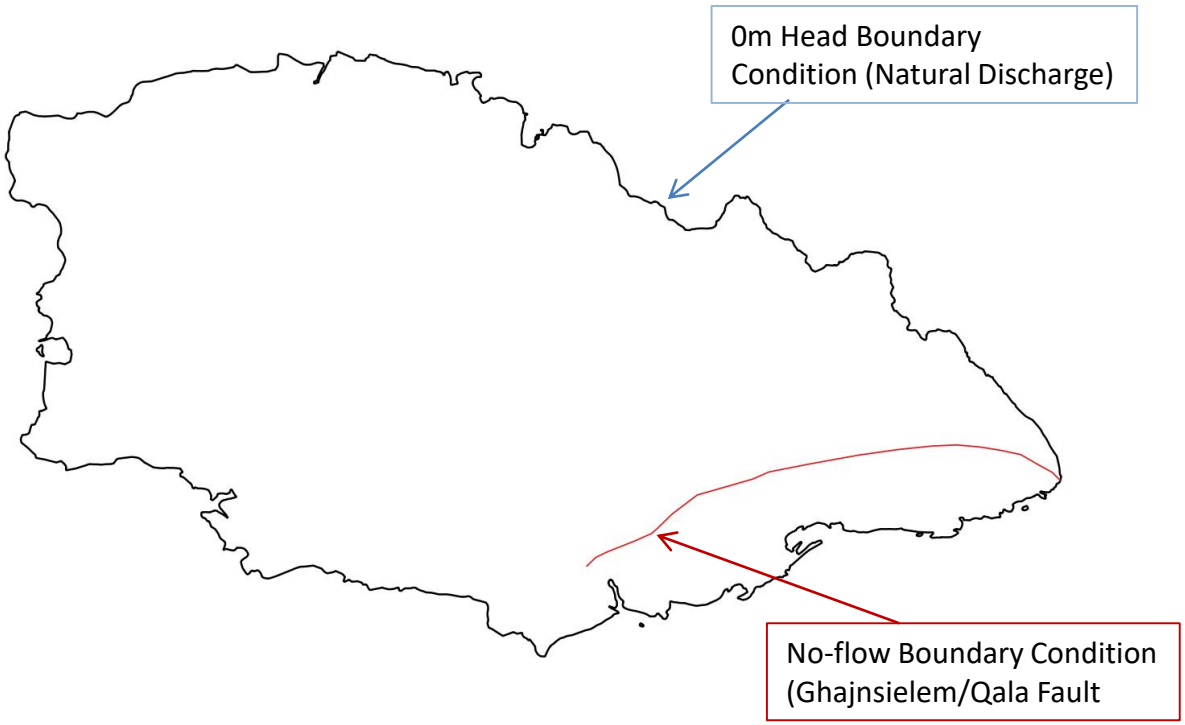
Model Definition

Boundary Conditions:

Groundwater body is bounded by the coast and the Ghajnsielem/Qala Fault in the south west which juxtaposes the Blue Clay formation with the Lower Coralline Limestone (sealing fault).



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Model Definition

Model Domain:

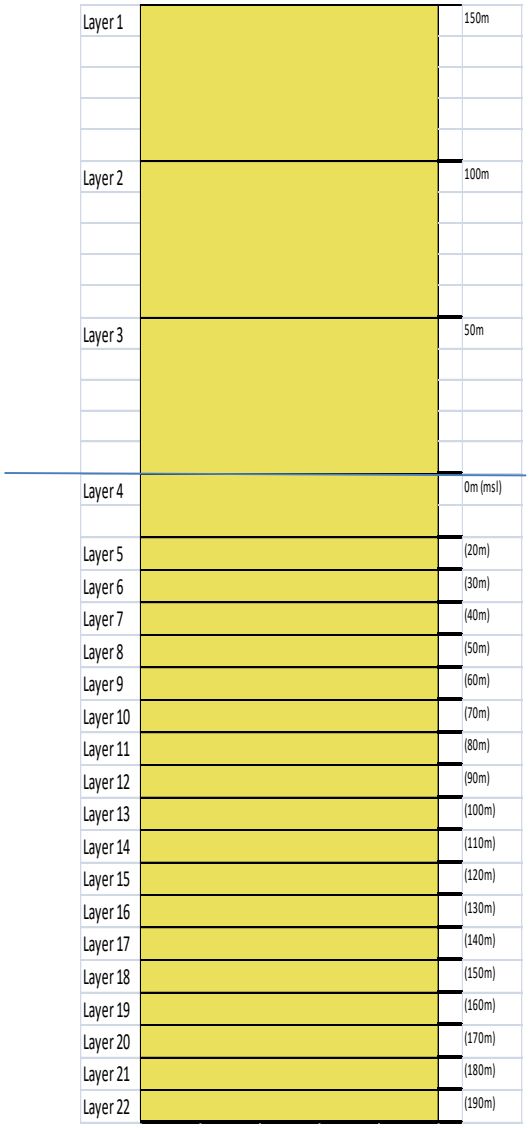
Horizontal Dimension

Discretization into a mesh of 173 rows by 288 columns square cells each of size 50 x 50 m; active and inactive cells.

Vertical Dimension

22 horizontal layers of constant thickness starting from 150m amsl down to 200m bmsl.

Increased discretization beneath sea-level to permit an improved representation of the freshwater-seawater interface.



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Model Definition

Hydrogeological Properties

The occurrence of the Globigerina Limestone at or below sea-level creates a resistance to flow due to the relative lower permeability of this formation.

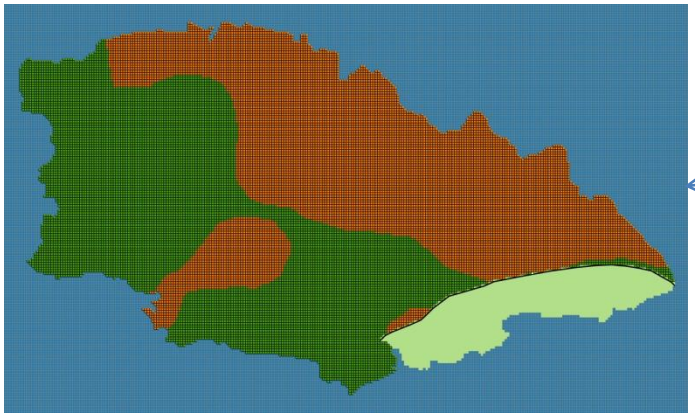
Hydraulic Conductivity:

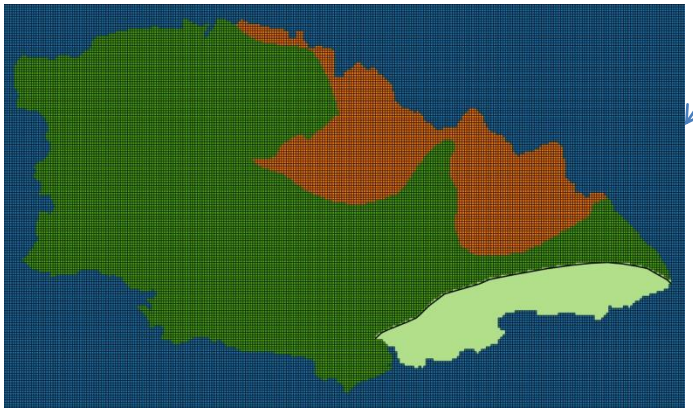
Globigerina Limestone

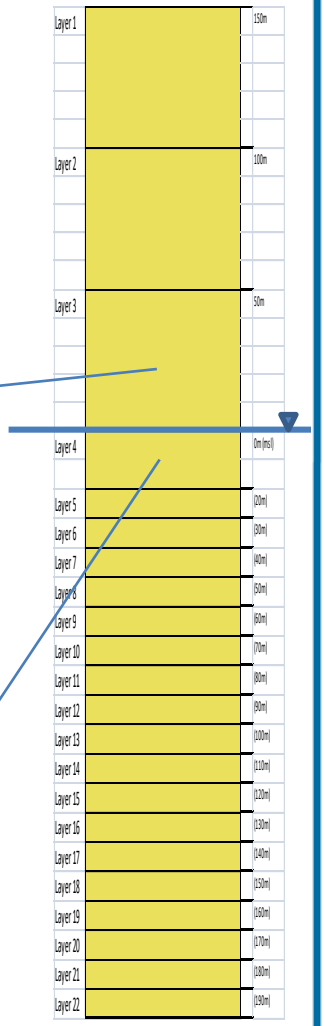
8 E -6 m/s

Lower Coralline Limestone

2 E -5 m/s







Globigerina Limestone

Lower Coralline Limestone

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Model Definition

Inputs (inflows) - Natural Recharge

Areas beneath the blue clay formation: *120mm/year*

Outcropping surfaces of Globigerina Limestone: *280mm/year*

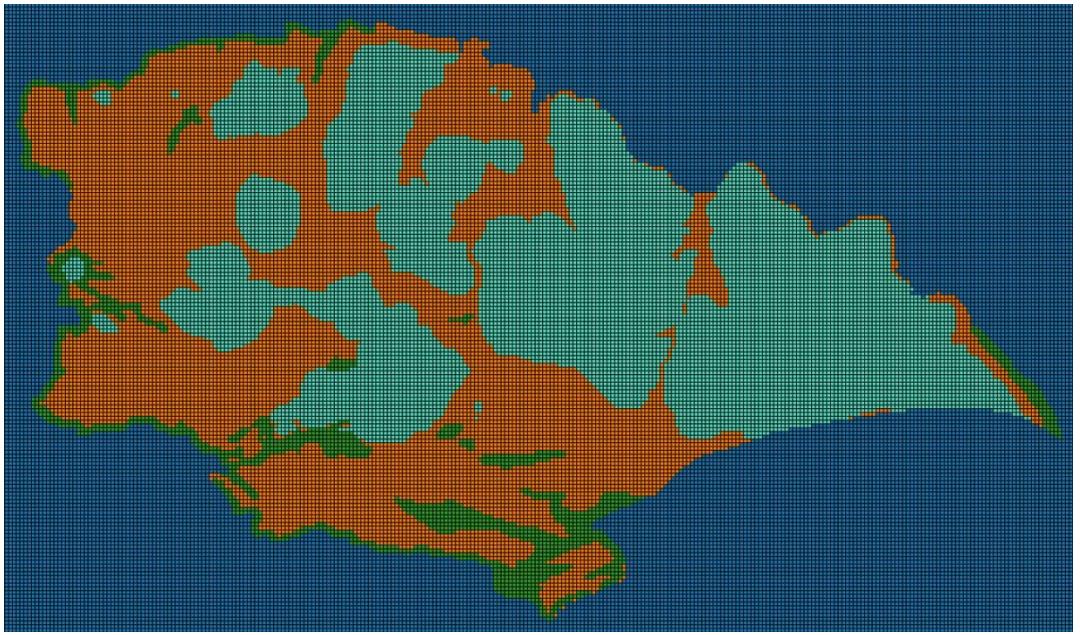
Outcropping surfaces of Lower Coralline Limestone: *350mm/year*

Recharge levels include a correction factor to take into account artificial recharge (leakages, dams, return flows).

Blue Clay

Globigerina Lmstn

Lower Cor Lmstn



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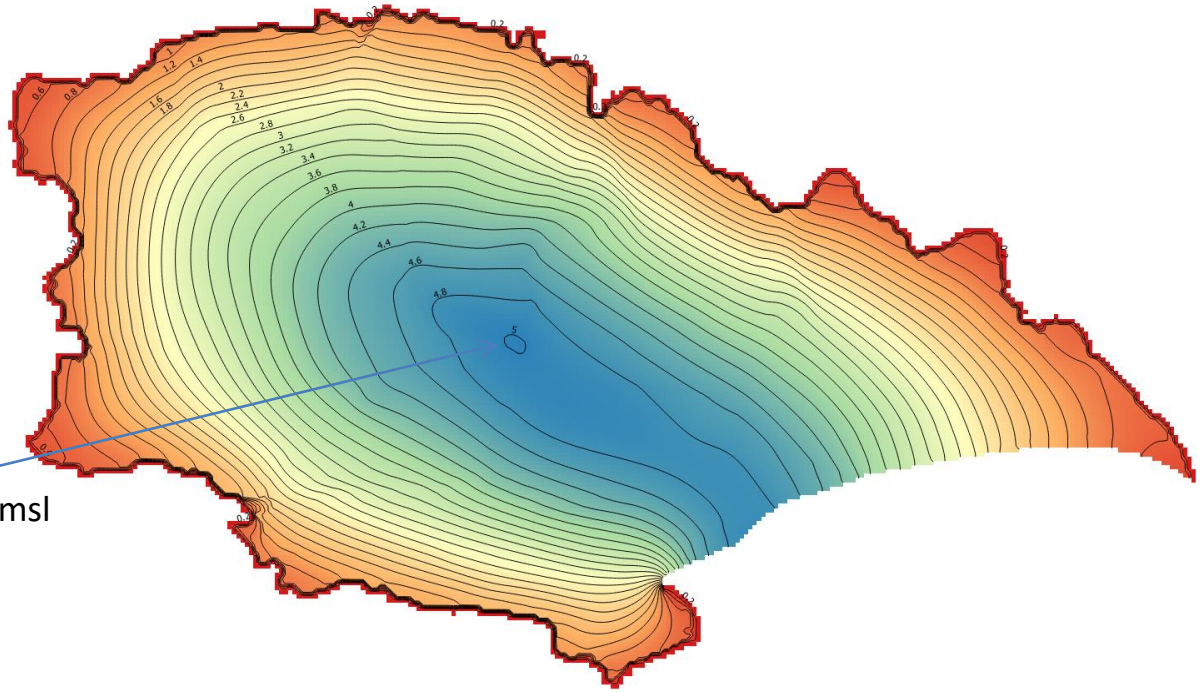
Steady State

- *Maximum head of +5m amsl in central region of the island.*
- *Values of the same order of those registered in drilling logs in the 1970s – when aquifer was still relatively unexploited.*
- *Mild impact in hydraulic head due to the presence of Globigerina Limestone at sea-level.*



Piezometric peak of 5.0m amsl

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Transient State

Including consideration to the exploitation of the aquifer system:

Public Abstraction Stations

Number: 36

Volume: 1.9 million m^3

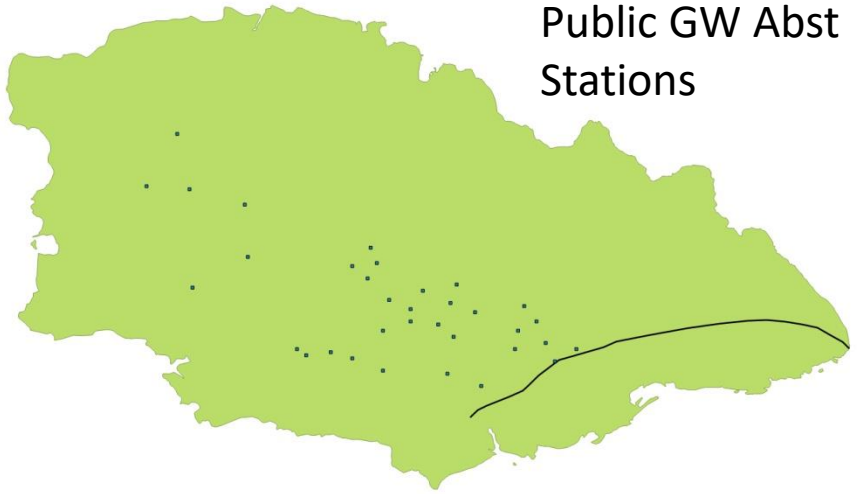
Private Abstraction Stations

Number: 340

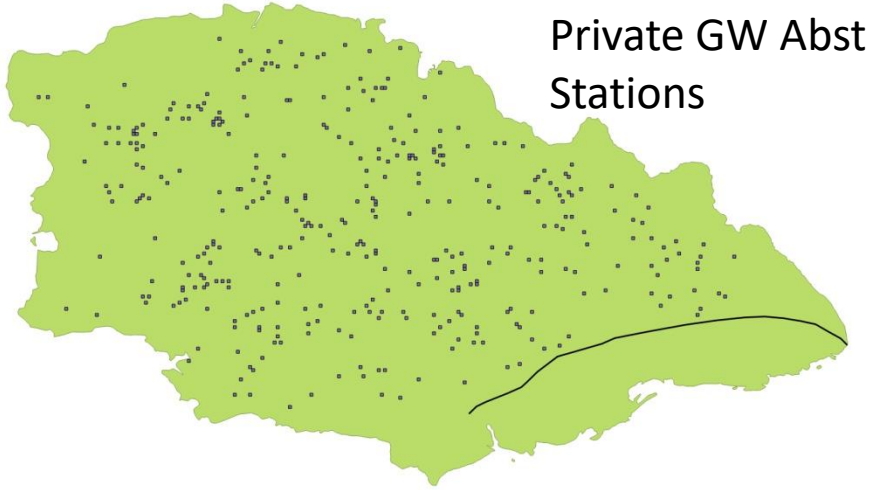
Volume: 1.7 million m^3

(metered data)

Total Abstraction from the aquifer system: 3.6 million m^3



Public GW Abst Stations



Private GW Abst Stations

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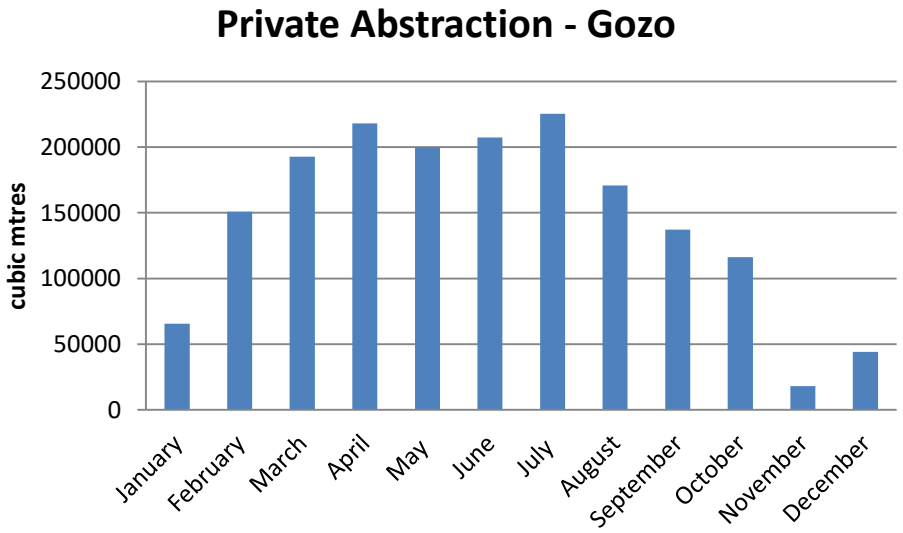
Transient State

Private Abstraction

- *Mainly of agricultural origin;*
- *Significant variation in monthly water demand – reflecting cropping seasons;*
- *Peak abstraction levels registered in April and July; and*
- *Estimates of unauthorised abstraction included through the pro-rata allocation of 1M m^3 additional abstraction on existing wells.*

12 stress periods (in addition to the initial stress period) Introduced in the model to take into consideration variations in agricultural groundwater abstraction.



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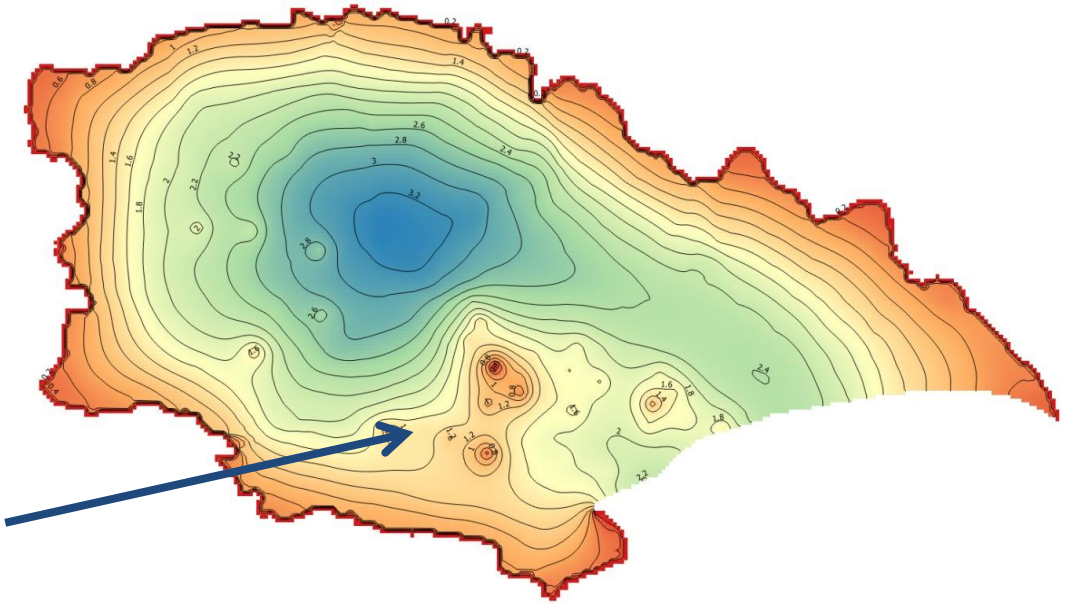
Transient State

Results:

- *Overall lowering of piezometric head - new peak of 3.2m amsl*
- *Regional impact of groundwater abstraction, head lowered to below 1.5m amsl in region of high groundwater abstraction (high density of public wells)*
- *Piezometric levels in accordance with measurements in gauging wells*



Region of high groundwater abstraction – high density of public groundwater sources

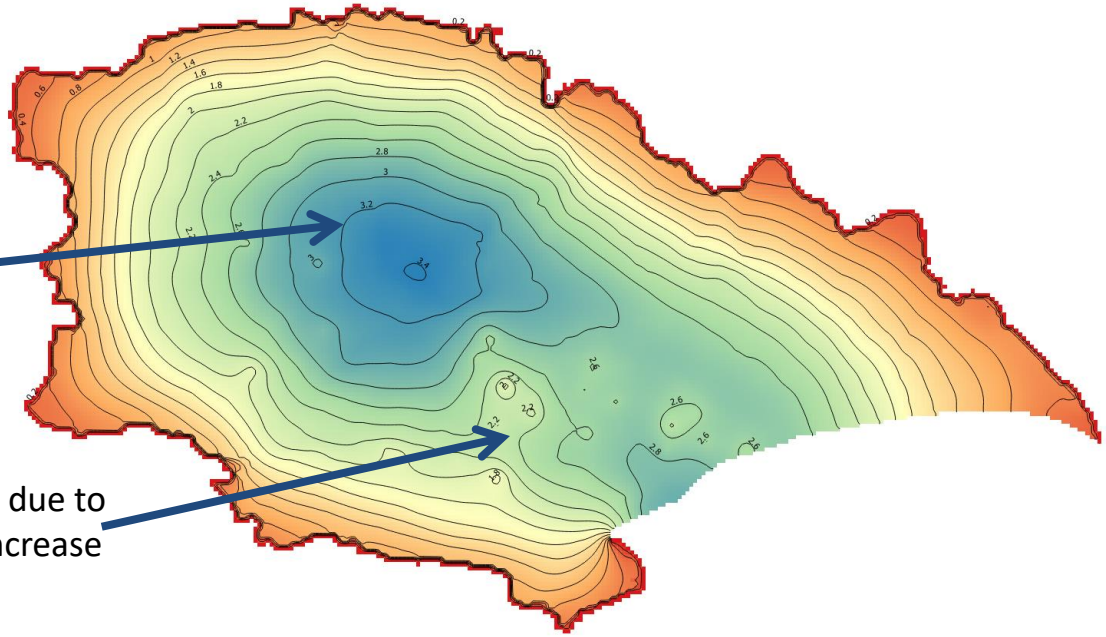
Management Scenarios

Scenario 1: Reduction of public abstraction by 50%

Recovery of aquifer system in the south-western region – direct impact of groundwater abstraction. Piezometric levels are now in the region of 2m amsl.

Marginal increases in piezometric head over the whole groundwater body – piezometric peak rises to 3.4m amsl

Marginal impact at groundwater body level.



Recovery of aquifer system due to lower abstraction rates – increase in piezometric head.

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Management Scenarios

Scenario 2: Managed Aquifer Recharge

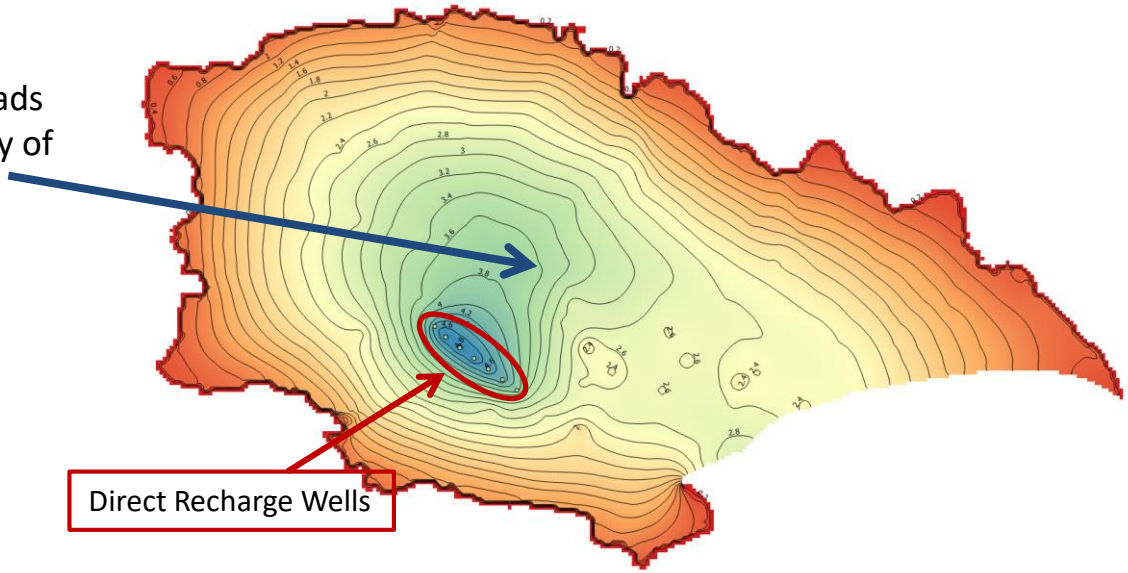
Installation of 7 recharge wells discharging to the aquifer a volume of 1million m^3 pa.

Simulates potential impact of diverting treated water produced in Gozo New Water Plant for MAR purposes.

Recovery of aquifer system at a local and regional level.

Movement of recharged water is towards public well fields.

Increased piezometric heads indicated over whole body of groundwater.



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Management Scenarios

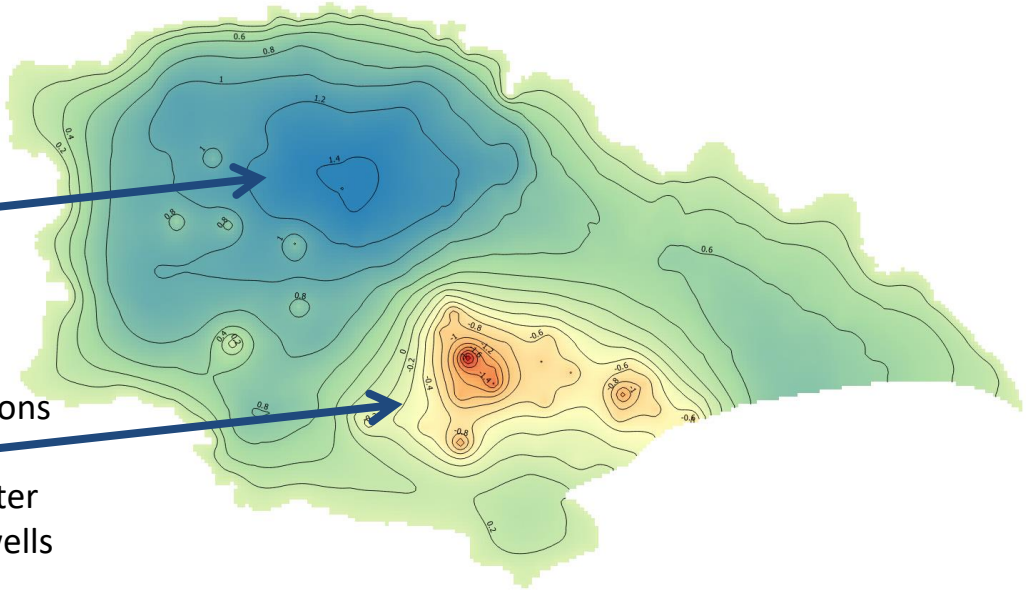
Scenario 3: Impact of Climate Change

Scenario assumes the overall reduction of recharge to groundwater by 20% due to climate change impacts.

Model indicates significant impacts at groundwater body level with marked decreases in piezometric heads.

Major impacts are indicated in areas of dense groundwater abstraction where negative heads result – indicative of critical upconing.

Lowering hydraulic heads at groundwater body scale



Marked impact indicated at regions with dense groundwater abstraction: intrusion of sea-water will lead to failure of pumping wells

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Conclusion

Water Balance

Model confirms the high natural groundwater discharge rates (estimated at levels of 50 – 60 %) of mean annual recharge: expected in small islands due to high ratio between coast (perimeter) and island area. Contribution to water balance calculations.

Model Optimisation

Model optimisation can be undertaken through:

- *Increased knowledge on the spatial variability of hydraulic parameters in the Gozo aquifer system,*
- *Updated data on private groundwater abstraction (including increased data from metering programme), and*
- *Increasing extent of gauging network to broaden model calibration.*

3rd River Basin Management Plan

Further development of the model is envisaged to enable its use in the status assessments to be undertaken within the frame of Malta 3rd RBMP (2021).

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Thank-you for your attention

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