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Actions for Systemic Aquifer Protection

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**Hydraulic analysis, model of the net and zoning
of the project. Technical report**

*ASAP - Actions for Systemic Aquifer Protection -
Implementation and demonstration of a Protocol to scale
down groundwater vulnerability to pollution due to
overexploitation - Task 3.1.*

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(i) Thanks

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We thank Acque Ingegneria that has supported the job and it has contributed to the creation of the final document.

Finally, thanks to all those people who have offered their support in the difficult task to analyze every matter and patiently they have discussed because of the connections of their activities with the ASAP project.

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(ii) Summary

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(iii) Purpose of the document

The purpose of this document is to describe the project activities which have brought to the definition of the simulation models of the water nets of the Pontedera district and the hypotheses which have been done regarding the subdivision, the distribution and to the quantification of the water request.

(iv) Warnings

1. You always check the most recent version on the portal of the ASAP project to the address that you can find in the first page of cover.

1 ==> HYDRAULIC ANALYSIS, MODEL OF THE NET AND ZONING OF THE PROJECT. TECHNICAL REPORT

This report is one of the deliverables provided by the ASAP Project based on the aquifer of Bientina (Pisa, IT). In particular the Report is related to the *Task 3. – Setting of the water net and lowering of the stratum collecting- Activity T3.1 – Hydraulic modelling and zoning*. The task has the aim to define the hydraulic modelling and zoning of the ASAP area.

1.1 ==> AIMS

The aim of this Technical Report is to describe the project activities which have brought to the definition of the simulation models of the water nets of the Pontedera district and the hypotheses which have been done regarding the subdivision, the distribution and to the quantification of the water request.

1.2 ==> FIELD

The zone of pertinence to which the present Report refers coincides with the ASAP area in which it is centred the project and it is included the water district of Pontedera (Pisa, IT) and the municipalities of Santa Maria a Monte, Calcinaia, San Miniato, Pontedera (excluding the metropolitan areas), Castelfranco, Bientina, Vicopisano, Santa Croce sull'Arno (excluding the metropolitan areas), Cascina.

1.3 ==> EXECUTION AND RESPONSIBILITIES

Acque Ingegneria (ACQING) is responsible to the layout of the report and the analysis.

2 ==> INTRODUCTION

After the evidences which are emerged by the risk Analysis, the partners of the project have decided to anticipate the task (and the results related to the modelling and zoning) starting it at the beginnings of May rather than at the end of July.

The principal reason of this choice has already been due to the water emergency mentioned in the analysis and here recalled.

In fact, the month of April 2007 has been characterized by conditions of sensitive hydrological deficit.

Then the situation of water lack has officially been recalled in the law n° 29 of May 21 of 2007 emanated by the Region Tuscany, it has set a resolution to the emergency state "in the territories with the necessity of measures of extraordinary and urgent character finalized to govern in unitary way and mostly incisive the use of the scarce available water resources for the different uses...".

In front of the emergency the leader Acque Spa, manager of the water service of the ATO, has held opportune to anticipate effectively the beginning of the sub-tasks related to the Task 3 in order to avoid to incur in non recoverable delays and at the same time in the interest to keep on furnishing the best possible service to the users.

In a similar context, the contribution of the ASAP activities has been fundamental to relieve the crisis.

In fact inside the same project presented by the Committee, the partners had recalled some themes regarding the consequential dangers which could potentially come from a change in the averages of the precipitations.

3 ==> HYDRAULIC ANALYSIS AND MODELLING

The net analysis and the modelling have been conducted on a net portion of 970 km that exclude the metropolitan areas of Pontedera and Santa Croce sull'Arno (they altogether amount to 28 km of net).

The territorial background elements that have been considered are those deriving by the use of the regional cartography (1:10.000 of the Region Tuscany) and in proximity of inhabited centres of the version 1:2000 and in the formats SHP or DWG.

In order to goal the distribution of the water request the main element results to be the royal of the building that has been used for the geo reference.

The ASAP hydraulic model realization involves the passage through consequential acquisition phases and cartographic data analysis in SHAPE file and dwg format and the flow measure data and pressure reachable, the first ones by tele control or by direct measure and the seconds exclusively made on the net.

The first phase consists on the individualization of hydraulic disconnection elements, such as reservoirs, and of flow incoming which allow to delimit the several zones and the single sectors defining in the context the conditions that produce the hydraulic load.

The water net acquired in SHAPE file format by the company GIS (Smallword), is elaborated as it regards the conducts physical parameters necessities to the simulation, roughness and interior diameter, and corrected by possible points of disconnection.

Subsequently, through opportune software in Arcview field, starting by the cartographic quotas values, it is created a digital terrain model (DTM. Digital Terrain Model), through which it is assigned the geodetic quota to the knots of the net.

The request attribution is preceded by a social-economic analysis of the territory in order to estimate the water consumption caused by the presence of industrial or agricultural activities and the incidence of this on the total consumption.

According to the productive tissue typology characterizing the ASAP area, it is attributed to the industrial users a consumption value of about 15% and the 20% of the total consumption, that is defined through the zoning (see forward).

In the ASAP hydraulic models, where the net characteristics have made it possible, it is tried to distinguish the industrial areas by the residential ones, attributing distinguished request diagrams.

The evaluation phase of the request, such as anticipated above, involves the elaboration of the datum geo referenciated related to the buildings. It is assigned a basic request to every building proportionally to the relationship between its own area and the total area of all the buildings belonging to the same category served by the water net that has to be modelled. The choice to proportionate the request in function of the area implicates indirectly that the height of the buildings is approximately constant. This project choice is mainly caused by the impossibility to have the georeferenciated datum of the users (counter) and of the correspondent consumption. However, it is important to underline that this choice is also confirmed by the field measures.

It has to be noticed that in the evaluation of the basic request, it has not been used an univocal criterion because of in some cases the request has been normalized while in others it represents the real consumption. In the first case the daily middle value introduced in the pattern is equal to 1 and it is introduced a multiplicative coefficient equal to the daily average. Instead, in the second case

the daily middle value introduced in the pattern is equal to the daily middle flow and the multiplicative coefficient is equal to 1.

Through a procedure of assignment basing on the position, the building characteristic request is assigned to the knot of the water net of distribution set in the immediate proximities according to a distance criterion previously established (considering only buildings with a maximum of 300 ms. by the conducts).

When the request is assigned, the use of GIS red, extension of Arcview, allows the exportation of the net in legible format, legible through the Epanet 2.0 program.

The following phase consists on the assignment of the patterns to the knots which, such us we have said above, can serve users with different characteristics. The pattern represents in the examined temporal period, generally 24 hours, the course of the real water consumption comprehensive of the possible losses, according to the model demand driven. The time-step considered is generally of 5 minutes. In order to construct the single patterns it uses the data taken by the zoning, which is mainly based on direct measures made through portable tools (PT878) and in some cases integrating the measured values with those of the company tele control.

In order to evaluate the correspondence between the created model and the real net it is used the Epanet calibration function, that allows to compare the temporal course of the pressure (or of the flow) measured in a characteristic point of the net with the output furnished by the program in the same knot.

1.1==>DEVELOPED MODELS

For the ASAP project it has been developed **an only model** that includes the isolated wells, the fields wells, the lifting systems, the conducts of principal adduction to the reservoirs of head of the nets of distribution.

<i>Model System of pick up and principal adduction</i>		
<i>Municipality</i>	<i>Net Model</i>	<i>Pick up zones</i>
All the 9 Municipalities of the ASAP Area	Cerbaie Model	Campo Pozzi Cascina OvestCampo Pozzi Centrale 1 e 2 Bientina, Campo Pozzi FontineTavolaia, Campo Pozzi Montecalvoli e Paduletta, Campo Pozzi Collettore nord e Collettore sud diVilla Maiolfi, Campo Pozzi Orentan, Pozzo Sant'Agata e Pozzi Castelfranco 2

Subsequently, starting from the reservoirs of head of the distribution nets they have been developed the single models of the nets.

Altogether they have been realized **11 simulation models** which cover the totality of the water distribution net of the Pontedera district.

<i>Distribution nets Models</i>			
	<i>Municipality</i>	<i>Net Model</i>	<i>Sector</i>
1	Bientina	Bientina 1 Model	Quattro Strade Santa Colomba
2	Bientina	Bientina 2 Model	Bientina City
3	Calcinaia	Calcinaia Model	Fornacette, Calcinaia City, Incanto, Calcinaia Industrial Zone
4	Cascina	Cascina Model	Pettori-Musigliano, Cascina center-Navacchio
5	Castelfranco di Sotto	Castelfranco 1 Model	Castelfranco City
6	Castelfranco di Sotto	Castelfranco 2 Model	Galleno
7	Pontedera	Pontedera Model	Pontedera City
8	San Miniato	San Miniato Model	Ponte a Elsa, San Donato, Poggio, Ponte a Egola
9	Santa Croce Sull'Arno	Santa Croce Model	Santa Croce City
10	Santa Maria a Monte	Santa Maria a Monte Model	Industrial Zone Cardeto, San Donato 5 Case Montecalvoli, Santa Maria a Monte City, Cerretti
11	Vicopisano	Vicopisano Model	Industrial Zone Noce, San Giovanni Vicopisano, Uliveto Caprona, Il Tinto

1 ==> ZONING

The preliminary measures to the zoning has been made basing on the representative scheme of the functional process lines of the aqueduct system, by the wells to the distribution nets, dividing for every Municipality, at schematic level, the districts and the sectors of interest. They have been installed the first measurers of pressure / flow in the strategic points: exits of the reservoirs, terminal sections of net, principal knots etc.

The sampling has been made trying to control a day of high and a day of low consumption. Assumed that the day of mayor request results to be on Saturdays, it is tried to assemble the measures on the weekend, succeeding to made 60 measurements of flow whose elaboration has brought to define 26 zones of consumption for each of which the characteristic values have been calculated.

The sampling has had as principal objective that to individualize the instant flow of sector determining a choice forced of the points of measure and that to realize some measures of pressure in the sensitive points necessities to the setting of the models.

In order to determine the instant water balance, they are considered the incoming flow points in the system represented by the exits of the reservoirs toward the distribution net or in some cases by the principal conducts. In fact, the nets are served by hanging reservoirs or by reservoirs basements and only in a few cases the feeding happens through structural connections with other systems (San Piero Bientina, La Catena San Miniato).

The net of flow and pressures measurers has not altered in any case the actual equilibrium of the flows. In fact, being the measurers used to ultrasounds, with a not invasive technology, it has been possible to effect the installation and the measure without interruptions of the service.

In this first phase not being anticipated structural interventions there is limited to effect the measures on the existing metallic carpentries, preferring the measure on elements in steel inox where the internal diameter is a known parameter, or on river crossings or inside grits of inspection, where it was possible to operate directly on the conduct.

Through the zoning it has been possible to acquire the necessary data to the determination of the instant balance of the ASAP sectors (brought in the chart of the following page).

The zoning has interested only those portions of net where there is the connection to the users (distribution nets), while they have not been being kept in consideration that lines of principal conducts where there are not lacing.

In order to make the subdivision of the zones a part of net has been identified, defined "Adduction", geometrically delimited but to which any consumption is not in partnership.

The flow data necessities to the formulation of the balances have been qualified eliminating the incongruities of the tied up measures to the lack of energy for brief periods or tied up to manoeuvres notes that on the net are done because of management reasons (for example. unloading, partial closings).

This has allowed to guarantee continuity to the value of the flow. Proceeding to the algebraic sums of the measures values of the feeding points, which contributes to form the instant consumption value, the characteristic values are determined to all the measured sectors calculating:

- 1) the minimum night time value considered as the average calculated in the period that goes from 03.00 to 5.00 o clock.
- 2) the medium daily value (it has been calculated from the hours 00.00 to 24.00)
- 3) the maximum daily value
- 4) the hourly pattern necessary to the hydraulic modelling phase

For each of these consumptions the temporal position is defined for day, month, year of the measure.

	<i>Municipality</i>	<i>Sector</i>	<i>File pattern</i>	<i>Date of measure (gg/mm/aaaa)</i>	<i>Minimum night time value (l/s)</i>	<i>Medium daily value(l/s)</i>	<i>Maximum value (l/s)</i>
1	Bientina*	Quattro Strade Santa Colomba	Santa colomba	14/07/07	7.97	9.40	10.85
1	Bientina	Bientina City	Bientina	14/07/07	17.19	27.35	36.43
2	Calcinaia**	Fornacette	zanobini	05/10/07	5.74	8.27	13.00
2	Calcinaia	Incanto	incanto	05/10/07	8.84	16.30	24.15
2	Calcinaia	Calcinaia City	Calcinaia center	05/10/07	15.53	21.84	28.33
3	Cascina	Pettori-Musigliano	Pettori	10/07/07	5.66	19.88	30.98
3	Cascina	Cascina center-Navacchio	Cascina center	10/07/07	67.52	107.10	143.41
4	Castelfranco di Sotto	Galleno	galleno	21/03/07	0.52	1.41	2.76
4	Castelfranco di Sotto	Castelfranco City	castelfranco	23/11/07	22.80	33.59	44.35
4	Castelfranco di Sotto	Orentano Villa Campanile	orentano	15/06/07	7.43	12.38	17.52
5	Pontedera	Pontedera City	pontedera	09/07/07	44.62	82.21	109.26
6	San Miniato***	Ponte a Elsa	Ponte a elsa	31/07/07	1.29	2.58	4.88
6	San Miniato	Poggio	Poggio	19/01/07	19.93	30.50	39.43
6	San Miniato	Ponte a Egola	Ponte a Egola	01/02/07	28.81	33.86	40.24
6	San Miniato	Autoclave/Ponte a Elsa	Poggio al Pino	22/02/08	0.40	1.02	2.40
7	Santa Croce Sull'Arno****	Staffoli	staffoli	04/01/07	2.46	4.81	8.61
7	Santa Croce Sull'Arno	Santa Croce City	city	15/05/07	23.85	39.94	58.96
8	Santa Maria a Monte	Industrial Zone Cardeto	cardeto	09/07/07	1.42	2.29	3.94
8	Santa Maria a Monte	S.Donato - cinque case- Montecalvoli	Montecalvoli south	09/07/07	2.78	5.97	8.71

	Municipality	Sector	File pattern	Date of measure (gg/mm/aaaa)	Minimum night time value (l/s)	Medium daily value(l/s)	Maximum value (l/s)
		south usciana					
8	Santa Maria a Monte	Montecalvoli north usciana	Montecalvoli north	09/07/07	1.38	3.07	5.30
8	Santa Maria a Monte	Ponticelli	Ponticelli	09/07/07	1.40	3.84	6.83
8	Santa Maria a Monte	Cerretti	Cerretti	09/07/07	5.37	11.89	20.82
9	Vicopisano	Industrial Zone Noce	Industrial Noce	08/02/08	1.98	2.29	4.25
9	Vicopisano	San Giovanni Vicopisano	San Giovanni Vicopisano	08/02/08	10.79	18.31	23.92
9	Vicopisano	Uliveto Caprona	Uloiveto caprona	08/02/08	6.40	8.57	11.35
9	Vicopisano	Il Tinto	tinto	08/02/08	2.39	3.95	6.56

Tab. 1: Zoning ASAP district

- * On Bientina the first champion measures had been effected on April 2007; in the chart they are reported both these and those more recent available at the moment of the report revision.
- ** On Calcinaia the first champion measures had been effected on January and July 2007; in the chart they are reported both these and those more recent available at the moment of the report revision.
- *** On San. Miniato the first champion measures had been effected on January / February 2007; in the chart they are reported both these and those more recent available at the moment of the report revision.
- **** On Santa Croce the first champion measures had been effected on January 2007; in the chart they are reported both these and those more recent available at the moment of the report revision.

ZONIZZAZIONE



1 ==> ENCLOSURES

- File referred to the 9 Municipalities of the ASAP area with the data referred to:
- characterization of the consumptions
- pattern for the hydraulic modelling

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