



LIFE06/ENV/IT/255

A.S.A.P.

**Actions for Systemic Aquifer Protection**

The ASAP project is partially funded by the European Union LIFE Programme

**Aquifer conditions after the A.S.A.P. application**

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

**(Rev. 0b)**

Type of document:	Analysis report
Deliverable n°:	D5.3
Author(s):	Acque Ingegneria
URI:	<a href="http://www.klink.it/asap">http://www.klink.it/asap</a>



<http://www.klink.it/gate/asap>



Provincia di Pisa



This page has been intentionally left white

## Thanks

This report is the result of the job of the A.S.A.P. Project Team.

Thanks to all those people who have offered their support in the difficult task to analyze every matter and patiently they have discussed them.

*Ing. Oberdan Cei*  
*(o.cei@acqueingegneria.net)*  
*Project manager*

## Summary

1==>Analysis report – aquifer conditions after the A.S.A.P. contribution.....	6
1.1==>Aims.....	6
1.2==>Circle.....	6
1.3==>Execution and responsibilities.....	6
2==>Introduction.....	7
3==>Effectuated investigations .....	8
3.1==>General considerations.....	8
3.2==>Pluviometric data.....	9
3.3==>Piezometric differences paper october 2002 – october 2008.....	11
3.3.1==>Comment to the graphs.....	12
3.3.2==>Piezometre 22: Corte Spagni - Porcari - (Pollino Aqueduct).....	12
3.3.3==>Piezometre 58: Cerbaie 2 Central Aqueducts.....	14
4==>Indexes.....	16
5==>Enclosures.....	17

## Purpose of this document

The principal purpose of the document is to operate a piezometric comparison between the situation related to the piezometry indicated in the **D5.1 - Technical report about the initial conditions of the aquifer** and the one related to the monitoring company of the piezometry made on October 2008 (last company available at the moment of the editing of this report considering that the data of the company of May 2009 have not totally been still elaborated) in order to verify how and if the Project intervention has influenced the aquifer conditions.

## Warnings

1. The authors of this document have tried, where it was possible, to use a comprehensible language for readers of different origins and users with different finalities, avoiding, where it was possible, the use of specific or sector terms.

## 1==>ANALYSIS REPORT – AQUIFER CONDITIONS AFTER THE A.S.A.P. CONTRIBUTION

This report is one of the deliverables provided by the ASAP Project centred on the Bientina aquifer (Pisa, IT). In particular, *the Analysis Report – Aquifer conditions after the A.S.A.P. contribution* is in relationship to the *Task 5.- Evaluation and validation of the ASAP Protocol*.

### 1.1==>AIMS

The aim of the present document is to operate a piezometric comparison between the situation related to the piezometry indicated in the **D5.1 - Technical report about the initial conditions of the aquifer** and the one related to the monitoring company of the piezometry made on October 2008 (the last available at the moment of the editing of this report considering that the data of the company of May 2009 have not totally been still elaborated) in order to verify how and if the Project intervention has influenced the aquifer conditions.

### 1.2==>CIRCLE

The circle of the report concerns the whole Bientina aquifer including some fields wells (Pollino and Tazzera) which don't directly belong to the A.S.A.P. area but they equally condition the analysis and it is preferred to include them in order to have a more detailed and punctual picture.

### 1.3==>EXECUTION AND RESPONSIBILITIES

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

## 2==>INTRODUCTION

The A.S.A.P. project is finalized to the recovery of the piezometric levels of the super exploited Bientina aquifer (Pisa). As it is known for a long time in this area, with the works in act, it has been reached and overcome the local recharge potentiality and we are in presence of an excessive exploitation of the stratum, with lowering that are particularly accented during the summer period.

Practically, in the examined area there are strong limitations to the possibilities of further exploitation of the underground waters and the phenomena in action impose the put in work of improvement and safeguard interventions, contemplated to the quantitative guardianship of the same resource and the mitigation of the negative effects produced by the great exploitation.

In particular, the objective of great interest from the ideological point of view has been the one to reduce the capitation of the 10%, in order to invert the trend (from -0.5 m/a to +0.5 m/a) and to bring the piezometric level to a value of -16.5 m from the head of the control piezometre, present in the Cerbaie 2 central, piezometre that from years it records the piezometric values present in such field wells. The quota of objective results to be the one reached during the year 2000.

A subsidence process activated by anthropic causes can be opposed and arrested eliminating the same causes particularly effecting interventions for the reduction of the collecting of underground waters with a more rational management of the available water resources, also keeping in consideration what it is provided by the Decree P.C.M. 04.03.1996 "Dispositions in water resources field" issued in application of the art. 4 of the law 5.1.94, n. 36. Such dispositions foresee that the rational use of the water resources has as finality the budget of the resources, superficial and underground, to staircase of basin.

All the studies already done in the past by numerous authors have put in evidence, in the investigation area, how currently an excess of collecting is recorded in comparison to the abilities of the stratum recharge. Such excess is appraised in the quantity that goes beyond the value of the resources which currently renew themselves, equal to 370-390 l/sec altogether, to calculate keeping in consideration the collecting to drinkable use of the fields wells of Orentano, Staffoli, Cerbaie 1 and 2, Cascine di Buti, and of the other works present in the zone for the various not drinkable uses.

### 3==>EFFECTED INVESTIGATIONS

#### 3.1==>GENERAL CONSIDERATIONS

The work program has provided the execution of many piezometric companies, opportunely displaced with a congruous number of checkpoints on the whole investigation area, during the period 2008-2009, respectively two in the period of soft spring and two in the period of thin autumn.

Particularly, it has been provided the elaboration of the collected data with cartographic representation of the piezometric surfaces, to staircase 1:25.000. At the end of the piezometric reliefs it will be possible to effect also the elaboration of a paper of the piezometric differences pre and post intervention, to staircase 1:25.000.

At the actual state of the facts they have been executed n.3 piezometric companies, those related to the soft one and to the thin one of 2008 and that of soft of the 2009.

At the end of the investigations a database of the acquired data will be predisposed containing the effected measures for every checkpoint.

The data collected with the company executed in May 2009 are still in phase of elaboration and they will appear in the Final Report.

In this report it is elaborated a **piezometric differences pre and during the intervention paper**.

It is still remembered that the piezometric reconstructions which have been performed they refer to the hydro geologic complex of the padule of Bientina in which they can be distinguished, under the graphical aspect, three different aquifer levels; nevertheless, such horizons introduce a continuity of circulation which makes possible and correct the reconstruction of the piezometric surface as expression of an only circulation "in great", regarding all the wells which have been selected and measured to the purpose.

The principal alimentation components of this underground water circulation we remember to be represented by:

- a) the contribution in out coming of the underground stratum of the lowland of Lucca, currently very low and nearly void because of the collecting to industrial and drinkable use in action in the area included between Carraia - Porcari - Altopascio;
- b) the direct infiltration, that is little important in the central part of the lowland (because of the presence of superficial grounds few permeable) but it becomes remarkable in the perimetral bands of passage between lowland and reliefs, where they appear on the surface terrestrials more permeable connected to the courses of water activity;
- c) the recharge operated by the aforesaid courses of water in the crossing of their apparatuses of conoid;
- d) the contribution of the aquifers, that is remarkable particularly on the Cerbaie side.

In the following paragraphs an analysis of the pluviometric regime of the last years is effected and it is offered the performed description paper of the differences.

### 3.2==>PLUVIOMETRIC DATA

The more complete pluviometric series available in proximity of the investigation area is the one which is collected near the Lucca centre pluviometre, station that counts 90 annuities of observation.

The data have been collected from the year 1916 to the year 2002 in the local Botanical Garden and, from the year 2003, with updating and automatization of the instrumentation, by the Authority of the F. Serchio Basin.

Being the present report centred on the piezometric comparison between the October 2002 and the October 2008, in preliminary way it is necessary to operate also an analysis on some pluviometric regimes recorded in the semesters preceding the two measure companies.

In the preceding semester the company of **October 2008 (April-September 2008)** they have been recorded in the Lucca pluviometre precipitations altogether equal to **362,0 mm**, datum that is attested on a **15% deficit** in comparison to the medium datum of 90 years (**426,1 mm**), with a difference equal to **64,1 mm**.

The same arc of time in the year **2002** had recorded **704,8 mm**, with a **65,4% surplus** and more **278,7 mm** of precipitations. In particular, the months of August (172,2 mm. – medium datum 53,2) and September (224,6 mm against an average of 106,2 mm) were very rainy.

In practice, in 2002 it rained 342,8 mm more than the semester preceding the piezometric measures, in comparison to the same period of the 2008.

This datum by itself is able to offer an important key of reading in comparison to the piezometric comparisons effected.

Besides, it has to be added that the collected data (see Tab. 1 in the following page) underline that in the last hydrologic year (January - December 2008) a pluviometric surplus of **8.6 %** has been recorded with a total of **1.303,2 mm** against the average of 1.200,3 mm observed on 89 years between 1916 and 2008.

In fact, examining the first semester of 2008 it can be noticed as the precipitations has been superior of the 19.5% in comparison to the historical average for such period, with 670.6 mm of rain recorded against the 561.4 related to the medium datum.

On the contrary, despite the abundant rains related to the months of November and December (and really for a summer particularly drought), the second semester has made to record a light deficit in comparison to the average (-0.5%), with 632,6 mm against the 635,9 of the medium datum of 90 years.

This datum has to be read considering the reduced summer precipitations, when in fact they have been recorded 0.2 mm of precipitations in the month of July (against an average of 31,2 mm), 12,6 in August (53,2 of average) 36,4 in September (average of 106,22 mm). In practice, in the three summer months a 74% deficit has had in comparison to the medium value.

Therefore, it is evident that at least from a pluviometric point of view, the abundant precipitations of the last period of the 2008 have brought to a re-equilibrium of a compromised system, without particularly meaningful excesses.

It has to be remembered that the 2007, with its 902.8 mm of precipitations had been particularly drought, going to occupy the eighth place in the classification of the least rainy years. On 89 years of observations they have been recorded inferior values in comparison to the 2007 only in other 7 cases. It is interesting to observe also that, in this classification, to the last ten places they appear 4 years related to the last decade (10° the 1985 with 905.8, 9° the 2006 with 904.2, 8° the 2007 with 902.8, 7° the 1997 with 874.0, 6° the 2003 with 873.6, 5° the 2001 with 869.2, 4° the 1921 with 840.0, 3° the 1956 with 832.0, 2° the 1989 with 796.7 and 1° the 1945 with alone 537.0 mm). Table 1: Pluviometric data (ref. Pluviometric Station of Lucca)

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
2002	47.2	99.8	3.4	88.8	109.2	84.8	25.2	172.2	224.6	138.4	206.6	148.8	<b>1349.0</b>
2003	69.6	48.4	22.6	104.8	2.8	39.8	19.4	8.8	32.0	111.2	274.4	139.8	<b>873.6</b>
2004	78.6	156.8	150.6	118.6	95.8	27.0	14.6	13.2	152.6	189.6	125.8	116.0	<b>1239.2</b>
2005	45.0	53.2	61.8	124.0	53.0	30.0	14.0	47.4	132.0	147.8	232.0	117.0	<b>1057.6</b>
2006	153.2	138.6	79.8	14.8	48.0	4.4	35.0	39.6	75.4	55.4	138.6	121.4	<b>904.2</b>
2007	115.2	142.8	72.6	4.8	118.4	13.8	0.6	41.2	166.4	74.8	50.6	101.6	<b>902.8</b>
2008	178.8	44.8	134.2	97.8	125.8	89.2	0.2	12.6	36.4	134.2	249.2	200.0	<b>1.303.2</b>
2009	190.4	135.6	182.2	92.0	1.6								
monthly average 1916-2009	124.8	103.6	96.5	95.6	81.8	58.2	31.1	53.2	106.2	151.0	165.3	133.3	<b>1200.3</b>

Tab. 1: Pluviometric data (ref. Pluviometric Station of Lucca)

In particular, as regards the piezometric reliefs effected during the 2008 they are noticed the following observations:

- in the preceding semester to the effected measures at the end of May - beginning of June 2008 they have been recorded altogether 683,0 mm of precipitations against an average of 90 years, in the same period, of 636,3 mm, value that points out a surplus of 7,3% in comparison to the average.
- On the contrary, as it was already said above, in the preceding semester to the measures effected in October 2008, they have been recorded 362.00 mm of precipitations against an average of 90 years, in the same period, of 426,1 and therefore with a deficit of 15% in comparison to the average.

These data point out therefore that the relief of May is slightly inserted in a context of superior recharge in comparison to the average while the relief of October offers a piezometric picture in a phase of thin particularly sustained. Besides, it has to be observed that the general picture, if compared to the preceding years, it substantially appears in resumption, in relationship to the increase of the precipitations had in 2008 in comparison to the two preceding years.

Besides, the period November 2008 - February 2009 has made to record precipitations of extraordinary intensity (775,2 mm against an average of 525,1 mm. 47,6% surplus!) and the effects of such abundance of precipitations have been recorded in all the plain of Lucca, with the stratum that in the central zone of this area results to be constantly on levels of abundant recharge since December of 2008.

### **3.3==>PIEZOMETRIC DIFFERENCES PAPER OCTOBER 2002 – OCTOBER 2008**

The piezometric differences founded between the reliefs of October 2002 and October 2008 have been put in evidence in the Tab. 1 in enclosure, the analysis of this elaborate allows to individualize, inside the area object of study, the variations suffered by the piezometric surface in this arc of time.

It has to be specified that the elaborate intends to furnish additional evaluation elements in comparison what is already emerged until now during the A.S.A.P. implementation, maintaining besides a generic interpretation that is tied up to manifold aspects.

Firstly, it has to be observed the pluviometric difference subsisting in the semesters which have preceded the two measure companies, as described in the preceding paragraph.

Secondly, the checkpoints availability (30) is joined to a sweater of measured wells not correspondent, because of in October 2002 the measures were effected by the Acque spa technicians, but it didn't exist yet a control net defined and ample as that actual (70 points of measure).

The paper has been performed through automatic triangulation, with the use of the software application Arcview 3.2 and with the help of some applications for modelling in 3d.

Made these due premises the elaborate underlines the followings aspects:

- It can be noticed a general lowering of the piezometric surface with sensitive reductions in correspondence of the field wells of Pollino and Tazzera (values of lowering to over 3-0 ms) and of the field wells of they Orientano (lowering between 1 and 2 ms), both in the north portion of the padule of Bientina.
- Other consistent lowering are observed on the east limit of the area of study where, in some wells of the aqueduct of Staffoli, they are noticed lowering among 1.8 and 2.0 ms.

- It is observed a **general recovery in the area of the centrals of the Cerbaie 1 and 2 and of Tavolaia**, where they are evident meaningful recoveries of the piezometric surface. The recoveries, individualized in this area in 5 of the 30 points used for the elaboration, they are **generally included between 0,5 and 1 m even if in a case the value of the piezometric raising results to be equal to 2,8 ms.**
- Other zone in which a piezometric recovery has been observed is the one in the west of the area of study, in correspondence of the conoide of Pieve di Compito.

Anyway, what has been said above confirms what has already emerged during numerous investigations on the area of study or:

- a) The confirmation of the presence in correspondence of the North portion of padule (fields wells of the Pollino and Tazzera) of a meaningful piezometric depression;
- b) The confirmation, even if with recovery elements, of the presence of a piezometric depression in correspondence of the fields wells of Cerbaie.
- c) The confirmation of the presence of another depression in correspondence of the field wells of Staffoli.

### **3.3.1==>Comment to the graphs**

For a more exhaustive reading of the course in the time of the piezometric levels it is also furnished in the present report the detail related to 2 of the points of great interest of the area of study or the 2 piezometres respectively displaced in proximity of the field wells of Pollino and the Field wells of Cerbaie 2.

Near these 2 piezometres it is in act for years for wish of the authority of Basin of the Arno River, a collecting of the data with fortnightly frequency and therefore the massive structure of the data results particularly meaningful.

### **3.3.2==>Piezometre 22: Corte Spagni - Porcari - (Pollino Aqueduct)**

The piezometre 135 of Corte Spagni, situated 500ms south in comparison to the field wells of Pollino, is one of the measure points of the Hydro-graphic Service in the Plain one of Lucca. Its levels are measured for decades and therefore they are particularly meaningful and strategic in the work of control and monitoring of the underground water stratum (see Enclosure 1).

It is relieved that the measured levels in the 2008 summer period have sensitively been characterized by values of great giacieny in comparison to the preceding years. In fact, the least value, equal to 7.91 ms and recorded on 19th September, results to be taller until now in comparison to all the least seasonal recorded in the last 5 years:

Date	Maximum giacency	Delta in comparison to 2008
01/10/2004	8.12	-0.21
12/09/2005	8.40	-0.49
08/09/2006	8.45	-0.54
10/08/2007	8.49	-0.58
19/09/2008	7.91	-

The recovery of the seasonal least levels in comparison to the preceding years is an essential factor to rise up again some piezometric levels and, in a seasonal context that as it has already said, it has been characterized by scarce summer precipitations (and in a general context of annual pluviometric deficit), it is index of the fact that the mitigation works realized or in adoption progress ("tubone", local reduction of the pumping, etc.) they are achieving, at least partly and locally, concrete and positive results.

In an ampler historical context it is remembered that the maximum giacency value has been reached on 23/10/03 with 8.80ms from the p.d.c.. The least one of September 2008 has been therefore taller in comparison to the absolute one of 2003 of about 0.89 cm.

Beginning from this moment the stratum levels are constantly rising up and they have been adverted in a remarkable way the abounded precipitations of November-December. In fact, the levels have culminated the day 03/04/2009 with 3.88 ms of giacency, taller value of recharge in comparison to all the measured recharges until now in the last 5 years of control.

Date	Maximum giacency	Delta in comparison to 2008
07/01/2005	5.05	-1.17
10/03/2006	4.33	-0.45
09/03/2007	4.98	-1.10
18/04/2008	4.52	-0.64
03/04/2009	3.88	-

It is remembered that, in the last historical recharge characterized by abundant rains on the average (November 2000), the recorded sogiacency had been equal to 3.55 ms and it was from that event that the stratum was not attested to inferior distances to the 4 ms by the p.c.

In comparison to the objective level of m 6.00 individualized for the piezometre of Corte Spagni by the Authorities of Basin of the Arno River and of the Serchio River, the measured levels are resulted to be superior to that limit for the whole inclusive period between January and June and from the end of November to the end of December 2008. In the remainders months of observation the level has placed itself below the threshold individualized by the Authorities of Basin.

It is interesting to observe that, if they are esteemed the days in which the piezometric levels have been maintained above the objective level, the 2008 results to be great long the one with the best data if immediately they are compared with the precedent years:

It is remembered that, in the last historical recharge characterized by abundant rains on the average (November 2000), the recorded soggiacency had been equal to 3.55 ms and it was from that event that the stratum was not attested to inferior distances to the 4 ms by the p.c.

In comparison to the objective level of m 6.00 individualized for the piezometre of Corte Spagni by the Authorities of Basin of the Arno River and of the Serchio River, the measured levels are resulted to be superior to that limit for the whole inclusive period between January and June and from the end of November to the end of December 2008. In the remainders months of observation the level has placed itself below the threshold individualized by the Authorities of Basin.

It is interesting to observe that, if they are esteemed the days in which the piezometric levels have been maintained above the objective level, the 2008 results to be great long the one with the best data if immediately they are compared with the precedent years:

Year	Number of days above the objective level	%
2005	122	33,4
2006	154	42,2
2007	134	36,7
2008	228	62,5

As last notation of statistic character it is underlined that the medium value of the piezometric levels during the 2008 results to have been equal to 6.57 ms. The same value in 2007 resulted to be equal to 6.74 ms, with a medium recovery therefore equal to 17 cm.

### **3.3.3==>Piezometre 58: Cerbaie 2 Central Aqueducts**

The piezometre is endowed with reader in continuous and being situated inside the field wells Cerbaie 2, it constitutes the point in which it is observed more markedly the tendency to the levelling of the piezometric values in this area. The behaviour of the piezometre is interested by a very modest cycles of slope and descent, even if it has to be said that during the first semester of the 2008 these oscillations seemed more slightly sustained for the recharge levels (see enclosure 4).

In substance the piezometric recovery observed during the winter-spring 2008 has appeared more intense and lasting than that observed in the two preceding years and almost much comparable to the phase of recharge happened during

the year 2004.

As observed in occasion of all the preceding analyses, these data confirm as the area of Cerbaie adverts in a very contained way of the seasonal oscillations, to it retries some levelling in which the Artesian level is maintained, regulating the pumping, in order to avoid further level depressions. In fact, with a further lowering and with superior soggiacency to the 20 ms the stratum, with complete depressurization of the aquifer, comes to lose the residual characteristics of artesianity (to this depth it ends the layer of the slimes and the clays of coverage and it begins the real aquifer) and it turns itself into free stratum with serious drawbacks for the wells management.

The following table offers the comparison with the previous data:

<b>Date</b>	<b>Maximum giacency</b>	<b>Delta in comparison to 2008</b>
22/10/2004	18.10	+0.30
13/09/2005	18.40	-
24/07/2006	18.60	-0.20
27/07/2007	18.30	+0.10
16/09/2008	18.40	-

**4==>INDEXES**

Tables index

Tab. 1: Pluviometric data (ref. Pluviometric Station of Lucca).....10

## **5==>ENCLOSURES**

- Graphic of the piezometric differences October 2002 - October 2008 - staircase 1:50.000

---

Aquifer conditions after the A.S.A.P. application Provincia di Pisa 2009-06-30 11:10:46

**This document is available on the Internet at**

**<http://www.klink.it/asap>**