

Drought management in the urban water supply system of Canal de Isabel II [Part 2. Examples of application]

Cubillo F., Ibáñez J.C.

in

Iglesias A. (ed.), Moneo M. (ed.), López-Francos A. (ed.).
Drought management guidelines technical annex

Zaragoza : CIHEAM / EC MEDA Water

Options Méditerranéennes : Série B. Etudes et Recherches; n. 58

2007

pages 407-415

Article available on line / Article disponible en ligne à l'adresse :

<http://om.ciheam.org/article.php?IDPDF=800549>

To cite this article / Pour citer cet article

Cubillo F., Ibáñez J.C. **Drought management in the urban water supply system of Canal de Isabel II [Part 2. Examples of application]**. In : Iglesias A. (ed.), Moneo M. (ed.), López-Francos A. (ed.). *Drought management guidelines technical annex*. Zaragoza : CIHEAM / EC MEDA Water, 2007 . p. 407-415 (Options Méditerranéennes : Série B. Etudes et Recherches; n. 58)



<http://www.ciheam.org/>
<http://om.ciheam.org/>

Chapter 21. Drought management in the urban water supply system of Canal de Isabel II

F. Cubillo and J.C. Ibáñez

Canal de Isabel II, Santa Engracia, 125, 28003 Madrid, Spain

Introduction

Canal de Isabel II's commitment to the efficient use and management of the water resource is the best contribution to the quality of service to the citizens and environmental sustainability of the Community of Madrid. The materialization of this commitment is supported in the establishment of protocols for the better development of all the assurance processes of water supply.

The Supply Manual developed by Canal de Isabel II falls under these protocols and its main objective is to establish the general planning and operation guidelines of the Supply System, to ensure water supply to urban centers in compliance with all established standards. All this is in the context of sustainability in the maintenance of the ambient conditions of all the bodies of water related to the supply system, and following the principles of efficient management of the water resource.

The supply standards should reflect the need for flexibility and adaptation of management to a high risk of insufficiency of resources to handle the present or immediate needs of each situation in areas with a broad climatic variability. These situations, usually generated by the occurrence of periods of low precipitation, constitute the main element of the dimensioning of the hydric systems and require specific management guidelines. Guidelines which should consider the worst meteorological records known as those which involve the occurrence of the most severe episodes, due to natural causes or those induced by man.

Among the outstanding objectives of the Supply Manual is the fulfillment of Law 10/July 5, 2001, of the National Hydrologic Plan, which in Article 27.3 establishes that for urban supply systems which serve a population in excess of 20,000 inhabitants, an "Emergency Plan in Case of Drought Situations" should be provided. Although the operation of this Emergency Plan is conditional to that drawn up by the corresponding Basin Agency ("Special plan of action in situations of alert and possible drought") to which the Emergency Plan should adapt, the Supply Manual of Canal de Isabel II reflects the prevention and management proposals of situations of scarcity in the strict context of the supply system of Canal de Isabel II. The definition of the identification and management guidelines of the scenarios of scarcity constitute a significant section of the Supply Manual, which represents a complete revision of the Drought Management Manual of Canal de Isabel II, edited in 1999 and updated in an annual basis.

The proposals of this Manual, in case of a drought of a high severity, will fall under the competencies of the Basin Agency (Tagus River Hydrographic Confederation, "Confederación Hidrográfica del Tajo", CHT), established in Article 55 of the rewritten text of the Water Act, as well as, if applicable, in the exceptional measures approved by the Government, under the coverage of Article 58 of the same law.

With the considerations related to the fulfillment of the requirements of the water quality supplied being of prime importance in the all supplies, the scope of the Supply Manual does not cover these points, since it is considered that the water quality requirements, established by the standards in effect, will be satisfied through the use of available installations in the Canal de Isabel II system, under normal conditions in the operation and availability of resources, as well as in the scenarios of scarcity of little seriousness.

The document does not attempt to carry out a diagnosis of the Canal de Isabel II supply system or of the actuation requirements to handle medium- and long-term future scenarios. Nor does it attempt

to determine and evaluate possible alternatives to guarantee an appropriate balance of resources and demands. Notwithstanding, in that related to short-term planning, the potential risk situations are made known and the conditions to manage these are established.

The presentations of the Supply Manual cover from the resource planning criteria up to the establishment of operating procedures with a clear orientation toward ensuring the sufficiency of the system to handle demands. The appraisals have been carried out from the consideration of global volumes, with a breakdown according to the different catchment sources and the main demand areas. The operating guidelines considered are based on monthly intervals of decision, consequently, excluding the weekly or daily scale of operation.

In summary, the Supply Manual of Canal de Isabel II expresses the protocols and good practices to:

- (i) Establish the risks of scarcity and incapacity of the supply system to satisfy all demands.
- (ii) Establish efficient management policies of the resource and water demand.
- (iii) Ensure an integrated and sustainable management of resources.
- (iv) Establish guidelines to operate the supply system handling short-term outlook.
- (v) Integrate the satisfaction of environmental constraints and sustainability of related ecosystems into the operation of the supply system.
- (vi) Manage the supply under conditions of drought and scarcity of resources.
- (vii) Manage the supply system in case of large-scale contingencies and anomalies, such as floods.
- (viii) Plan actions to guarantee the water supply in the medium and long term with the established risk level.

Basic principles of water supply in Canal De Isabel II

The Supply Manual of Canal de Isabel II outlines the Basic Principles of water supply for its system, which are:

- (i) The main mission of the water supply in Canal de Isabel II is to ensure the supply to all its users, according to the conditions stipulated by the regulations in effect.
- (ii) The use of natural resources necessary for carrying out the function of a water supplying body to urban centers will be carried out within the framework of sustainability of ecosystems linked to the bodies of water whose conditions are affected as a consequence of the activity of the supply system.
- (iii) All hydric resources in the supply system will be used under the principles of integrated management.
- (iv) The guarantee of equilibrium between the availability of natural resources and the total consumption demanded in the supply system, for present and future scenarios, will be handled by giving particular priority to efficient management solutions of all the components of the supply and demand cycle.
- (v) The assurance strategies of the supply for future scenarios will be established in the corresponding planning studies, within the frameworks established by the National Hydrologic Plan and the Tagus Basin Plan.
- (vi) All the actions considered for the assurance of the availability-demand equilibrium will be calculated with the evaluation of its social, environmental and economic implications.
- (vii) Droughts, understood as periods with low precipitation patterns, are a normal phenomenon although of little frequency in the scope of availability of resources of the Community of Madrid.

Droughts, understood as a climatic phenomenon triggering episodes of high-risk of nonfulfillment of the service standards, constitute a main part of the planning and management work of the supply of Canal de Isabel II.

(viii) In a combined consideration of efficient utilization of resources and recognition of adjusted balances between availability and consumption, in present scenarios and those of the immediate future, it is assumed the need to possibly resort to the temporary reduction of consumption. In spite of this, the commitment to always satisfy 91% of demand is established, within the historically recorded climatic context¹. The reference objective for the need to introduce reductions in consumption is established at 4% of the years². These assumed reductions do not require savings rates in excess of 9% of the average normal annual volumes, and under all circumstances will have an extent of less than one year.

(ix) The ecosystems dependent on the management of the CYII supply system will also be affected by the conditions of scarcity of resources triggered by drought episodes. In these cases, the need to restrict the fulfillment of the conditions for normal assurance, on a subsidized basis with urban supply, will be assumed.

(x) The assurance of the supply in the CYII also considers episodes of greater severity than those planned. Within the principles of risks and contingencies management, the encountering of episodes of prolonged scarcity of resources for supply, as a consequence of the occurrence of one or more of the following situations is considered:

- Periods of higher climatic severity than that recorded.
- Consumption increases in excess of those forecasted.
- The occurrence of eventualities which limit and condition the normal use of the infrastructure which forms the supply system.

Scenarios of possible climatic changes have been outlined within these planned risk strategies.

Scenarios of risk of scarcity of resource in the supply system of Canal de Isabel II

Canal de Isabel II establishes three degrees of risk of scarcity or insufficiency of resources to handle all its demands:

- (i) Risk of severe scarcity
- (ii) Risk of heavy scarcity
- (iii) Risk of emergency scarcity

The process followed to integrate the risk management in the supply assurance process is that of characterizing each of these possible *scenarios of scarcity* under the terms of risk related to them, and from this characterization, determine the *levels* which identify the commencement of the scenarios, and establish its corresponding management procedures.

1. The acceptance of the need to reduce consumption 9%, based on voluntary savings, by the citizens for a limited number of years, forms part of the integrated planning practices and efficient management of the resource in all scopes subject to occasional periods of scarcity, since it is feasible with a slight incidence on society, according to that justified in the Manual. These reduction amounts have been maintained in the policies of the supply management in Canal de Isabel II, and particularly in its Drought Management Manual, whose first version is dated 1992.

2. This figure is that which has been maintained for longer than a decade in the planning criteria of the supply of Canal de Isabel II in its search to fine-tune with the general criteria of National Hydrologic Planning and most accepted guidelines in the water supply of western cities.

Usually, the concept of *risk* is understood as the product of the probability of occurrence of an event by the consequences deriving from this. According to this concept, the impact or consequences of each risk scenario has been mainly characterized by the implications they would have in the quality of service, with this being understood to be reductions in the supply of the volumes of normal demands. These reductions will have a different scope according to the risk scenario involved and, in reality, will correspond to that established a priori to handle and resolve each scenario. In regard to the other component of the risk calculation, the probability of occurrence has been based on the volume of reserves stored in the system in each month of the year, since the probability that the reserves are below a determined value is the parameter which best reflects the capacity of the system to handle its immediate demands, and its value in each month of the year implies a specific probability of occurrence of runoff in the prior time intervals.

So, for each scenario it is considered:

(i) The probability of occurrence that the level of reserves is below an established value.

(ii) The consequences, the impact on the supply, in the form of consumption reductions of a different intensity, implemented to solve each situation and prevent the occurrence of a scenario of greater severity.

In reality, with the management of each scenario, reducing the consumption and seeking temporary augmentation of inflow of resources, what is being sought is to reduce the probability of occurrence of a risk of worse consequences. Or, in brief, reduce the total risk of nonfulfillment of the supply requirements.

In the context described previously, the *scenarios* are related to the characteristics of the situation, and particularly to the impact related to this and the indicative *levels* of the commencement of the scenario, of stored reserves and, consequently, the probability of occurrence.

Following, the scenarios of scarcity and their consequences are described and, subsequently, the levels of commencement of these scenarios.

Scenarios of scarcity

The impacts corresponding to each scenario of scarcity will be variable and proportional to the severity of the considered scenario. These impacts have been calculated from the basic principle of the management guidelines of this type of risk, which is to ensure the surmounting of the episode identified in the risk, together with the prevention of incurring the following scenario of greater severity.

The surmounting and prevention guidelines and the objectives considered for each type of action have been established from rigorous evaluations of feasibility of implementation of the management measures of the risk situations, in regard to the time required for obtaining the proposed objectives, and in regard to the amount of the proposed demand reductions.

The calculation of these scenarios has been carried out departing from the identification of severe scenarios, to be avoided through risk management procedures associated with each less severe situation.

Consequently, the method consists in beginning to consider the worst possible situation and, from this, determine the conditions under which it would be necessary to act and with which to prevent that this situation materializes, always in a context of a specific probability.

On the other hand, and as has been indicated, on listing the scenarios of scarcity considered, a graduation of three scenarios is presented, whose main differences are:

(i) *Emergency scarcity*: Critical situation, which does not reach the total lack of supply, but would have certain dramatic effects of consumer rationing.

(ii) *Heavy scarcity*: This is the neatest scarcity scenario, with little probability of occurring, whose main management objective is to prevent the occurrence of an emergency scenario. It involves restrictions in the supply.

(iii) *Severe scarcity*: This is that of the lowest consequences for the users of the supply, and with little probability of occurrence, with impacts generally accepted by the citizens and assumed in the hydrologic planning criteria and efficient and sustainable use of resources.

Due to that indicated previously, the scarcity scenarios described in the following sections, beginning with those of the greatest severity. Each scenario describes the main characteristics, the related impact for surmounting these and the hypothetical conditions under which it is assumed that its management will be carried out.

Scenario of emergency scarcity

The point of departure could have been the consideration of an episode of absolute absence of reserves in any of the storage elements of the storage system, as the most dramatic situation imaginable to be avoided, but this referent is unfeasible when applied to an urban population of more than five million inhabitants. Instead, an emergency scenario has been established, in which the situation would be more dramatic due to the social and economic implications that the simple fact of facing it in a set of large communities, as is the case of the Community of Madrid.

Notwithstanding, within the preventive measures of this scenario, the precautions against the hypothesis of the total absence of reserves has been considered.

This emergency scenario, which should be considered as a referent of a dramatic situation, which will correspond to an extremely low probability of occurrence, would present a balance of surmounting with the following main parameters:

(i) Impacts on supply:

- Demand rationed to the basic needs of the population, estimated at 80 l/inhabitant per day for domestic use, and 50% of the normal water duties for remaining activities.
- The quality conditions of the water supplied could not be guaranteed with the same degree of commitment as in situations of less severity.
- The environmental constraints of surface fluvial runoff cannot be fulfilled to any degree.
- Only urban tree species of special value and interest would be provided with irrigation.
- Anticipated maximum duration of 12 months.
- The socioeconomic costs would be enormous in implementing a rationing system.

(ii) Scenario management conditions:

- Surface runoff corresponding to that defined as extreme hydrologic drought.
- Reduced availability of underground reserves as a consequence of the continued use during scenarios of scarcity which, by necessary would have occurred prior to this dramatic situation. An average extraction of 1.50 m³/s is estimated.
- Runoff complement of 70 hm³ from the Alberche River.
- Supply complement of 40 hm³ obtained through the reuse of recycled water and exchanges from other concessionaires who may assign their rights.
- The maximum duration of continuation in this dramatic situation should be 12 months, which it is understood would be the duration in providing the population with an extraordinary solution to alleviate the situation.
- Notwithstanding, it is necessary to point out that the fulfillment of the conditions of inflow of resources and demands indicated would render a balance which would result in a prolonged continuation beyond that indicated.

Scenario of heavy scarcity

This scenario is of a transitional nature among the situations of severe scarcity, anticipated and assumed as part of the cyclical management of demand and the emergency scenario described previously.

This is an authentic *drought* situation, with significant social, environmental and economic impacts, which will be associated with the occurrence of climatic episodes of a greater severity than those recorded up to the date, and will occur as a consequence of the prolongation of a period of scarcity. Its solution will require forceful restrictive measures.

(i) Impacts on the supply:

- Would correspond to average reductions of demand of 26%.
- Anticipated maximum duration of 24 months, including in case of the occurrence of one of the worst recorded hydrologic periods.
- It is not possible to comply with the fluvial environmental constraints and an attempt would be made to maintain the urban tree species of value and interest and of the highest fragility. Loss of seasonal plant species.
- The socioeconomic costs would be significant as a consequence of the water consumption restrictions in commercial and industrial activities.

(ii) Management conditions of the scenario:

- The reduction values will be reached as a consequence of restrictive and support measures. The distribution of these demand reductions in the different types of use will be adapted.
- Surface runoff equivalent to those of a heavy hydrologic drought.
- Resource runoff complement by an amount of 192.5 hm³, of which, 60 will originate from strategic reserves, 101 from the Alberche River, and the rest from the reuse and use exchanges.

Scenario of severe scarcity

This scenario corresponds to that of a moderate impact on users, considered within the cyclical management policies of demand, to adjust on an elastic basis the demands to the hydrologic irregularity and to the real supply capacities of the supply system. Its establishment may be imposed by policy-setting plans in the hydrologic plans, supply standards, preferential and acceptance studies on the part of the users, or otherwise, in situations of imbalance between resources and demand, as the only way to adjust the resource availability to existing global demands.

In the case of Canal de Isabel II, this scenario has formed part of the efficient management policy for longer than a decade, is included in the basic principles and is in line with that established as general criteria to appraise the availabilities in the basin hydrologic plans (Technical Instructions and Recommendations for the Drawing Up of the Intercommunity Basin Hydrologic Plans).

(i) Impacts on the supply:

- An average reduction of demand of 9% and a maximum duration of 12 months are considered.
- The environmental impacts would translate into a reduction of the environmental constraints to only 25% of the discharges established for El Vado and El Atazar reservoirs, from March to September.
- The socioeconomic costs would be very low.

(ii) Scenario management conditions:

- The reduction values in the consumption will mainly be reached as a consequence of voluntary changes of the individual user's habits and attitudes, and in the temporary conservation from all public

centers and institutions. The distribution of these demand reductions in different types of use will be adapted.

– The surface runoff is the same as those of a severe hydrologic drought.

– Inflow of resources complement for an amount of 263 hm³, of which 79 will originate from strategic reserves, 169 from the Alberche River, and the rest from the Sorbe River and the Almoguera Mondéjar system.

Levels of commencement of scenarios of risk of scarcity

As was indicated previously, risk management is made from the identification and typification of certain scenarios of very little frequency, and a measurement of the probability that this occurs. With both factors it is necessary to conclude in a series of values related to each risk scenario which identifies these situations and serves as reference for the commencement of the corresponding corrective action.

The probability of occurrence of the risk scenarios indicated in the previous section will be a consequence of the combination of the following factors:

- (i) Present or short-term forecasted consumption.
- (ii) Capacity of the supply system infrastructures.
- (iii) Reserve volumes stored in the different components of the system.
- (iv) Probability of a certain hydric runoff being produced.

The presentation followed is that of identifying the values of stored volumes which will determine, for an established hydric runoff pattern, the commencement of each of the risk scenarios. The hydric patterns used have been those typified in the situations of drought and scarcity of resources section, and specifically those corresponding to hydrologic droughts.

The patterns considered and the resulting scenario commencement values are described below:

Level of commencement of risk of severe scarcity

This would be the series of volumes stored monthly corresponding to the occurrence of a severe hydrologic drought or to any of the consecutive monthly sequences (from 1 to 48 months) to which a probability of occurrence equal to or less than 4% applies.

These values correspond to the distribution of consumption considered for the immediate future, but these values would be reached with a higher probability, as a consequence of demand growth in excess of that considered in the establishment of the operating policies of the system for the short term.

The commencement level of this risk scenario has been determined as the monthly reserve volumes in which only 4% of the years would be incurred. The extension of the scenario covers up to the monthly values which could be reached in case of the worst hydrologic sequence recorded (which is the border between the severe and heavy hydrologic droughts) and which, in addition, would ensure a minimum precautionary period of 12 months before incurring the scenario of heavy scarcity, even in case of the occurrence of the worst monthly sequences. The highest value is adopted each month, of those obtained with each of the criteria. This commencement level of the scenario of risk of severe scarcity corresponds to that which will be defined as the beginning of the drought situation in the supply system.

The values of monthly volumes of reserves which determine the commencement of this scenario are indicated in Table 1 below and are reflected in Fig. 1.

Table 1. Monthly reserve volumes (in hm³), for the commencement of the different risk scenarios

	Level of severe scarcity	Level of heavy scarcity	Emergency level
October	345.2	169.6	69.9
November	311.9	148.0	67.7
December	305.7	138.5	66.9
January	314.5	138.5	66.5
February	309.3	127.6	67.6
March	328.4	156.3	69.2
April	358.5	194.1	70.7
May	348.6	226.4	74.4
June	383.4	255.9	78.9
July	401.7	248.0	80.4
August	391.6	221.5	77.7
September	369.8	198.0	73.9

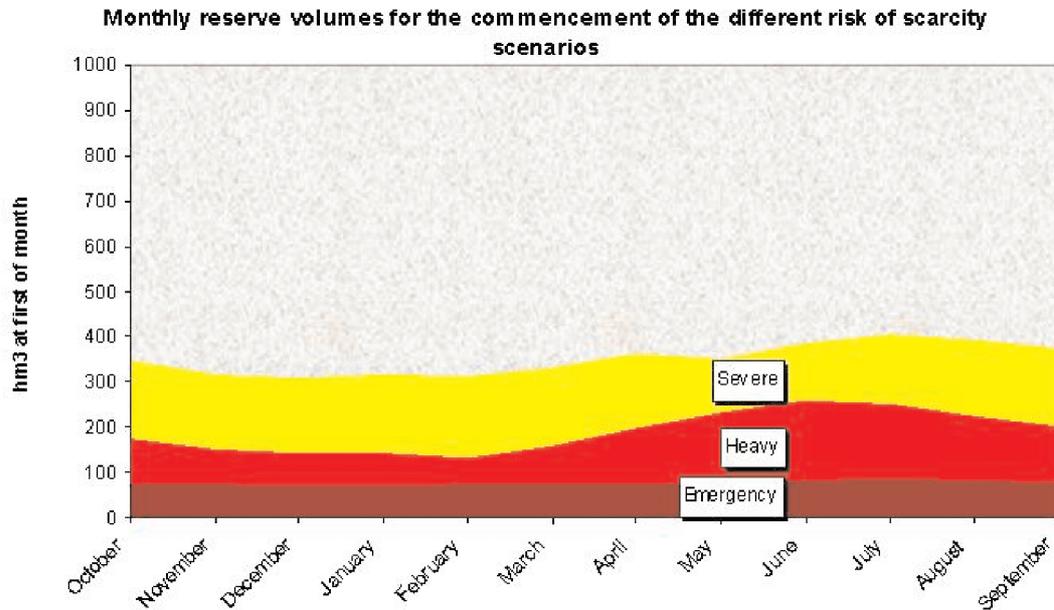


Fig. 1. Monthly reserve volumes for the commencement of the different risk of scarcity scenarios.

Level of commencement of risk of heavy scarcity

This will be the set of monthly values of surface storage corresponding to the occurrence of a hydrologic sequence of less runoff than the severe hydrologic drought (periods of less runoff than that historically recorded of a duration of less than six months should not trigger this scenario).

This scenario may also be incurred as a consequence of the nonfulfillment of the consumption reduction objectives, or inflow of resources to the system, considered for surmounting the scenario of risk of severe scarcity.

The commencement levels of this scenario have been determined as those which would be incurred only in case of the occurrence of hydrologic droughts with lower runoff than those historically recorded. In addition, they would ensure a minimum precautionary period of 24 months before incurring the scenario of emergency scarcity, even in case of the occurrence of the worst consecutive monthly sequences of runoff corresponding to that typified as a heavy hydrologic drought, once immersed in this scenario.

This commencement level of the scenario of risk of severe scarcity corresponds to that which will be defined as the commencement of a heavy drought situation in the supply system.

The values of monthly reserve volumes which determine the commencement of this scenario for the 2003 period are listed in Table 1 and reflected in Fig. 1.

Level of commencement of risk of emergency scarcity

This would be the set of monthly values of surface storage corresponding to the occurrence of a hydrologic sequence of less runoff than the heavy hydrologic drought (periods of less runoff than that typified as heavy of a duration of less than six months should not trigger this scenario).

This scenario may also be incurred as a consequence of the nonfulfillment of the consumption reduction objectives, or inflow of resources to the system, established for scenarios of risk of heavy or severe scarcity.

The commencement levels of this scenario have been determined as those in which only in case of the occurrence of hydrologic droughts with runoff less than that typified as heavy and which in addition ensures a minimum precautionary period of 12 months to find an emergency solution which permits to recover scenarios of a lesser severity, even in case of the occurrence of the worst consecutive monthly sequences of runoff corresponding to that typified as an emergency hydrologic drought.

In spite of the theoretic positive balances of runoff and consumption established in the management of this scenario, it is assumed that the volume of surface reserves should be equivalent to two months of consumption under these rationing conditions at all times, in order to handle temporary irregularities of the minimum runoff forecast and the distribution of uses among the different reservoirs of the system.

This level of commencement of scenario of risk of emergency scarcity corresponds to that which will be defined as the commencement of the emergency drought situation in the supply system.

The values of monthly volumes of reserves which determine the commencement of this scenario for the 2003 period are indicated in Table 1 and reflected in Fig. 1.

Normal scenario

Levels of surface reserves over the commencement values of a situation of severe scarcity. Harnessing of resources according to the normal guidelines and according to the priorities established.

The mission of this scenario, in relation to the risks of scarcity indicated previously, is to ensure the integrated and efficient use of the different sources of resources, under conditions of abundance, in order that the probability of occurrence of scenarios of scarcity is that initially established on defining the risk scenarios. This probability, which in previous sections is exclusively related to the hydrologic runoff pattern, will evidently be conditioned by the operating guidelines during the normalcy scenarios.