

JOURNAL OF ENVIRONMENTAL HYDROLOGY

The Electronic Journal of the International Association for Environmental Hydrology

On the World Wide Web at <http://www.hydroweb.com>

VOLUME 4

1996



MANAGEMENT ALTERNATIVES TO IMPROVE THE ENVIRONMENTAL QUALITY AT DEL FUERTE LAKE, ARGENTINA

PART I. METHODOLOGICAL ISSUES

Fabio Peluso
Eduardo Usunoff
José González Castelain
Fabián Grosman

Instituto de Hidrología de Llanuras
Azul
Pcia. de Buenos Aires, Argentina

This paper presents the methodology used for the environmental assessment at Del Fuerte Lake, Argentina, which emerged as a need by the local (i.e., municipal) government to have a diagnostic study of the lake's environmental status and plausible management alternatives. The first task was an exploratory one, aimed at defining the system's functional structure. In it, the domain was taken to be the lake itself plus all organizations, institutions, and individuals which are in various ways related to such a water resource, and distinguishing between 'natural' and 'institutional' structural components.

In order to assess the 'natural' environmental status, several studies were completed, namely, water and sediment quality, organoleptic diagnosis, ichthyological analysis of sport fishing-relevant species, and limnological parameters. As for the 'institutional' status, a comprehensive survey through tailored polls of all involved protagonists was carried out. It revealed their objectives, demands, and interests, as well as the exogenous and endogenous variables they need to know to foresee the evolution of their particular sector. Once the various components were identified, all possible relationships among them were quantified and analyzed to obtain, for each of them, a description in terms of sense and magnitude. This was deemed to be a good approach because of the highly complex network of interactions among the components. It was thus possible to highlight 'hot' nodes (i.e., conflicting points where multiple interactions converge) and, finally, to come up with numerical estimates of the system's status. The conclusion is that the applied methodology can be considered both adequate and expeditious, given the time and fund constraints imposed by the local government to complete all field and laboratory tasks and to release a thorough report.

INTRODUCTION

Public officials in Tandil City, Buenos Aires Province, Argentina, (population: 110,000) requested an analysis of the quality of Del Fuerte Lake (59° 8' W, 37° 21' S), a nearby water body, to be followed by a management plan. This study was initiated with the objectives being to determine the lake's environmental status and to propose maintenance and improvement-oriented measurements. Del Fuerte Lake is a flood control reservoir created by a dam in a small valley, surrounded by medium hills, at the confluence of two creeks. The man-made dam created a water body of about 15 hectares in area with a mean depth of 2.1 m, upstream from Tandil City.

Several signs of incipient degradation of the lake water quality raised concerns, particularly because of their unknown effect on the various uses of the lake. The Instituto de Hidrología de Llanuras, a regional hydrological research team, was asked to prepare and execute a low-budget environmental assessment and management study (US\$ 8000) in no more than 45 days.

The study is made up of two sequential steps: (a) environmental field survey, designed to assess the system's functional structure and to estimate the actual impact of anthropogenic activities, and (b) management alternatives, a group of integrated suggestions aimed at correcting or mitigating all possible negative impacts. The management alternatives attempted to address most of the possible uses of the water resource, preserving the biophysical and ecological integrity of the site, and analyzing their potential effects on the local community.

This paper describes the methodology used for the field survey and environmental assessment. The accompanying paper presents the results and gives details of the feasible management alternatives.

METHODOLOGY

The field and laboratory tasks were completed in about 30 days, whereas the data processing and report writing took 15 days (between February 1 and March 15, 1995). The study included a group of diagnoses: limnologic (with details of ichthyological aspects), sanitary, survey of the various uses, institutional and community interests, review of the current municipal laws, etc., in an attempt to obtain as comprehensive a characterization as possible. The next step was to generate an analytical tool for the raw data, which is explained below.

Identification of the Structural Components of the System

The system was defined as the lake itself and the institutions, profit-making organizations, and individuals which, in one way or another, have some link with the lake (because of their making use of it, their proximity, or their having voiced their interest in its preservation). Geographically, the area was restricted to that covered by the lake plus its two tributary creeks and the reservoir outflow. The system is made up of 'natural' and 'institutional' components, which, in time, were divided up in several sectors. The natural component, associated with the biophysical-ecological sector, involves physical, chemical and biological elements. The institutional component, otherwise seen as people-related issues, were grouped in economic, sociocultural, technical, and government sectors.

Natural component

This component was characterized by considering the following items (details can be found in González Castelain et al., 1995):

- a) *Lake water organoleptic assessment*: qualitative parameters were defined on the basis of the

water 'aspect'. A sampling grid was established and several parameters measured, namely, foam, smell, floating rubbish, loss of open water area by aquatic vegetation (any type), depth loss by sedimentation, water visual aspects, margin status, and evaluation of activities hindered by the current lake status.

b) *Limnologic diagnosis and quality of water and sediment*: carried out with the purpose of gaining insight into the potential benefits and constraints the site has with respect to recreational activities. The sediment and water analyses used standard techniques (APHA-AWWA-WPCF, 1989). The water quality variables measured were the concentration of major ions (calcium, magnesium, sodium, potassium, fluoride, sulfate), electrical conductivity, pH, chemical and biochemical oxygen demands (COD and BOD, respectively), chlorophyll concentration, main nutrients (total nitrogen and phosphorous, soluble phosphorous, nitrate, and ammonium), turbidity, depth of light penetration, oxygen concentration at various depths, and routine bacteriological count. As for the sediment, with samples taken throughout the lake, the parameters measured were percentage of volatile solids, COD, total and organic phosphorous, Kjeldahl-nitrogen, and routine bacteriological analyses. Some of the samples were utilized to study the protist community, which is a good index of the degree of the system's saprobic status, hence, the degree of sediment pollution.

c) *Ichthyologic diagnosis*: its objective was to define the structure of the fish community. Various fishes were captured with different gillnets. Each specimen, after taxonomic identification, was characterized by standard length, weight, head length, sex, gonadal maturity, and gonadal weight. Digestive tracts and scales were saved for other tests. Because the silverside fish (*Odontesthes bonariensis*) bears the greatest social importance (sport, recreational activities), studies of its population were of greater detail (constraints for growing, microenvironment distribution, food supply sources, etc.).

Institutional component

An exhaustive survey was carried out which included camping site owners, fishing and sailing clubs, recreational resorts, retail stores around the lake, and public and private transportation managers. The survey also included several government offices: municipal (Public Works Direction, Tourism Direction, Coordination of Open Public Sites, Promotion and Development Secretary, Rural Roads Secretary, Municipal Hospital), Hydraulic Provincial Direction, Bromatology Direction, ecology-concerned groups, permanent residents, and tourists. Through polls and interviews, information about their roles and interests with respect to the lake was obtained, as well as the identification of endogenous and exogenous variables they need to handle in order to assess their institutional/personal standpoint (a methodology adapted from Gallopín et al., 1980). All local laws and regulations were also retrieved and analyzed.

The working variables were:

- ◆ Direct profit-making activities which depend on the lake's water quality: their number, infrastructure available, number of costumers, access to such activities, associated costs, etc.
- ◆ Indirect profit-making activities: same as above.
- ◆ 'Environment' values: tourist count, cost of houses in the area, the lake as an employment-generating resource, general services available, and forecasting of urban development in the area.
- ◆ Lake 'social' value from the viewpoint of residents and tourists: number of users, views they hold about the environmental status, the available infrastructure and services, and the environmental

preservation as it relates to the lake.

- ◆ Difficulties encountered by each protagonist for carrying out their activities and fulfilling their objectives.
- ◆ Sediment, water and fishing quality.
- ◆ Lake organoleptic features.
- ◆ Identification of potential pathologies associated with the study site.
- ◆ Effects of the actual water storage capacity of the lake (i.e., sediment accumulation).
- ◆ Technical and financial feasibility for cleaning up the site.
- ◆ Degree of enforcement of current municipal laws or rules and existence of management plans.
- ◆ Identification of point and diffuse sources of contamination.

Identification of the Functional Relationships in the System

This assessment took into account (a) objectives, demands, and interests of each protagonist, and (b) the exogenous and endogenous variables needed to predict the evolution of the respective sectors. The methodology was adapted from that described by Gallopín et al. (1980) and Westman (1985).

Having characterized the various sectors and established their particular goals, all possible relationships among those elements were drawn and given a numerical value. Each relationship was seen as an interaction, with an origin and a target. As such, those relationships have a sense and a magnitude (I: high, M: medium, and L: low, being positive or negative depending on their effect) which was based on the responses to the poll and the results of the many interviews. With this database a general picture of the system's actual status was generated, based on the higher level interactions (either positive or negative). It was then possible to identify nodes or points of confluence of multiple interactions among components.

Analysis of the Lake's Structural-Functional Model

Because the final user of the results is a political decision-making institution (the municipal government), there was an attempt to obtain a single numerical result for the model to be used as a graphical and sound reference. Each negative or positive interaction was assigned a value of -1 and 1, respectively, and summed up (adapted from Gallopín, 1980). It is important to note that, while using a strictly mathematical operation, in essence qualitative terms are being handled. Nevertheless, and independently of its absolute value, this seems to be a good approach in the sense that the larger the result, the lesser would be the cost/benefit ratio for a given status of the system. Two details deserve special comments: (a) because the management alternatives include elements not currently present their numerical result should be carefully considered (e.g., if the current status renders a value of +2 and the best alternative converges to a value of + 28, that does not necessarily imply that an improvement multiplier of 14 is to be expected), and (b) due to financial constraints for future investments, the management alternatives did not seek to maximize the final result, but rather to minimize the current negative elements. Figure 1 shows the model obtained for Del Fuerte Lake, with the final result emerging from the mathematical operation above described.

RESULTS AND CONCLUSIONS

The study activities were planned so as to keep as integrated a view as possible, which has long been recognized as the proper approach to study environmental issues. It implies dealing with a large amount of information from many sources that, very commonly, is not quantifiable. On the other hand (and this study is a good example), public organizations are almost never willing to accept that the

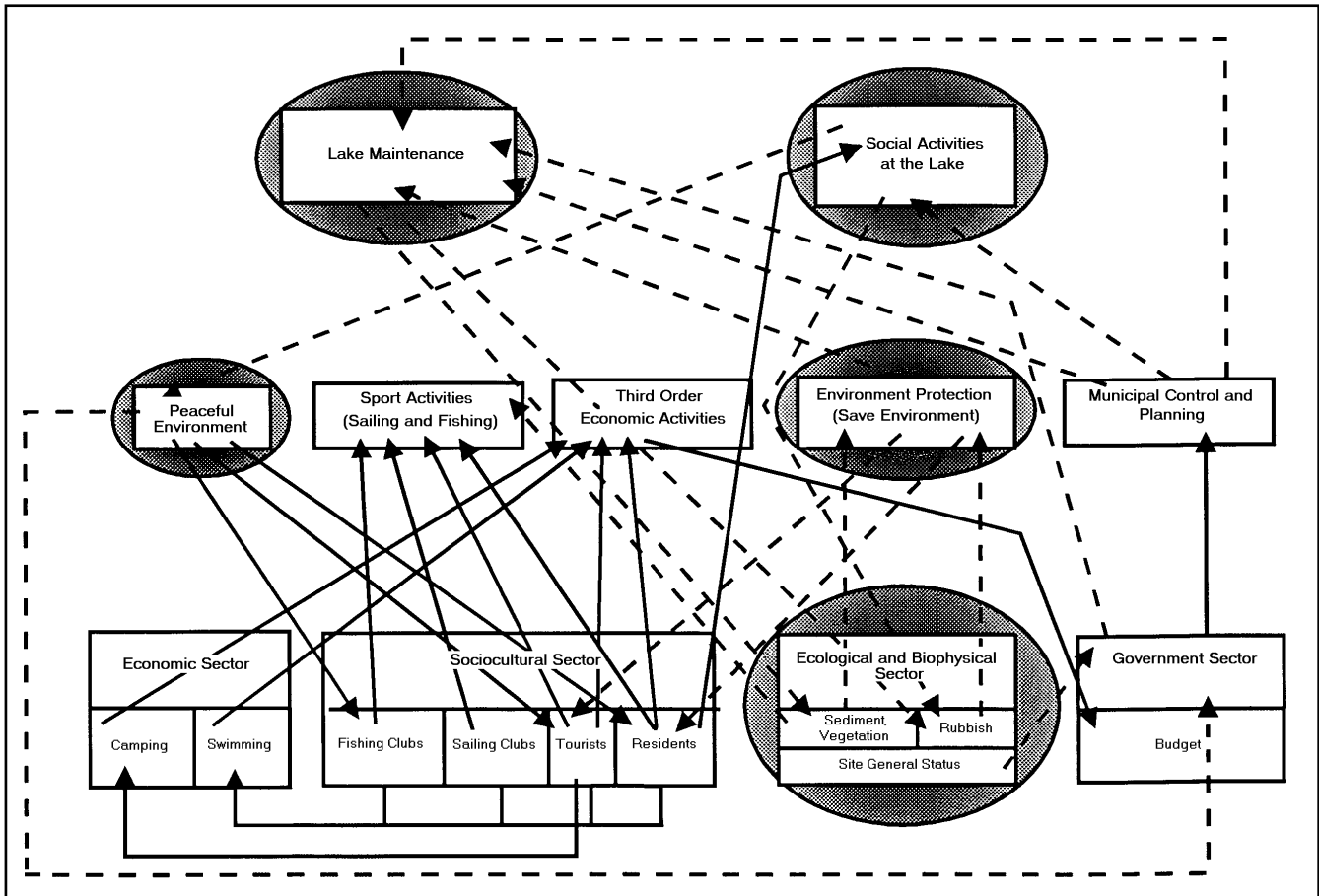


Figure 1. Interactions (arrows) and nodes (grey ovals) for Del Fuerte Lake system; solid lines: positive interactions, dotted lines: negative interactions. The addition of all interactions yields a value of +4.

studies should take adequate time and that substantial funds are needed. Given this scenario, expedited methodologies and fine-tuned, low-budget surveys represent an acceptable solution. In this particular case, such an approach yielded a model which was considered to be good enough to proceed to the next step of building several management alternatives.

ACKNOWLEDGMENTS

The authors deeply appreciate the review and comments made by several colleagues, whose cooperation helped improve many elements of this paper.

REFERENCES

American Public Health Association, American Water Works Association, Water Pollution Control Federation. *Standard Methods for the Examination of Water and Wastewater*, 17th Edition, 1989.

Gallopin, G., T. Lee and M. Nelson; The environmental dimension in water management: The case of the Dam at Salto Grande. *Water Supply and Management*, Vol. 4, pp. 221-241, 1980.

González Castelain, J., F. Grosman, F. Peluso and E. Usunoff; Diagnóstico limnológico, sanitario, ictiológico y estado ambiental del Lago Del Fuerte, Ciudad de Tandil. *Informe Final*. Instituto de Hidrología de Llanuras, 160 p., 1995.

Westman, W.; Ecology, Impact Assessment and Environmental Planning. *Wiley-Interscience*, John Wiley and Sons, 532 p., 1985.

JOURNAL OF ENVIRONMENTAL HYDROLOGY

The Electronic Journal of the International Association for Environmental Hydrology

On the World Wide Web at <http://www.hydroweb.com>

VOLUME 4

1996



MANAGEMENT ALTERNATIVES TO IMPROVE THE ENVIRONMENTAL QUALITY AT DEL FUERTE LAKE, ARGENTINA PART II. RESULTS AND PROPOSAL

Fabio Peluso
Eduardo Usunoff
José González Castelain
Fabián Grosman

Instituto de Hidrología de Llanuras
Azul
Pcia. de Buenos Aires, Argentina

This paper presents a spectrum of management alternatives of Del Fuerte Lake (Tandil City, Argentina), which emerged as a result of an environmental assessment whose methodology was described in Part I of this paper. A complex network of interactions among the components was identified, including several conflicting instances (defined in terms of interests, goals, and roles of all involved protagonists). Two different scenarios were distinguished: (a) problems related to the lake maintenance, and (b) issues concerning the type and application of regulatory measurements.

The management alternatives proposed are posed so as to eliminate or minimize the adverse effects of both type of conflicting situations. To do so, the current elements are reviewed and redefined and new elements are incorporated, all that under the premise of generating proposals of immediate application in the context of the existing municipal laws. The central issue is the redefinition of the so-called Lake Entity (LE), which was created to administer such a resource, although it never achieved an adequate functional status. The main goal is to transform it so that it can become a decentralized, cooperative, independent, and executive organization, of which all involved protagonists take part and open to the participation of the various technical and community groups. The LE would take on administrative and regulatory responsibilities and, after checking for agreement among the involved groups/individuals, propose and keep track of tactical and strategic issues directed towards the maintenance/improvement of the site.

INTRODUCTION

This paper presents the results of the methodological issues described in Part I of this paper, as they were applied to the Del Fuerte Lake system (Tandil City, Argentina) in order to characterize its current environmental status. Such a study consisted of (a) an exploratory phase, aimed at defining the system's structural and functional characteristics, and the impact of anthropogenic activities, and (b) a management phase, whose objective was to come up with proposals attempting to correct, ameliorate, and prevent the effects of the possible impacts. The conclusions of both activities will be presented below. It is assumed that the interested reader is familiar with Part I of this paper

RESULTS OF THE EXPLORATORY PHASE

System Structure: Natural and Institutional Components

Three diagnoses were obtained for the biophysical-ecological sector:

(a) Organoleptic evaluation of the lake: Some zones of 'unpleasant' aspect were detected, such as the sites where the two tributary creeks flow into the lake, the west margin of the lake, and the water outlet (dam), where rubbish, masses of aquatic vegetation, and sediment accumulation were found. Such features impact negatively on the users of the site and are not compatible with the potential uses of the water resource.

(b) Limnologic diagnosis and quality of water and sediment: The tributary creeks are an important source of phosphorous and nitrogen, although they carry low organic matter to the lake. The high chlorophyll concentration, the low penetration of light and the abundance of floating vegetation (submerged and riparian), point to the environment's high productivity. The oxygen content profiles indicate a state of oversaturation up to a depth of 1.5 m, whereas below a depth of 2-2.5 m undersaturation was measured (González Castelain et al., 1995). Taking into account the measured parameters and the classification found in Vollenweider (1968), the lake can be considered as hypereutrophic. There is a related accumulation of sediments carrying high levels of organic matter.

The results of the bacteriological analyses determined that the water does not impede any activity where direct contact occurs (National Technical Advisory Committee, 1968). Both the lake water and that of the tributary creeks did not show any sign of colifecal bacteria presence. Counts of total aerobic mesophilic bacteria and specific studies of the protist community are in agreement with the degree of abundance of biodegraded organic matter mentioned above.

(c) Ichthyological diagnosis: The submersed aquatic vegetation creates microenvironments which have great influence on the distribution of the fish community. The small size species (Fam. Characidae, Cichlidae, Poeciliidae, Jenynsiidae) are favored to the detriment of the Silverside fish (*Odontesthes bonariensis*), which needs open waters and is the target of sport fishing. There would not be interspecific competence for food. The relatively high abundance of fish matches the advanced trophic status of the system. The demographic parameters measured on samples of Silverside fish suggest that the species is under high pressure by sport fishing. The age distribution - mostly young specimens of 1 to 2 years - coincides with the high mortality rate due to fishing.

The socio-cultural diagnosis took into account most of the public and private institutions related to the system (directly or indirectly). Several pieces of information were retrieved: goals pursued, demands, and any kind of interest they may have on the lake, as well as the exogenous and endogenous

variables they consider important in order to define their institutional/individual standpoint (Gallopín, 1980; Westman, 1985).

The goals most frequently mentioned were: (a) control over the water resource; (b) tourism promotion; (c) innocuous lake-water status; (d) environmental protection; (e) the real capacity of the lake as a flood-preventing reservoir; (f) the achievement of an adequate environmental status in order to trigger/enhance direct and indirect profit-making activities; (g) grouping of people with similar recreational interests; and (h) promotion of sport activities which rely on the 'healthy' status of the system.

The demands voiced most were: (a) 'healthy and clean' environment; (b) landscape enjoyment; (c) being able to carry out recreational and sport activities; (d) peacefulness; (e) appropriate infrastructure; and (f) taking part of social meetings.

The endogenous variables highlighted by the various protagonists were: (a) environmental quality; (b) costs associated to the maintenance of the current infrastructure and services; (c) 'green belt' (grass, trees) status around the lake; (d) the effect of sediments accumulation on the lake's storage capacity; (e) cleaning frequency of swimming pools at a resort nearby; (f) number of members of recreational and sport clubs; (g) number of people who attend fishing and sailing competitions; (h) municipal economical and financial status; and (i) number of tourists and weather in summer.

As for the exogenous variables, they were identified as: (a) environmental quality (cleanup of the lake's margins, lake deepening, traffic); (b) number of members of recreational and sport clubs; (c) degree of community pressure for cleaning up the lake, the tributary creeks, and the effluent; (d) municipal funds available for general-purpose lake maintenance; (e) municipal control of the lake and/or existence of a management plan; and (f) aggressiveness of tourism promotion and number of tourists.

Identification of the System Functional Relationships

Once all sectors were characterized, then came the step of assessing the 'perceptions' of the involved protagonists about the current status (i.e., lake environmental quality) as well as of the exogenous and endogenous variables which were deemed as very instrumental in predicting the evolution of their respective sectors. All relationships among the various components were determined, and given a sense and a sign. Considering the high-level interactions described in Table 1, a schematic of the current situation was drawn (see Figure 1 in Part I of this paper). When it came to analyzing the conflicting points (nodes), it was evident that the system could be split into two subsystems with different problems as far as their environmental consequences goes: the first subsystem refers to lake maintenance issues, whereas the second one has to do with controlling and regulatory features. It should be noted that such subsystems are obviously interrelated, and that the division established was done for practical reasons.

Model Analysis

The first subsystem - lack of maintenance - is built around three nodes: **hindered status of the site**, the lack of fulfillment of the **environmental protection** objective, and the **lack of lake maintenance actions**. The municipal officers claim that the local government carries on activities aimed at preserving the site, but all other sectors do not believe that such actions are good enough to impede the general degradation of the system. That induces a negative effect on the 'Environmental Protection' goal, which is common to many protagonists. In turn, such a situation generates other

Table 1. Relationships among the various elements at Del Fuerte Lake system (in order to obtain a simpler operational view, some of them were collapsed into the larger groups seen in Figure 1, Part I).

Relationship: Origin⇒Target	Sign	Variables employed for its characterization
1. Objective economic tertiary activities ⇒Municipal government (permits, taxes)	+	Municipal viewpoint
2. Objective social activities at the lake ⇒General status of the site	-	Protagonists perception, organoleptic survey
3. Objective social activities at the lake ⇒Traffic problems	-	Protagonists perception
4. Objective municipal control and planning ⇒Social activities at the lake	-	Protagonists perception
5. Objective municipal control and planning ⇒Lake maintenance	-	Protagonists perception, organoleptic survey
6. Objective tourism promotion ⇒Economic tertiary activities	+	Protagonists perception
7. Objective environmental protection ⇒Lake maintenance	-	(Inferred)
8. Objective environmental protection ⇒Residents	-	Residents perception, number of users, other protagonists perception
9. Objective environmental protection ⇒Tourists	-	Tourists perception, municipal viewpoint
10. Objective lake maintenance ⇒Sediment accumulation, presence of aquatic vegetation	-	Sediment accumulation, maintenance status, protagonist perception
11. Objective peacefulness ⇒Fishing	+	Fishermen perception
12. Objective peacefulness ⇒Residents	+	Residents perception
13. Objective peacefulness ⇒Government sector	-	Municipal viewpoint sector
14. Objective peacefulness ⇒Tourists	+	Tourists perception
15. Traffic problem ⇒Peacefulness	-	Protagonists perception
16. Biophysical-ecological sector, sediment, vegetation ⇒Sailing	-	Protagonists perception, organoleptic survey
17. Biophysical-ecological sector, sediment, vegetation ⇒Fishing	-	Protagonists perception, organoleptic survey, ichthyological study
18. Biophysical-ecological sector, sediment, vegetation ⇒Environmental protection	-	Protagonists perception, organoleptic survey, ichthyological and limnological studies
19. Biophysical-ecological sector, site general status ⇒Government sector	-	Protagonists perception
20. Economic sector, campings ⇒Economic tertiary activity	+	Number of users, membership, residents views, campings owners perception
21. Economic sector, swimming pools ⇒Economic tertiary activity	+	Number of users, residents perception, organoleptic survey, swimming pools owners perception
22. Local government sector (Public Works and Tourism Promotion) ⇒Municipal planning and control	+	Perception by municipal officers
23. Local government sector (Budget Office) ⇒Lake maintenance	-	Perception by municipal officers (costs)
24. Socio-cultural sector, fishing clubs ⇒Fishing	+	Number of fishermen, membership, clubs infrastructure
25. Socio-cultural sector, fishing and sailing clubs ⇒Swimming pools	+	Swimming pools owners perception, number of users, infrastructure availability and status

continued..

26. Socio-cultural sector, sailing clubs ⇒Sailing	+	Number of sailing-interested people, number of annual sailing events, attendance to such events, number of boats
27. Socio-cultural sector, residents ⇒Economic tertiary activities	+	Protagonists perception
28. Socio-cultural sector, residents ⇒Social activity at the lake	+	Residents perception, other protagonists perception
29. Socio-cultural sector, residents and tourists ⇒Sailing and fishing clubs	+	Membership, protagonists perception, number of annual sailing or fishing events, attendance to such events, clubs infrastructure
30. Socio-cultural sector, residents and tourists ⇒Sports (other than sailing)	+	Protagonists perception, number of sport-interested people, attendance to sport events
31. Socio-cultural sector, residents and tourists ⇒Sailing	+	Protagonists perception, number of sailing-interested people, membership, clubs infrastructure, attendance to sailing events
32. Socio-cultural sector, residents and tourists ⇒Swimming pools	+	Swimming pools owners perception, number of users infrastructure availability and status
33. Socio-cultural sector, residents and tourists ⇒Fishing	+	Protagonists perception, number of fishermen, membership and infrastructure of fishing clubs
34. Socio-cultural sector, tourists ⇒Economic tertiary activities	+	Number of people interested in camping out, infrastructure status, protagonists perception
35. Socio-cultural sector, tourists ⇒Campings	+	Number of potentially users, infrastructure status, tourists perception, campings owner perception

negative issues: worsening of the current status, the depth loss and the abundance of aquatic vegetation affect the sport-related activities (sailing, windsurf, fishing, swimming), the ‘Clean Environment’ demand by residents and tourists is not fulfilled. Inasmuch as swimming in the lake is not seen as a safe activity, many residents and tourists use the nearby swimming pools (which means paying a fee). The lake maintenance (dredging, for example) has a negative component for the government because the lack of genuine funds has delayed the start of effective actions.

Likewise, interactions between the socio-cultural and the economic sectors are found because of the way that goals, demands and interests of the protagonists are affected (e.g., use of camping facilities by tourists, importance given by residents to sailing and sport-fishing, residents and tourists looking for a peaceful place). In addition to that, tourists, residents, and the economic sector favor the reactivation of tertiary profit-making activities (retail stores, private transportation services, etc.), which would promote the bettering of the municipal economy through increased revenues.

The second subsystem - lack of regulatory measurements - presents four nodes: the **hindered status of the site** seen as opposed to the objective of **environmental protection**, and an important ‘noisy’ **social activity** which acts negatively on the objective of **peacefulness**.

The current municipal laws are not considered as achieving an adequate level of regulation of the social activities in and around the lake, which causes some of the degradation of the system. There is a worsening of the lake’s sanitary status (rubbish accumulation) as well as additional effects on certain objectives (peacefulness, for example, because of disordered traffic and noise) of three elements belonging to the socio-cultural sector (sport-fishermen, tourists, and local residents). The on-going deterioration of the site affects the objective of **environmental protection**, which is common to many sectors, and gives raise to an increasing demand of maintenance tasks and the issuing of controlling and ordering rules, which become more difficult to be fulfilled by the local government as time advances because of lack of funds.

The addition of positive and negative interactions yields a final (relative) value of +4 for the current status in the system (see Figure 1 in Part I of this paper).

RESULTS OF THE SEARCH FOR MANAGEMENT ALTERNATIVES

The proposed management alternatives are aimed at achieving an adequate level of time-sustainable maintenance/improvement of the system based on two concepts: to fulfill as many objectives as possible among those voiced by the various sectors, and to keep the integrity of the natural environment. Such concepts summarize most of the retrieved demands and are in agreement with the existing municipal laws and rules. It should be said that what will be presented below is the best management alternative. Other proposals can be obtained by disregarding some of the suggested measures, which would yield higher cost/benefit ratios and, of course, present other 'best' management alternatives.

Policy and Strategies

It is imperative to modify the current municipal laws in order to reduce the number of conflicting nodes. The possible tactics, strategies, and specific proposals are constrained by the government's economical-financial status and the municipal management timing. Relevant suggestions are as follows:

- ◆ Revitalization of the Lake Entity (LE), an administrative and regulatory organization already created by municipal laws, although allowing the participation of all involved protagonists. Its existence should be guided by three principles (Bráñez, 1991): **independence** (with respect to the local government), **an active participation** of all sectors in technical-administrative issues and the definition of policies and strategies, and **social openness**.
- ◆ Instead of the lake and its surroundings, the LE should consider the entire watershed, which would produce a better control on all productive activities upstream (agriculture and cattle raising) and on urban development issues. This way, the system would be defined not only by the lake and its tributaries but also by their influence areas.
- ◆ Allowable uses on the basis of their potential environmental impact should be defined.
- ◆ There should be a reassignment of roles and functions, so that rights and responsibilities for each sector are clearly laid out.
- ◆ The LE should be as executive as possible in central issues (e.g., environmental management, enforcement of ad-hoc laws/rules, financial resources to carry on its planned activities).
- ◆ A detailed diagnosis should be implemented (including natural and institutional elements) to highlight all problems which may affect the target water resource.
- ◆ A water quality monitoring network should be organized.
- ◆ There is ample room to start actions oriented at improving and embellishing the site.
- ◆ The system is to be integrated naturally to the community, so that it can be considered as a factual patrimony.
- ◆ A revalorization of the lake should be promoted in the community as a way to erase the wrong current concept of a 'highly dangerous site'.
- ◆ Major efforts should be directed towards reducing the problems emerging from this study.

Correcting the System Conflicting Nodes

An adequate combination of the policies and strategies above, which were overlapped on the existing situation, yielded a value of +29 (Figure 1), which represents a giant step forward with

respect to the current status (+4) as shown in Figure 1, Part I.

An executive LE may be able to correct the lack of maintenance in and around the lake, by making use of the tools described above. That implies cleaning up margins, eliminating the aquatic vegetation, dredging of certain areas, etc., which (a) reverts the negative interactions on the

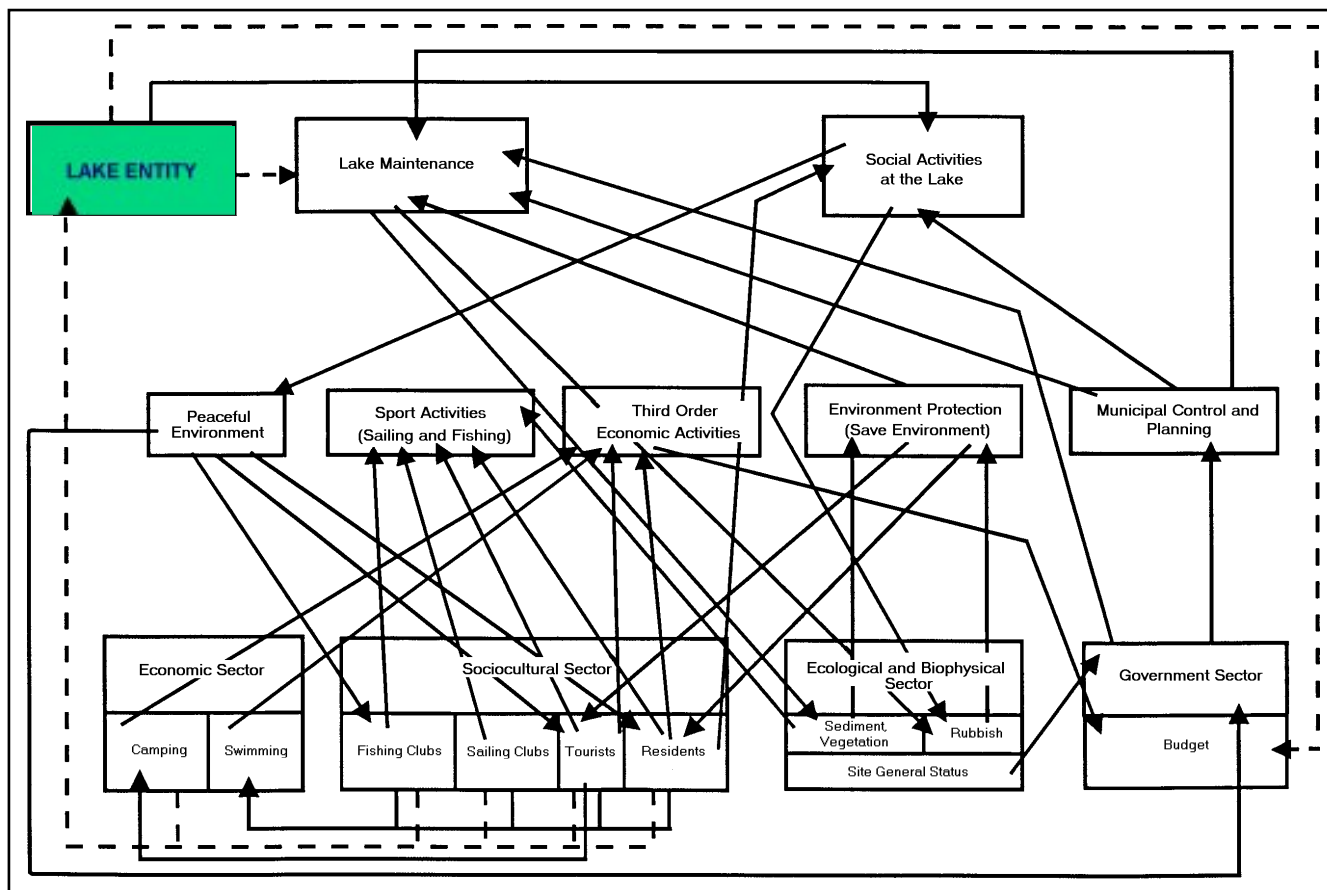


Figure 1. Interactions (arrows) for the Del Fuerte Lake system considering the existence of the Lake Entity; solid lines: positive interactions, dotted lines: negative interactions. The addition of all interactions yields a value of +29.

biophysical-ecological sector, (b) fulfills some objectives: environmental protection, promotion of fishing and sailing activities, and (c) due to the positive impact of having a clean site on the socio-cultural sector, there would be a noticeable development of tertiary profit-making activities. Such a potential status of the system reduces progressively the current complexity related to maintenance and cleanup issues, and increases the municipal revenues.

The LE would be in charge of regulatory and management details. In doing so, several interactions change their original sign (from negative to positive): socio-cultural sector, biophysical-ecological sector, as well as the goal of peacefulness. Positive effects would be generated among sectors (socio-cultural, economical) and objectives (tertiary profit-making activities, environmental protection, and promotion of recreational and sport activities).

CONCLUSIONS

This study was carried out keeping in mind the fact that there were few funds allocated for it (US\$ 8000), and that the local government wanted to have answers in no more than 45 days. In spite

of that, it was possible to achieve a 'sufficient' characterization of the site and its problems, which gave rise to a number of proposals aimed at correcting the current degraded state and establishing the basis of a future management plan. The comparison made between the current status and that potentially emerging from the application of the suggested and feasible strategies, through the quantification of all interactions, shows a substantial improvement.

Given the expected demand by local governments for expeditive, low-budget studies, this study shows that non-trivial results can be obtained with these constraints. Moreover, it is clear that acceptable solutions can be found making an adequate balance between the community goals and the existing government laws/rules, which closes the gap between utopian and economically and administrative feasible management plans.

ACKNOWLEDGMENTS

The authors deeply appreciate the review and comments made by several colleagues, whose cooperation helped improving the correct understanding of many statements in the paper

REFERENCES

- Bráñez, R.; Aspectos institucionales y jurídicos del medio ambiente, incluida la participación de las organizaciones no gubernamentales en la gestión ambiental. *Banco Interamericano de Desarrollo*, Washington, D.C., 142 p., 1991.
- Gallopin, G., T. Lee and M. Nelson; The environmental dimension in water management: The case of the Dam at Salto Grande. *Water Supply and Management*, Vol. 4, pp. 221-241, 1980.
- González Castelain, J., F. Grosman, F. Peluso and E. Usunoff; Diagnóstico limnológico, sanitario, ictiológico y estado ambiental del Lago Del Fuerte, Ciudad de Tandil. *Informe Final*. Instituto de Hidrología de Llanuras, 160 p., 1995.
- National Technical Advisory Committee; Water quality criteria report to the Secretary of the Interior. *Federal Water Pollution Control Administration*, Washington, D.C., 234 p., 1968.
- Panero, M.; Comités de cuenca como metodología de trabajo regional e interinstitucional. Pp. 126126in: IEMA. Latinoamerica, Medio Ambiente y Desarrollo. *Fundación Jorge E. Roulet*, 1990.
- Vollenweider, R.; Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorous as factors in eutrophication. *Technical Report Org. Econ. Coop. and Dev.* (OECD), DAS/CSI/68.27, Paris, 1968.
- Westman, W.; Ecology, Impact Assessment and Environmental Planning. *Wiley-Interscience*, John Wiley and Sons, 532 p., 1985.

ADDRESS FOR CORRESPONDENCE

Eduardo J. Usunoff
Instituto de Hidrología de Llanuras
Intendente Giraut s/n - C.C. 178
7300 Azul - Pcia. de Buenos Aires
ARGENTINA
e-mail: ihlla@uncagr.edu.ar
