

**CEC SECRETARIAT REPORT  
ON THE DEATH OF  
MIGRATORY BIRDS AT  
THE SILVA RESERVOIR  
(1994-95)**

REPORT OF THE  
COMMISSION FOR ENVIRONMENTAL COOPERATION  
SECRETARIAT

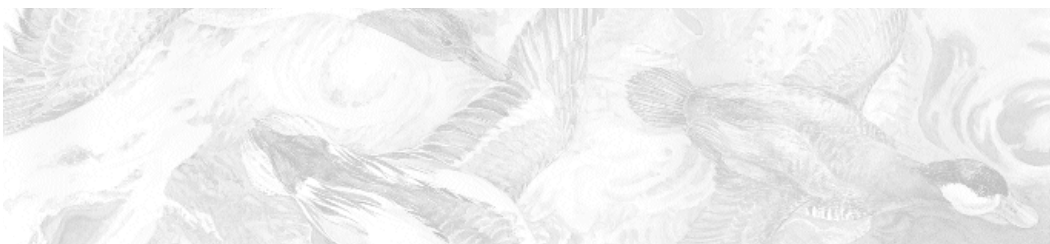
*TO THE*

COUNCIL OF THE COMMISSION  
FOR ENVIRONMENTAL COOPERATION

*SUBMITTED TO*

THE COUNCIL PURSUANT TO ARTICLE 13  
OF THE NORTH AMERICAN AGREEMENT  
ON ENVIRONMENTAL COOPERATION

Oaxaca, Mexico  
October 1995



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**The Death of Migratory Birds at the Silva Reservoir (1994-95)** is a Report of the Secretariat of the Commission for Environmental Cooperation (CEC).

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# NORTH AMERICAN AGREEMENT FOR ENVIRONMENTAL COOPERATION

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Three nations working together to protect the environment.

A North American approach to environmental concerns.

The Commission for Environmental Cooperation was established by Canada, Mexico and the United States in 1994 to address transboundary environmental concerns in North America. While the idea to create such a commission originated during the negotiations of the North American Free Trade Agreement (NAFTA), it derives its formal mandate from the North American Agreement for Environmental Cooperation (NAAEC).

The Agreement (NAAEC) builds upon and complements the environmental provisions established in NAFTA. It creates a North American framework whereby trade and environment-related goals can be pursued in an open and cooperative way.

In broad terms, the NAAEC sets out to protect, conserve and improve the environment for present and future generations. How? The parties to the Agreement set out the following objectives:

- to protect the environment through increased cooperation;
- to promote sustainable development based on mutually supportive environmental and economic policies;
- to support the environmental goals of NAFTA and avoid creating trade distortions or new trade barriers;
- to strengthen cooperation on the development of environmental laws and enhance their enforcement; and
- to promote transparency and public participation.

In signing the NAAEC, the governments of Canada, Mexico and the United States committed themselves to a core set of actions, including:

- reporting on the state of the environment;
- striving for improvement of environmental laws and regulations;
- effective enforcement of environmental law; and
- publication and promotion of information.



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The **Silva Reservoir Report** is submitted by the Secretariat to the Council of the Commission for Environmental Cooperation (CEC), pursuant to Article 13 of the North American Agreement on Environmental Cooperation (NAAEC). The report is composed of three parts. Part I, the Executive Summary, outlines the Secretariat's suggestions and conclusions; Part II, the Secretariat's Overview, provides background on the Silva Reservoir waterbird mortality and outlines the circumstances that gave rise to the report, and the Secretariat's approach and rationale for conducting the study. Part III is the report of the International Silva Reservoir Scientific Panel, established to address the scientific aspects of the incident.

The report responds to the request of the National Audubon Society, the *Grupo de los Cien Internacional*, and the *Centro Mexicano de Derecho Ambiental* (Mexican Environmental Law Centre) submitted to the Secretariat on June 6, 1995. The petition asked the Secretariat to prepare a report on the winter 1994-95 mass mortality of migratory waterbirds in the *Presa de Silva* (Silva Reservoir), located in Mexico's Guanajuato State. The petition (excluding supporting documents) is included as Annex 1 to this report.

The petitioners requested that the report include an account of actions taken by the government of Mexico in connection

with the waterbird die-off, as well as initiatives taken to control and reduce pollution in the Turbio River Basin where the Silva Reservoir is located, on the assumption that pollution may have caused or contributed to the die-off. The chronology of events occurring in the Silva Reservoir are provided in Part II, together with a brief discussion of the petition.

In undertaking the report, the Secretariat noted that the protection and conservation of migratory species, particularly waterbirds, has traditionally been a subject of mutual interest to Canada, Mexico and the United States, such interest expressed in part through cooperative arrangements pertaining to migration such as the North American Waterfowl Management Plan. Migratory birds are an important component of the CEC's 1995 work program.

The Secretariat further noted that the mass mortality of waterbirds in the Silva Reservoir (an estimated 20,000 to 40,000 birds) transcends local and national borders. The waterbirds that winter in the Reservoir, including shovelers, pintails, green-winged teal, ruddy ducks, American coot and eared grebes, are a shared resource of the three NAFTA countries; they migrate to Mexico from Canada and the United States along recognized flyways that are extensively protected by international treaties and agreements ratified by the three nations.

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## CEC REPORT PREPARATION

To respond to the petition and address the problems specific to the Silva Reservoir, the CEC Secretariat created the International Silva Reservoir Scientific Panel composed of specialists in waterbird biology, wildlife disease, toxicology, ecology, hydrology and chemical engineering. The panel was instructed 1) to report to the Secretariat on the possible causes of mortality of waterbirds in the Silva Reservoir; and 2) to provide advice as to what can be done: a) to reduce the likelihood of another die-off in the reservoir and watershed; b) to propose a response mechanism if and when similar die-offs occur in the territories of Canada, the United States and Mexico; and c) to identify opportunities for international cooperation arising from the work of the panel.

## CAUSES OF WATERBIRD MORTALITY IN THE SILVA RESERVOIR

Between 20,000 to 40,000 waterbirds are estimated to have died in the Silva Reservoir during the winter of 1994-95. The International Silva Reservoir Scientific Panel concluded that *“the overriding cause of mortality of waterbirds at the Silva Reservoir was botulism; however, a small percentage of birds may have died of other causes”*. The panel found that exposure to heavy metals, in particular chromium, lead and mercury, was indicated in some of the birds that the panel analyzed. In particular, the panel noted the elevated levels of chromium in surface sediment in the Silva Reservoir. Chromium is a heavy metal that is widely used by the industry of the region. The panel also pointed out that pollution from untreated sewage contributes to the

extremely eutrophic state of the reservoir, a condition that is often a precursor to outbreaks of botulism.

The panel also emphasized that any contaminant that could kill birds in the reservoir (heavy metals, organic pollutants, pesticide poisoning, etc.) could have contributed to an outbreak of botulism. In this scenario, bird carcasses from an initiating episode serve as the protein source for the botulinum toxin.

The International Silva Reservoir Scientific Panel based its conclusion on a variety of evidence. The signs exhibited by affected birds, the conditions in the reservoir, the long duration of the incident, the large number of affected birds, as well as the response of affected birds to treatment, were all consistent with an outbreak of botulism. The presence of botulinum type C toxin in tissues of several birds collected and frozen at the time of the incident and the presence in Silva Reservoir sediment of viable *Clostridium botulinum* spores capable of producing botulinum type C toxin provided further corroborating evidence.

The panel noted that the Silva Reservoir waterbird mortality should be viewed in the larger context of such events. Although the 20,000 to 40,000 waterbirds that died represents a significant number, die-offs of similar magnitude, as well as mortality involving up to 100,000 waterbirds, have occurred with relative frequency in North America since the end of the 19th century, continuing up to the present. Some of the largest recorded mass die-offs (up to one million migratory waterbirds) occurred early in this century in the United States and Canada. The National Wildlife Health Center (NWHC) has

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recorded at least 25 die-offs since 1970, each involving from 20,000 to 100,000 waterbirds. Most recently, a major die-off of 60,000 waterbird occurred in Alberta, Canada, during the summer of 1995. Mortality of this magnitude has also been reported in Mexico, for example in 1976 and 1977 at Sayula Lake, Jalisco.

The causes of death in these mass die-offs, where ascertained, were varied. Of the 25 die-offs reported by the NWHC, 17 were caused by botulism or avian cholera. Other causes of significant mortality include oil spills, and, less commonly, duck plague and trauma from storms. Waterbird deaths caused by toxins released from decomposing blue-green algae are rarely associated with mass die-offs. Similarly, pesticides and other man-made poisons have caused deaths involving from hundreds to a few thousand birds.

In addition to submitting recommendations to the CEC Secretariat for improving environmental conditions in the Turbio River Watershed and the Silva Reservoir that could reduce the magnitude and frequency of waterbird mortality, the International Silva Reservoir Scientific Panel presented conclusions and recommendations pertaining to international opportunities for wildlife management and disease control. As well, the panel commented on its initial impressions of the process. The Panel's recommendations are detailed in Part III.

## **CEC SECRETARIAT CONCLUSIONS AND SUGGESTIONS**

The Silva Reservoir incident could have an important long-term impact that goes well beyond the specifics of the waterbird

mortality. The incident, involving migratory species, clearly has relevance to all three countries in addition to having many facets of a more local or national nature. It serves as a reminder of the many biological connections that link the three countries and reinforces the shared responsibility that the three countries have to work together to conserve and protect these important international resources. The incident also provides an important learning experience and points to a number of potential opportunities to design and tailor responses that are addressed at the local, national and continental scales as circumstances warrant.

The Secretariat recognizes the important effort made by Mexican governmental agencies, scientific institutes and social organizations within the framework of the National Commission established by the Mexican government with the aim of identifying and evaluating the causes of the waterfowl mortality in the Silva Reservoir. Mexican authorities have also led in the development of the Turbio Basin Initiative and have been able to build a broadly-based constituency of stakeholders who are involved in efforts to clean up the Turbio River Basin.

## **MANAGING THE RESERVOIR**

In considering specific actions that might prevent, or at least minimize the likelihood of similar mass die-offs of waterbirds at the Silva Reservoir, the International Silva Reservoir Scientific Panel suggested four options for the Mexican government and Mexican people to consider, together with a summary of the major advantages and disadvantages of each option.

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The Secretariat endorses the panel's suggestions and, to this end, the Secretariat suggests to the Council of the CEC that:

- 1) these Silva Reservoir management options be considered:
  - monitor the Silva Reservoir for waterbird mortality and have in place an organized response plan if and when mortality is observed;
  - drain the Silva Reservoir if there is evidence of the onset of a waterbird die-off;
  - actively keep birds off the Silva Reservoir and develop other water body sites as more attractive habitat for migratory birds; and
  - alter the topography of the Silva Reservoir to make the reservoir less conducive to botulism outbreaks.
- 2) an assessment be conducted of the technical, engineering and economic feasibility of modifying the topography and operating regime for the Silva Reservoir, the assessment to be undertaken on a cost-sharing basis between Mexico, the United States and Canada, to determine the potential for establishing a modified storage reservoir that will enhance present irrigation uses while minimizing the potential for botulism outbreaks and perhaps alleviating some of the pollution problems that now exist.
- 3) the Mexican government be supported in its effort to actively encourage the increased involvement of local citizens in developing and implementing future actions with respect to the Silva Reservoir, since this participation will be important to the success of the efforts needed in this regard.

Drainage of the reservoir, the second option, might be regarded as a last resort that would be implemented only if monitoring of waterbirds on the reservoir indicates the onset of a waterbird die-off event. Options a) and c) would be made much more effective with significant local involvement and support. The fourth option, altering the topography of the reservoir, would provide a more permanent resolution to the problems at the reservoir. Considerable progress could be achieved by exploring the potential to design, modify and operate this reservoir, and perhaps other reservoirs, so as to make them less conducive to outbreaks of botulism. Ideally, this could also provide a means of addressing some of the pollution problems while at the same time maintaining or enhancing other uses of the reservoir.

With respect to suggestion 2, the Secretariat of the Commission would, if the governments so wish, be prepared to initiate a process for exploring the feasibility of altering the topography and operation of the Silva Reservoir. A first step might be to convene a small interdisciplinary panel of experts to develop design criteria for small irrigation reservoirs. Such an effort would challenge those involved to design small multipurpose reservoirs that are resistant to serious botulism problems. Design criteria for the Silva Reservoir could well have application to small reservoirs in each of the three countries.

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## Continental Waterbird Management

One of the principal recommendations of the International Silva Reservoir Scientific Panel is that Mexico develop a national program for wildlife health surveillance and for the investigation of, and response to, wildlife disease outbreaks. The Panel further recommends that this program be developed in partnership with existing programs in Canada and the United States.

The Secretariat endorses this recommendation and, **to this end, the Secretariat suggests to the Council of the CEC that:**

- 4) the governments of the United States, Canada and Mexico establish a Task Force of officials with responsibilities for migratory birds and aquatic habitat to:
  - a) work with Mexico in developing a national program for wildlife surveillance and for the investigation of, response to, and reporting of wildlife disease outbreaks;
  - b) build on existing programs and develop a cooperative North American system for the surveillance, investigation of, response to, and reporting of wildlife disease outbreaks.

## Managing Watersheds

The first principal recommendation of the International Silva Reservoir Scientific Panel is that Mexico continue through to completion the Turbio Basin Initiative. This initiative is both unique and comprehensive. It is an important

effort to involve a relatively broad cross-section of interests and stakeholders.

**To this end the Secretariat suggests to the Council of the CEC that it:**

- 5) encourage the Mexican authorities to continue to assign high priority to the Turbio Basin Initiative that was formally signed on February 9, 1995, and that the Initiative be continued through to its completion;
- 6) recommend to the governments of Canada and the United States and their relevant agencies to actively work with Mexico and its relevant agencies to seek opportunities to enhance this Initiative, as well as similar initiatives in the Lerma River/Lake Chapala Watershed through such means as:
  - a) technology transfer;
  - b) joint initiatives involving government, academia, industry and foundations; and
  - c) professional interchanges involving experts in hydrology and engineering, watershed research, and water quality monitoring and modeling.
- 7) recommend the establishment of an independent mechanism for monitoring and reporting on the progress and results of the implementation of the Turbio Basin Initiative. That this mechanism be broadly representative of all interested stakeholders, that it consist of representatives of governmental agencies and non-governmental organizations, and that it ensure appropriate access to relevant information on the progress of the implementation of the Initiative; and

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8) recommend to the governments of the United States and Canada that they actively support the Mexican government in pursuing international funds to establish necessary programs and activities and to help to build local and national capacity. A variety of funding means should be explored, including the World Bank and the Global Environmental Facility (GEF), as well as bilateral sources. The North American Development Bank in particular could represent a relevant source of financial resources for this end.

While neither the Panel nor the Secretariat examined regulatory and compliance issues, it is clear from analysis taken by the Mexican National Commission and by the Panel, that the Turbio River Basin is a highly polluted ecosystem and that much effort is needed to ensure an important decrease of industrial pollution in the region. These efforts will be important to the success of the Turbio Basin Initiative.

In this regard, the Secretariat suggests to the Council of the CEC that it:

9) recommend to the Mexican government to conduct a comprehensive evaluation of the environmental compliance situation in the Turbio River Basin area and that it design and implement a targeted pollution prevention program so as to decrease industrial pollution in a substantial way. The

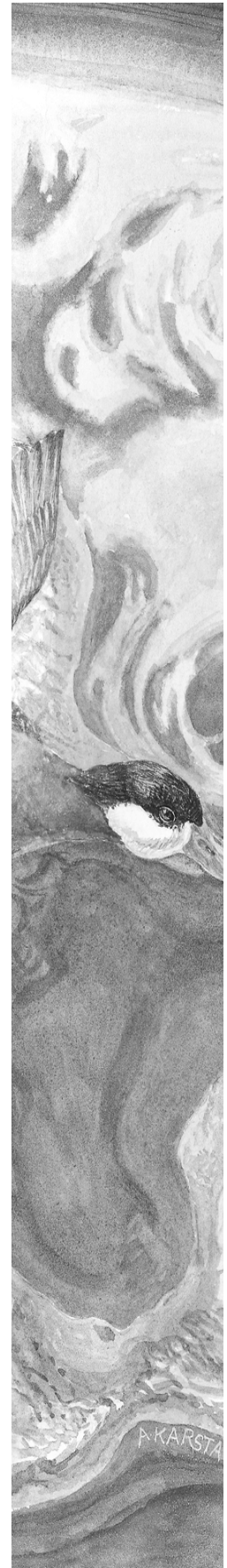
utilization of the mechanism proposed in suggestion 8), to follow up on these efforts, would be recommended in order to promote credibility, complementarity in actions, transparency and the participation of all interested stakeholders.

## **INTERNATIONAL OPPORTUNITIES**

The International Silva Reservoir Scientific Panel placed considerable emphasis on international opportunities. The Secretariat agrees with the positions expressed by the Panel in this regard. The Secretariat, like the Panel, believes that the Silva Reservoir incident could become an important catalyst for increased cooperation between Mexico, the United States and Canada and will make every effort to foster and encourage such an outcome.



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### MORTALITY OF MIGRATORY WATERBIRDS IN THE SILVA RESERVOIR

Migratory waterbirds from central Canada and the United States began arriving in the Silva Reservoir, located in central Mexico's Guanajuato State, in September 1994. The majority of birds arrived in November and December. The exact number is unknown as migratory bird populations fluctuate. As well, the chronology of events that occurred during the first months of the birds' arrival at the reservoir is unclear. Local residents first notified the appropriate health authorities of migratory waterbird mortality in the Silva Reservoir in October and early November. In late November and early December, a mass mortality or die-off of from 20,000 to 40,000 waterbirds took place, as evidenced by the degree of decomposition of the carcasses by mid-December.

In December, the deaths of thousands of migratory waterbirds attracted the attention not only of local residents, but also of national and international mass media and environmental organizations. Mexico's attorney general of the Ministry of the Environment, Natural Resources and Fisheries was notified of the mass die-off of migratory waterbirds on December 13, 1994, through the ministry's representatives in Guanajuato. An official delegation from the attorney

general's office arrived at the reservoir the following day to obtain samples for laboratory analysis. The attorney general subsequently ordered the ministry's *Comisión Nacional del Agua (CNA)*, which has oversight responsibility for federal water bodies, to investigate the causes of waterbird mortality at the reservoir. The CNA convened a panel in June 1995, composed of 19 representatives of governmental and non-governmental agencies (NGOs), as well as Mexican universities.

Local environmental groups and volunteers launched a rescue effort of the sick birds at the time of the die-off. Captured birds were treated with antibiotics, vitamins, glucose solution, clean water and food. The *Fundación Ecológica de Guanajuato (FEG)*, a non-governmental organization, began monitoring the reservoir in the third week of December and produced daily reports on the number of sick and dead birds, identified the species affected and counted the rehabilitated birds that were released. *FEG* members and volunteers transported sick birds to a field hospital situated near the shore of the reservoir. Approximately 500 sick birds were transferred to the León Zoo from which they are expected to be released this autumn (1995). In January, bird populations in the reservoir, as well as the numbers of sick and dying birds, decreased considerably. At the end of

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February, after the birds had abandoned the site, the CNA drained the reservoir of all its water.

### **PETITION SUBMITTED TO THE COMMISSION FOR ENVIRONMENTAL COOPERATION (CEC)**

On June 6, 1995, three non-governmental organizations (NGOs), the National Audubon Society, the *Grupo de los Cien Internacional* and the *Centro Mexicano de Derecho Ambiental* submitted a petition requesting the CEC Secretariat to prepare a report on the Silva Reservoir die-off under Article 13 of the North American Agreement on Environmental Cooperation (NAAEC). The petitioners asked that the Secretariat report both on the causes of the mortality of thousands of waterbirds at the Silva Reservoir and on the success of a joint federal-state initiative to monitor and reduce contamination in the watershed to which the Silva Reservoir belongs. The petitioners noted they suspected the contamination of causing or contributing to the mass mortality of the waterbirds. The petitioners also requested that the report contain an account of the Mexican government's actions in response to this waterbird die-off. (For the full text of the petition, see Annex I.)

### **SECRETARIAT'S CRITERIA FOR ACCEPTING THE PETITION AND PREPARING THE REPORT**

The petition was submitted pursuant to Article 13 of the NAAEC. Paragraph 1 of the Article allows the Secretariat to prepare reports, stating that: "*The Secretariat may prepare a report for the Council on any matter within the scope of*

*the annual program. Should the Secretariat wish to prepare a report on any other environmental matter related to the cooperative functions of this Agreement, it shall notify the Council and may proceed unless, within 30 days of such notification, the Council objects by a two-thirds vote to the preparation of the report.*" The Secretariat's work program for the year 1995 contains a project on migratory bird species. The CEC is to provide a coordinating framework to support national initiatives and trinational programs, as well as projects carried out by North American citizens for the purpose of protecting highly migratory species.

The Secretariat developed criteria with which to assess the merits of proposed Article 13 reports.

These criteria, which are listed below, were considered by the Secretariat and were important factors in the Secretariat's decision to prepare a report.

- The extent to which the matter under consideration directly relates to the annual program.
- How would the preparation of a report advance or contribute to the objectives of the Agreement and of the annual program?
- Impacts of budget and human resources on the work of the Secretariat.
- Whether other national or international organizations are more ideally suited to report on the matter.
- The extent to which a report by the Secretariat would impact beyond the discrete issue at hand as well as consideration of any multiplier effect produced by the report.

- 
- Whether any controversy generated by the report would advance or retard the overall development of the issue
  - Whether the report would contribute to trilateral or continental policies, provide a model, or develop useful information for issues of trinational significance.

## THE SILVA RESERVOIR AND THE TURBIO BASIN INITIATIVE

The Silva Reservoir is located 315 kilometers northwest of Mexico City in central Mexico's Guanajuato State. Built in 1884, it is one of several reservoirs in the Turbio River Basin constructed for irrigation of surrounding farmland. Though historical records are not available, it is likely that the Silva Reservoir has provided a refuge for migratory birds for the past century.

Situated about two kilometers northwest of the Silva Reservoir is the Santiago River, which feeds the reservoir through the San Roque Canal. The flow of the Santiago River is augmented by the León River, which carries untreated wastewater from the city of León, a thriving industrial centre noted for its tanneries. Without León's wastewater, which accounts for 70% of the river's volume during the winter months, the Santiago River is normally dry from November to June.

Besides the city of León, the municipality of San Francisco del Rincón in which the Silva Reservoir is located, at least 58 of the region's industries (including textile, leather, petroleum, coal, rubber and plastics factories) and area farmers discharge untreated wastewater into the Santiago. At the point of diversion into the Silva Reservoir, the river is almost entirely sewage. The water also contains

metals, red-dye, endosulfan and other pesticides, nutrients from agricultural runoff, and other pollutants. This water empties into the shallow basin of the Silva Reservoir, which has an average depth of about one metre. It should not come as a surprise that this extremely eutrophic reservoir and the Turbio River Basin of which it is a part (named for the Turbio River into which the Santiago flows) are part of a highly polluted ecosystem. (For a detailed description of the Silva Reservoir and the Turbio River Basin see Part III, the report of the International Silva Reservoir Scientific Panel.)

Several government programs have attempted to address pollution in the Silva Reservoir and the Turbio River Basin since 1987 with only limited success. In recognition that past efforts were stalled, the Mexican government revised its clean-up and restoration plan for the basin, expanding its scope, introducing accountability measures and establishing a time limit of two years for completion of its mandate. The new *Programa de Saneamiento Integral del Rio Turbio*, or Turbio Basin Initiative, established on February 9, 1995, is widely supported by residents of the watershed. The Initiative is guided by a federal-state committee, the federal *Comisión Nacional del Agua (CNA)* and Guanajuato State representatives. In addition to government, its members include representatives of industry and NGOs, including the *Fundación Ecologica de Guanajuato (FEG)*.

The Initiative's goal is the clean-up of industrial and municipal wastewater generated in León, San Francisco del Rincón and the neighboring municipality of La Purísima. The Initiative's five main components, slated for completion by mid-1997, include:

- Construction and start-up of a municipal wastewater treatment plant for the city of León. With a capacity of 2.5 m<sup>3</sup>/second, the plant will require an investment of NP\$200,000,000.00 (approximately US\$35 million). It is a conventional biological treatment plant.
- Construction of an ecologically-friendly industrial park near the city of León to which 120 tanneries are expected to relocate. The industrial park is to be equipped with a wastewater treatment plant with a capacity of 0.3 m<sup>3</sup>/second. This treatment plant would require an investment of NP\$60,000,000.00 (approximately US\$10 million). This facility is designed to allow reuse of 50% of the water entering the plant and recovery of 95% of the residual chromium generated during the tannery process.
- Construction and start-up of a municipal wastewater treatment plant for San Francisco del Rincón and la Purísima. The plant would have a capacity of 0.2 m<sup>3</sup>/second and a cost of NP\$20,000,000.00 (approximately US\$4 million).
- Construction of 49 industrial water treatment plants to process discharges from tanneries and other small industries that will remain outside the industrial park. Currently, ten of these plants are under construction.
- Strengthening inspection and enforcement activities by the appropriate authorities.
- Promotion of public awareness and scientific research on the environmental problems of the area.

## **STRATEGY PURSUED BY THE CEC SECRETARIAT IN PREPARING THE REPORT**

### **Creation of the International Silva Reservoir Scientific Panel.**

On July 6, 1995, the CEC Secretariat created the International Silva Reservoir Scientific Panel, which it charged with producing a scientific and technical evaluation of the possible causes of the Silva Reservoir mass waterbird mortality and drawing up recommendations aimed at preventing a reoccurrence. The panel was composed of nine recognized experts (Annex 3) from the three North American countries. Members served in a personal and professional capacity and not as representatives of their governments and agencies. The panel was created pursuant to Article 13 of NAAEC. As such, it was able to draw on the technical, administrative and financial support of the CEC Secretariat in carrying out its work. Dr. Andrew Hamilton coordinated the work of the panel on behalf of the CEC Secretariat.

The International Silva Reservoir Scientific Panel has been the Secretariat's primary means of building consensus on the scientific and technical dimensions of the migratory waterbird mortality. The panel's conclusions and recommendations have provided much of the foundation for the Secretariat's own deliberations and suggestions. The panel's recommendations are primarily focused on changes and initiatives that are desirable from the perspective of a scientific panel. The Secretariat strongly endorses the panel's recommendations and welcomes the opportunity they provide for the Secretariat and others to consider and suggest possible approaches and specific actions that could be taken in furthering and elaborating on these recommendations.

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## Terms of Reference the Report.

The terms of reference (Annex 4) approved by the International Silva Reservoir Scientific Panel were designed to:

- assess the probable causes of the mortality of local and migratory birds in the Silva Reservoir;
- determine the historical background as well as to forecast possible future incidents of mass mortality of waterbirds in the Silva Reservoir and other locations in the Turbio River Watershed;
- assess similar occurrences of mass mortality of resident and migratory waterbirds in Canada, the United States and Mexico;
- assess the nature, extent and significance of water pollution in the Silva Reservoir and the Turbio River Watershed;
- consider current initiatives, including local ones, to reduce pollution in the Turbio River, and recommend actions for achieving this;
- provide a summary of existing response mechanisms in North America for dealing with waterbird mortality;
- identify opportunities for international cooperation which may help to solve the Silva Reservoir problem;
- provide by August 31, 1995 a written report to the Secretariat covering the items listed and such matters as the panel considered appropriate;

- evaluate the strengths and weaknesses of the process by the CEC Secretariat in responding to the petition submitted by the three non-governmental organizations, as well as actions to be taken in writing future reports pursuant to Article 13 of the NAAEC.

## Meetings and Activities of the International Silva Reservoir Scientific Panel

The International Silva Reservoir Scientific Panel had eight weeks, beginning July 6, in which to complete its work. The Panel held its first meeting on July 6 and 7 in Montreal. Subsequently, it held other meetings in Mexico City (July 25 and 26) and Montreal (August 24 and 25). Some members of the Panel traveled to Mexico between July 10 and 14 to interview Mexican experts and government officials. On these same dates, several Panel members visited the Silva Reservoir to obtain frozen samples of dead birds from the mortality incident. Panel members also took sediment samples from the reservoir. The carcass and sediment samples proved important to the Panel's deliberations. Opinions and advice of experts and government officials familiar with the incident also proved significant. Additionally, many scientists and experts from the three countries provided relevant publications and advice.

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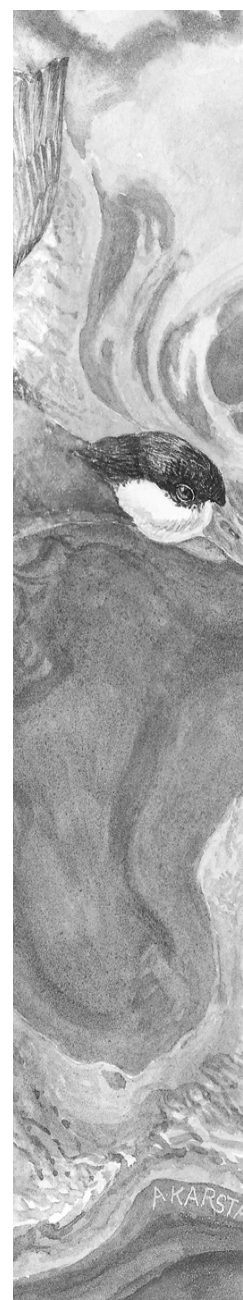


# AN ASSESSMENT OF THE 1994-95 MASS MORTALITY OF RESIDENT AND MIGRATORY WATERBIRDS AT THE PRESA DE SILVA IN MEXICO'S TURBIO RIVER BASIN

## PART III

*Prepared by The International Silva Reservoir Scientific Panel*

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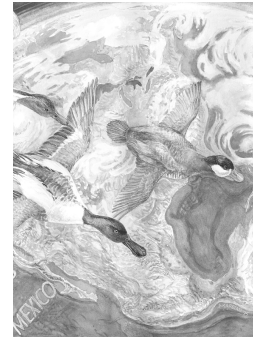


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# AN ASSESSMENT OF THE 1994-95 MASS MORTALITY OF RESIDENT AND MIGRATORY WATERBIRDS AT THE PRESA DE SILVA IN MEXICO'S TURBIO RIVER BASIN

## PART III

Prepared by The International Silva Reservoir Scientific Panel



### OVERVIEW AND BACKGROUND

The International Silva Reservoir Scientific Panel owes its existence to a set of unique circumstances. The mass mortality of 20,000 to 40,000 resident and migratory waterbirds that took place during the winter of 1994-95 at the *Presa de Silva* in Mexico's *Río Turbio* Basin (Silva Reservoir in Mexico's Turbio River Basin) was an important factor. However, as disturbing and unfortunate as the mass mortality was, there have been many examples of similar waterbird die-offs. They continue to occur. A waterbird mortality incident of similar magnitude occurred in Alberta, Canada, at the time that this report was prepared, and recent media reports indicate that an almost unprecedented die-off of waterbirds in England is now in progress. In these and numerous other cases, avian botulism is the identified cause.

The *Presa de Silva* became an important international media event when the observations and concerns of people living near the *Presa de Silva* were echoed by local and international environmental groups who helped to bring media attention to the Silva incident. Media

attention was often focused on the fact that many of the dead birds were ones that had migrated from the United States and Canada and were a part of a shared continental natural resource. Many of the affected species are protected under the International Migratory Bird Treaty Act. Some of them are also an important food resource for indigenous people living in remote communities.

Another important factor is the new North American Agreement on Environmental Cooperation (NAAEC), which was negotiated in 1993 as a side agreement to the North American Free Trade Agreement (NAFTA). The NAAEC contains many articles that could serve as a basis for treating the Silva issue as a matter warranting special attention. For example, Article 1 includes the objective "to increase cooperation between the parties (Canada, the United States and Mexico) to better conserve, protect, and enhance the environment, including wild flora and fauna."

Of even more importance is Article 13 of the NAAEC. The Article provides the Secretariat of the new Commission for Environmental Cooperation (CEC) a far-

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reaching mandate to prepare reports on matters covered within its annual work plan or, in some circumstances, on matters falling within the scope of the Agreement. It was this Article that prompted three environmental non-governmental organizations (NGOs) the National Audubon Society, the *Grupo de Los Cien Internacional* and the *Centro Mexicano de Derecho Ambiental*, to request the Secretariat to prepare a report addressing the deaths of resident and migratory waterbirds at the *Presa de Silva* in Mexico's *Río Turbio* Basin.

### **THE INTERNATIONAL SILVA RESERVOIR SCIENTIFIC PANEL**

The Secretariat of the Commission for Environmental Cooperation formed the International Silva Reservoir Scientific Panel to assist in preparing a report on the mass mortality of resident and migratory waterbirds that occurred during the winter of 1994-95 at the *Presa de Silva* in Mexico's *Río Turbio* Basin. The panel was made up of nine members — three from each country — with expertise in a variety of scientific and engineering disciplines including waterbird biology, wildlife diseases, wildlife toxicology, ecology, hydrology and industrial chemistry. Dr. Linda Glaser, Dr. Jorge Soberón and Mr. Joe Carreiro, from the United States, Mexico and Canada respectively, served as co-chairs of the panel. Throughout their work, the members served in a personal and professional capacity while being encouraged to keep their respective agencies and governments aware of the activities and progress made by the panel.

The International Silva Reservoir Scientific Panel had eight weeks to complete its work. It formally began its

work and held its first meeting in Montreal on July 6 and 7. The panel has subsequently held two other regular meetings, on July 25 and 26 in Mexico City and on August 24 and 25 in Montreal. In addition, several members of the panel spent the period from July 10 and 14 in Mexico, where panel members met with Mexican experts and government officials. Some members of the panel also visited the *Presa de Silva* site. Two panel members, Dr. Linda Glaser and Dr. Trent Bollinger, obtained samples of frozen waterbirds that had died during the mass mortality at the reservoir. In addition, a series of sediment samples were taken from the then-exposed bottom sediment of the reservoir.

The panel relied on a number of sources of information as well as the expertise and experience of its membership. A great deal of useful information concerning the mass waterbird mortality at the *Presa de Silva* was made available to the panel. Government, academic and NGOs have all participated in gathering this information. Once the importance of the matter was recognized, an exceptional effort was made to document and understand what had happened. While this information tends to relate primarily to the later period of the incident, it was nevertheless very useful to the panel. Officials of the *La Comisión Nacional del Agua* (National Water Commission) were particularly helpful in providing information on the *Río Turbio* and *Río Lerma/Lago Chapala* watersheds (*Turbio* River and *Lerma* River / *Lake Chapala* watersheds). These officials also helped to acquaint panel members with initiatives underway to reduce pollution in these watersheds.

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The samples collected by panel members referred to above were also important to the panel's deliberations. Another important source of information was the opinion and advice of experts and officials familiar with the incident. Scientists and other experts in all three countries provided many relevant publications as well as high-quality advice.

The panel had two primary tasks. The first was to provide the panel's assessment of the cause(s) or probable cause(s) of the bird deaths that occurred last winter in the *Presa de Silva*. The second was to provide advice as to what can be done: a) to reduce the likelihood of a recurrence of a similar die-off in the reservoir and watershed; b) to provide for an appropriate response mechanism if and when similar die-offs occur in the territories of Canada, the United States and Mexico; and c) to identify opportunities for international cooperation that could arise as a result of the work of the panel.

## CONCLUSIONS AND RECOMMENDATIONS OF THE PANEL

### Waterbird Considerations

**The panel has concluded that the overriding cause of mortality in waterbirds at the *Presa de Silva* was botulism; however, a small percentage of birds may have died of other causes.** Exposure to heavy metals, including lead, mercury and chromium, was indicated in some of the birds and may have contributed to their deaths. The pollution of the reservoir by untreated municipal sewage contributes to the extremely eutrophic state of the reservoir, a situation that is often an important factor in the initiation of botulism

outbreaks. Similarly, conditions that could kill a moderate number of birds on the reservoir, such as exposure to heavy metal and organic pollutants, could also trigger a subsequent and larger die-off from an outbreak of botulism, as the bird carcasses from an initiating episode could serve as the necessary protein source for production of botulism toxin.

The untreated municipal sewage entering the *Río Turbio* and its tributaries is undoubtedly a major contributing factor to the excessive algae growth in the *Presa de Silva*. The effects of industrial pollutants such as chromium are not as visible, but excessive amounts of pollutants are entering the *Presa de Silva* via the *Canal San Roque*. Sediment cores taken in the deeper parts of the reservoir have much higher concentrations of chromium in the surface layers than in the lower sediment. While the significance of these concentrations (200 to 300 parts per million [ppm]) to waterbirds is uncertain, the levels are an order of magnitude greater than the guidelines adopted by the United States Environmental Protection Agency (EPA) for non-polluted sediments.

The definitive test for botulism is based on serum samples from sick, live birds. Since the outbreak is over, it is almost impossible to be certain that the bird deaths were due to an outbreak of botulism. Nevertheless, the overwhelming weight of evidence, in the judgment of panel members, points to an outbreak of botulism. As explained in the text of this report, the major lines of evidence leading to this conclusion are:

- the descriptions of the signs exhibited by the affected birds as well as the video recordings of the dead and dying birds at the *Presa de Silva*. The signs exhibited by the birds and the

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conditions in the reservoir were typical of those seen with other documented cases of botulism;

- the reports from the *Fundación Ecológica de Guanajuato* (Ecological Foundation of Guanajuato) and the *Zoológico León* (León Zoo) indicated that many affected birds recovered when given basic care. This too is typical of botulism outbreaks;
- the presence of botulinum type C toxin in tissues of several birds collected during the die-off;
- the presence of viable *Clostridium botulinum* spores capable of producing botulinum type C toxin in sediment of the *Presa de Silva*;
- that many of the conditions in *Presa de Silva* were conducive to botulism outbreaks, including the shallow basin, the fluctuating water levels, the extreme eutrophy and the abundance of algae;
- that the mortality of the waterbirds continued over a period of several months;
- that other postulated causes, such as poisoning by chromium or other heavy metals, the presence of algal toxins associated with the decomposition of blue-green algal blooms, poisoning by a pesticide such as endosulfan, and the presence of dyes at concentrations toxic to waterbirds were considered but, in the judgment of the panel, the available evidence in support of any or all these possibilities was not nearly as compelling as that for botulism.

**The panel recommends that Mexico develop a national program for wildlife health surveillance, for the investigation of, and response to, wildlife disease outbreaks.** Such a program would facilitate timely and

effective responses to wildlife health issues and disease outbreaks and would provide a focal point for coordination within Mexico. It would also provide an opportunity for collaborative work with similar programs in the United States and Canada. Such collaborative programs would also enable the three countries to develop appropriate continental responses to wildlife disease outbreaks, especially those involving migratory and endangered species.

The panel also offers a number of response options for consideration by the Mexican government and Mexican people. These short- and medium-term options include: 1) monitoring the *Presa de Silva* for waterbird mortality and having in place an organized response plan, if and when waterbird mortality is observed; 2) draining the *Presa de Silva*; 3) actively keeping birds off the *Presa de Silva* and developing other water body sites as more attractive habitat for migratory birds; and 4) altering the topography of the *Presa de Silva*. These options and some of their respective advantages and disadvantages are discussed later in this report.

## **Watershed Considerations**

Detailed information on the hydrology, ecology and limnology of the watershed was not as easy for the panel to obtain as that relating directly to the *Presa de Silva* incident. Although we have no doubt that a longer and more complete search would have yielded considerably more information, in some instances the information may not be available. The information obtained by the panel clearly shows that the *Río Turbio* and its major tributaries are a very polluted and highly stressed ecosystem. As outlined above

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and elsewhere in the text of this report, the panel considers the generally degraded condition of the *Río Santiago*, a major tributary of the *Río Turbio*, to be an important contributing factor to the waterbird die-off that occurred at the *Presa de Silva*. The *Río Turbio* Watershed is an important sub-basin of the larger *Río Lerma — Lago Chapala* Watershed.

The challenges involved in developing appropriate and cost-effective remedial measures to restore and maintain the ecological integrity of the waters of the *Turbio* and *Río Lerma — Lago Chapala* Watersheds are very great. The panel acknowledges the considerable efforts that are now underway to limit industrial and municipal pollution in these basins. The *Programa de Saneamiento Integral del Río Turbio* (Turbio River Initiative) being led by the *Comisión de Trabajo para el Saneamiento* is a comprehensive clean-up program for the river. The panel believes that this unique comprehensive effort to address the serious water pollution problems in the watershed warrants continued and increased support. **The panel encourages the Mexican government and people to continue to work towards the full implementation of the *Programa de Saneamiento Integral del Río Turbio*.**

The aquatic ecosystems in the *Río Lerma — Lago Chapala* Watersheds are very important to the people of Mexico. Despite the many stresses that have been placed on these systems in the last few decades, they continue to support a significant proportion of the unique and diverse fish species that once existed in these watersheds. The *Río Lerma — Lago Chapala* Watershed ecosystem provided a geographically-isolated setting for the evolution of many species of fishes unique to this basin. Large lakes and their watersheds, especially those that have

existed for long periods of time, are ideal locations for the evolution of new species of freshwater fish and other freshwater organisms. Unfortunately, the biodiversity of these once-sheltered ecosystems is particularly sensitive to disruptions, especially those resulting from human activity. In essence, the same physical barriers that once served to protect and enable the rapid evolution of species now prevent endemic species from reaching other less threatened ecosystems. The separate initiatives now underway to improve water quality in the *Río Turbio*, *Río Lerma* and in *Lago Chapala* will potentially have important benefits for the conservation and sustainable use of freshwater biological diversity in the region.

The panel had limited time to focus on the larger watershed issues. However, there will be a continuing need for monitoring, modeling and research to fill in important gaps in the understanding of the system, to better assess the state of the affected ecosystems, and to monitor and document the recovery that can be expected to accompany the implementation of remedial programs such as those underway under the *Programa de Saneamiento Integral del Río Turbio* and the *Río Lerma — Lago Chapala* initiative. Clearly, *Lago Chapala*, Mexico's largest lake, is serving as an integrator of the stresses and remedies taking place within its watershed. The potential for important hydrology, ecology and limnology investigations to help establish the lake and its components as primary indicators of progress is clear. The panel notes the importance of *Lago Chapala* to Mexico and to the basin and encourages further effort to develop a more comprehensive understanding of the lake and its interdependence with its watershed and the human activities within that watershed.

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## International Opportunities

The International Silva Reservoir Scientific Panel believes that the *Presa de Silva* incident could become an important catalyst for increased cooperation between Mexico, the United States and Canada. At one level, there is potential for increased cooperation, collaboration and assistance among the federal governments and their responsible agencies and jurisdictions. Other sectors that could all play important and significant roles in fostering and encouraging meaningful cooperation include industrial and financial interests, universities and other academic institutions, environmental NGOs, private foundations and private citizens.

**The panel urges the governments of Mexico, the United States and Canada to foster and encourage cooperative initiatives to address both the waterbird and watershed dimensions of the *Presa de Silva* incident. It further recommends that the Commission for Environmental Cooperation (CEC) continue to play an active role in assisting governments through promoting and facilitating cooperative activities and initiatives aimed at understanding and addressing the many stresses on the waterbirds and waters of the *Río Turbio* and *Río Lerma* — *Lago Chapala* Watershed ecosystem.** The panel believes that the Commission's continuing active support would be an important contribution to the conservation and protection of the environment in the basin, while also making an important contribution to furthering ecologically and economically sustainable development. The intent is not to divert attention from other worthy opportunities. The panel recognizes that there are many other areas in the three

countries that would benefit from cooperative initiatives. Rather, it is the panel's hope that progress made in responding to the *Río Turbio* incident would in turn provide encouragement and stimulus elsewhere.

## The Panel's Initial Impressions of the Process

The members of the panel see a great deal of potential for the Secretariat of the Commission for Environmental Cooperation (CEC) to make major contributions to the achievement of objectives set out in the North American Agreement on Environmental Cooperation (NAAEC). However, the Secretariat is likely to find itself under considerable pressure to respond to an unmanageable number of requests to prepare reports under Article 13. In the panel's opinion, the timely and selective use of the opportunities provided by this Article are critical to its effective use by the Secretariat. The panel also notes that the Article enables the Secretariat to consider the preparation of reports without the necessity of waiting for formal requests. Although the panel believes that issues such as the *Presa de Silva* incident can serve as important catalysts for cooperative initiatives and action, it also encourages the Secretariat to be alert to the more proactive opportunities provided by Article 13.

The panel believes that this first use of Article 13 by the Secretariat of the CEC has provided important opportunities that would not have been available prior to the negotiation of the NAAEC. Although the panel accepted the short timeframe allowed to complete this work and recognizes the need for a quick response, it urges the Secretariat to



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recognize that it is desirable to provide more time whenever feasible.

The approach to financing of the panel's work seems appropriate for reports of this nature. In the view of the panel, an effective balance was achieved between seeking advice, building consensus and ensuring cooperation. The panel feels it is appropriate for the "partner" governments to cover the salary costs of personnel who are involved on a part-time basis with the work of the CEC. The panel agrees that it is appropriate for the Secretariat of the CEC to cover the travel costs of all panel participants. In future, the panel recommends that, where

appropriate, the Secretariat and the parties to the Agreement arrange to second or assign experts on a full-time basis from government or elsewhere to assist in the preparation of Article 13 reports. Finally, the panel feels that panel members involved in the preparation of such reports who are at a financial disadvantage, such as private consultants, university personnel, and persons from NGOs should be compensated by the Secretariat for their time as well as for specific products such as laboratory analyses. This would make it easier for such people to participate in future panels.

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# ISSUE BACKGROUND

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A die-off during late 1994 and early 1995 of several tens of thousands of ducks and other waterbird species in the *Presa de Silva*, Guanajuato, is one of the largest registered in Mexico. The event was the object of major media focus and raised many questions about human health and the ecological implications of a watershed stressed by municipal and industrial effluents, and agricultural and industrial activities.

Environmental awareness in Mexico has improved noticeably in the last fifteen years. This is perhaps due to the rapid and obvious deterioration of environmental quality in major cities and in the countryside, and the resulting explosion of civil groups. Whereas in the seventies there was a single registered non-government organization (NGO) dedicated to environmental issues, at this time there are about 700 registered groups. In addition, scientific capabilities have increased dramatically both in numbers and in the level of expertise (as an example, in 1995 there are more than 150 scientists in Mexico who have Ph.Ds in Ecology, which is at least ten times the number existing in 1975). Sustained pressure from NGOs, an increasingly vocal scientific sector, international commitments and media attention have moved Mexico towards changes in legislation and policies that reflect a much greater environmental awareness.

On the international front, an important recent development was the negotiation of the North American Agreement on Environmental Cooperation (NAAEC), which took place as a result of the North American Free Trade Agreement (NAFTA). NAAEC was envisioned as a mechanism to promote 1) cooperation among countries to solve environmental problems; and 2) compliance with each country's environmental legislation.

Traditionally, Mexico, Canada and the United States have demonstrated a joint interest in migratory birds, especially waterbirds, and have cooperated in their management for many years. Migratory birds are regarded as a shared resource of the three countries. Bird-watchers, nature lovers, hunters and scientists are very interested in waterbirds, not only as subjects of study in their own right, but also as indicators of ecosystem health and of factors potentially harmful to humans.

Following a submission from three NGOs (the National Audubon Society, the *Grupo de Los Cien Internacional* and the *Centro Mexicano de Derecho Ambiental*), the Secretariat of the trinational Commission for Environmental Cooperation (CEC), which has a number of reporting roles under the NAAEC, decided to convene a panel of experts from the three countries. The purpose of this panel was to present the Commission

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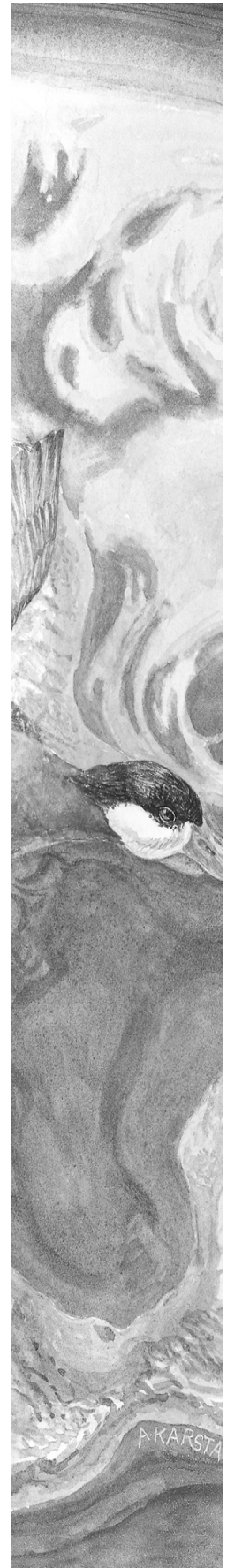
with a report on 1) the possible causes of the die-off; and 2) preventive and corrective measures which, if taken, would minimize the likely impacts of such a die-off. Canada and the United States have experienced many such events. By combining this experience with resident expertise in Mexico, the Secretariat hoped that Mexico and the other parties to the Agreement would be in a better position to anticipate, manage and prevent such catastrophes in the future.

The panel was pleased to find that the Mexican government and the people in the region surrounding the *Presa de Silva* have shown a strong response and stewardship, recognizing the environmental tragedy and doing their best in the face of a rapidly escalating waterbird mortality. Ecologists, chemists, veterinarians, wildlife specialists and many citizens worked *gratis* to provide help and advice to the government. Much of this effort was also of help to the work of this panel.

# PRESA DE SILVA DIE-OFF

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### Location and Chronology of Events

Migratory waterbirds from nesting areas in central Canada and the United States first arrived on the *Presa de Silva* in Guanajuato State during September 1994. Sustained by the polluted *Río Santiago*, a tributary of the *Río Turbio*, the *Presa de Silva* is located 35 kilometres south of the city of León and 315 kilometres northwest of Mexico City in central Mexico. A tributary of the *Río Santiago*, the *Río León*, flows south from the city of León. The *Presa de Silva* is about 365 kilometres inland from the Pacific coast (Figures 1, 2, and 3).

Although there are no accurate estimates of waterbird numbers at the *Presa de Silva* during the time of the mortality event, populations were reported to fluctuate over time, with the largest numbers occurring in November and December. The chronology of events in these early months is unclear. Low level mortality in birds on the reservoir was apparently observed by local residents in October or early November, and concerned residents relayed this information to local health officials at that time. Starting in November, Mexican officials began to release water from the reservoir for crop irrigation. The rate of mortality apparently increased in mid-November to early December, based on local reports, video recordings and on the degree of decomposition of birds found in mid-December.

By mid-December, the large number of sick and dead birds on the *Presa de Silva* caught the attention not only of residents, but also of media and environmental groups. News of the mortality event reached the public through newspaper, television and word of mouth. The *Comisión Nacional del Agua* initiated its investigation of the event at that time. Several government and non-government organizations (NGOs), and universities participated in the investigation effort. Water, sediment, and carcass samples were collected for study. Collection and disposal of carcasses were also initiated.

In addition to the investigation, local environmental groups and volunteers responded to the die-off by capturing and treating affected birds. Treatment included administration of antibiotics, vitamins, glucose solution, fresh water and food. Regular monitoring of the site began by the third week in December. The *Fundación Ecológica de Guanajuato* (Ecological Foundation of Guanajuato) kept daily records of the number of sick and dead birds, the species of birds affected, and the number of birds that recovered and were later released. Sick birds were collected and taken to the “field hospital” located near the shore of the reservoir. About 500 sick birds were taken to the *Zoológico León* (León Zoo). Birds that recovered were periodically released on other reservoirs within the *Río Turbio* Basin. Birds that did not

respond to therapy in time for the spring migration were kept at the zoo, and released in the fall of 1995.

Populations of birds on the reservoir and the number of birds found sick and dying were reported to decrease in January and remained at low levels until the third week of February according to data supplied by the *Fundación Ecológica de Guanajuato*. Beginning in mid-February, the population of waterbirds on the *Presa de Silva* increased and, with this

increment, there was a corresponding increase in mortality. The larger population in February may represent the migration of birds from more southern overwintering sites to breeding grounds in the north. By the end of February, the reservoir was almost completely drained and waterbirds that had survived began their spring migration. A few affected birds remained on the small ponds along the east side of the reservoir, which still contained water.

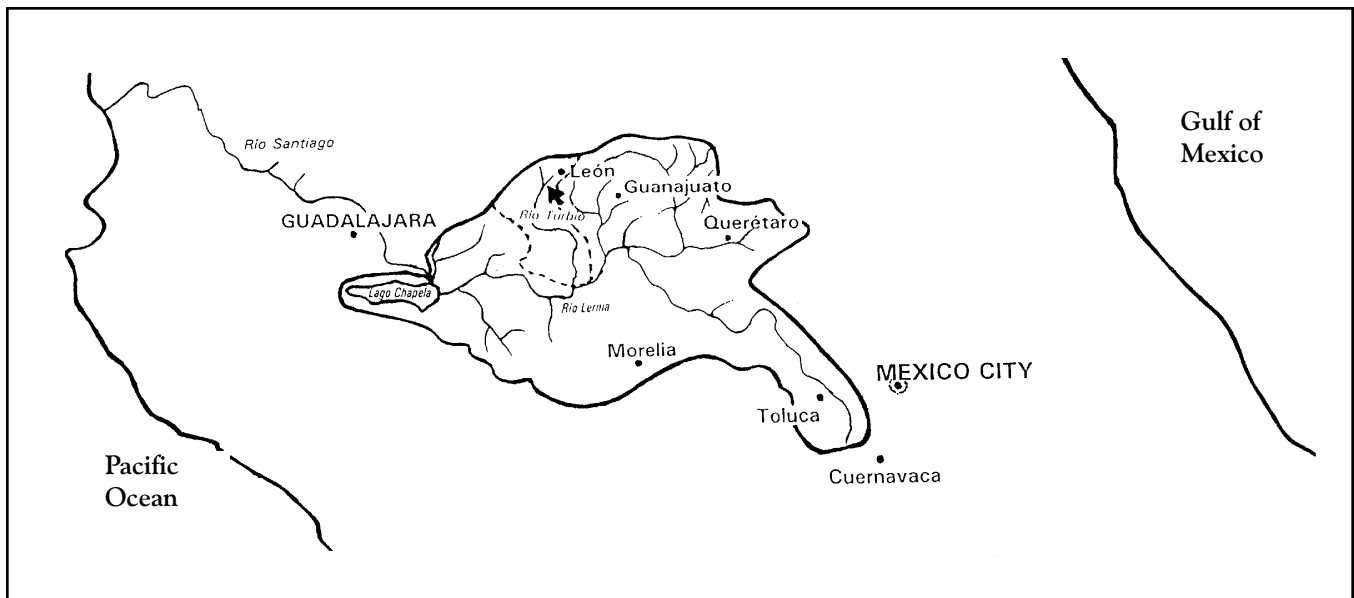


Figure 1. Location of Mexico's *Río Turbio* Basin.

- Watershed divide for the *Río Turbio* Watershed
- - - Watershed divide for the *Río Lerma* — *Lago Chapala* Watershed
- ↖ Location of the *Presa de Silva*

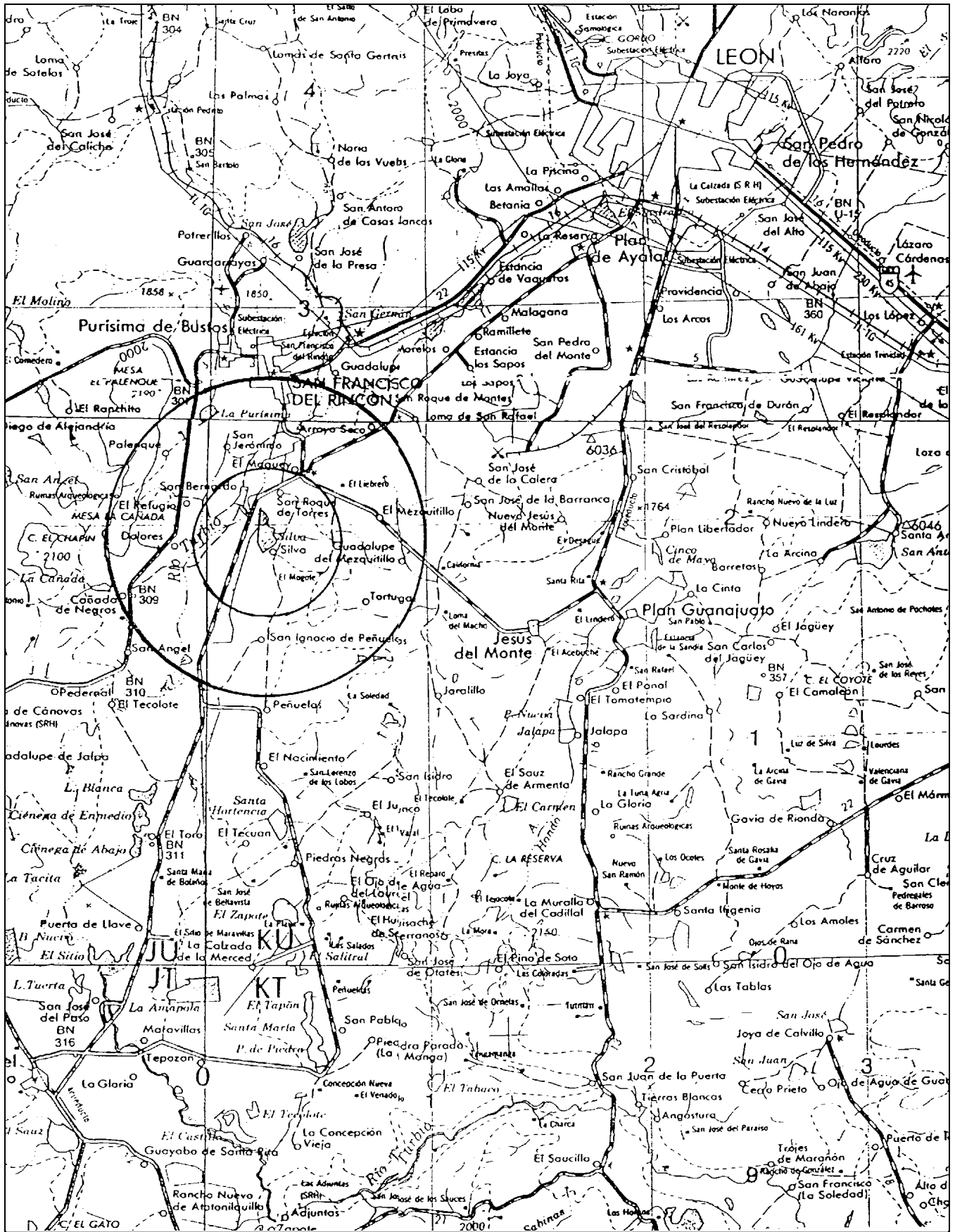


Figure 2. The location of the Presa de Silva.

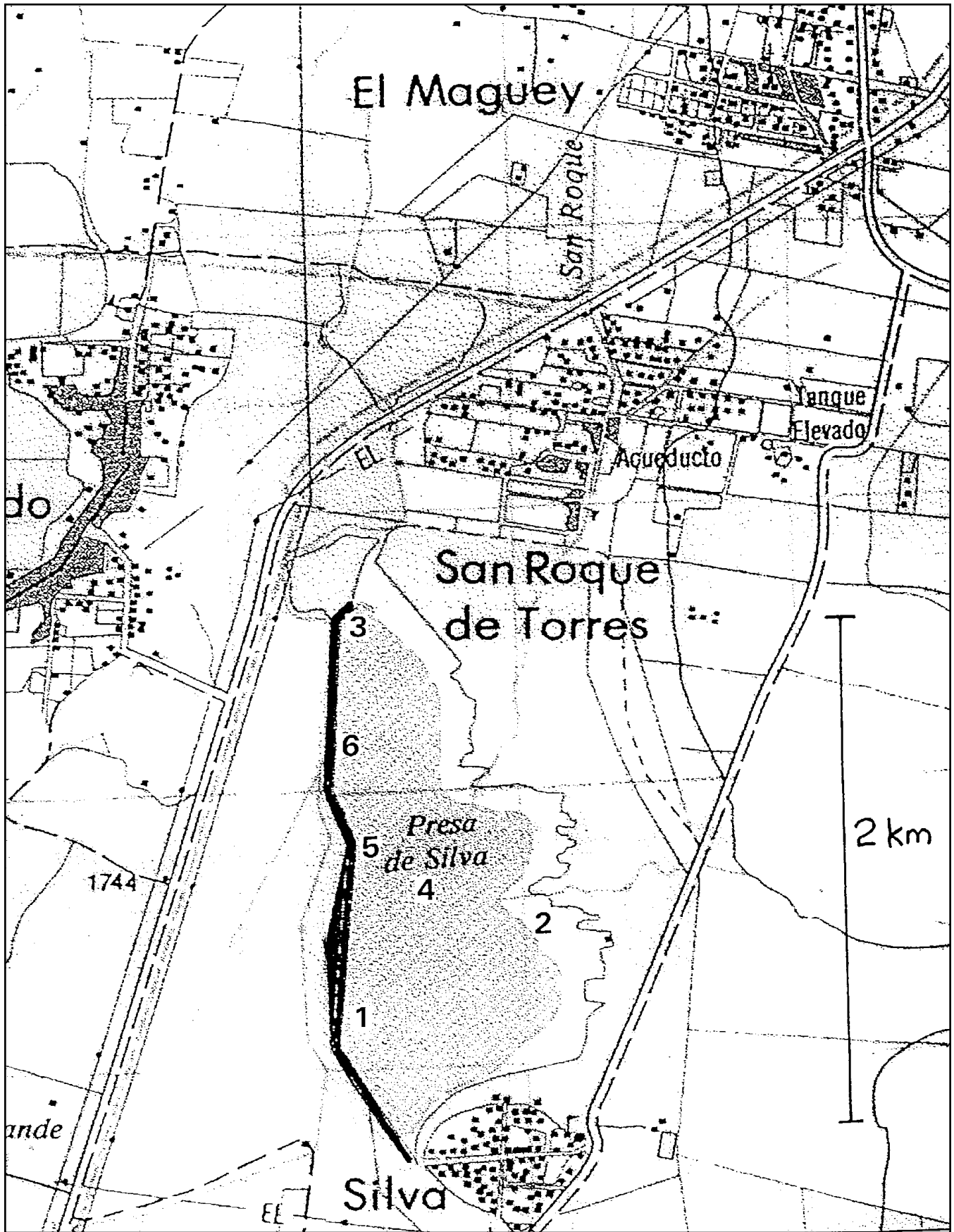


Figure 3. The *Presa de Silva* and immediate vicinity.

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## Significance of the *Presa de Silva* Die-off

The migratory bird mortality on the *Presa de Silva* is estimated to have killed between 20,000 and 40,000 birds. Although a significant number of birds were lost in this event, it is similar in magnitude to many other migratory waterbird die-offs that have been recorded since the late 1800s in North America. Several larger die-offs have been reported. Some of the largest known incidents of mortality occurred early in the century and are estimated to have killed hundreds of thousands to a million birds respectively (Bear River Migratory Bird Refuge, Utah, U.S.: 1932 - 250,000, 1929 - 100,000 to 300,000, 1910 - up to a million; Pakowki Lake, Alberta, Canada: 1994 - 100,000; Central Valley, California, U.S.: 1969 - 100,000). Die-offs between 20,000 and 100,000 waterbirds occur relatively often and can be attributed to only a few causes. As an example, the United States-based National Wildlife Health Center has recorded at least 25 such incidents in that country since 1970. Of these, 17 were caused by either botulism or avian cholera. Mortality of this magnitude has also been reported in Mexico at Lake Sayula in Jalisco State, in 1976 and 1977 (Landazuri Ortiz, 1978). In one year on Lake Sayula, mortality was estimated at 60,000 birds, primarily dabbling duck species. Experts suspected the probable cause of death was botulism.

Botulism, without exception, is the disease documented to cause the greatest mortality (up to one million individuals in some years) in western North American migratory waterbird populations. Few other causes result in such large die-offs. Avian cholera also causes large-scale mortality, especially in duck and goose

species. Major losses have occurred in migratory waterbird populations in Canada and the United States since the late 1940s, with estimated mortality ranging upward to 80,000 birds. Avian cholera is now considered endemic in Central Flyway snow goose populations and is suspected to be a cause of mortality of snow geese in Chihuahua State, Mexico. Other causes of significant mortality include oil spills and, although less common, duck plague, and trauma from storms. Some mortality events of this magnitude have gone unconfirmed as to the cause, such as a die-off of an estimated 100,000 seabirds in the Gulf of Alaska in 1983 and again in 1993 (U.S. National Wildlife Health Center, unpublished data). Emaciation was a significant finding but the causes of the die-off were not determined. An estimated 150,000 eared grebes died at Salton Sea in 1992 and the cause of mortality is as yet unknown (U.S. National Wildlife Health Center, unpublished data). Waterbird deaths have been associated with the release of toxins from decomposing blue-green algae, but it is rare for large numbers of birds to be affected. Similarly, pesticides and other predominantly anthropogenic poisons tend to cause mortality, involving hundreds to, at the most, a few thousands of birds.

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## **Involvement of Agencies, Universities and Volunteers, etc.**

The dedication and concern of the many people from governmental, environmental and academic institutions is evident when considering the time and energy that has been devoted to studying the *Presa de Silva* mortality event. The panel has met and had discussions with a number of people and has found only cooperation and a willingness to contribute time and knowledge in helping it to understand the complexity and seriousness of this problem.

We have graciously been given information for review from the following groups:

### Mexican Federal Government

- *Comisión Nacional del Agua*
- *Procuraduría Federal del Medio Ambiente*
- *Centro Nacional de Servicios de Diagnóstico de Salud Animal*
- *Laboratorio Nacional de Salud Pública*
- *Instituto Mexicano de Tecnología del Agua*
- *Comisión Mexico – USA para la Prevención de la Fiebre Aftosa*

### United States Federal Government

- National Wildlife Health Center, National Biological Service, Department of the Interior

### State and Municipal Governments

- *Secretaría de Salud del Estado de Guanajuato*
- *Procuraduría Federal de Protección al Ambiente de Guanajuato*
- *Comisión Nacional del Agua, Delegación Guanajuato*
- *Laboratorio Clínico de Celaya y Toxicología Industrial*
- *Sistema de Agua Potable y Alcantarillado de la Ciudad de León*
- *Zoológico de la Ciudad de León*

### Private Companies

- *IDECA S.A. de C.*
- *Laboratorios Atlatec S.A. de C.V.*
- *Laboratorios ABC Química, Investigación y Análisis S.A. de C.V.*

### Non-Governmental Organizations

- *Fundación Ecológica de Guanajuato, A.C.*
- *National Audubon Society*
- *Grupo de los Cien*
- *Centro Mexicano de Derecho Ambiental*
- *Ducks Unlimited de México, A.C.*

### Universities and Research Centers

- *Departamento de Ciencias Básicas, Universidad Iberoamericana, León.*
- *Facultad de Ciencias, UNAM*
- *Facultad de Química, UNAM*
- *Facultad de Medicina Veterinaria y Zootecnia, UNAM*
- *Instituto de Biología, UNAM*
- *Instituto de Ciencias del Mar y Limnología, UNAM*
- *Instituto de Geofísica, UNAM*

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## Observations and Investigations on the Mortality at the *Presa de Silva*

Over the five-month period of the die-off, signs observed in affected birds were documented by written descriptions and video recordings. Overt signs demonstrated by sick birds, as reported by members of the *Fundación Ecológica de Guanajuato* and others, consisted of partial to complete paralysis of the legs, inability to fly, generalized weakness and, in some cases, prolapse of the third eyelid or nictitating membrane. The most severely affected birds were completely recumbent, were unable to keep their heads erect, and had difficulty breathing. Video tapes made during the die-off confirm these observations.

During the die-off, approximately 200 birds were necropsied by veterinarians at the *Zoológico León*. Of the necropsied birds, approximately 80% were judged to be in poor or emaciated body condition. "Erosion" of the gizzard and the presence of blood in the anterior intestine were also noted in several of the birds; however, exact numbers are not known.

Detailed necropsies on 61 birds, including light microscopic evaluation and toxicological analysis, and analyses of water and sediments, were performed by specialists from the *Universidad Nacional Autónoma de México*. Necropsy findings included alterations in liver, kidney, muscle, bone, and intestine. The specialists hypothesized that severe damage to the digestive tract caused by acute intoxication was the cause of death in the majority of these birds. Elevated concentrations of heavy metals, in particular chromium and lead, were detected in some tissue and sediment samples.

The *Comisión Nacional del Agua (CNA)* undertook extensive monitoring of water, sediment and bio-logical samples. Collections were initiated in December 1994, and analyses were conducted by 13 laboratories. The results of these analyses and preliminary findings and conclusions on the causes of the die-off are summarized in a report issued in June of 1995.

In response to an invitation from Mexico's minister of the environment, personnel from the United States Department of the Interior's National Wildlife Health Center traveled to Mexico in March 1995 to provide technical assistance to Mexican government personnel regarding the wild bird mortality on the *Presa de Silva*. A summary of their findings and recommendations was made to the Mexican government. Their findings included environmental conditions recorded during the outbreak and clinical signs in affected birds consistent with botulism. Presence of botulism toxin was demonstrated in an enzyme-linked immunosorbent assay (ELISA) performed on the pooled sample of livers and gizzards at the center's diagnostic facility.

The *Presa de Silva* was visited by members of the panel on July 12. During this visit, soil samples from eight locations were taken from the *Presa de Silva* Basin (Figure 4). These samples were transported to the Canadian Cooperative Wildlife Health Centre (CCWHC) laboratory in Saskatoon, Saskatchewan, Canada and were tested for the presence of *Clostridium botulinum* spores using techniques described by Wobeser *et al* (1987). A subsample of soil weighing 0.5 g was incubated under anaerobic conditions in cultured meat medium for five days. Supernatants from seven of



Figure 4.

Top: Trent Bollinger, a member of the International Silva Reservoir Scientific Panel, preparing to collect a soil sample adjacent to a residual pool of standing water within the then (July 12, 1995) mostly dry *Presa de Silva*.

Right: Dam near the point where the *Canal San Roque* carries water to the *Presa de Silva* illustrates the voluminous amount of foam generated below the spillway.



these eight cultures were inoculated into the peritoneum of mice, of which five died soon after. The supernatants from four of these five cultures, demonstrated to be toxic to mice on initial inoculation, were further tested by inoculating each supernatant into a pair of mice. A half hour previously, one mouse from the pair had been inoculated with botulinum type C antitoxin, while the second mouse was untreated and therefore susceptible to type C toxin. In all four cases, the antitoxin-protected mice survived intraperitoneal inoculation with supernatant, whereas unprotected mice died after demonstrating symptoms typical of botulism poisoning. These results confirm the presence of *Clostridium botulinum* spores, capable of replication and production of botulinum type C toxin in soil samples from the *Presa de Silva*.

Also during the visit, 15 birds, which had been found dead at the *Presa de Silva* in January, and which were frozen by members of the *Fundación Ecológica de Guanajuato*, were given to members of the panel for study. Seven birds were transported to the (CCWHC) of Saskatoon and eight birds were transported to the National Wildlife Health Centre, Madison, Wisconsin, United States, where they underwent complete necropsy evaluation. Copies of each of these necropsy reports are being kept by the CEC as part of a reference file on the *Presa de Silva*.

Botulinum type C toxin was demonstrated in lung extracts from two of the seven birds (a shoveler and pintail) examined by the CCWHC. Insufficient sample precluded adequate testing of the other birds. However, lung extracts from three of these other birds (one pintail, one green-winged teal and one ruddy duck) inoculated intraperitoneally into mice caused symptoms of botulism and death. These five birds were in good body condition



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with no abnormal findings at necropsy. Two of the birds had significant necropsy findings. The first was an adult male shoveler that was severely emaciated, had marked hepatic atrophy and a moderate membranous glomerulopathy. Mercury concentrations in the liver of the shoveller were elevated (2.8 mg/kg wet weight) compared to concentrations in the livers of the other six birds (analysis performed by the Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada). Heavy metal exposure may have contributed to the death of this bird. The seventh bird was an adult male American coot that had pectoral muscle necrosis, blood in the pericardial sac and inflammation of the esophagus and heart. The cause of the abnormalities in the coot was not determined. Tissues from all seven birds were cultured for bacterial pathogens and none were found.

In the eight birds examined by the National Wildlife Health Center, seven were in fair to good body condition. One bird (a northern shoveler-007) was in poor body condition with no apparent cause for emaciation. The other finding noted on necropsy was congestion and/or fluid in the lungs of four birds. Laboratory tests included a mouse inoculation test for botulism type C toxin, and toxin was demonstrated in heart blood drawn from four of the eight birds. Bacterial cultures of liver samples from two birds showed no significant growth. Brain cholinesterase activity was normal in the three birds that were tested, which indicated that they had not been exposed to organophosphorus or carbamate pesticides. Liver and kidney tissues were analyzed in a heavy metal scan and liver tissue was analyzed for the presence of organochlorine compounds by the Patuxent Analytical Control Facility. Results showed one bird (pintail-001) with a markedly elevated chromium

concentration of 79 ppm dry weight(dw)\21 ppm wet weight(ww) in liver. Shoveler-007 did have an elevated concentration of chromium in kidney (12 ppm dw\3.1 ppm ww). Mercury was also detected at elevated concentrations in three birds: 1) shoveler-004 had 4.1 ppm dw\1 ppm ww in kidney and 4.3 ppm dw\1.2 ppm ww in liver; 2) ruddy duck-006 had 5.6 ppm dw\1.8 ppm ww in liver; and 3) eared grebe-008 had 7.3 ppm dw\2.4 ppm ww in liver and 5.7 ppm dw\1.7 ppm ww in kidney. Examination of tissues histopathologically revealed no evidence of damage to liver or kidney tissues from these metals, but histopathology findings were not definitive because of the autolytic condition of the tissues.

### Probable Causes

During the course of its assessment, the panel considered several possible causes of the waterbird mortality. A discussion of each of these possible causes follows.

#### Botulism

Botulism is a form of food-poisoning caused by toxins produced by the bacterium *Clostridium botulinum* in decaying matter. This bacterium exists in two forms: a resistant spore form found in sediments and soil of marshes and a proliferative form that produces toxin. The spore form can persist in the environment for years, surviving adverse conditions including drying and freezing. Germination and rapid replication of bacteria occurs in dead protein-rich organic material under anaerobic conditions. Typically, the most potent toxin is produced by *Clostridium botulinum* bacteria, which proliferates in dead invertebrates and/or vertebrates. Fly

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larvae or maggots in vertebrate carcasses are a well-recognized source of toxin for waterbirds.

Although botulism was considered by officials in Mexico as a possible cause of mortality early in the die-off, initial tests to detect botulinum toxin were negative and the diagnosis was rejected. However, the acute nature of the disease and the presence of birds with symptoms of leg paralysis progressing to generalized weakness and paralysis affecting large numbers of birds over a period of weeks to months is still highly suggestive of botulism poisoning. More recent evidence reviewed by the panel further implicates botulism as a significant, if not the most significant, cause of mortality at the *Presa de Silva*. Evidence for this conclusion includes:

- descriptions by individuals and observations from videotapes, which show affected birds with signs typical of botulism;
- reports from the *Fundación Ecológica de Guanajuato* and the *Zoológico León* that many affected birds recovered with basic supportive care. Few diseases show such rapid recovery with minimal care, particularly those listed as probable causes in this report;
- the presence of botulinum type C toxin in tissues of several birds collected during the die-off;
- the presence of viable *Clostridium botulinum* spores capable of producing botulinum type C toxin in sediment of the *Presa de Silva*;
- the conditions in the *Presa de Silva*, which were generally conducive to botulism outbreaks, including the shallow basin, the fluctuating water levels, the highly eutrophic state of the system, and the abundance of algae.

In some seasons, at least 85% of the water in the *Presa de Silva* is sewage from the city of León. Additional nutrients, metals and other pollutants are introduced into the water from other municipalities, from industry and from agricultural runoff within the *Río Turbio* Watershed. Added nutrients stimulate the growth of large populations of phytoplankton and zooplankton. Subsequent widespread die-offs of these populations create conditions that are ideal for the initiation of a botulism outbreak. Contamination of water bodies by sewage has been associated with botulism die-offs elsewhere. In a reference associating botulism with wastewater discharge, it has been stated that “Numerous outbreaks of avian botulism have been associated with sewage and other wastewater discharge into marsh environments. This relation is not presently understood, but has occurred often enough that wetland managers should discourage the discharges of these effluents when substantial waterbird or shore bird use is occurring or is likely to occur on an area during the ensuing 30 days” (Locke and Friend, 1987). The panel agrees with this statement.

Soil samples collected from the *Presa de Silva* during a July 1995 visit of the panel demonstrated viable *Clostridium botulinum* spores capable of replication and production of botulinum type C toxin. Botulism spores capable of producing botulinum type C toxin are readily isolated from water bodies or basins with a history of botulism and are found in a low percentage of water bodies without a history of botulism (Wobeser, *et al*, 1987). Botulinum type C toxin was also demonstrated in blood and tissue extracts from birds collected and frozen during the die-off, and subsequently necropsied in July 1995. This, in conjunction with the absence of significant pathological findings

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supporting other possible causes in the majority of birds, supports the hypothesis that botulism was the dominant cause of death at the reservoir.

## Chromium

Chromium contamination within the Turbio River Basin has long been recognized. Its presence was detected in the potable water of the city of León as early as 1975 (Armienta *et al*, 1993; Armienta-Hernandez and Rodriguez-Castillo, 1995). In the Valley of León, anthropogenic sources of chromium in ground water include solid wastes from the chromate manufacturing and tannery industry, and brick ash as fertilizer. The chromium in both the waste and fertilizer greatly exceeds chromium input from the natural weathering of pyroxenites. The tanning industry is very important to the region; there are approximately 1,000 tanneries of varying size in the *Río Turbio* Basin. As described elsewhere in this report, sites sampled downstream from the León Valley, including the *Presa de Silva*, exhibit chromium concentrations which exceed some clean water and sediment criteria (e.g., United States Environmental Protection Agency [U.S. EPA] freshwater acute and chronic criteria are 0.016 and 0.011 mg Cr/L, respectively; unpublished U.S. EPA guidelines for non-polluted sediment are <25 mg Cr/kg dry weight), although the sites generally meet Mexican norms for water and sediment quality. Chromium concentrations in water, sediment and plants for the protection of birds and other wildlife have yet to be established.

Our evaluation of data focuses principally upon concentrations in tissues of birds collected between December 1994 and February 1995 at the *Presa de Silva*. The range of values, and arithmetic mean or geometric mean (used because

concentrations were not normally distributed) were derived from four sources, summarized in Table 1.

In the June 1995 report of the *Comisión Nacional del Agua*, results are presented on chromium concentrations determined by laboratories complying with rigorous quality assurance and quality control standards. Analyses were conducted using U.S. EPA and American Standards, Testing and Materials standard methods. Chromium concentration in the liver averaged 0.26 mg/kg ww (n=10 samples), with a range of not detected to 0.90 mg/kg. In kidney, chromium concentrations averaged 1.05 mg/kg ww (n=4 samples), and ranged from not detected to 3.38 mg/kg. Chromium levels in gizzard-containing food contents averaged 7.21 mg/kg ww; however, chromium was not detected in empty gizzards. It should be noted that all concentrations are on a wet weight basis. If converted to a dry weight basis, values might be up to five times greater.

In an English translation of the July 3, 1995 report results of the *Grupo Universitario Interdisciplinario* of the *Universidad Nacional Autónoma de México* are presented on chromium concentrations in unspecified species of waterbirds. At least one of the laboratories in the group participates in the international inter-calibration of data that is part of the United Nations Environment Program (UNEP). In the text, liver concentrations of chromium are reported to be 1.14 mg/kg dw (n=16 samples), with a range of not detected to 6.60 mg/kg (6 of 16 values >1 mg/kg, but only one value exceeded 4 mg/kg). In kidney, chromium concentrations ranged from not detected to 3.36 mg/kg dw (n=7 samples; 3 of 7 values >1 mg/kg). Chromium levels in fecal samples (n=4) ranged from 2.00 to 42.5 mg/kg dw.

Eight specimens collected by local biologist Mr. Roberto Avina during the die-off were provided to the International Silva Reservoir Scientific Panel in July of 1995. These samples included one pintail (*Anas acuta*), four shovelers (*Anas clypeata*), two ruddy ducks (*Oxyura jamaicensis*) and one eared grebe (*Podiceps nigricollis*). Liver and kidneys from these specimens were analyzed for chromium by inductively coupled plasma emission spectrometry by the Patuxent Analytical Control Facility of the U.S. Fish and Wildlife Service, which utilizes rigorous standards of quality control and assurance. The geometric mean concentration of chromium in liver was 1.60 mg/kg dw, although individual values ranged from 0.367 to a high of 79.4 mg/kg (4 of 8 values >1 mg/kg, but only 1 of 8 values >4 mg/kg). The geometric mean concentration of chromium in kidney was 1.069 mg/kg dw, with values ranging from 0.408 to 12.8 mg/kg (3 of 8 values >1 mg/kg, but 1 of 8 values >4 mg/kg).

Another group of seven specimens, also collected by Mr. Roberto Avina during the die-off, were provided to the panel in July of 1995. These samples included two pintails, two shovelers, one ruddy duck, one green-winged teal (*Anas crecca*) and one American coot (*Fulica americana*). Liver tissue from these specimens were analyzed for chromium by graphite furnace atomic absorption spectroscopy by the Freshwater Institute of the Canadian Department of Fisheries and Oceans. Concentrations of chromium ranged from 0.11 to 0.23 mg/kg ww.

Relatively little is known about the toxicity of chromium to birds as reviewed by Eisler (1986). Survival, growth and feed efficiency of growing male domestic chickens (*Gallus domesticus*) fed up to 100 ppm Cr<sup>+6</sup> for 21 days were unaffected (Romoser, Dudley, Machlin and Loveless, 1961). Adult black ducks (*Anas rubripes*) fed diets containing 10 ppm or 50 ppm Cr<sup>+3</sup> for 10 months survived and

Source	Tissue	Average (mg/kg)	Range (mg/kg)	N
Comisión Nacional del Agua	Liver	0.26 (ww)	N.D. - 0.9 (ww)	10
	Kidney	1.05 (ww)	N.D. - 3.38 (ww)	4
	Gizzard with food	7.21 (ww)		
	Gizzard, no food	N.D. <sup>1</sup>		
Grupo Universidad	Liver		N.D. - 6.6 (dw)	16
	Kidney		N.D. - 3.36 (dw)	7
	Feces		2.00 - 45 (dw)	4
Patuxent	Liver	1.6 (geo mean, dw)	0.367 - 79.4 (dw)	8
	Kidney	1.069 (geo mean, dw)	0.408 - 12.8 (dw)	8
Canadian Department of Fisheries and Oceans	Liver	0.15 (ww)	0.11 - 0.23 (ww)	7

<sup>1</sup> N.D. signifies no data available.

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exhibited normal reproduction and blood chemistry (Haseltine, Sileo, Hoffman and Mulhern, unpublished report). In the above study, concentrations of chromium in liver and kidney averaged 0.33 and 0.28 mg/kg dw, respectively. However, black duck ducklings fed 10 ppm or 50 ppm Cr<sup>+3</sup> for up to 10 weeks exhibited altered growth patterns and increased evidence of nephrosis; there was some evidence of reduced duckling survival at 50 ppm chromium (Haseltine *et al*, unpublished report). Based upon dietary feeding studies in birds and laboratory mammals, chromium may be viewed as very toxic to extremely toxic, with adverse effects documented at 10 mg/kg in the diet in sensitive species of birds. Tissue concentrations in excess of 4 mg/kg dw should be viewed as presumptive evidence of excessive chromium exposure, although the significance of tissue chromium is somewhat unclear (Eisler, 1986).

Based upon chromium concentrations in gizzard contents, fecal samples, liver and kidney, and comparing these to the threshold of chromium toxicity in birds, it is unlikely that the massive waterbird die-off at the *Presa de Silva* was solely due to the ingestion of lethal concentrations of chromium. However, it is important to note that one or more individuals from three of the four samples described above had chromium concentrations in liver or kidney that exceeded the threshold of excessive exposure.

#### Endosulfan and Other Pesticides

In the report of the *Comisión Nacional del Agua*, a spill of the agricultural chemical endosulfan was identified as being the cause of the localized death of waterbirds at the *Presa de Silva*. Data addressing this hypothesis is now available from two sources.

In the June 1995 report of the *Comisión Nacional del Agua*, results are presented on endosulfan concentrations as determined by laboratories complying with rigorous quality assurance and quality control standards. Analyses were conducted using U.S. EPA and the Association of Analytical Chemists standard methods. One of the participating laboratories detected endosulfan I, endosulfan II and endosulfan sulfate at low concentrations (0.032, 0.114 and 0.216 mg/kg ww) in one set of pooled liver samples (n=20) of ducks collected January 5, 1995. However, residues of endosulfan were not detected in eight other pooled samples, some collected as late as January 13, 1995.

Eight specimens collected by local biologist Mr. Roberto Avina during the die-off were provided to the panel in July 1995. These samples included one pintail (*Anas acuta*), four shovelers (*Anas clypeata*), two ruddy ducks (*Oxyura jamaicensis*) and one eared grebe (*Podiceps nigricollis*). Liver samples from these individuals were analyzed for endosulfan I, endosulfan II and endosulfan sulfate by U.S. EPA standard methods at the Mississippi State Chemical Laboratory. This is a contract laboratory of the Patuxent Analytical Control Facility of the U.S. Fish and Wildlife Service which utilizes rigorous standards of quality control and assurance. Endosulfan I, endosulfan II and endosulfan sulfate were not detected in any of these samples.

A great deal is known about the bioaccumulation and toxicity of endosulfan in non-target animals (Naqvi and Vaishnavi, 1993). This broad spectrum insecticide is a central nervous system poison. Unlike other organochlorine pesticides, endosulfan is not persistent *in vivo* as it is rapidly metabolized through sulfation and eliminated by terrestrial vertebrates.

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Bioaccumulation factors for birds are less than 1 (NRCC, 1975). In birds (mallard *Anas platyrhynchos*, bobwhite *Colinus virginianus*, ring-necked pheasant *Phasianus colchicus*, red-winged black bird *Agelaius phoeniceus*), the acute median lethal dosage (LD50) of this pesticide ranges from 35 to >320 mg/kg (very toxic to extremely toxic range; NRCC, 1975), although the acute median lethal dietary concentration (LC50=2906 parts per million in feed) suggests that this compound is only moderately toxic to Japanese quail (*Coturnix japonica*) (Hill and Camardese, 1986).

In field studies, geese that fed for 17 days upon weeds in strawberry fields sprayed with endosulfan (21 pounds/acre) exhibited no signs of poisoning, and no residues were detected in liver, fat or stomach contents (Dustan, 1965). Ultra-low volume aerosol application of endosulfan (6-12 grams/hectare) did not evoke differences in avian species diversity between sprayed and unsprayed transects, and no species suffered catastrophic decline (Douthwaite, 1980). In this study, predatory birds feeding upon fish were apparently unaffected, and endosulfan residues (I + II + sulfated metabolite) in fish eagle (*Haliaeetus vocifer*), pied kingfisher (*Ceryle rudis*) and reed cormorant (*Phalacrocorax africanus*) were quite low in brain ( $\leq 0.205$  mg/kg ww) and liver ( $\leq 0.122$  mg/kg) (Matthiessen, Fox, Douthwaite and Wood, 1982). Endosulfan concentrations in water, sediment and plants for the protection of birds and other wildlife have yet to be established.

Although endosulfan residues were detected at low concentrations in one pooled sample of duck livers, the absence of residues in liver and other tissues from birds collected at *Presa de Silva*, and the prolonged time course of the die-off,

suggest that it is unlikely that the massive mortality could be attributed solely to endosulfan poisoning.

The panel also considered the potential for effects of other pesticides. However, concentrations of organochlorine pesticides and metabolites (other than endosulfan), and organophosphorus and carbamate pesticides were rarely detected (not detected to <1 mg/kg ww) in tissues of waterbirds collected from the *Presa de Silva* (analyses of *Comisión Nacional del Agua* and of the Patuxent Analytical Control Facility). Detected concentrations were well below any known toxicological effect levels in birds (Blus, 1995). In addition, brain acetylcholinesterase activity was not depressed in three specimens analyzed by the National Wildlife Health Center, further refuting the notion of acute organophosphorus pesticide poisoning.

#### Red Dye

The Analytical Chemistry Laboratory of the *Universidad Nacional Autónoma de México* conducted a forensic investigation of sediment and water samples taken from the *Presa de Silva*. Several contaminants were identified in sediment samples including benzene, ethyl benzene, nitrobenzene, hydrocarbons from diesel fuel or gasoline and the coloring agent carmine red. The carmine red agent was identified to be a combination of triazine and halogenated aromatic pigments and dyes. It was suggested that a dyeing agent was dumped into the reservoir, although the toxicological characteristics of these agents were not discussed. Without further chemical or toxicological characterization of the product's industrial use, it is difficult to accept or reject this hypothesis as the cause of massive avian mortality at the *Presa de Silva*.

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## Algal Poisoning and Infectious Diseases

Algal poisoning also was considered a possible cause of mortality. Genera of blue-green algae potentially capable of producing lethal toxins were observed in water samples collected from the *Presa de Silva*, but the water was not tested for the presence of toxin; therefore, this etiology remains highly speculative. Tissues were cultured, and no infectious viral, bacterial, or parasitic cause of mortality was identified. All reports to date agree that an infectious disease was not responsible for the die-off.

## General Contaminant Loading

One of the conclusions in the report of the *Grupo Universitario Interdisciplinario* of the *Universidad Nacional Autonoma de México* states that disease symptom data coupled with macroscopic and microscopic findings implicate heavy metal as the probable cause of the incident. To evaluate this hypothesis, the panel examined metal concentrations from four sources.

In the June 1995 report of the *Comisión Nacional del Agua*, results are presented on heavy metal concentrations in ducks that died at the *Presa de Silva*. In liver, concentrations of cadmium and lead ranged from not detected to 0.70 and not detected to 7.9 mg/kg ww, respectively. Mercury was not detected in liver samples. In kidney, lead concentration ranged from not detected to 13.18 mg/kg wet weight, but cadmium and mercury were not detected.

In an English translation of the July 3, 1995 report of the *Grupo Universitario Interdisciplinario* of the *Universidad Nacional Autónoma de México*, results are presented on cadmium, lead and mercury

concentrations in unspecified species of waterbirds. In liver, concentrations of cadmium, lead and mercury ranged from 0.80 to 6.8, not detected to 19.6, and 0.001 to 2.37 mg/kg dw, respectively. In kidney, cadmium, lead and mercury ranged from 2.12 to 16.7, 0.25 to 3.14 and not detected to 14.4 mg/kg dw, respectively.

Eight specimens collected by local biologist Roberto Avina during the die-off and provided to the panel were analyzed by the Patuxent Analytical Control Facility of the U.S. Fish and Wildlife Service for various heavy metals. In liver, the concentrations of cadmium, lead and mercury ranged from 0.265 to 1.91, not detected to 1.66, and not detected to 7.40 mg/kg dw, respectively. In kidney, cadmium, lead and mercury ranged from 0.354 to 10.1, not detected to 1.12, and not detected to 5.78 mg/kg dw, respectively.

Seven additional specimens, also collected by Mr. Roberto Avina, were provided to the panel. They were analyzed by the Freshwater Institute of the Canadian Department of Fisheries and Oceans for several heavy metals by graphite furnace atomic absorption spectroscopy. Mercury was analyzed by flameless atomic absorption spectroscopy. In liver, the concentrations of cadmium, lead and mercury ranged from 0.081 to 1.21, 0.005 to 0.223, and from 0.038 to 2.80 mg/kg ww, respectively.

Dry weight concentrations are typically up to five times greater than ww calculations. Cadmium concentrations in liver and kidney that exceed 10 mg/kg ww have been suggested to be the threshold for cadmium contamination. Levels at 13 to 15 mg/kg wet weight are thought to be indicative of significant hazard. Concentrations in excess of 200 mg/kg

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ww in kidney are thought to be life-threatening (Eisler, 1985). A few samples analyzed by the *Grupo Universitario Interdisciplinario* of the *Universidad Nacional Autónoma de México* had tissue concentrations of cadmium that approached the threshold for cadmium contamination.

Lead concentrations in liver that exceed 2 mg/kg ww are considered elevated, and concentrations in excess of 8 mg/kg ww provide evidence of lead poisoning (Eisler, 1988; Friend 1985). Several samples analyzed by the *Comisión Nacional del Agua* and the *Grupo Universitario Interdisciplinario* of the *Universidad Nacional Autónoma de México* approached or exceeded the threshold of lead poisoning. However, none of the samples analyzed by the Patuxent Analytical Control Facility approached the threshold for lead poisoning.

Mercury exposure in adult birds may be documented by concentrations of 1 mg/kg ww in liver and kidney; however, the threshold of harm in these tissues is extremely variable ranging between 20 and 60 mg/kg ww (Eisler, 1987; Heinz, 1995). Several samples analyzed by the *Grupo Universitario Interdisciplinario* of the *Universidad Nacional Autónoma de México* and the Patuxent Analytical Control Facility had mercury concentrations indicative of exposure, but values were below the threshold of harm.

The degree of variability of metal concentrations observed in birds is not unexpected. Although concentrations of cadmium, lead and mercury in some waterbird liver and kidney samples collected at the *Presa de Silva* are indicative of heavy metal exposure, the observed concentrations rarely exceed harmful effect and lethality thresholds. It is unlikely that the massive mortality of birds at the *Presa de Silva* could be attributed solely to heavy metal intoxication.

### Summary of Probable Causes

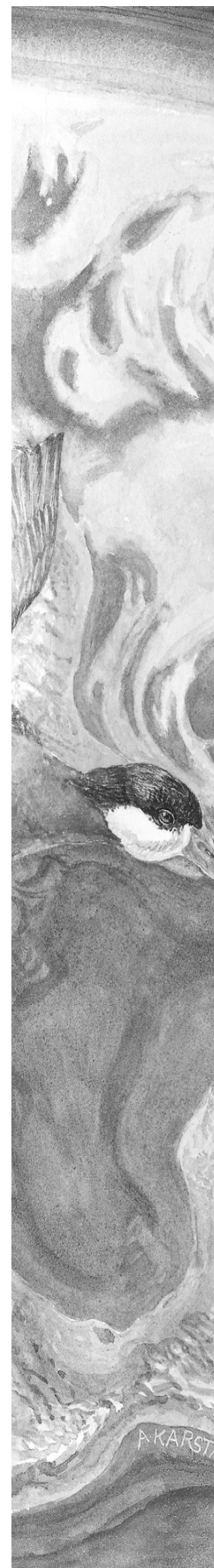
We believe the die-off at the *Presa de Silva* was primarily due to botulism; however, a low percentage of birds may have died of other causes. Exposure to heavy metals including lead, mercury, and chromium was demonstrated in some of the birds and may have contributed to their mortality. Contamination of the reservoir by untreated residential sewage resulting in eutrophication of the reservoir may have been an important factor in the initiation of the botulism outbreak. Equally, anything in the reservoir that could kill birds, such as heavy metal or pesticide poisoning, could also trigger a subsequent and numerically greater outbreak of botulism, as the bird carcasses from an initiating episode could serve as the necessary protein source for production of botulinum toxin.



# RÍO TURBIO WATERSHED

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## THE RESERVOIR AND WATERSHED

The *Presa de Silva* is located about 315 kilometres (km) northwest of Mexico City in the *Río Turbio* Basin. It is 35 km south of the city of León in the state of Guanajuato, Mexico. The nearest municipality is San Francisco del Rincon at 7 km. The *Río Turbio* Basin has an approximate area of 4,500 km<sup>2</sup> and is a subwatershed of the *Río Lerma*. The area from León to the Silva is characterized by high human population densities and a specialized leather industry. The *Presa de Silva* was constructed in 1884. In the 1930's, the *Canal San Roque* was constructed, allowing the diversion of water from the *Río Santiago* into the reservoir. At normal supply level, the reservoir has an area of about 120 ha. (296 acres) and a volume of approximately 700,000 m<sup>3</sup> (0.7 million cubic metres or 567 acre-feet). It is very shallow, averaging less than one metre in depth. Runoff collected from rainfall contributes 2.2 mcm of water per annum, while the *Río Santiago* supplies 7.5 mcm per annum. A total volume of 9.7 mcm is used each year for irrigation. Although it varies seasonally, on an annual basis the approximate residence time for water stored in the reservoir is one month.

The *Río Santiago* is about 2 km to the northwest of the *Presa de Silva* and is connected by the *Canal San Roque*. Upstream of the *Presa de Silva*, the Turbio and its tributaries supply water to several other reservoirs including Mastranzo, Trinidad, and San German. In the *Presa*

*de Silva*, the *Río Turbio* system contributes about 70% of the water during the rainy season and nearly 100% during the dry season (December to June). The river begins near León in the *Sierra de Comanja* and *Comanjilla* and flows south to join the *Río Lerma*, which then flows west to *Lago Chapala*. This lake, the largest in Mexico, discharges to the Pacific Ocean through the *Río Santiago*, much of which is diverted to supply the city of Guadalajara. The total drainage area of the *Río Lerma* Basin is approximately 52,000 km<sup>2</sup> (Davalos-Lind and Lind, 1993) with a population of about six million people (Limon *et al*, 1989).

Natural runoff through the Turbio Basin occurs primarily during the rainy season. In 1994, annual runoff from rainfall was 10.04 million cubic meters, about 63% of the historical mean value. In addition to rainfall, natural flows in the *Río Turbio* and its major tributaries are heavily augmented by untreated wastewater from the city of León, which is supplied by groundwater sources. Without León's wastewater, the *Río Turbio* would remain dry from November through June. Total domestic and industrial wastewater flows from León to the *Río Turbio* are approximately 78.5 mcm per annum, or about eight times the total annual runoff from rainfall into the *Río Turbio*. When combined with figures for 1994 rainfall, the total flow in the *Río Turbio* in 1994 was approximately 88.5 mcm (78.5 mcm from wastewater plus 10.05 mcm of rainfall) immediately downstream from León, slightly below the historical mean value of 94.5 mcm.

## WATER QUALITY

In addition to the city of León, San Francisco del Rincon and neighboring industries (in particular, the leather and shoe industry and agricultural sector) discharge largely untreated wastewater into the river. Due to the scarcity of water, it is common practice in Mexico to use sewage and wastewater for irrigation of certain crops. Furthermore, natural water bodies are used to transport this wastewater to irrigation reservoirs. As a

result, water quality in the *Río Turbio* is extremely poor. Upstream of the *Presa de Silva*, two sewer systems (León and San Francisco del Rincon) and at least 58 companies are known to contribute wastewater to the *Río Turbio*. Although some industries treat their wastewater, in general untreated effluent flows from the source into the *Río Turbio* system. Table 2 indicates flow and organic load discharged into the *Río Santiago* and the *Río León* upstream of the *Presa de Silva*.

Type of discharge	Volume (mcm/year)	Volume (%)	Organic load (cod/year)*	Organic load (%)
Municipal from León	69.38	83.07	24,283	32.12
Industrial from León	9.46	11.33	45,727	60.49
Municipal from S.F. del Rincon	2.23	2.67	808	1.07
Industrial from S.F. del Rincon	0.07	0.08	226	0.3
Independent industry	2.38	2.85	4,553	6.02
<b>TOTAL</b>	<b>83.52</b>	<b>100</b>	<b>75,597</b>	<b>100</b>

\*tcod = tonnes chemical oxygen demand.

Source: *Comisión Nacional del Agua (CNA)*, 1995

When compared with Mexican standards for water quality, analyses performed by the *Comisión Nacional del Agua* in December 1994 demonstrate the poor water quality at a number of stations. As indicated in Table 3, the chemical oxygen demand exceeds the Mexican national standard for irrigation water by several fold; the same is true for conductivity. This is not surprising since, as stated previously, during the dry season, most of the water in this part of the *Río Turbio* system is wastewater from León. During

the wet season, at least 70% of the *Río Turbio* is untreated wastewater. The table also shows the values required by the *Norma Oficial Mexicana* (Official Mexican Norms). Although some parameters clearly exceed the norms, it should be noted that the water meets the hexavalent chromium norms for irrigation and for the discharge of the tannery effluents into receiving waters. There are no standards for total chromium in water used for irrigation.

Parameter	Río León	Presa de San German	Canal San Roque	Norm for irrigation*	Norm for discharge**
pH	8.3	8.0	8.1	6.0 - 9.0	6.0 - 9.0
Grease and oil (mg/l)	16	23	8	10	60
Settling solids (mg/l)	< 1.0	2	< 1.0	1.0	1.2
Total suspended solids, TSS (mg/l)	82	215	54	30	300
Chemical oxygen demand, COD (mg/l)	725	600	500	120	-
Biochemical oxygen demand, BOD (mg/l)	322	305	158	80	300
Hardness as CaCO <sub>3</sub> (mg/l)	443	365	365	-	-
Chloride (mg/l)	717	630	569	***	-
Conductivity (mmohs/cm)	4,188	3,769	3,909	1,000	-
Sodium (mg/l)	29	28	22	-	-
Sulfate (mg/l)	114	103	20	130	-
Sulfide (mg/l)	1.0	0.8	0.2	1.0	30
Hexavalent chromium (mg/l)	< 0.1	< 0.1	< 0.1	1.0	0.12
Total chromium (mg/l)	0.211	1.315	0.13	-	6

\* Maximum value; \*\* maximum value, single sample; \*\*\* not available.

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In setting norms for wastewater discharges, the acceptable concentrations of parameters in effluent from the tanneries are normally higher than those for irrigation. Apparently the standards account for the dilution of wastewater by other sources of sewage and by natural sources of water. The effectiveness of these standards is demonstrated by the fact that parameters generally meet the norms for irrigation. However, parameters like chemical oxygen demand (COD) and biochemical oxygen demand (BOD) are clearly higher than published standards.

### **PROGRAMA DE SANEAMIENTO INTEGRAL DEL RÍO TURBIO (THE TURBIO RIVER INITIATIVE)**

In recognition of the severe levels of pollution and contamination in the *Río Turbio*, the *Comisión Nacional del Agua* initiated a comprehensive, collaborative clean-up program. The purpose of the program is to gradually clean up the waters of the Turbio by promoting a new water-oriented culture, which ensures that people use water efficiently and sustainably. By promoting open and timely communication, the initiative strives to coordinate and maximize the effectiveness of efforts of various sectors and groups in the communities along the watershed.

The original scope of this initiative was restricted to municipal and tannery wastewater of the city of León. In 1993, this scope was extended and the initiative now includes all industrial and municipal wastewater generated in León, San Francisco del Rincón and another community named Purísima. Below, we summarize our understanding of the initiative's five key areas, scheduled to be finished by the middle of 1997:

- Construction and startup of a municipal wastewater treatment plant in the city of León. The plant will have a capacity of 2.5 m<sup>3</sup>/second and requires NP\$200 million (approximately US\$35 million). The plant is to be a conventional biological treatment plant.
- Construction of an ecological industrial park near León for the relocation of approximately 120 tanneries. The industrial park will feature a residual wastewater treatment plant with a capacity of 0.3 m<sup>3</sup>/second. This treatment plant requires a total investment of NP\$60 million (approximately US\$10 million). The new facility is designed to allow 50% of the water to be reused and 95% of the chromium to be recovered.
- Construction and startup of a municipal wastewater treatment plant for San Francisco del Rincón and Purísima. The plant will have a capacity of 0.2 m<sup>3</sup>/second and a cost of NP\$20 million (approximately US\$4 million).
- Construction of 49 small industrial wastewater treatment plants to process the discharges from tanneries and other small industries that will remain outside the industrial park. Currently, 10 of these plants are under construction.
- Strengthening the inspection and enforcement actions by the appropriate authorities.
- Promotion of public awareness and scientific research on the environmental problems of the area.

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## ENHANCING ENVIRONMENTAL QUALITY IN THE RÍO TURBIO BASIN

A recent report by the *Comisión Nacional del Agua* (1995) on the *Programa de Saneamiento Integral del Río Turbio* estimated that, with regard to the *Río Turbio*, “93% of the contamination originates in the urban and industrial waste of León.” Clearly, if the contamination of the system is to be reduced, the panel agrees the most important place to start is León. León is the center of a large hide tanning industry; thousands of hides per day are imported from North and South America. Chromium is heavily used in this industry and is perhaps the best potential tracer of influences of industrial activities in the *Río Turbio* Watershed. A report by the tanning industry (1990) calculated that the average emission of total chromium was about 19.3 kg per day for each of some 34 industrial sites, for a total loading of about 650 kg/day. This figure is in agreement with that derived by the *Programa de Saneamiento Integral del Río Turbio* (1995), which cited a loading of 528 kg/day from León.

### Chromium in Sediment of the *Presa de Silva*

The *Grupo Universitario Interdisciplinario* (UNAM) collected eight sediment samples in February 1995, by inserting a 5-cm plastic corer into the *Presa de Silva* sediment to a depth of about 30 cm. The cores were extruded and separated into two sections, one section included the top 3 to 5 cm; then the next 2 cm were discarded and a second 3-5 cm section was taken immediately below that. The sediment samples were freeze-dried, homogenized in a mortar and divided in three sub-samples, which were submitted

to different laboratories for independent analyses. Total chromium concentrations were higher in the surface sediments (225 - 114 ppm) than in deeper sediments (169 - 107 ppm). Chromium concentrations in the littoral zone (155 - 111 ppm) were lower than in the deeper zone (258 - 104 ppm), a difference attributed to the fact that the deeper areas of the reservoir remain flooded for a longer period each year.

The *Comisión Nacional del Agua* in a June 16, 1995 report on the *Programa de Saneamiento Integral del Río Turbio* cites down-core profiles of several sediment samples taken from the *Presa de Silva*. These profiles (Figure 5) consistently showed higher chromium concentrations in the upper layers of reservoir sediment than in the lower layers. In the core samples taken from the deeper areas of the *Presa de Silva*, the concentrations of chromium are an order-of-magnitude greater in the upper parts of the sample than in the lower parts of the sample.

Taken together, these observations indicate a significant increase in inputs of chromium to the *Presa de Silva* over time. This increase is related to flooding and clearly establishes a relationship between water quality in the *Río Turbio* and the contamination of the *Presa de Silva*. Unfortunately, none of the sediment layers reported have been dated; therefore, there is no information on which to estimate rates of accumulation of contaminants.

Some chromium from the upper *Río Turbio* Basin may have reached as far downstream as *Lago Chapala*. Hanson (1992) reported that chromium in sediments in the lake exceeded those in the sediments of the *Río Lerma*, which one would expect if the river has been

delivering chromium to the lake where it has been accumulating. However, the data do not preclude the presence of chromium in the lake as a result of natural, geological processes in the basin.

Sediment cores to compare historical and modern levels of chromium in layers of sediment in the lake have not been reported.

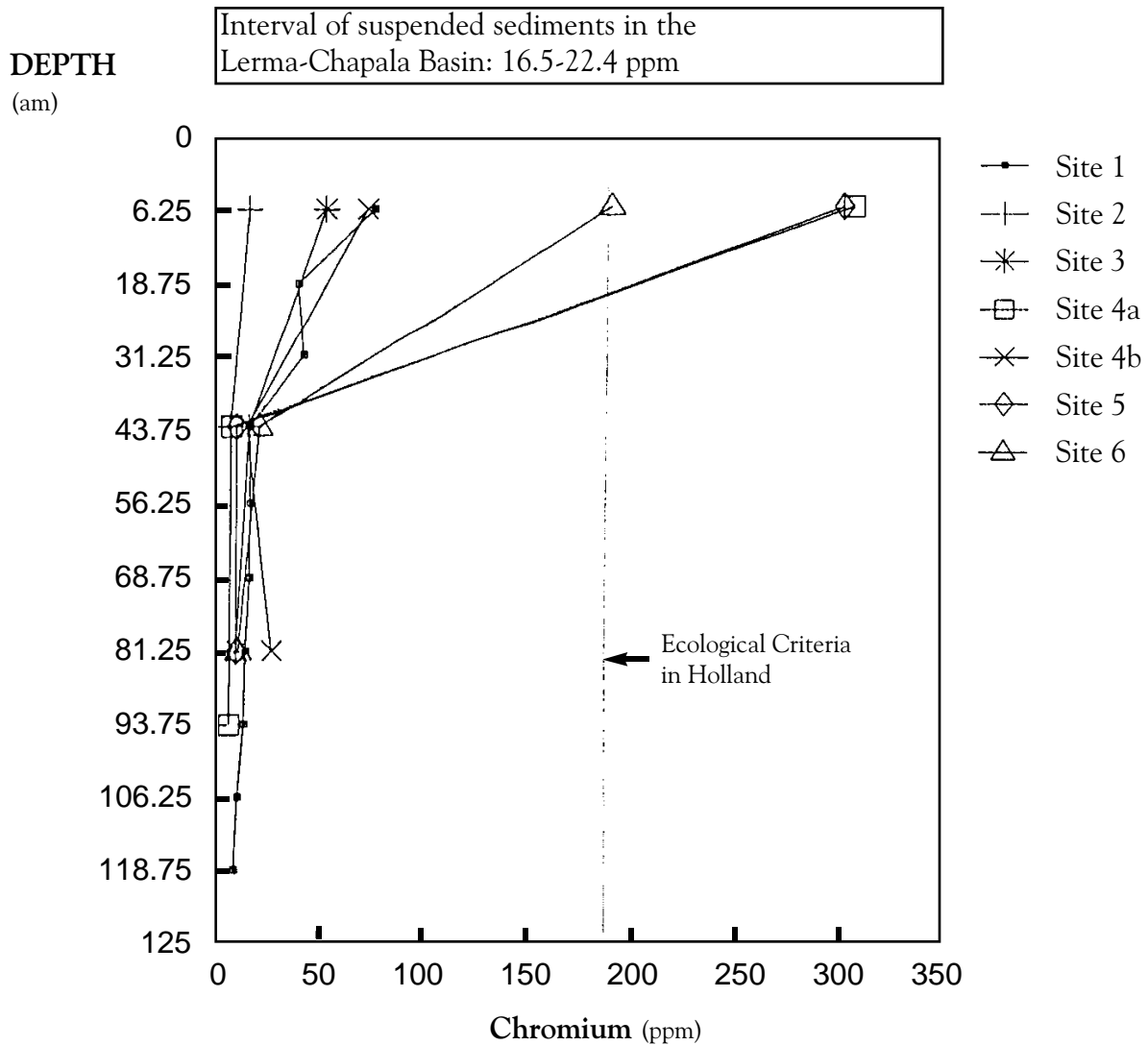


Figure 5. Distribution of chromium in sediment cores taken in 1995 from the bottom of the *Presa de Silva*. Core sample sites indicated in Figure 5. Figure from *Comisión Nacional del Agua* report on the *Programa de Saneamiento Integral del Río Turbio* dated June 16, 1995.



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In recognition of its role in contamination of the *Río Turbio*, the leather industry of León has been investigating ways to limit its discharges. A pilot-scale plant has been used to test the effectiveness of technologies to remove (trivalent) chromium from wastewater (Landgrave, 1995). The results of 35 experiments indicate that 99% of chromium present initially can be recovered for recycling using a flocculation/sedimentation process. This technology has been incorporated into the design of a new industrial effluent treatment system under construction in León.

## SUMMARY

The quality of water diverted into *Canal San Roque* and thence to the *Presa de Silva* indicates a river basin under considerable stress. Water at the diversion weir on *Río Santiago* was observed by our site team to produce hundreds of cubic meters of foam as a consequence of its short drop (approximately 2 metres) over the diversion structure. *Río Turbio* is reported to receive 65.6 mcm per annum of municipal and 11.9 mcm per annum of industrial wastes from León alone, before diversion into the *Presa de Silva*. Given the level of baseline flows, this implies extraordinarily eutrophic water. The panel was informed that during the dry season, more than 90% of the *Río León* flow at San German Reservoir is actually untreated municipal wastewater.

The Mexican government, recognizing the need to monitor water quality, allocated precious resources decades ago to begin assembling long-term data for the *Río Turbio* Basin downstream of the San German Dam. A 21-year time series on selected water quality parameters is apparently available with year-round data, although the panel was unable to

obtain this information. These data might be useful in developing tracers and indicators linked to water quality objectives developed in conjunction with the *Programa de Saneamiento Integral del Río Turbio*.

Much less scientific attention has been given to the *Río Lerma* system itself, including the *Río Turbio*, than to *Lago Chapala*. Recently, Soto-Galera *et al*, (1995) analyzed historic data from the Lerma Watershed in an effort to relate water quality measurements to biological changes as reflected by the abundance of fish fauna. Fish are perhaps the best indicator of the quality of their habitat and the study by Soto-Galera *et al*, has shown the loss of fish from numerous reaches of rivers within the system. These authors were able to compare fish studies done over 50 years ago with similar studies done over the period from 1985 to 1993. Their results were dramatic. Although the *Río Turbio* was not reported numerically, the graphic produced by these authors indicated that sites in the upper *Río Turbio* Basin could be described as “low water quality and fish missing” or “regular water quality and sensitive species missing.” No sites in the upper *Río Turbio* met the criteria to be described as “high water quality and presence of sensitive species.” These results indicate that the Turbio Basin Initiative is both appropriate and timely. However, as there appear to be no studies of the invertebrate fauna of the *Río Turbio*, it is not obvious whether the fish have been lost because of direct toxic effects or because of disruptions at lower trophic levels.

The panel was able to obtain only limited information on the limnology of the *Río Turbio* System. The panel was not aware of information on the benthic community

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of the *Río Turbio*, *Canal San Roque* or *Presa de Silva*. The benthic community likely forms an important component of the local food chain in the *Presa de Silva* and likely provides an important food source for overwintering birds. The *Presa de Silva* is shallow and periodically drained for irrigation; the composition of benthos and plankton varies by season. Some sampling to determine the kinds of plant and animals forming the benthos and the plankton in the *Presa de Silva* would be very valuable in assessing current conditions and potential. In particular, information would be most valuable during the periods of filling and draw-down. In addition, monitoring benthos during the dewatered season would help to estimate the species that survive in the sediments and serve as an inoculum to re-establish the community during the wet season. Their proximity to bottom sediment makes benthic species prone to accumulate contaminants from upstream sources. Analyses using sediment slices at a few depths could reveal the kinds of stress-resistant species

residing there, the extent of the stresses they respond to and the potential role of these species in toxic blooms. These analyses might also reveal past patterns of toxic algal growth. In addition, studying insect larval states is also likely to be important and could help to determine the quantities available for waterbirds.

Although sediment cores were collected in conjunction with the *Programa de Saneamiento Integral del Río Turbio*, to enhance the value of these samples, it would be desirable if ages could be associated with core depth. This might be done with a series of cesium determinations. If successful, this would pinpoint the cesium-137 peak in the mid-1960s and, when also analyzed for key contaminants, would allow the calculation of accumulation or sedimentation rates for the brilliant red dye, chromium, selected organics (endosulphan), plankton and perhaps the presence of botulism spores.

# CONTINENTAL CONTINGENCY PLANS AND MONITORING ACTIVITIES

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# CONTINENTAL CONTINGENCY PLANS AND MONITORING ACTIVITIES

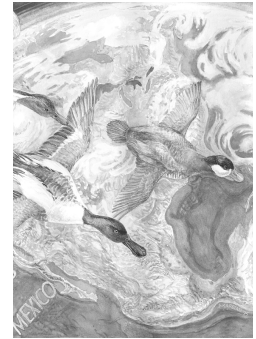
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Although waterbird die-offs of the magnitude seen at the *Presa de Silva* are unfortunate, they occur annually in North America. Appropriate responses to these die-offs are important to determine the cause or causes and if possible, to reduce the level of mortality. Disease in wildlife and fish can also act as an indicator of environmental degradation that may impact the health of humans and domestic animals. For all of these reasons, it is important for all three North American countries to have in place agencies and trained personnel capable of monitoring the health status of wildlife and fish, and responding to disease outbreaks such as the one that occurred at the *Presa de Silva*.

An effective system to monitor and survey wildlife health has four main components:

- The rapid detection of sick or dead wildlife in the field. Ideally, this is accomplished by a team of field personnel sensitized to wildlife disease issues who actively monitor susceptible wildlife populations and respond to reports from the public of health problems in wildlife. These persons should be individuals trained in basic disease investigation techniques. They should know who to contact for diagnostic assistance and how to collect and submit samples for diagnosis.

- Accurate diagnosis or identification of the disease. This requires specialists trained in wildlife disease and implies a central role for veterinary pathologists, or equivalently-trained individuals working with laboratories that provide services such as toxicology, bacteriology, parasitology, and/or virology. In large die-offs, when a zoonotic disease or other disease of national/international significance is detected, wildlife disease specialists should actively participate in the site investigation. Good communication should exist between the detection and diagnosis components of the surveillance team.
- Good information management. Information on disease occurrences must be recorded and tabulated in sufficient detail and in a manner which allows the creation of summaries and the monitoring of disease trends. The information should be summarized at a regional, national and international level.
- The effective communication and use of surveillance information. The timely transfer of information, in an understandable form, to wildlife managers and administrators who understand its implications is critical. This information can then be used to make informed and rational decisions on wildlife health issues. Responses to die-offs, such as the one that occurred at the *Presa de Silva*, would be based



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on information provided to administrators by the surveillance team.

The study of wildlife disease is a relatively new field involving biologists and veterinarians. Specialists are found in universities, veterinary colleges, government agencies and others. Many are involved in research of particular wildlife health problems, while others are involved in disease surveillance and investigation. In the United States, there are national, regional and state organizations charged with surveillance, investigation and research on wildlife disease. These include the federal National Wildlife Health Center of the National Biological Service in Madison, Wisconsin, whose responsibilities include federally-owned lands, migratory birds and endangered species; the Southeast Cooperative Wildlife Disease Study, University of Georgia, Athens, Georgia, which is supported by both federal and state agencies; and the wildlife agencies of numerous states, which employ disease specialists in their wildlife management programs.

In Canada, federal, provincial or territorial wildlife agencies and non-government organizations (NGOs) joined with Canada's four veterinary colleges to establish the Canadian Cooperative Wildlife Health Centre (CCWHC), which provides wildlife health services nationwide. Four provinces also employ wildlife disease specialists in their wildlife agency. In both Canada and the United States, federal, provincial and state departments of agriculture often contribute expertise in disease diagnosis and investigation of wildlife health issues. At present, an organized wildlife disease surveillance and reporting program has yet to be developed in Mexico.

# RECOMMENDATIONS OF THE PANEL

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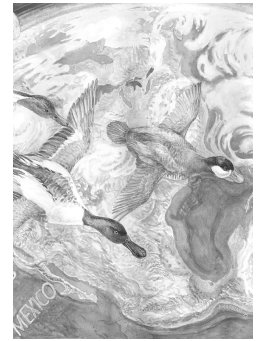


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## RECOMMENDATIONS OF THE PANEL

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The International Silva Reservoir Scientific Panel makes two principal recommendations, one concerning the Turbio Basin Initiative and the other concerning wildlife death surveillance and wildlife disease outbreaks.

**The Panel recommends that Mexico continue, through to completion, the Turbio Basin Initiative.**

Although it does not have a perfect understanding of the initiative, the International Silva Reservoir Scientific Panel recognizes the importance of the Turbio Basin Initiative, and strongly endorses it as a plan that will contribute to reducing the likelihood of a reoccurrence of the *Presa de Silva* waterbird die-off. The commission charged with implementing the initiative was created by the signatories, which include the Mexican federal government, major municipalities, water and sewer system operators, both individual industries and their associations, key agricultural interests and private sector environmental organizations. The Panel endorses this collaborative approach to the initiative.

Municipal and industrial wastewaters have a dominant influence on this river system. It is unrealistic to expect that the *Río Turbio* could ever be returned to its pre-development state. Despite this, the

initiative notes that remarkable improvements can be made by:

- Proper treatment of raw-discharge municipal wastes and pre-treatment of co-discharged industrial effluent.
- Proper treatment of large industrial waste sources, together with recycling components, which would otherwise be discharged as pollutants.
- Provision of an industrial park setting where a large proportion of small manufacturing/processing firms can relocate and be served by proper waste treatment facilities.

While the Panel acknowledges the importance of each of these, it suggests that stakeholders involved in the initiative strive to 1) develop clear and common objectives related to environmental quality; 2) improve their knowledge of the environment and the manner in which their activities affect this environment to better achieve these objectives; and 3) monitor and communicate progress.

**The Panel recommends that Mexico develop a national program for wildlife health surveillance and wildlife disease outbreak investigation in partnership with existing programs in Canada and the United States.**

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The absence of such a program in Mexico at the time of the *Presa de Silva* incident resulted in delayed response to this die-off and continued uncertainty as to the ultimate cause of the deaths. Gaps in information occurred because scientists with wildlife biology and wildlife disease expertise were not involved from the onset in the investigation. The establishment of a surveillance-and-response program would allow for a timely and appropriate response to wildlife health issues. This organization, working in collaboration with similar organizations in Canada and the United States, could address wildlife issues on a continental basis such as those relating to migratory and endangered wildlife species. A working group established between the three countries could facilitate exchange of information, assist in training of wildlife disease specialists and development of disease contingency plans.

**The Panel suggests a number of options pertaining to the *Presa de Silva*. The following are response options outlined for consideration by the Mexican government and Mexican people in preparation for the return of migratory birds to the *Presa de Silva* in the fall of 1995. Each option is summarized in a paragraph. The level of effort required to successfully undertake each option and the level of risk associated with each option is also briefly addressed.**

- a) Monitor the *Presa de Silva* for waterbird mortality and have in place an organized response plan if and when mortality is observed.

This option has the least impact to the area initially and provides a mechanism to better understand the causes of waterbird mortality at this site. It requires effort and people to provide timely response should mortality be observed. Monitoring the reservoir requires active surveillance by personnel familiar with migratory bird species and their behavior. If mortality is observed, a disease contingency plan would go into effect to provide a quick and efficient response to the mortality. Training must be provided to personnel to allow them to carry out this option. The local response outlined in a contingency plan is the first step in development of a national plan for response to wildlife mortality as described in the last section of these recommendations. This low-cost activity will provide a long-term temporal perspective on mortality factors and contamination at the reservoir, although it will not prevent mortality. If a die-off should occur, a labour intensive cleanup might ensue.

- b) Drain the *Presa de Silva* if there is evidence of the onset of waterbird die-off.

If no water were in the reservoir, then waterbirds would not use the site and there would be no risk of mortality on the *Presa de Silva*. It must be understood that we do not have enough information to know if mortality occurs on other area wetlands or what risk there is to *Silva* birds displaced to other wetlands. The problem may leave the *Presa de Silva*, but it does not mean it is gone. The Panel understands that this drastic measure also

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has severe economic consequences to local communities because the water in the *Presa de Silva* is a vital resource for agricultural and other uses. This option could also be part of a modified version of option C. Instead of hazing birds off the water, the reservoir would be drained with alternate wetland development.

- c) Actively keep birds off the *Presa de Silva* and develop other water body sites as more attractive habitat for migratory birds.

This option requires the most effort to undertake and, if successful, provides a low risk of mortality occurring again on the reservoir. Keeping the birds off the reservoir is a difficult undertaking and requires ongoing commitment. Keeping birds off the reservoir is accomplished by hazing birds using mechanical noise devices, scarecrows, or people in watercraft. In addition, other water body sites would be identified and developed to attract the displaced *Silva* birds. This requires identifying sites no less than 25 kilometres from the *Presa de Silva* and providing a readily available food source to birds at these sites (e.g. harvested grains). The objective is to eventually move the migratory waterbird population from the *Presa de Silva* to other wetlands. This is estimated to require: 1) 3-5 years to accomplish; 2) people to monitor the *Presa de Silva* for bird activity and upkeep of hazing devices selected to keep birds off the reservoir; 3) people to monitor the alternate wetland(s) and provide food for birds at those site(s); and 4) training. This is a low-cost activity that will prevent birds from coming to the *Presa de Silva*. However, this undertaking is labour intensive and could concentrate birds at other water bodies, increasing the possibility of disease outbreak at the locations.

- d) Alter the topography of the reservoir.

Mexican authorities could reshape the reservoir topography toward a steep-sided deeper and smaller basin to minimize large areas of mudflats and the very shallow water levels. These changes in reservoir characteristics would reduce the risk of botulism outbreaks. However, these changes may adversely affect the irrigation capability of the reservoir. This activity would change the waterbird species attracted to the reservoir (shift from dabbling to diving species). Such an undertaking would be relatively costly and, while it could be effective in reducing the potential for future waterbird die-offs, some risk would still remain.

**The Panel urges the governments of Mexico, the United States and Canada to foster and encourage cooperative initiatives to address both the waterbird and watershed dimensions of the *Presa de Silva* incident. It further recommends that the Commission for Environmental Cooperation (CEC) continue to play an active role in assisting governments through promoting and facilitating cooperative activities and initiatives aimed at understanding and addressing the many stresses on the waterbirds and waters of the *Río Turbio* and *Río Lerma* — *Lago Chapala* Basin ecosystems.**

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The International Silva Reservoir Scientific Panel believes that the *Presa de Silva* incident could become an important catalyst for increased cooperation between Mexico, the United States and Canada. At one level, there is clear potential for increased cooperation, collaboration and assistance among the federal governments and their responsible agencies and jurisdictions. Other sectors, including industrial and financial interests, universities and other academic institutions, environmental non-governmental organizations (NGOs), private foundations and private citizens could all play important and significant roles in fostering and encouraging meaningful cooperation.

The Panel believes that the Commission's continuing active support would be an important contribution to the conservation and protection of the environment in the basin, while also making an important contribution to furthering ecologically and economically sustainable development. The intent is not to divert attention from other worthy opportunities. The Panel recognizes that there are many other areas in the three countries that would benefit from cooperative initiatives. Rather, it is the Panel's hope that progress made in responding to the *Río Turbio* incident would, in turn, provide encouragement and stimulus elsewhere.



### **ANNEX 1: SUMMARY OF THE JUNE 6, 1995 PETITION TO THE COMMISSION FOR ENVIRONMENTAL COOPERATION FROM THE NATIONAL AUDUBON SOCIETY, THE GRUPO DE LOS CIEN INTERNACIONAL AND THE CENTRO MEXICANO DE DERECHO AMBIENTAL.**

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Commission for Environmental Cooperation  
Montreal, Canada

**In Re: Silva Reservoir, Guanajuato,**  
Mexico,

National Audubon Society, *Grupo de los Cien Internacional*, and *Centro Mexicano de Derecho Ambiental*, Submitters.

#### **Article 13 Submission**

The undersigned National Audubon Society, *Grupo de Los Cien Internacional* and *Centro Mexicano de Derecho Ambiental* (Submitters), request that the Secretariat of the Commission for Environmental Cooperation (CEC) prepare a report under Article 13 of the North American Agreement on Environmental Cooperation (Environmental Cooperation Agreement), addressing the deaths of tens of thousands of native and migratory

waterfowl in December 1994 at the Silva Reservoir, in Mexico's Turbio River Basin. Submitters request that the CEC report on Mexico's response to the bird kill at the Silva and on a local initiative to control and reduce contamination in the Turbio Basin that may have caused or contributed to the Silva incident.

Although months have passed since 40,000 waterfowl died in one of the worst bird kills ever recorded, the cause of the deaths is still unknown. The absence of specialized technical expertise and adequate financial resources has hampered efforts to investigate and respond to the crisis. At the same time, scarce resources and uncertain interest have constrained the Mexican Government's promising but limited Turbio Basin Initiative, a project designed

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to promote contaminant source reduction and environmental education in the Turbio Basin.

Submitters ask that the CEC report on both the Silva Reservoir incident and the Turbio Basin Initiative. A CEC report can shed light on the underlying cause of the bird deaths and help prevent a recurrence at Silva or in other North American waters. A report can also foster international support for the Turbio Basin Initiative by identifying and promoting technical cooperation and multilateral support. If successful, the initiative can reduce the possibility of another bird kill at Silva by addressing the broader contamination issues in the Turbio Basin, and can serve as an important model for future source reduction and watershed cleanup efforts in other parts of Mexico, Canada and the United States.

As detailed below, the CEC has the authority to prepare a report on the Silva Reservoir incident and the Turbio Basin Initiative because both the incident and the initiative raise substantial transboundary environmental issues affecting all three North American Free Trade Agreement (NAFTA) parties. The CEC is the only entity capable of bringing international attention to this situation in a positive and cooperative manner. In fact, the CEC is in a unique position to marshal international resources and focus international support on cooperative long-term solutions for the Silva Reservoir and the Turbio Basin, and for other watersheds in North America.

## **I. Jurisdiction**

The CEC has jurisdiction to report on the Silva Reservoir incident and the Turbio Basin Initiative under Article 13 of the NAFTA Environmental Cooperation

Agreement. This Article provides that “[t]he Secretariat may prepare a report for the Council on any matter within the scope of the annual program.” (Environmental Cooperation Agreement at Article 13.1.) The 1995 annual program, in turn, includes within its scope environmental protection efforts affecting “highly migratory species,” such as the waterfowl killed at the Silva Reservoir. (Annual Program at .P95.24.) The annual program specifically states “[t]he [CEC] will provide a coordinating mechanism to assist national environmental protection efforts and to support tri-national and citizen programs affecting highly migratory species.” *Id.* Thus, the CEC has direct jurisdiction to prepare a report on the issues raised in this Submission.

Even if the annual program did not include migratory species within its scope, the CEC would have jurisdiction because it is authorized to “prepare a report on any other environmental matter related to the cooperative functions of this Agreement,” upon notice to the Council, unless the Council objects to the preparation of such a report by a two-thirds vote within 30 days of the notice. (Environmental Cooperation Agreement at Article 13.1.) The cooperative functions of the Environmental Cooperation Agreement include “transboundary... environmental issues” such as conservation of migratory species, and “the conservation and protection of wild flora and fauna and their habitat.” (Environmental Cooperation Agreement at Article 10.2[I].)

In addition, the CEC has the authority to “provide the Parties and the public information on where they may receive technical advice and expertise with respect to environmental matters.” (Environmental Cooperation Agreement at Article 11.7.)

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Finally, the report requested by Submitters is fully consistent with the CEC's objectives, which include "foster[ing] the protection and improvement of the environment in the territories of the Parties," (Environmental Cooperation Agreement at Article 1[a]), "increas[ing] cooperation between the parties to better conserve, protect, and enhance the environment, including wild flora and fauna," *Id.* (at Article 1[c]), "strengthen[ing] cooperation on the development and improvement of environmental... policies and practices," *Id.* (at Article 1[f]), "enhanc[ing] compliance with... environmental laws and regulations," *Id.* (at Article 1[g]), "promot[ing] transparency and public participation in the development of environmental... policies," *Id.* (at Article 1[h]), and "promot[ing] pollution prevention policies and practices." *id.* (at Article 1[j]). The report requested by Submitters would serve each of these objectives.

## II. Submitters

The National Audubon Society is a non-profit NGO incorporated under the laws of New York with a principal place of business in New York, NY. Its primary mission is the conservation of birds, wildlife and habitat. Audubon has 540 chapters in the United States and Latin America, including the San Miguel de Allende and Queretaro chapters located near the Silva Reservoir. Audubon has more than 500,000 individual members in the United States, Canada and Mexico, including members living in and near San Francisco del Rincón and León, Mexico.

*Grupo de Los Cien International, A.C.* is a non-profit NGO incorporated under the laws of Mexico with a principal place of business in Mexico City, Mexico. Its primary missions are to raise public awareness of environmental issues in Mexico and to combat environmental deterioration in the country.

*Centro Mexicano de Derecho Ambiental, A.C.* is a non-profit NGO incorporated under the laws of Mexico with a principal place of business in Mexico City, Mexico. Its primary mission is to promote greater understanding of, and compliance with, Mexican environmental laws.

Submitters are interested NGOs within the meaning of Article 13 of the Environmental Cooperation Agreement, and as such have standing to furnish "relevant technical, scientific or other information" to the Secretariat in support of an Article 13 investigation and report. (Environmental Cooperation Agreement at Article 13.2b.) This Submission and accompanying Statement of Facts furnish such relevant information, and Submitters stand ready to provide further information or to assist the CEC with its investigation of the Silva incident in any way the CEC deems necessary and appropriate.

## III. Factual Summary

### A. The Silva Incident

In December 1994, residents of San Francisco del Rincón began noticing large numbers of dead and dying birds in and around the *Presa de Silva*, Silva Reservoir, a 300-acre irrigation reservoir located in the Turbio River Basin in the state of Guanajuato, Mexico. By the end of the month, an estimated 40,000 birds had died, and an extensive local response to the crisis was mounted. Volunteers rescued dozens of sick and dying birds, and treated them in makeshift rehabilitation centers. Dead birds were buried in mass graves alongside the reservoir, and elaborate schemes were devised to prevent greater numbers of birds from landing in the contaminated water.

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Unable to remediate the contamination, and unable to halt a growing death toll, Mexico's *Comisión Nacional del Agua* (CNA) responded by draining the reservoir in mid-January 1995. A trip to Silva by Submitters in late February revealed only a dry lake bed where the reservoir had once teemed with wildlife.

Since the crisis began, the Mexican government has taken steps to investigate the cause of the deaths through its lead agency, CNA. But to date, no plausible explanation has been found, nor any credible theory proven. Early reports linked the deaths to the presence of chromium, a chemical used extensively in facilities operating upstream from Silva. But later government reports held that the deaths were caused by a one-time release of the commercial pesticide endosulfan by unknown persons allegedly observed near the reservoir in December.

The endosulfan poisoning claim has not yet been substantiated, and CNA's investigation has made no apparent recent progress. Without further investigation, the precise cause of the Silva incident will remain unknown, and the opportunity to address the cause and to prevent a likely recurrence may be lost.

#### **B. The Turbio Basin Initiative**

Early in 1995, while CNA was still reviewing the Silva Reservoir incident, Mexico's environment secretariat announced a cleanup effort for the Turbio River Basin as a whole. The Turbio Basin Initiative seeks voluntary commitment from municipalities, businesses and NGOs to support a plan for contaminant source reduction in the basin. Although the Initiative does not address all contaminant sources emptying into the Turbio Basin, and does not reach all industrial dischargers, it represents an

important beginning. It also provides an opportunity to reduce contamination in the Silva that may well have contributed to the December bird kill.

But even this Initiative may lack the political, technical and financial backing necessary to succeed. Local residents have welcomed the Turbio Basin Initiative, but express concern that it will be abandoned, just as a similar government plan to reduce discharges from local tanneries was dropped for lack of support in 1991. The Initiative relies on voluntary participation, yet businesses that were asked to invest in source reduction technology claim that financing is unavailable for those investments. Similarly, NGOs that were requested to develop plans for research, study and environmental education face the same limitation. As of the date of this Submission, the Initiative appeared stalled as participants searched for sources of funding and technical cooperation.

#### **C. The CEC's Role**

The Silva Reservoir and the Turbio River have become symbols of environmental waste. Untreated sewage and industrial effluent flow unchecked into the Turbio River Basin, and the reservoir, which once teemed with waterfowl and other wildlife, lies drained. Tens of thousands of birds that would have migrated back to the United States and Canada are buried in mass graves surrounding the now-empty reservoir. The question remains whether the scene will be repeated with next year's migration.

But the attention and support of the CEC can transform these symbols of waste into a model of multilateral cooperation. With the leadership of the CEC, support from the international community,



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commitment and initiative from local officials, and cooperation from industrial and environmental groups, the Turbio River Basin and the Silva Reservoir can recover. Moreover, the lessons learned at Silva can protect migratory waterfowl throughout Mexico, Canada and the United States.

The NAFTA parties conceived of a commission able to address common concerns without resort to dispute and controversy, and able to bring a multilateral perspective to shared environmental issues. The Silva case presents an opportunity to fulfill that vision by helping Mexico prevent a recurrence of the bird kill as well as reduce and control underlying sources of contamination in the Turbio Basin while building a model for addressing similar concerns throughout the North American region. It allows CEC to fulfill one of its principal missions – to respond to a national environmental problem that has international consequences, while remaining sensitive to local priorities and to the possibility of creating effective regional models.

#### IV. Request for Report

Submitters ask that the CEC report on the cause of the waterfowl deaths at the Silva Reservoir and the Mexican Government's response. In addition, Submitters ask that the CEC report on sources of international support for the Turbio Basin Initiative, which can offer a long-term solution for the Turbio River Basin and the Silva Reservoir. Submitters request that the report:

- Assess the cause of the bird kill at the Silva Reservoir, and the Mexican government's response to the incident so that a recurrence can be avoided;

- Assess the impact of the Silva incident, and the loss of an important, shared natural resource, on citizens of the NAFTA parties;
- Identify available financial and technical support from NAFTA parties, trade associations, NGOs and international agencies to investigate and respond to the Silva incident and to assure the success of the Turbio Basin Initiative;
- Encourage technical cooperation in support of the Turbio Basin Initiative;
- Make recommendations regarding the use of national, international and multilateral institutions to provide financial and technical support for the Silva incident response and the Turbio Basin Initiative;
- Make recommendations to the NAFTA parties regarding national or multilateral mechanisms or policies to help avoid similar incidents in the future; and
- Promote the Turbio Basin Initiative as a model for similar public participation and pollution prevention projects in other watersheds in North America.

By issuing a report on the Silva Reservoir and the Turbio Basin Initiative, the CEC can inform the broader public within all NAFTA countries about what has happened in Guanajuato. CEC can also support efforts to redress the environmental conditions that caused the loss of an important shared natural resource in the first place — efforts that may serve as a model for other regions in Mexico, Canada and the United States.

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By issuing such a report, the CEC can fulfill its unique function of representing the interests of all three NAFTA signatories and their citizens in protecting our shared natural resources.

*Respectfully submitted,*

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Dated: June 6, 1995

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## ANNEX 2: REFERENCES FROM THE INTERNATIONAL SILVA RESERVOIR SCIENTIFIC PANEL REPORT

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\* A copy of each referenced document is being maintained in a *Presa de Silva* reference file by the Commission for Environmental Cooperation. **English translations of all or part of the documents numbered in bold type are also maintained in the reference file.**

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## ANNEX 3: INTERNATIONAL SILVA RESERVOIR SCIENTIFIC PANEL MEMBERSHIP

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## ANNEX 4: TERMS OF REFERENCE, INTERNATIONAL SILVA RESERVOIR SCIENTIFIC PANEL

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### International Silva Reservoir Scientific Panel - Terms of Reference

- 1) The International Silva Reservoir Scientific Panel was formed, effective July 6, 1995, pursuant to Article 13 of the North American Agreement on Environmental Cooperation. The primary function of the Panel will be to provide the Secretariat of the Commission for Environmental Cooperation with a scientific and technical assessment of matters related to the deaths of waterbirds which occurred in late 1994 and early 1995 at the Silva Reservoir in Mexico's Turbio River Basin.
- 2) The International Silva Reservoir Scientific Panel shall consider the factors, circumstances and events associated with the deaths of resident and migratory waterbirds in December 1994 at the Silva Reservoir, in Mexico's Turbio River Basin and shall:
  - a) provide an assessment of the cause, causes or probable causes of the deaths of resident and migratory waterbirds at the Silva Reservoir;
  - b) provide an assessment of the historical and probable future occurrences of similar and related waterbird mortalities in the Silva Reservoir and elsewhere in the Turbio River Basin;
  - c) provide an overview assessment of the occurrences of similar mass mortalities of resident and migratory waterbirds in Canada, Mexico and the United States;
  - d) provide a general assessment of the nature, extent and significance of water pollution in the Silva Reservoir and in the Turbio River Basin upstream of the Silva Reservoir;
  - e) consider current initiatives, including local initiatives, to reduce pollution in the Turbio River Basin and to provide advice as to what might reasonably be done to reduce pollution in the Turbio River Basin;
  - f) provide a summary of existing response mechanisms with respect to waterbird mortalities in North America, and advise on the potential for collaboration;
  - g) identify opportunities for international cooperation that are available or that may become available as a result of the Silva Reservoir event and/or as a result of the work of the Panel;
  - h) provide, on or before August 31, 1995, a written report to the Secretariat of the Commission for Environmental Cooperation covering the items listed in this paragraph and such other matters as the Panel considers appropriate;
  - i) provide, by September 30, 1995, a written retrospective evaluation of the strengths and weaknesses of the process used in addressing the Silva Reservoir event and to recommend measures that might be taken with respect to the preparation of future reports under

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Article 13 of the North American Agreement on Environmental Cooperation.

- 3) The International Silva Reservoir Scientific Panel shall provide, by July 7, 1995, a draft work plan outlining the means by which it plans to carry out its work. This work plan shall provide an initial assessment of the timing, allocation and associated costs of work to be carried out by, or under the direction of, the Panel.
- 4) The Secretariat of the Commission for Environmental Cooperation shall, within the limits of its capabilities, endeavor to provide technical, administrative, translation and financial support to the work of the Panel, including work carried out by consultants and others working under the general direction of the Panel. In the event that the Panel identifies resource requirements in excess of those anticipated by the Secretariat, the Secretariat shall make every effort to obtain the resources required to meet these unanticipated needs so identified by the Panel;
- 5) The membership of the International Silva Reservoir Scientific Panel shall be made up of knowledgeable persons with expertise relevant to the tasks assigned to the Panel.
- 6) Members of the International Silva Reservoir Scientific Panel are encouraged to draw on expertise, advice and support from within their respective agencies and institutions, however, in carrying out the work of the Panel, they are requested to serve in a personal and professional capacity and not as representatives of their governments, agencies or institutions.
- 7) Members of the International Silva River Scientific Panel are encouraged to make full use of materials provided in the submission by the National Audubon Society, the *Grupo de los Cien Internacional*, and *Centro Mexicano de Derecho Ambiental* as well as materials that may be provided by government agencies, academic institutions, industrial interests, environmental non-governmental organizations and others as appropriate.
- 8) The International Silva Reservoir Scientific Panel shall strive for consensus in the decisions that it makes and in the conclusions and recommendations that it comes to during the course of its work. The Panel, if it so chooses, may vote on any issue on which it wishes to make a decision.

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## ANNEX 5: LETTER OF TRANSMITTAL FROM THE INTERNATIONAL SILVA RESERVOIR SCIENTIFIC PANEL

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### INTERNATIONAL SILVA RESERVOIR SCIENTIFIC PANEL

September 1, 1995

Mr. Victor Lichtinger  
Executive Director  
Commission for Environmental Cooperation  
393, St-Jacques St. West, Suite 200  
Montreal, Quebec H2Y 1N9

Dear Mr. Lichtinger:

The International Silva Reservoir Scientific Panel is pleased to forward this report to the Secretariat of the Commission for Environmental Cooperation. The report addresses matters related to the mass mortality of resident and migratory waterbirds that occurred at the *Presa de Silva* (Silva Reservoir) during the winter of 1994-95. The Panel would also like to communicate its willingness to assist the secretariat, if so requested, in the interpretation and elaboration of materials presented in the Panel's report and with such other related material as the secretariat may in the future find to be necessary and appropriate.

The Panel acknowledges the generous and helpful assistance that it has received from many individuals and organizations. Mexican government officials have typically been very helpful in making information available to the Panel, in taking time from their schedules to meet with members of the Panel and in generally expediting the work of the Panel.

The National Audubon Society, the *Grupo de Los Cien Internacional* and the *Centro Mexicano de Derecho Ambiental* were also very helpful in providing help and assistance to the Panel. These were the three organizations that requested the Secretariat of the Commission for Environmental Cooperation to prepare a report under Article 13 of the North American Agreement on Environmental Cooperation.

The Panel would also like to acknowledge the help of the many scientists, engineers and other experts from throughout North America who invariably responded positively to requests for information and advice.

The members of the International Silva Reservoir Scientific Panel would like to express their thanks for having had this opportunity to participate in the first international study under Article 13 of the North American Agreement on Environmental Cooperation. We also hope that the Panel's report to the Secretariat of the Commission for Environmental Cooperation will assist the Secretariat in its own first report under Article 13 of the Agreement.

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*Respectfully submitted,*

Dr. Jorge Soberón  
Co-chairperson  
Comisión Nacional para el  
Conocimiento y Uso de la  
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