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Environmental Evaluation of the Gabcikovo (Bös)-Nagymaros River Barrage System

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Section 1

INTRODUCTION

1.1 PURPOSE

Bechtel has independently reviewed the Gabcikovo (Bös)-Nagymaros Barrage (GNB) Project in terms of potential environmental impacts, operational considerations, and currently planned mitigation measures. We have examined the project from the standpoint of its stated goals of integrating and optimizing multiwater resources for the purposes of power production, navigation, flood control, regional development, water supply and water quality, agriculture and forestry, natural biological values (including fishery and wildlife), recreation, visual enhancement, and preservation of archaeological values.

Our approach to the environmental review was a multidisciplinary effort, which focused on:

- Defining significant impacts associated with the project that warrant evaluation and mitigation
- Determining additional baseline data needed for impact definition
- Reviewing planned mitigations to reduce impacts to insignificant levels or to enhance project benefits
- Identifying additional investigation measures that could reduce impacts further
- Assessing effectiveness of the monitoring program by defining preoperational environmental conditions and operational conditions

Where possible, the significance of potential project-related impacts were qualitatively defined in the context of construction and operation activities, and the expected duration of the impacts. Impact discussions in this evaluation reflect the amount of data and analyses available for the environmental review. For example, the hydrologic regime of the project area

1
Introduction

Appendix 1

REFERENCES

VIZITERV, Consulting Company for Water Engineering, July 1989. Informatory Documents[(a)] for the Gabcikovo/Bös-Nagymaros River Barrage System.

1. Summary Description, compiled by Dr. Endre Zsilak, Chief Project Engineer.

2. Standard Specifications, Regulations and Orders on Environmental Protection.

3. Engineering Geology. Compiled by: Dr. Jeno Mantuano, Chief Project Engineer.

4. Hydrological Conditions of the Danube and its Tributary Streams.

4.1 Surface Water Regime. Prepared by Ferenc Papp, Chief Project Engineer.

4.2 Subsurface Water Regime. Prepared by Dr. Jeno Mantuano.

4.3 Sediment Regime of the Danube Stretch Affected by the Gabcikovo-Nagymaros Hydroelectric Development Project.

4.4 Comprehensive Report "Exploration of the Ice Regime over the Danube Reach Influenced by the Bös-Nagymaros River Dam Project."

4.5 Quality of Surface Waters, Prepared by: Mrs. Eva Bartalis-Tevan, Biologist, Technical Advisor; Dr. Szabolcs Tyahun, Biologist; Dr. Pal Varga, Chemical Engineer; and Mr. Nandor Varday, Chemical Engineer.

4.6 Subsurface Water Quality, Prepared by: Ferenc Herzog, Chief Project Engineer.

5. Biological Conditions.

5.1 The Flora, Vegetation, Fish Fauna, and Biological Monitoring of the Gabcikovo/Bös-Nagymaros River Barrage System, Experts: Dr. T. Simon, Doctor of Biological Sciences and Dr. C. Lang, Candidate in Biological Sciences.

(a) Please refer to pages A1-4 through A1-35 for contents of these Informatory Documents.

5.2 Plant Nutrient Supply in the Danube River and its Hydrobiological Features, Experts: Dr. T. Kiss Keve, Candidate for Biological Sciences, MTA-OBKI, Hungarian Danube Research Station; Mrs. E. Tevan-Bartalis, Biologist, Technical Consultant, EDU-KÖVIZIG; Dr. Sz. Tyahun, Biologist, KOV-KÖVIZIG; Dr. P. Varga, Chemical Engineer, Head of Department, KOV-KÖVIZIG; Dr. N Varday, Chemical Engineer, Head Section EDU-KÖVIZIG.

6. Agricultural and Silvicultural Land Use, Compiled by Consulting Company for Water Engineering.

7. Archaeological and Monuments Assets and Annex, Compiled by: VIZITERV with participation of experts.

8. Aesthetic Quality and Character of Landscape, Produced by: VIZITERV based upon experts.

9. Recreation - Tourism, Compiled by: VIZITERV based upon the expert's report.

10. Social and Economic Aspects, Prepared by Ferenc Kollar, Chief Engineer of the River Barrage Project.

11. Evaluation of Conditions and Effects. Compiled by: Dr. D. Orloci, Civil Engineer, Senior Research Fellow.

12. The Monitoring Network 1.

12.1 The Monitoring Network Operative in 1988, Compiled by: Dr. Jeno Mantuano, Chief Project Engineer.

12.2 Comprehensive Report on Observations up to 1985. Szigetköz

12.2.1 Comprehensive Report

12.2.2 Legend to Table 1 - Table 49

12.2.3 Legend to Figures 1-27 and Maps 1-4

12.3 Comprehensive Report on Observations up to 1985. Section Downstream of Gönyü.

12.3.1 Legend to Table 1 - Table 22

12.2.2 Legend to Figures 1-16 and Maps 1-3

Power Engineering Influences of Introducing An Environment Protecting Operation Pattern on the Operation of the Bös-Nagymaros River Barrage System. Research Report. Budapest Technical University, Department of Water Management, 1989.

The Monitoring System of the Bös (Gabcikovo)-Nagymaros River Barrage System. Conception of Evaluation.

A Kisaalföld: Duna-szaKasz és a Kajesolodo mellékvizek halai és halaszato. 1987. Kalman Jancso anl Janos Toth authors. Translated from A Kisaalföld Duna-szaKasz Ökologiaja.

1.0 SUMMARY DESCRIPTION

CONTENTS

1.0 SUMMARY DESCRIPTION

CONTENTS (Cont'd)

2.0 STANDARD SPECIFICATIONS, REGULATIONS AND ORDERS ON ENVIRONMENTAL PROTECTION

CONTENTS

3.0 ENGINEERING GEOLOGY

CONTENTS

3.0 ENGINEERING GEOLOGY

CONTENTS (Cont'd)

4.0 HYDROLOGICAL CONDITIONS OF THE DANUBE AND ITS TRIBUTARY STREAMS

4.1 Surface Water Regime

CONTENTS

4.2 Subsurface Water Quality

CONTENTS

4.3 Sediment Regime of the Danube Stretch Affected by the Gabcikovo-Nagymaros Hydroelectric Development Project

4.4 Comprehensive Report "Exploration of the Ice Regime Over the Danube Reach Influenced by the Bös-Nagymaros River Dam Project"

4.5 Quality of Surface Waters

CONTENTS

4.6 Subsurface Water Quality

CONTENTS

5.0 BIOLOGICAL CONDITIONS

5.1 The Flora Vegetation, Fish Fauna, and Biological Monitoring of the Gabcikovo/Bös-Nagymaros River Barrage System

CONTENTS

ANNEXES

1. Checklist of the flora of Szigetköz (1987)
2. The flora of the Danube valley between Györ and Nagymaros in 1987-1988
3. Synthetic tables of associations (1937-1957, based on Zólyomi and I. Kárpáti)
4. Recent phytosociological releve of the monitoring sample sites (1987-88)
5. Recent fish fauna of the Danube (based on J. Tóth, in Simon (ed.) 1978)
6. Fishery records of major fish species (1968-1985)
7. Map of the Szigetköz Landscape Protection Area
8. Bird records in 1987, 1988
9. Records of aquatic invertebrates, 1987, 1988
10. Diversity and equitability tables

5.2 Plant Nutrient Supply in the Danube River and Its Hydrobiological Features

CONTENTS

6.0 AGRICULTURAL AND SILVICULTURAL LAND USE

CONTENTS

6.0 AGRICULTURAL AND SILVICULTURAL LAND USE

CONTENTS (Cont'd)

<u>List of Tables and Figures</u>

Maps

7.0 ARCHAEOLOGY AND MONUMENTS ASSETS AND ANNEX

CONTENTS

7.0 ARCHAEOLOGY AND MONUMENTS ASSETS AND ANNEX

CONTENTS (Cont'd)

ANNEX

ANNEX

1. LIST OF MAPS

2. LIST OF FIGURES

ANNEX (Cont'd)

23. Esztergom: (35.1.1-13) - lay-out of the medieval Esztergom showing the old parts of the town
24. Esztergom: site of the medieval edifices of the Royal town (35.1.10) on the present town map
25. Esztergom: (35.2) the town in 1595, copper engraving of Hans Sibmacher
26. Esztergom - Zsidód: (35.1.2) excavation of the church and cemetery of Arpadian time
27. Esztergom: Szentkirály (35.1.5) - ground plan of XIIth century church
28. Esztergom: town wall of Viziváros (35.1.11) - around 1735, engraving of F.B. Werner
29. Esztergom: town walls of Viziváros (35.1.11) around 1850
30. Esztergom: town walls of Viziváros (35.1.11) around 1860, engraving of L. Rohbock
31. Esztergom: Héviz (35.2.3) street scenes of Bajcsy-Zsilinszky Street
32. Pilismarót: Malompatak (36.1) watch tower
33. Pilismarót: (36.1) Roman castrum
34. Dömös: Kövespatak (37.1.2) Roman watch tower
35. Visegrád: (Pone Navata) (38.1.1) Roman camp
36. Visegrád: view of 1595. Etched copper engraving made after the drawing of Jakob Hoefnagel
37. Visegrád: view of 1600. Etched copper engraving of Dilich
38. Visegrád: royal palace (38.2.9) ground plan
39. Visegrád: Citadel (38.2.22) ground plan
40. Nagymaros: view. Steel engraving of Rohbock-Fesca

3. LIST OF PHOTOGRAPHS

1. Rajka: Roman Catholic church (1.2.5)
2. Hédervár: main facade of the manor-house of Hédervár (8.2.2)
3. Hédervár: manor-house of Hédervár with the park pavilion (8.2.2)
4. Hédervár: the centaur statue of the manor-house park (8.2.2)
5. Györ: main facade of the pontifical cathedral (24.2.1)
6. Györ: side facade of the pontifical cathedral and the chapel ruin of Roman age (24.2.1)
7. Györ: pontifical cathedral, higher altar (24.2.1)
8. Györ: pontifical cathedral, so-called Hédervary chapel with the herma of St. Ladislas (24.2.1)
9. Györ: episcopal castle with the casemate (24.2.2)
10. Györ: so-called Sforza bastion of the fortress system (24.2.2)
11. Györ: view of the so-called castle bastion (24.2.2)
12. Györ: episcopal castle and its fortress system from the Danube (24.2.2)
13. Györ: so-called Sforza bastion of the episcopal castle (24.2.2)
14. Györ: Roman Catholic, former Carmelite church and convent (24.2.3)

15. Győr: Roman Catholic, former Carmelite church during a flood (24.2.3)
16. Győr: Roman Catholic, former Carmelite church with the bridge leading to the island (24.2.3)
17. Győr: view of Széchenyi Square with the Benedictine church (24.2.4)
18. Győr: The Benedictine church and friary (24.2.4)
19. Gönyü: inn of the former mail-coach station (25.2.1)
20. Gönyü: Roman Catholic church (25.2.2)
21. Ács: Roman Catholic church (27.2.1)
22. Ács: Calvinist church (27.2.2)
23. Ács: Eszterházy-Zichy palace (27.2.3)
24. Szőny: Roman Catholic church (29.2.1) exterior
25. Szőny: Roman Catholic church (29.2.1) interior
26. Almásneszmély: Water mill (30.2.3) present appearance
27. Almásneszmély: Water mill (30.2.3) around 1903-1910
28. Almásneszmély: Calvinist church (39.2.5) exterior
29. Süttö: Roman Catholic church (31.2.1) interior
30. Süttö: Roman Catholic church (31.2.1) interior
31. Süttö: Reviczky manor-house (31.2.3)
32. Nyergesújfalu: Viscosa Plant (33.1.4) excavation of Bronze Age urn graves
33. Nyergesújfalu: Roman Catholic church (33.2.1) exterior
34. Nyergesújfalu: Roman Catholic church (33.2.1) interior
35. Nyergesújfalu: Roman Catholic parsonage (33.2.2)
36. Tát: granary (34.2.3)
37. Esztergom: Szt. Györgymezö Danube bank (35.1.13) research of houses of Arpadian age
38. Esztergom: Helemba sziget (35.1.29) excavation of a church and cemetery of Arpadian age
39. Esztergom: Helemba sziget (35.1.29) escavation of the walls of the XIIIth century palace 1959. Stephen Méri
40. Esztergom: Szentkirály (35.1.5) excavation of a cemetery and settlement of Arpadian age
41. Esztergom: Várhegy (35.2.1)
42. Esztergom: Várhegy (35.2.1), below it the dwelling houses of Viziváros
43. Esztergom: Várhegy (35.2.1) and the Roman Catholic parish church of Viziváros
44. Esztergom: royal castle (35.2.1) castle chapel
45. Esztergom: Viziváros (35.2.2) archiepiscopal palace, Roman Catholic parish church of Viziváros and the pontifical cathedral
46. Esztergom: Roman Catholic parish church of Viziváros (35.2.2)
47. Esztergom: Viziváros (35.2.2) detail
48. Esztergom: former Franciscan church (35.2.4), today it belongs to the seminary
49. Esztergom: Széchenyi Square 7 (35.2.4) Gróh or Saracen-house
50. Esztergom: Deák Ferenc Street 3 (35.2.4) so-called Obermayer house

ANNEX (Cont'd)

51. Esztergom: Roman Catholic parish church of the inner city (35.2.4)
52. Esztergom: Royal town (35.2.4) at the time of the flood of 1876. Photo by József Beszédes
53. Esztergom: Royal town (35.2.4) at the time of the flood of 1876. Photo by József Beszédes
54. Pilismarót: Homoki szölök (36.1.12) - excavation of the fortress of Roman age
55. Pilismarót: Homoki szölök (26.1.12) - excavation of Roman vessel furnace
56. Pilismarót: Roman Catholic church (36.2.2) exterior
57. Pilismarót: Roman Catholic church (36.2.2) interior
58. Pilismarót: Heckenast manor-house (36.2.4) exterior
59. Pilismarót: Heckenast manor-house (36.2.4) painting in secco of the upstairs hall (detail)
60. Dömös: School garden (37.1.4) brick kiln
61. Dömös: Roman Catholic church (37.2.2) exterior
62. Dömös: Roman Catholic church (37.2.2) interior
63. Dömös: Statue of St. John of Nepomuk (37.2.3)
64. Dömös: boat station (37.2.5)
65. Visegrád: royal palace (38.2.9) detail
66. Visegrád: royal palace (38.2.9) detail
67. Visegrád: Salamon tower and Citadel (38.2.22)
68. Nagymaros: view with the church
69. Nagymaros: Kossuth Square 11 (39.2.8)
70. Nagymaros: Szt. Imre Square 4 (39.2.9)
71. Nagymaros: Kossuth Square 7 (39.2.8)
72. Nagymaros: Kossuth Square 9 (39.2.8)
73. Zebegény: Roman Catholic church (40.2.1)
74. Zebegény: railway viadict (40.2.3)
75. Szob: Roman Catholic chapel (41.2.4) present condition
76. Szob: Roman Catholic chapel (41.2.4) archive photo
77. Szob: Luczenbacher manor-house (41.2.2)
78. Letkés: Immaculata statue (43.2.2)

8.0 AESTHETIC QUALITY AND CHARACTER OF LANDSCAPE

CONTENTS

LIST OF FIGURES, TABLES, AND DRAWINGS

FIGURES:

TABLES:

DRAWINGS:

9.0 RECREATION AND TOURISM

CONTENTS

LIST OF TABLES

MAPS ENCLOSED

1. Tourist regions and settlements by nature attractive for tourism
2. Touristic potentialities and features of attractions
3. Improvements of riverside recreation facilities
4. Improvements of the water sports facilities

10.0 SOCIAL AND ECONOMIC ASPECTS

CONTENTS

11.0 EVALUATION OF CONDITIONS AND EFFECTS

CONTENTS

12.0 MONITORING NETWORK 1

12.1 The Monitoring Network Operative in 1988

CONTENTS

CONTENTS (Cont'd)

12.2 Comprehensive Report - Observations up to 1985 - Szigetköz

CONTENTS

12.3 Comprehensive Report on Observations up to 1985 - Section Downstream of Gönyü

CONTENTS

CONTENTS (Cont'd)

TABLE OF CONTENTS

LIST OF TABLES

Appendix 1
References

For project operation monitoring along the reach between Gönyü and Visegrád, monitoring should be conducted at potential areas of seepage from higher reservoir levels, critical biological and archeological sites, and between the river and the bank filter wells. The frequency of measurement should be based on the expected rate of change in water levels. Some sites may warrant continuous monitoring; others might be measured four times a year.

8. Ground water quality sampling and quality analysis should be conducted monthly for 2 years to establish baseline conditions. Vertical sampling of a few deep wells should also be conducted. During project operations, ground water quality testing should be conducted at critical sites and over a widely spaced grid along the right bank reach at 3-month intervals.

9. Ground water level data should be collected at all biological monitoring stations to monitor habitat changes. Stream gauging and water quality data should be collected at sensitive waterfowl locations such as Ásványráró.

10. Annual waterfowl surveys on the main Danube channel and side arms along the length of Szigetköz should be conducted. Data can be compared with preoperational survey results to determine changes in populations.

11. Seasonal surveys should be conducted for the four protected birds in the Szigetköz to detect changes in habitat use and abundance.

12. If protected mammal species are identified during preoperational surveys, seasonal surveys should be continued during monitoring.

13. Annual fish surveys including migration and spawning conditions should be conducted in the main channel and side arms of the Szigetköz and Mosoni to determine cumulative impacts.

14. DO levels should be monitored in both reservoirs.

15. Monitoring for forestry should only be considered if ground water levels cannot be maintained by the artificial recharge system as planned. No monitoring for agricultural crops or livestock is recommended.

excessive amounts of farm fertilizers seeping into the ground water in the Szigetköz and along the lower reaches of the project. We understand that construction of sewage treatment facilities at Györ has started and evaluation of industrial effluent treatment is under way. These and other effluent treatment plans should be pursued.

6. It is strongly recommended that sewage treatment facilities at Györ be operational before the Nagymaros reservoir is filled.

7. Local authorities should develop recreation and land use plans to enhance benefits of new tourism opportunities while limiting adverse impacts to existing land use and sensitive biological areas.

1.5.2 Monitoring Recommendations

Recommendations regarding the GNB project monitoring program are summarized as follows. Detailed discussions are presented in Section 3.

1. The project has expended substantial efforts to develop data to be used to implement mitigation of project-related environmental impacts. A program to educate the public about these efforts would do much to develop support for the project and to answer criticism developed by the opposition.

2. After project startup, the approximately 50 stream flow measuring stations (existing or planned) can be reduced for project operation purposes to about 10 stations, located at all project input sources. All measuring stations should be monitored until project operating rules for all ranges of input conditions (streamflow, sediment load, and pollutant load) have been verified.

3. After surface water levels versus ground water level correlations have been verified, the surface water level measuring stations can be reduced to those at headworks and tailraces of project structures, two locations along the old Danube River channel, and control structures for the seepage interception channels.

4. Cross section surveys should be conducted at 1 km intervals along the Hrusov-Dunakiliti reservoir to establish areas of major sediment deposition for the first 2 to 4 years of project operation. After major sites of sediment deposition are identified, the number of annual surveys can be reduced to four cross sections - one cross section should be located at the upstream end of the reservoir to check clearance in the navigation channel.

   During the first 2 to 4 years, annual cross section surveys should be conducted in Nagymaros reservoir at 3 km intervals and at reaches where bank filter wells are located. After areas of deposition are identified the annual surveys can be reduced to about five locations.

5. Annual analyses of bottom sediments should be conducted in both reservoirs to determine heavy metal content and to check that the bottom environment is conducive for keeping the metals in the stable adsorbed state.

6. During the first year of project operations, water quality sampling and analyses should also be conducted for the two reservoirs, Mosoni Danube, old Danube channel, and the Szigetköz side arm channel to check that the water quality model is properly calibrated and project operations are maintaining the required water quality level.

   Sampling and analysis should be increased during summer months when algal blooms are occurring. During the sample day, DO measurements should be taken twice (morning and evening) to record the diurnal DO changes. After the first year, sampling frequency can be reduced to monthly and the number of measuring stations may be reduced to selected key locations.

7. For project operations monitoring in the Szigetköz area, ground water level measurements should be reduced to three lines between the Mosoni Danube and the old Danube channel to track the ground water profile, and at areas of special concern. Continuous monitoring in these wells is recommended. Another 10-15 sites should be selected for long-term measurements and measured twice a year.

1.5.1 Mitigation Recommendations

1. VIZITERV should continue evaluating the peak operations (including seasonal changes) of the Gabcikovo plants with gradual load buildup. Variations in river levels due to peaking modes can significantly impact downstream resources including recreation and natural habitats.

2. Additional preoperational data are needed to define impacts to biological resources, especially fisheries, and develop effective mitigations. Additional data should include seasonal surveys for waterfowl, fish, other wildlife species, and four protected birds to determine distribution, abundance, and seasonal habitat use. Surveys should focus on the old Danube channel and side arm/oxbows in the Szigetköz. Consideration should be given to increasing the flow rates to the main channel. A system-wide DO modeling program should be conducted. Based on the modeling results, appropriate mitigation (e.g., spill flows, mechanical aeration, alternating operational modes) should be developed if warranted. The effectiveness of a control gate to allow fish passage at Ásványráró, to allow spawning fish access to the side channel system, should be evaluated. If warranted by a preproject fish survey, appropriate fish protection and guidance systems at the barrages should be developed.

3. Revegetation programs using native species should be considered for areas along the Danube. Restoration of area adjacent to existing remnant forests along the Mosoni Danube should also be considered. This would also meet goals of the Szigetköz Landscape Protection Area policy.

4. Modeling is needed to assess the possibility of reduced DO in the two reservoirs, and to develop any necessary water quality mitigation measures.

5. One of the most effective ways of improving the quality of both surface and ground water and its attendant effects on ecological conditions is to clean up the sources of the pollution. It is not the intent of this report to discuss such concerns, but some of the more critical areas of concern are the sewage discharge into the Mosoni at Györ; the leaching of bauxite red muds, and the asbestos cement plant, near Komárom; and the

Development in the Danube bend area is currently limited by the lack of adequate sewage treatment and floodplain restrictions. The project will provide new sewage capacity and eliminate the need to restrict construction in the floodplain. This, coupled with planned improved roadway access, will foster regional growth. Growth in this area could be beneficial to local economies, but adverse impacts could occur if not properly regulated.

The need for electrical power in Hungary is increasing due to economic development. The possibilities of exploitating fossil fuels are limited and imported electrical energy is expensive and undependable. The project provides a clean, non-exhaustible source of energy, and does not rely on imported energy resources.

The implementation of the project is of international importance for Danube navigation. Anticipated improvement resulting from the project include: extended navigation time from 250 to 330 days annually; permanent nighttime navigation; increased freighter fleet cargo capacity of at least 20 percent; and decreased probability of navigation accidents. These benefits will be shared by the Danube countries, as well as other countries involved in navigation along this international waterway. It is anticipated that due to project construction, the tonnage of cargo shipped in the Danube will double in 10 years.

The project will provide protection against the 10,000-year flood in the region upstream of Palkovicovo/Szap. Along the downstream reaches, levees will provide protection against the 1,000-year flood. Over the life of the project, this should result in a significant protection to Danube River landowners and residents, who could experience agricultural and sylvicultural loss, structural damage to buildings, and even loss of life during large floods.

1.5 SUMMARY OF RECOMMENDATIONS

Detailed discussions of recommended mitigations and additions and changes to the monitoring program are included in Sections 2 and 3. Recommended mitigations are summarized below.

- Clearance of forest and riverbank vegetation during construction reduces the natural appearance of the riverbanks, reducing their visual quality. Revegetation plans should be developed and implemented for all cleared areas along the river. This would reduce the adverse visual impact to a level of insignificance

- Construction of the barrage and auxiliary structures at Nagymaros would introduce new structures into a primarily natural and very scenic landscape. Extensive architectural design modifications (including underground structures and transmission lines) which have been incorporated into project design will substantially reduce the adverse visual impacts associated with the new structures

- Development of the proposed riverbank recreation area will provide new viewing opportunities to the population and proposed development of an attractive recreation area adjacent to the barrage site would substantially reduce the adverse visual impact associated with the project

Recreation. The project will create a new linear riverside recreation opportunity (a park) from Nagymaros to Győr, and possibly beyond. The park will provide new recreation opportunities for biking, hiking, sightseeing, and picnicking. A biking/hiking trail created along the protective embankments will also interlink the numerous small settlements along the river, dispersing some of the recreation/tourism away from the heavily concentrated recreation centers in the Danube bend to the less concentrated areas between Gönyü and Nyergesújfalu. The proposed riverside park will be a beneficial impact.

Water sports and riverside recreation (bathing) are two existing attractions of the study region. However, bathing conditions in the study area have deteriorated due to crowding and the Danube's poor water quality (downstream of Győr). Pleasure boating is also fairly limited along most of the Danube in the project area due to border protection restrictions. In general, the project would not improve or degrade these existing conditions. Specific impacts, both adverse and beneficial, are summarized below.

- Increased flows into the Mosoni Danube and Danube side arms in the Szigetköz area will improve and enhance recreation opportunities (bathing and boating) in this area due to controlled year-round flows and consequently improved water quality

- Decreased flows in the old Danube will adversely affect fishing and boating opportunities, but increased opportunities in the Mosoni Danube will help mitigate this impact

- Between Dunaremete and Nyergesújfalu, high fluctuations in water levels in the Danube resulting from peak power operations could adversely impact small boating and bathing opportunities. The impact on boating is not expected to be significant due to existing border restrictions. Bathing opportunities will be most adversely affected upstream from Gönyü, where water conditions are not degraded. Modified peak power operations which will reduce water level fluctuations are currently being evaluated by VIZITERV

- Tourism in the Szigetköz area is expected to increase due to improved recreation opportunities and the installation of a new sewage treatment facility. This could be either beneficial or adverse, depending on how well planners prepare for this growth

- Protective dikes and embankments built along the riverbank will eliminate existing boat landing sites, camp sites, picnic areas, and bathing places. These impacts will be offset in areas with concentrated recreation use (Visegrád-Dömös, Esztergom, and Pilismarót) by the development of new recreation areas

- Tourism in the Danube bend area is expected to increase due to construction of the new sewage treatment facility and the new bridge across the Danube. This could benefit local economies but could also have adverse effects if local planners do not carefully control future growth patterns

Socioeconomics. Construction and operation of the project will affect local, regional, national, and international social and economic conditions. Local effects in the Szigetköz area will include improved agricultural and forestry productivity due to water management (flood protection, controlled water supply, and a reduction in waterlogging). This will benefit the employment and income levels of the local population. The project will also improve recreation in the area and provide a new sewage treatment facility. These two factors are likely to contribute to an increased rate of community growth. Growth in this area will be beneficial to the local population if it is planned for and carefully regulated.

Changes in land use due to the project will not be significant. Reduction in agriculture and forestry production were recognized and compensation was made. Compensation has also been made for loss of residences and public buildings due to the reservoir or related projected facilities.

Some loss of forestry production will result from reduced flows along the Danube, even with the artificial recharge system, but this amounts to about 3 percent of the present forest and about one-third of the value of forest production in this area. This loss has also been compensated. Increased costs for transportation of forest products will occur. The artificial recharge system plans call for dikes across side arms of the Danube, further reducing water transportation. Compensation has been made through funding for new road construction to provide alternate transportation means.

Archaeology. The archaeological, historical, and monument resources within the study area represent relics both of Hungarian and European human civilization. The project has funded excavation of a number of important sites, and mitigation measures have been developed in conjunction with the Monument Plan Council of the National Committee for Technical Development to protect some of the most significant resources. However, significant impacts to archaeological and monument assets could potentially occur due to construction and operation of the proposed project.

Construction could damage or bury a number of known archaeological sites precluding future scientific study and excavation. Agreement was reached with archaeologists as to which archaeological sites were to be preserved by modification of project design, and what construction methods were to be utilized for specific sites.

Project operations will inundate the archaeological site on Helemba Szigetköz. The site on Helemba Szigetköz has been partially excavated. A possible mitigation for this could be that the entire site be excavated and significant artifacts and relics removed to the museum for preservation and public display.

Controlling the ground water levels at 103.5 m above sea level will reduce the accessibility of deep-lying archaeological artifacts in the Esztergom Royal Town area, but will also enhance accessibility to those artifacts presently buried above the mean ground water level. Current access to these artifacts is limited due to extensive surface development (buildings, roads, etc.). In the future, if and when excavation is desired, this impact could be mitigated by installation of a local dewatering system. Because of the limited surface access to these sites and the uncertainty of future excavation, it is not recommended that funding for a dewatering system be included as part of the project. It is recommended that ground water levels be monitored during project operations, to ensure that the ground water level does not rise about the predicted level of 103.5 m/asl. Future funding for excavation should include a dewatering system.

Visual Resources. The Danube River is the dominant visual feature within the project area. Construction and operation of the project will change the visual appearance of the Danube River and its riverbank throughout the project area. The significance of these changes is based on: the scenic quality of the landscape; the degree of visibility the project would have in the landscape; the ability of the project features to blend in or be visually absorbed by the surrounding landscape; and the potential population viewing these changes and the relative value they place on maintaining the present landscape character.

The following visual impacts are anticipated with project implementation:

- The substantial decrease in the flow in the old Danube channel will alter the existing appearance of the river. Additionally, riverside vegetation along the old riverbank will die or be removed, adding to the dry abandoned appearance of the channel. This impact could be mitigated by implementing a revegetation plan in the riverbed channel. However, the significance of this impact is not high due to low population exposure

- Introduction of new protective embankments along natural riverbanks will alter their appearance. This impact could be mitigated to an insignificant level by planting grass or lawn on the slopes of the embankments and vegetation at the foot of the embankment

Changes in ground water and surface water levels could also potentially impact the sensitive wildlife area near Ásványráró, the habitat of the four protected birds discussed above, as well as other wildlife resources. The most effective approach to mitigating impacts is to first determine occurrence and use of the area by these sensitive species and better assess impacts to these species and their habitats. If adverse effects are anticipated, it is recommended that water levels and water quality be closely monitored for at least 1 year in these areas to establish preproject conditions. Based on this information, water levels and water quality needed during operation to minimize impacts on the birds can then be determined and integrated into project operations. Also, establishment of a protected area near Ásványráró to protect these species could be considered.

Additional data are also needed for other wildlife species occurring in the Szigetköz and other portions of the project area before impacts can be determined or mitigations developed. A literature survey should be conducted to determine the potential occurrence of important species and then seasonal surveys could be done to determine the actual occurrence, abundance, and seasonal use in the project area.

Additional data are needed on fish species distribution, abundance, spawning locations, and spawning periods to enable accurate prediction of project-related impacts on fish resources. Seasonal baseline fish surveys over a 1-year period using multiple sampling techniques should be designed and conducted prior to project operations and used to better assess and mitigate potential impacts.

Changes in flow rates in the Dunakiliti reservoir and the main channel of the Danube River in the Szigetköz area are expected to result in fish stranding mortalities and changes in species composition (i.e., decreased numbers of those species adapted to fast-moving water conditions).

Operation of the barrage systems and power stations may result in decreased concentrations of DO and adverse effects on fish. The potential for oxygen deficiency effects should be evaluated by use of a system-wide DO modeling program and, if warranted, operational controls to mitigate DO decreases should be evaluated (e.g., alternating modes, spill flows, mechanical aeration).

Loss of migratory fish access to spawning grounds in the side channel system will result from blocking the outlets to the Danube and installating the weir at Ásványráró to maintain the water levels in the side arms. This is expected to result in a regionally significant, long-term impact on some fish species inhabiting the Danube. The ability to operate the Gabcikovo facilities while maintaining adequate flow to the main channel above Gönyü should be evaluated. Use of a control gate to allow fish passage at Ásványráró also should be considered in conjunction with baseline information on fish spawning migrations.

Entrainment and turbine-induced mortality of fish and lower order organisms will occur at the Gabcikovo and Nagymaros power stations. The significance of these effects should be assessed once baseline fish surveys have been conducted and, if warranted, an appropriate fish protection system should be developed.

The project has incorporated fish locks at Dunakiliti and Nagymaros to mitigate impacts on spawning fish due to blocked fish migration.

<u>Land Use</u>. The project impacts on land use in the project area were evaluated based upon anticipated changes in crop and forestry production and recompensation of losses of land or buildings.

The project will provide several benefits to agriculture and forestry production in the Szigetköz with installation of the artificial recharge system. These benefits include increases in arable land with more control of ground water levels and floods, as well as a more stabilized water supply for irrigation.

local areas. It is recommended that the hills be examined to identify potential areas where unwanted seepage may occur. Exploration and installation of monitoring wells should be carried out in those areas where seepage is possible, and where previous studies have not been adequate.

Biology. Biological resources in the project area are not entirely well defined and the amount of information varies. Specific biological information has been collected at the 12 biological monitoring stations, 9 of which are concentrated in the Szigetköz-Gönyü reach, 2 in the Gönyü-Nyergesújfalu reach at Tát and Almásneszmély, and 1 at Szentendre Island.

The floodplain vegetation along the Danube has experienced strong anthropogenic effects related to flood management, silviculture, and wild game management. Limited natural vegetation occurring in the project area includes a willow-poplar gallery forest, willow thicket, and ash-oak-elm gallery forest. These vegetative associations also provide diverse habitats for wildlife, especially in the Szigetköz portion of the project area. Important waterfowl species including grey herons, black storks, cormorants, night herons, and mute swans are known to utilize habitats near Ásványráró in the Szigetköz. Four protected bird species, the willow tit, treecreeper, little ringed plover, and penduline tit occur in habitats provided by natural vegetation along the Danube channel and side arms.

Construction of project facilities (including the Dunakiliti reservoir), and flood protection and bank stabilization structures will remove natural vegetation along the Danube. In addition, a zone approximately 250-300 m wide and reaching approximately 25 km along the Danube will be subject to aridification when flows are diverted from the Danube to the Gabcikovo navigation canal. Revegetation programs with native species in other areas and along dikes are recommended to mitigate loss of natural vegetation, wildlife, and associated wildlife habitats in these areas. Reestablishment of native forest along the Mosoni Danube, an objective of the Szigetköz Landscape Protection Area policy should be considered as a component of these revegetation programs.

- The original KET plan anticipated peaking operations at Gabcikovo for a minimum of 5 hours per day. The KET project operation would produce significant water level fluctuations at the upstream end of the Nagymaros reservoir. For example during summer months, peak power operations would produce 1.3 to 4.7 m^3/min rate of rise in water level and a 2.5 to 3.5 m change in water level over 24 hours. This is greater than current practices on the Columbia River in the U.S., where similar hydroelectric/navigation lock projects are operated. During the summer, the allowed water level changes on the Columbia River are 0.75 cm/min and 1.5 m over 24 hours. It is recommended that evaluation of modified Gabcikovo peaking operations be continued to assess possible reductions to project impacts associated with the large water level changes

<u>Ground Water</u>. The extensive mitigation measures planned by the project to control the impacts on ground water conditions appear adequate. To verify whether or not the mitigations are effective, the network of monitoring wells will provide a good measure, and allow modifications to be made to correct any deficiencies. To avoid the situation where unexpected conditions occur in sensitive areas, and because of the time required to make necessary corrections, vegetation and wildlife may be adversely affected and may not be able to recover, the following recommendations are suggested.

1. Detailed studies of critical areas in the Szigetköz should be conducted to determine if additional control measures are needed to mitigate impacts on the recharge of ground water. For example, the heron habitat area near Ásványráró may require close control of ground water fluctuations to maintain the proper environment for the breeding and feeding habitat. The hydrogeologic characteristics of a specific area will most likely differ from the homogeneous, isotropic conditions assigned in the analog modeling studies of the total area. Detailed studies of the critical areas can determine if the variations are significant, and the need for modifications in the general mitigation measures can be anticipated.

2. Mitigation measures to prevent waterlogging in the three major lowland areas adjacent to the Nagymaros reservoir have been provided. Within the intervening hill areas, where high natural banks are present, the raised ground water levels are expected to remain well below the ground surface. However, with the rise in base level, some seepage may occur in low areas not presently considered to be wetlands. Although such occurrences may not be widespread in the highlands, they could cause undesirable wet ground in

The recommended studies for water quality and biology may result in identification of the need to modify the project's operational strategies. In addition to mitigation measures outlined by VIZITERV, alternate operational modes for the Gabcikovo power plant should be closely reviewed. Presently, alternate operational modes (including seasonal variations) are being studied to revise the original KET operation plan. Modified peaking schedules could help reduce potential significant impacts to biological and recreation resources caused by downstream fluctuations. Increased flow releases from the Hrusov-Dunakiliti reservoir to the main channel should be considered as a way of reducing signficant impacts expected downstream.

In comparison with U.S. hydropower monitoring systems, the proposed GNB monitoring system is unique because it monitors more parameters than the Columbia River Basin, Ohio River Basin, or Tennessee Valley Authority (TVA). Hydropower facilities on these rivers monitor water quality and/or minimum streamflows for fish and recreation, but do not monitor the array of environmental parameters sampled in the GNB monitoring system. With a few additions, this system will represent a state-of-the-art monitoring program for integrating environmental considerations with operations.

The monitoring program developed for the GNB project will assess changes in environmental resources affected by project operations and the effectiveness of project mitigation measures. Our review has identified aspects of the planned monitoring program that can be reduced, and recommended additional monitoring that would enhance the overall effectiveness of the program. However, mitigation measures should be in place (or clearly established, in the case of operational rules) prior to startups at either the Gabcikovo or Nagymaros power stations.

Benefits of the project as well as impacts and mitigations proposed by the project, or recommended by Bechtel are summarized below. Detailed discussions regarding impacts and mitigations measures are contained in Sections 2 and 3.

Hydrologic Regime. GNB surface and ground water conditions have been thoroughly studied by VIZITERV and other experts. The project's planned releases to the Mosoni Danube and the Szigetköz side arms will improve water quality in these surface waters. Project mitigations to minimize adverse impacts on the hydrologic regime have been incorporated into project design, including the artificial recharge system in the Szigetköz, and interceptor channel system at Dunakiliti reservoir, Esztergom, and Pilismarót. Potential problems that we believe require additional studies to quantify impacts and effectively develop mitigations are the water quality and water level fluctuations downstream of the Gabcikovo barrage. Revisions to the KET operation criteria are currently being studied. Reduction in water level fluctuations downstream of the Gabcikovo barrage will mitigate many of the impacts discussed below. Specifically:

- Water quality in both reservoirs could be possibly reduced below historical levels (DO below 6.0 mg/l) during summer months due to detention times, increased temperature, nutrient loads, and associated algal blooms

- Water quality during the summer months should be estimated using available computer models which simulate reservoir/ powerhouse operations and changes in DO and water temperature

- If undesirable water quality is identified, alternative mitigation measures should be evaluated to determine the most cost-effective means to maintain the water quality at or above historic levels. Possible mitigation measures include continuous release through the Gabcikovo power plant to reduce detention time and releases over the Dunakiliti weir to promote more aeration

- Concern has been expressed by others that heavy metals accumulated in deposited sediments might be remobilized under anaerobic conditions and migrate into the ground water. The circumstances required to alter the bottom sediments are highly unlikely to occur, especially since the DO level will be tracked in the reservoirs and operational measures will be initiated to keep DO above minimum levels. However, it is recommended that sediment buildup be monitored, especially over ground water recharge areas, and heavy metal concentrations in these sediments be regularly measured. Should undesirable amounts of heavy metals accumulate over sensitive areas, this material can be removed. Alternatively, methods for controlling the reservoir bed DO levels should be investigated and implemented if found cost effective has been thoroughly studied and potentially significant impacts have been identified by VIZITERV and associated experts and Bechtel concurs with this assessment. More limited data and analyses are available regarding project-related impacts on biological resources. Therefore, a more detailed impact analysis was made for biology than that provided by VIZITERV. Our impact analysis considered the potential effects the project could have on the environment's social benefits to man, such as agriculture and regional development, and the impact of the project on the intrinsic values of environmental resources such as biology. Additional data collection and modeling is recommended where needed for either additional impact definition or determination of the adequacy of the proposed mitigation and monitoring program.

We have approached the environmental evaluation with the philosophy that impacts must be identified, appropriate mitigations must be in place prior to project operation, and the project monitoring program will be used to ensure the effectiveness of these mitigations.

1.2 BACKGROUND INFORMATION

Information used in the review of environmental effects related to the GNB project are based upon:

- A 3-day site visit to the project area
- Summary documents provided by VIZITERV (see Appendix 1 for detailed list)
- Selected publications and
- Interviews with VIZITERV professionals and other experts

The site visit included a review of construction sites at Dunakiliti weir, Gabcikovo power plant and navigation canal, Nagymaros barrage site, and selected intercept channels and sidearms in the Szigetköz. In addition, a general reconnaissance was conducted along accessible areas on the right side of the Danube River from Visegrád to Süttö and on the left side of the Danube River from Nagymaros to Szob. All impact evaluations in Section 2 are based upon data and analyses provided by VIZITERV and interviews with VIZITERV professionals and other experts. This information and a list of experts interviewed are summarized in Appendix 1.

1.3 PROJECT DESCRIPTION

The physical structures, planned water releases, and flow regimes of the GNB project used as the basis for evaluating environmental impacts associated with the project are described below. In this report, we have evaluated the complete GNB project, including the Gabcikovo and Nagymaros barrage systems and associated structures. The peak operating data used as design criteria for the original conception of the project and structures is used in this evaluation. However, it should be noted that studies are currently under way to revise those operational criteria.

1.3.1 Physical Structures

The GNB project will regulate Danube River flows over an approximate 160 km reach of the river from Bratislava to Visegrád. Principal components of the project in both the Hungarian and Czechoslovakian territories are:

- The upstream Hrusov-Dunakiliti reservoir formed by the Dunakiliti barrage and Gabcikovo power station
- The power navigation canal that transports water from the upstream reservoir to the Gabcikovo (Bös) power station
- The Gabcikovo (Bös) power station and shiplock
- The Nagymaros barrage, power station and shiplock which regulates releases from the lower reservoir

The Hrusov-Dunakiliti reservoir and Gabcikovo (Bös) power station, barrage, and shiplock are scheduled for completion and operation by 1990. Completion of the Nagymaros barrage, power plant, and shiplock has been delayed indefinitely.

The environmental evaluation presented in Section 2 is limited to impacts affecting Hungarian territories (right side of the Danube River), although we recognize that both sides of the Danube will be affected by the GNB project.

Barrages at Dunakiliti and Gabcikovo have created the Hrusov-Dunakiliti reservoir, which will provide an elevation drop needed for power generation at Gabcikovo. The reservoir will also provide sufficient depth for river navigation, and sufficient capacity for storing daily inflows for 15 to 19 hours and releasing the stored water over a 9-to 5-hour period for peak power production. Water diverted for power production and navigation purposes will reenter the Danube River downstream of the Szigetköz area. The power canal has a design capacity to continuously pass 4,000 m^3/s. Therefore, the peak flood flows in the Szigetköz can be reduced by 4,000 m^3/s. Studies are under way to reevaluate these design criteria.

1.3.2 Planned Water Releases and Flow Regimes

During normal daily operations, most of the stored water will be diverted through the Gabcikovo powerhouse. However, continuous flows will be released over the Dunakiliti weir into the old Danube River channel to reduce environmental impacts to the old Danube River channel area. The amount of river maintenance release is still being evaluated; however, the currently planned release is 100 m^3/s. The historical average annual river flow in the old Danube River channel is about 2,000 m^3/s.

The upper reservoir water level will range between elevations 129 and 131 m above sea level (asl). This impoundment level will raise the normal water surface elevation at Dunakiliti by 8 m. Further, the impoundment level will be between 2 to 6 m above the right bank ground level along 10 km of the reservoir right bank dike. To minimize seepage from the reservoir to the adjacent low land area, a clay blanket extends from under the dike 150 m into the reservoir. To control the reservoir seepage that passes under the dike, an interceptor/collection channel is constructed parallel to the dike. The estimated seepage water, of about 50 m^3/s, will be routed to the Danube side arm channel at the upstream end of the Szigetköz. These collected seepage flows together with supplemental releases from Dunakiliti weir/shiplock will be used to help maintain desired ground water and surface levels in the Szigetköz.

With the planned 100 m^3/s continuously released at the Dunakiliti weir, the average depth of flow in the upstream reach of the old Danube River channel will be reduced from 6 to 2 m. The water level at the confluence with the power tailrace canal and the old Danube River channel will be controlled by the Nagymaros reservoir impoundment and will be near the prior GNB project average water surface level. However, in the old Danube River channel downstream water level will fluctuate daily according to the power releases at the Gabcikovo powerhouse. These daily fluctuations can be ± 2.5 m, at the tailrace confluence and ± 1.0 m, 10 km upstream of the tailrace confluence according to the original Joint Convention (KET) operation plan (the operational criteria that would produce these fluctuations are under study and revision to minimize daily fluctuations). These daily water level changes will require riverbank stabilization to control erosion. Such erosion control measures are planned for the GNB project.

The water level in the side arms of the Szigetköz is currently influenced by daily water level changes in the old Danube River channel. The southern border of the Szigetköz is delineated by the Mosoni Danube. This arm will also receive releases from the Hrusov-Dunakiliti reservoir. The forecasted release to the Mosoni is 20 m^3/s, which is greater than the previous average flow in the upstream reach. The previous 20-year average has been 5-15 m^3/s depending on the stage of the Danube River at Rajka.

The Nagymaros barrage will develop a 120 km long reservoir with a normal water surface elevation near 109 m/asl. This impoundment will provide a 9 m elevation drop for power generation, and sufficient depth to allow navigation up to the Gabcikovo shiplock. The reservoir will also act as an equalization pond by receiving the generation flows from Gabcikovo (about 4,000 m^3/s for 5 hours) and releasing these flows at an uniform rate to the natural flowing river downstream. Further, the Nagymaros weir and shiplock, with the gates fully open, will safely pass the 1,000-year flood event.

For the 40 km segment upstream of Nagymaros barrage, the new normal water level will be above the right bank ground elevation. Lowland areas will be either filled with local sandy soils, or diked. Drainage/seepage interception channels will be excavated parallel to the landward side of the dikes, in order to ensure that the surface waters are properly drained. In some cases, pumping stations will be added to the drainage channels to lift the collected landward water into the Danube.

Peak hydroelectric generation at the Gabcikovo powerhouse will significantly affect the flow regime in the Nagymaros reservoir. According to the KET operation plan for the design low-flow case, power releases will change from zero to 4,500 m^3/s and continue at $\pm$ 4,500 m^3/s for the 5-hour peaking duration and then reduce to a zero release. This changing inflow pattern can cause the water level upstream of the reservoir to rise and fall up to 4 m during daily operations. These operating criteria are also being revised. At the downstream end of the reservoir, the water level change will be attenuated to about 1 m. Riverbanks and levees are to be protected by geomembranes overlain with riprap to control potential erosion.

1.4 SUMMARY AND CONCLUSIONS

1.4.1 Summary

Bechtel has reviewed the GNB project to independently identify potential environmental impacts and benefits related to the project and assess the effectiveness of planned mitigation measures and the project monitoring system. This review is based upon data and analyses provided by VIZITERV, interviews with VIZITERV experts as well as other experts, and a site visit of the project area. A wide range of environmental issues have been examined by the Bechtel team, including potential impacts on surface and ground water hydrology, geology, archaeology, land use, biology, recreation, visual resources, and socioeconomics.

The GNB system is an ambitious project, combining water management goals of power production, navigation, and water supply with environmental protection measures. From an environmental viewpoint, the project is important because of the planned diversion of 30 km of the Danube River and the peaking mode of the Gabcikovo power plant.

The project has used a sound technical and scientific basis to identify impacts and appropriate mitigations. However, several areas should be considered for additional studies or mitigations. These include ensuring that (1) water quality is maintained along the Danube by completion of wastewater treatment plants; (2) archaeological resources that are affected by the project are thoroughly investigated; (3) additional studies are conducted to define biological baseline conditions and appropriate mitigations; and (4) sufficient flow releases into the old Danube River channel in the Szigetköz will maintain planned ground water levels.

Several benefits will come from the project, including increased archaeological research, creation of a new riverbank park, improved water quality in the Mosoni Danube, better flood protection, improved navigation, and the generation of electric power.

1.4.2 Conclusions

Our review has shown that potentially adverse impacts in hydrology, land use, visual resources, and recreation have received close attention by VIZITERV. Based on the data available, these impacts will be mitigated to minimize them sufficiently. However, potential impacts to biological and archaeological resources may be significant, and planned mitigations may not be sufficient to reduce impacts to an insignificant level. While the artificial recharge plan in the Szigetköz is well conceived and will be effective in protecting and enhancing forestry and agriculture in the Szigetköz, conflicts may be present with protecting biological resources. Additional baseline data and biologic modeling are needed to better define impacts to biological resources and plan effective mitigations. Additional data needed include information on the seasonal occurrence and habitat use of important wildlife species such as waterfowl and protected species in the Szigetköz area. Modeling of dissolved oxygen (DO) levels in the reservoirs is also recommended to quantify potential impacts to surface water quality and fisheries. Additional flows to the old Danube River channel and side arms may be necessary, to augment the benefits of the artificial recharge system and mitigate impacts to biological resources, but until more biological baseline conditions are established, this cannot be clearly determined.

Section 2

IMPACT EVALUATION AND MITIGATION MEASURES

To provide an independent review of the environmental consequences of the Gabcikovo (Bös)-Nagymaros Barrage (GNB) Project, the impact evaluation presented below focuses on identifying impacts that are beneficial or that are significantly adverse and warrant mitigation. We have followed the philosophy that significant impacts must be identified prior to project construction and operation, and qualified - or, where possible - quantified. Clear impact definition is needed to determine the extent to which adverse changes can be successfully mitigated, and to determine the effectiveness of planned and recommended mitigations.

To define impacts, a detailed preoperational (baseline) database must be available. Data collected during a preoperational monitoring program is used to assess the effectiveness of installed mitigations or planned operational rules for flow regimes, and to adjust mitigations as necessary during operation. The project preoperational monitoring system is very detailed in many resource areas, particularly hydrology and archaeology, and more general in other areas, particularly biology. We recognize that that variations in the preoperational monitoring system database is due to the evolutionary circumstances (social and political) surrounding the project since its inception. The delay in completing the Nagymaros barrage portion of the project affords an opportunity to further define the biological preoperational monitoring system, resulting in a better assessment of impacts and effective mitigations.

The impact evaluation and discussion of planned and proposed mitigations presented below begins with a discussion of the criteria considered in defining impact significance. These criteria are generally based on accepted U.S. standards and practices. Due to the variable database, quantification of significant impacts to high, medium, and low is not possible. Impacts have been defined qualitatively as being potentially significant (or not),

2
Impact Evaluation and Mitigation Measures

beneficial, or adverse. Planned or recommended mitigation measures are discussed and the impacts evaluated. Table 2-2 in Section 2.8 summarizes the impact evaluation, planned project mitigations, and Bechtel's recommended mitigations.

2.1 HYDROLOGIC REGIME

2.1.1 Surface Water

The GNB project will regulate the daily Danube River flows over an approximate 160 km reach of the river. The potential significant project-related impacts to the area's hydrologic regime have been identified by VIZITERV in the summary documents outlined in Appendix 1. The significant project-related impacts are discussed in sufficient detail here to allow evaluation of planned and proposed mitigation measures and evaluation of the project monitoring system.

Significant impacts associated with the GNB project on the existing surface water distribution, sedimentation, and surface water quality throughout the Danube River reach of the project (from 1,696 to 1,860 river km) are evaluated according to the changes from historic averages and patterns described below. The historic average annual river flow through the Danube River project reach range from 2,000 - 2,400 m^3/s. The average streamflow velocity for this flow ranges from 0.9 to 1.1 m/s. The river depths for the average flows have been 5 to 6 m. The average annual suspended sediment inflow at Bratislava is estimated to be 7 million tons. The amount of this material annually deposited along the project river reach under preproject conditions has not been estimated. However, due to upstream barrage construction, the sediment inflow has shown a decreasing trend over the last 10 years.

Because of its importance to aquatic life and its role in the breakdown of pollutants, dissolved oxygen (DO) is a key water quality parameter considered in this evaluation. From 1984 to 1988, the DO content recorded at the Dunakiliti barrage site averaged 10.3 mg/l with minimum and maximum levels of 6.7 and 13.6 mg/l, respectively. The minimum DO level for Class I water (highest quality) in Hungary is 6.0 mg/l.

Hrusov-Dunakiliti Reservoir. Barrages at Dunakiliti and Gabcikovo will create the Hrusov-Dunakiliti reservoir. Surface water flowing into the reservoir will be stored and released through the Gabcikovo power plant for 5 hours per day. These power releases will be diverted from 30 km of the Danube River (from river station 1,800 km to 1,840 km). Average daily inflows, up to 4,000 m^3/s, will be diverted through the Gabcikovo power plant. However, project mitigation measures include continuous releases to the old Danube River channel, the adjacent side arms, and the Mosoni Danube to meet the Szigetköz's water demands for environmental preservation and agriculture. The current planned average diversions are 100 m^3/s to the old Danube River channel, 50 m^3/s each to the left and right side arm channels, and 20 m^3/s to the Mosoni Danube. The impacts to the old Danube River channel and Szigetköz area due to surface water redistribution will be discussed in the subsequent section.

The reservoir water level will range between elevations 129 and 131 m above sea level (asl). This impoundment level will raise the normal water surface elevation at Dunakiliti by 8 m. Further, the impoundment level will be between 2 to 6 m above the ground level along 10 km of the reservoir right bank dike. To minimize seepage from the reservoir to the adjacent low land area, a clay blanket will be installed under the dike, extending 150 m into the reservoir. To control the reservoir seepage that passes under this blanket, an interceptor/collection channel will be constructed parallel to the dike. The primary purpose of this channel is to drain the seepage water, thereby maintaining the local ground water level near the historic levels. Thus, the impact of saturating adjacent lands will be mitigated. This seepage water, estimated to be about 50 m^3/s, will be routed to the Danube side arm channel at the upstream end of the Szigetköz.

Sedimentation. The flow velocity in the Hrusov-Dunakiliti reservoir will range from almost zero to about 0.5 m/s during peak power production. The average flow velocity in this reach of the Danube without the GNB project is about 1.1 m/s. This reduced velocity in the new reservoir will induce settlement of suspended solids. According to VIZITERV studies, approximately 70 to 80 percent of the suspended sediment inflow will be deposited, primarily in the upstream portion of the reservoir where the inflows first encounter the reduced velocity regime. Deposition will also occur along the areas adjacent to the reservoir dikes. Sediment accumulation could fill the dead storage volume in the reservoir in about 60 years. However, during major floods, the gates at Dunakiliti weir will be lowered to allow safe passage of the flood flows. At these times some flushing of deposited sediments can be expected and therefore filling of the dead storage area will take more than 60 years.

Sediment accumulation in the upstream portion of the reservoir will have to be monitored to ensure that safe navigation depths are maintained. Periodic dredging of this area may be required. Sediment accumulation in the downstream portion of the reservoir will build up a less permeable bottom layer which will help reduce reservoir seepage.

Surface Water Quality. The impoundment of Danube River flows in the Hrusov-Dunakiliti reservoir will affect the quality of surface waters. Settlement of 70 percent of the suspended solids will clarify the water. The water surface area will be increased about four times. This larger surface area will increase oxygen gas absorption, and thereby improve the DO content of the water. The longer detention time will allow the natural biological process to reduce the organic load under favorable DO and temperature conditions. These three factors will improve the water quality. However, during the summer months, the clarified water depth will increase, allowing deeper light penetration. This, together with the already high nutrient load, will promote increased algae production. When the extra organic load from algae growth is mixed with the incoming organic load, a reduction in DO supply will occur. When DO is significantly reduced, the biological breakdown of the organic load will also be reduced. Reduction of the DO level below 6 mg/L, the limit for Class I water, would constitute an adverse impact. With a DO level at or above 6 mg/L, the Danube waters would maintain the project aerobic environment. Thus, there should be no significant impact to aquatic life or to downstream potable water works due to the GNB project.

To determine if there is a water quality impact due to the GNB project, a quantitative evaluation is recommended. This evaluation should first establish what conditions - organic load, water temperature, nutrient load, etc. - might produce undesirable water quality. If such conditions can be expected - even if they have a low probability of occurrence - then possible mitigation measures should be quantitatively assessed to determine the most likely cost-effective mitigation. Such analysis could be accomplished using existing water quality computer programs and the existing project database. The U.S. Environmental Protection Agency (EPA) computer program QUAL2E (see Appendix 2) can be used for this analysis.

If DO levels fall below acceptable levels, a proposed project mitigation measure is to temporarily pass flows over the Dunakiliti weir to reduce the detention period and thereby minimize oxygen depletion. This action would be initiated based on reduced DO levels detected by the project monitoring program. Other possible mitigation measures which could be considered would be to temporarily change the Gabcikovo power plant operation to a run-of-river plant, thereby reducing detention time and mechanical aeration (example is shown in Appendix 3).

A second potential water quality problem has been identified concerning heavy metals. Heavy metals tend to be adsorbed on suspended sediments. While Danube sediment sampling for heavy metals is limited, varying concentrations of Hg, As, Cd, Fe, Zn, and Mn have all been measured. Under GNB project conditions, the suspended sediments will be deposited in the reservoir as previously described. Deposited sediments with adsorbed heavy metals can remain in a stable state indefinitely. However, if the reservoir bed environment were to become anaerobic, either due to stratified conditions in the reservoir (which is unlikely), or deposition of organic material with the sediments, the heavy metals can be dissolved. For example, the insoluable ferric and manganic salts will be transformed to soluable ferrous and manganous form under anaerobic conditions. In the soluable state, the metals could pass into the underlying ground water regime adding an unwanted pollution load to the ground water.

There are measures which can be implemented to control this problem. The most positive measure is treatment of industrial effluent for removal of heavy metals. Industrial effluent is the major source of heavy metal load in the Danube. The second measure is to monitor reservoir deposition and to sample the sediments. Should sediments with undesirable metal concentrations be detected near ground water recharge areas, these sediments can be removed by dredging. The buildup of sediments is a slow process and remedial dredging could probably be accomplished at 3- to 5-year intervals. A third measure would be to monitor the reservoir bed environment to check that the adsorbed heavy metal state has not been altered. This will require testing representative sediment samples to determine what conditions will cause the metals to dissolve. Should an undesirable reservoir bed environment be detected, sediment removal by dredging can be initiated, or the anaerobic condition can be alleviated by forced vertical mixing using pumps or mechanical aerators.

Szigetköz. Reducing the flow in the old Danube River channel reach (about 30 km long) from the historic 2,000 m^3/s average to 100 m^3/s will significantly impact the adjacent environment. With the planned 100 m^3/s continuously released at Dunakiliti weir, the average depth of flow in the upstream reach of the old Danube River channel will be reduced from 6 to 2 m.

The water level at the confluence with the power tailrace canal and the old Danube River channel will be controlled by Nagymaros reservoir impoundment and will be near the prior GNB project average water surface level. However, the downstream portion of the old Danube River channel water levels will fluctuate daily according to the power releases at the Gabcikovo powerhouse. For the Joint Convention (KET) operation case with a 1,500 m^3/s average inflow into the upper reservoir and 700 MW peak power, the daily fluctuations will be ± 2.0 m, at the tailrace confluence and ± 1.0 m 10 km upstream of the tailrace confluence. These daily water level changes will require riverbank stabilization to control erosion. Such erosion control measures are planned for the GNB project. The operation of Gabcikovo powerhouse and the resulting downstream water level fluctuations are being evaluated. We understand that VIZITERV is evaluating alternate operation modes and that a modified operation plan will eventually be adopted which will yield smaller water level changes.

The water level in the side arms of the Szigetköz is currently controlled by the water level in the old Danube River channel up to 2,500 m^3/s as backwater effects. Beyond this flow rate the side arm dikes are overtopped and water flows directly into the side channels. Therefore, without additional water level controls, the water level depth in these side arms would be reduced up to 4 m, with flow diverted from the old Danube River channel. However, mitigation measures to control surface waters in the right bank side arms are planned to maintain the historical water levels in the Szigetköz area. Mitigation measures include improving the existing system of dikes which channelize the side arms waters and planned flow releases of approximately 50 m^3/s (more if needed) at the side arm headwaters. A rockfilled drop structure will be placed near the downstream end of the side arm channels. The purpose of this structure will be to maintain the desired upstream backwater level in the side arms and, most importantly, to keep this backwater level above the daily water level changes in the old Danube River channel induced by the Gabcikovo powerhouse operation.

The southern border of the Szigetköz is delineated by the Mosoni Danube. This arm will also receive releases from the Hrusov-Dunakiliti reservoir. The forecasted release to the Mosoni is 20 m^3/s which will be a benefit of the project. This release is greater than the previous average flow in the upstream reach of the Mosoni. The previous 20-year average has been 5 to 15 m^3/s depending on the stage of the Danube River at Rajka.

Sedimentation. The sediment load in the releases to the old Danube River channel and the side arms will be reduced due to sediment deposition in the upstream reservoir. Further, the flow velocities will generally be equal to or greater than the prior GNB project flow velocities in the same channels. Therefore, sediment deposition in the old Danube River channel and the Szigetköz area will be significantly reduced from historic levels. The amount of sediment deposition in the areas with the GNB project has not been estimated but is not anticipated to be a problem.

Water Quality. The old Danube River channel and the side arms will receive flows from the upstream reservoir. As previously discussed, the water quality in the Hrusov-Dunakiliti reservoir will be improved, except for possible seasonal degradation problems. Concerning flows released over the Dunakiliti weir, the water quality will be improved because of the aeration induced when the flow tumbles over the concrete energy dissipation blocks.

Water quality in the side arms will be improved. The currently stagnated side arms waters will be replaced by the steady 50 m^3/s or more flow released from the upstream reservoir.

The water quality in the Mosoni will be equal to or better than the past water quality, except for the downstream reach just above the confluence with the Danube. Here the daily water levels will fluctuate by $\pm$ 1.5 m, according to the KET operation plan. These fluctuations will alter backwater up to the city of Györ. At present there are a number of raw sewage water discharges into the Mosoni Danube at Györ. Except when major flows (greater than 3,000 m^3/s) occur in the Danube once or twice a year, the sewage effluent is passed into the Mosoni Danube and diluted. However, under GNB project conditions, the fluctuating backwater at Györ will hinder mixing of the raw sewage. We understand that a sewage collection and treatment plant for Györ is under construction and will be operational in 1993. It is strongly recommended that this treatment plant be in operation prior to impounding water in Nagymaros reservoir. This would eliminate what otherwise would become a health hazard if the current once- or twice-year sewage mixing problem were to be transformed into a daily problem.

<u>Nagymaros Reservoir</u>. The Nagymaros barrage will develop a 120 km long reservoir with a normal water surface elevation of 108 m. This impoundment will provide a 9 m elevation drop for power generation, and sufficient depth to pass navigation up to the Gabcikovo shiplock. The reservoir will also act as an equalization pond by receiving the generation flows from Gabcikovo (about 4,000 m^3/s for 5 hours) and releasing these flows at an uniform rate to the natural flowing river downstream. Further, the Nagymaros weir, with the radial gates lowered, will safely pass the 1,000-year flood event.

Along segments of the right bank, some dikes will be raised and the impounded water level will be raised above the right bank ground elevation. This will impact surface drainage from the right bank area, blocking normal drainage paths into the Danube River. To mitigate this impact, seepage/drainage interception channels will be constructed parallel to dikes where the reservoir water level will be above the adjacent ground level. The seepage/drainage flows collected in these channels will be lifted into the reservoir at a number of pump stations at the downstream reach of each interception channel. The water level in these channels will be maintained below the surrounding ground surface level, thereby mitigating the drainage problem.

Peak hydroelectric generation at the Gabcikovo powerhouse will significantly affect the flow regime in the Nagymaros reservoir. According to the KET operation plan for the design low flow case with 900 m^3/s inflow and 700 MW peak power production, daily peak power releases will change from zero to 4,500 m^3/s within one hour and continue at $\pm$ 4,500 m^3/s for 5 hours, then reduce to a zero release. This rapidly changing inflow pattern will cause the water level at the upstream of the reservoir to rise 4 to 5 m over a 5-hour period. At the downstream end of the reservoir this water level will be attenuated to a 1 m rise. This daily wave action will erode all exposed river banks and levels without mitigation. To control erosion, riverbanks and levees are to be fortified with riprap placed on geomembranes.

Current practice for the Columbia River in the U.S., where similar hydroelectric and shiplock facilities are in operation, require water level changes to be restricted to 0.5 m/hour and 1.1 m/24 hours during the months of April through September, and to 1 m/hour and 2 m/24 hours during the months of October through March. This practice has been established to accommodate the fish environment, recreational boating needs, and commercial navigation requirements.

As an example of actual river operation results, the recorded Columbia River water level changes for the reach of river downstream from the Bonneville Dam and Power Plant during a normal year (1980) were:

- o Maximum for 1 day - 1.9 m
- o Maximum for 1 month - 3.7 m
- o Maximum for 1 year - 5.4 m

Sedimentation. Except for short periods during major floods, the sediment load into Nagymaros reservoir will be reduced because of the retention of over 70 percent of the sediment load in the upstream reservoir. However, sediments will be received from runoff along the 120 km river reach of the Nagymaros reservoir and from the tributary rivers. In the upstream end of Nagymaros reservoir, little or no sediment deposition is expected along this reach because of anticipated velocity changes. Sediment deposition is expected in the 50 km downstream end of the reservoir, primarily along the shallow riverbanks where flow velocities are lowest. VIZITERV has estimated that sediment deposition in the lower reach river bank areas will be 4 to 5 cm annually. However, during major flood events, the radial gates at the Nagymaros weir will be lowered to the riverbed level and some flushing of bottom sediments is to be expected.

Some concern has been expressed regarding the potential for sediment deposition over the river gravel areas which link the Danube water to the filter bank water wells, primarily located along the river reach from Komárom to Nagymaros. Such deposition could form a more impermeable layer above the gravels and reduce seepage into the gravels and into the ground water wells. However, the deposition is expected only along the side banks, leaving the center channel section clear of sediments. Should this occur, the flow path to the water wells will be increased and the flow rate will be proportionately decreased. Because permeability of the river gravels is high, the increased flow path length is not expected to significantly reduce the flow to the ground water wells. However, it is recommended that the water level of these wells be monitored together with adjacent river water levels. Should a trend of reduced well water levels be seen together with relatively steady river water levels, blanketing of the river gravels with sediments may be occurring. This problem might be controlled by periodically lowering the weir gates at Nagymaros to flush deposited sediments or by selectively dredging the sediment deposits. Such dredging would be controlled to remove only the top sediment layer while leaving the underlying gravels largely intact.

Surface Water Quality. The quality of water in the Nagymaros reservoir will depend on the quality of the inflowing waters from:

Hrusov-Dunakiliti reservoir
Mosoni Danube tributary
Right bank communities and industries
Vag tributary, left bank
Garam tributary, left bank
Ipoly, left bank

Eighty-five percent of the inflow is from the upper Hrusov-Dunakiliti reservoir; therefore, the quality of these waters will control the water quality in Nagymaros reservoir.

The next largest pollution load is from the left bank triburary rivers Vag, Garam, and Ipoly. These combined inflows represent 10 percent of the inflow into Nagymaros reservoir. These tributaries exhibit water quality indices worse than those of the Danube.

The possible change in Danube River water quality due to impoundment in Nagymaros reservoir has not been evaluated. Water quality during some months of the year will likely improve due to settlement of suspended sediment and more biological breakdown in the upper reservoir, when the DO content is sufficient to continue this process. During summer months water quality is characteristically lower than average levels. Within the Nagymaros reservoir, water quality could decrease further than historic levels because of the combination of higher reservoir water temperature and longer detention time for algae production. The possibility of this impact needs to be studied and quantified to determine:

- Combination of parameters, if any, that would cause water quality degradation over historic levels (i.e., flow rate, organic load, nutrient load, water temperature, and DO content)

- Probability of critical combination of parameters occurring

- Appropriate water quality control measures (i.e., treatment of source pollutant loads, reducing reservoir detention times during critical periods, passing more flows over the Dunakiliti Weir and energy dissipation blocks to aerate the water, etc.)

Such quantitative evaluations can be performed using the QUAL2E computer program which would model the two reservoirs together with the water quality processes (see Appendix 2).

The possibility that heavy metals may concentrate in settled sediments and later dissolve into waters drawn into the river bank water supply wells also exists for the Nagymaros reservoir. This is particularly likely because the Vag inflows have higher concentrations of heavy metals. Again, an analysis of representative sediments should be conducted to determine if there is any likely combination of events which could dissolve the adsorbed metals. If unacceptable conditions are determined to be possible, appropriate mitigation measures should be identified, tested quantitatively, and selected for later mitigation when required. Possible mitigation measures include temporarily stopping industrial discharges (the main source of metal contaminants), improving industrial effluent treatment, temporarily opening the gates at Nagymaros, flushing flows from the reservoir, selective dredging, or mechanical aeration.

2.1.2 Ground Water

Hrusov-Dunakiliti Reservoir. The Hrusov-Dunakiliti reservoir and the Danube River down to the city of Gönyü overlay a large ground water basin which also extends under most of the Small Hungarian Plain (Kisalföld). The Danube is the predominant source of recharge to this basin (reported estimate is 90 percent of total recharge). Downstream of the Small Hungarian Plain basin, below Gönyü, the Danube traverses a series of small ground water subbasins containing discontinuous aquifers extending to as much as 70 m depth. The uppermost aquifers in these subbasins are in direct contact with the Danube River.

Downstream from the Nagymaros barrage site, the very permeable and shallow gravels of the Danube River channel are the source of bank-filter water supply wells providing a major part of the supply to Budapest. Similar well fields provide water supply to communities upstream of Nagymaros. Concern has been expressed that operation of the project may impact those wells.

VIZITERV and its experts have conducted extensive and detailed subsurface investigations of these ground water basins and have established relationships between the aquifers and the Danube River. Based on the results of those studies, the impacts that GNB project facilities and operations will have on these resources is evaluated below.

Impacts the project may impose on the ground water hydrology are of four general categories:

- o Changes in the ground water recharge characteristics of the Danube River
- o Changes in the fluctuation and level of the water table
- o Changes in the quality of ground water
- o Changes in the filtering characteristics of the riverbanks

The significance of each impact is evaluated primarily with respect to ground water as a resource. Other impacts of immediate consequence, such as waterlogging of lowland areas, are also discussed. It should be recognized that some potential impacts associated with ground water changes described in this section may have significant consequences for other resource areas. Such effects will be discussed in specific sections addressing those resource areas. Potential project impacts on ground water hydrology are discussed by three subareas:

- o Dunakiliti reservoir to Gönyü
- o Gönyü to Nagymaros
- o Downstream of Nagymaros

Dunakiliti to Gönyü Subarea. From Bratislava/Pozsony to Vének/Gönyü, the Danube crosses a deep structural basin filled with very permeable sand and gravel layers of Quaternary or recent geologic age. Thicknesses of those deposits range from 10 to 12 m at the edges of the basin to more than 300 m in the central area near Ásványráró. Fine-grained, low-permeable layers are present, but are discontinuous. The full thickness of the deposits responds as one aquifer, which is referred to as the "gravel aquifer" of the Szigetköz.

From where the Danube first flows onto the basin, it is a source of recharge – that is, ground water flows away from the Danube River channel, southeastward beneath the Szigetköz to the Mosoni Danube. Ground water discharges to the Mosoni Danube and Raba-Hansag water system, which in turn flows back to the main Danube channel near Györ. The Mosoni is a drainage boundary within the basin. Ground water to the south migrates northeastward and also discharges to the Mosoni Danube.

The water table beneath the Szigetköz fluctuates in response to the rise and fall of the Danube stage. The response is progressively less with distance from the Danube River channel. Seasonal fluctuations, based on the 35 years of water level records in observation wells, range from 4.5 m near the Danube to 0.7 m at some distance from the river.

Impoundment of Danube River water in Hrusov-Dunakiliti reservoir and diversion of around 30 km of the Danube River channel will alter the recharge regime to the gravel aquifer. Recharge from the reservoir area will be increased because large portions of the reservoir are unlined and exposed to the gravel aquifer. The reservoir area open to the aquifer is over twice that of the bypassed old Danube channel. Recharge will also increase because the reservoir water level will be raised 4 to 8 m above the average river level, thus increasing the driving force for recharge. On the other hand, recharge from the old Danube channel will be reduced because the historic average annual flow of 2,000 m^3/s in this channel reach will be reduced to 100 m^3/s. The net change to the aquifer ground water supply due to the altered recharge regime will be minimal - possibly increasing or decreasing slightly.

Measurable impacts will occur, however, to the ground water levels adjacent to the reservoir and the old Danube River channel. Where land surface areas adjacent to the reservoir are below the normal reservoir impoundment level, seepage from the reservoir will raise the water table - possibly inundating local depressions. To manage this problem, seepage interception channels have been constructed parallel to the reservoir dikes as part of the project. These interception channels will transport the reservoir seepage to the Szigetköz side arm channels and will maintain the local ground water level near historic levels. No additional mitigation is recommended.

The planned project release to the old Danube River channel is significantly less than the historic average river flow. This reduced flow rate will lower the water level in the old Danube River channel by 5 m at the Dunakiliti weir and to no change at the old Danube River channel/power tailrace canal confluence. The ground water table in the adjacent Szigetköz area will be lowered because the Danube is the major recharge source.

To keep Szigetköz ground water levels near historic levels, an artificial ground water recharge plan has been adopted for the GNB project. The plan is to release water from the seepage interception channels and the reservoir into headwaters of the selected side arm channels and the Mosoni Danube. The extra flows in the side arm channels will provide a new ground water recharge source. Analog model studies of the Szigetköz ground water basin were conducted to help design the new side channel recharge system. These studies have indicated that the average water table level can be maintained within 50 cm of the preproject level of 80 to 90 percent of the Szigetköz, and the historic level fluctuations will be reduced. However, the analog model study included the assumption of a homogenous but unisotropic gravel aquifer is homogeneous and isotropic. For the area-wide plan, this assumption is justified and supportable. However, the Szigetköz subsurface does vary from place to place in composition and characteristics. Therefore, we suggest evaluation of specific areas where careful management of the ground water level is important, such as the heron habitat area near Ásványráró, to determine if additional ground water control measures are necessary.

Should a site-specific evaluation identify variable subsurface conditions, additional ground water control measures can be developed, such as constructing small water supply ditches and/or drainage ditches. These evaluations should be conducted before the project is operational.

Gönyü-Nagymaros Subarea. Below Gönyü, the Danube leaves the broad, open Small Hungarian Plain and enters an area of moderate to high relief, flanked by hills and intervening lowland areas. Within the hill areas the river is confined by high banks above the maximum flood level, and there is little to no width of flood lowland. Materials underlying the hills are either consolidated bedrock, or relatively low-permeable materials.

There are three lowland reaches in this subarea; Komárom to Dunaalmás, Tát to Esztergom, and Pilismarót. These subareas are underlain by multilayered alluvial deposits to varying depths with the sand and gravel layers comprising aquifers. The water table in these areas is commonly near, or at, ground surface. Extensive drainage networks have been established for agricultural development.

Water supply in this region has been primarily oriented to surface water as a source. The ground water resource has not been developed in the vicinity of the Danube River. A major reason, it appears, is that impairment of the of shallow ground water quality is pervasive. The use of "bank-filtered" wells in the last 2 or 3 decades has allowed effective "natural" filtration of Danube water. These filter wells are located to minimize interception of ground water from the adjacent areas. Several fields of bank-filter wells are present along the Danube River in this subarea.

With the construction of the Nagymaros barrage, the mean level of the river will be raised from 1 to 6 meters in the subarea. To adjust to this new Danube water level, the water table away from the river will rise correspondingly unless some remediation measures are imposed.

Along reaches of Nagymaros where the mean project water level would be above the land side ground level, seepage interception channels will be constructed parallel to the reservoir dike. As previously discussed, these interception channels will control seepage from the reservoir and maintain the local ground water level near the historic average level. This measure is appropriate and workable and no further mitigations are recommended.

In the hill areas, where natural high banks exceed the highest flood levels, the raised ground water will generally remain deep and have insignificant impact on the area. Protective measures are planned for some industrial plants and community facilities near the river. However, seepage may occur in areas not previously expected. It is doubtful that such occurrences would cause seriously detrimental effects, but it could result in undesirable developments, such as marshy, wet ground. It is recommended that the occurrence of ground water in those areas be reviewed to identify potential areas where unwanted seepage might occur. Ground water level measuring stations should be added to the monitoring system as necessary to allow surveillance of these local seepage areas during project operation.

The Nagymaros reservoir will impact the bank filter wells by affecting the capacities of the wells and the quality of the extracted water. With regard to the capacity of the wells, the increased river level and the reduction of seasonal fluctuation will provide a higher, and more constant driving force, or head, to induce infiltration. This will increase the potential capacity and dependability of the wells. On the other hand, sediment deposited on the reservoir bank will tend to reduce the capacity of the wells because it will develop a low-permeability layer that could restrict infiltration.

To monitor inflow to the bank filter wells, many of the wells are provided with observation wells between the river and the extraction well. The purpose has been to detect reduction in well efficiency. Monitoring these wells in conjunction with the reservoir level will also provide an indication of whether or not sediment deposition in the reservoir is affecting well capacity. Should it be proven that inflow into some wells is significantly reduced due to reservoir side sediment deposition, the sediments should be removed by dredging.

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Quality of the water extracted by the bank-filtered wells will depend primarily on the quality of the river water. The filtering characteristics of the sand and gravel materials will not be affected by the reservoir. Because the water level of the reservoir will be higher than the existing water level, the wells will draw a lower percentage of ground water from adjacent areas, which are the present sources of poor quality water. Should an undesirable dissolved constituent be introduced into the Danube River, the filter characteristics will not prevent that constituent from eventually reaching the filter wells except to the extent of the adsorption capacity of the filter material.

The same concern for heavy metal accumulation exists for the Nagymaros reservoir as for the Hrusov-Dunakiliti reservoir. As previously discussed, representative sediment samples should be tested to determine the particular circumstances necessary to turn the stable adsorbed metals to the soluble state. The monitoring of bottom sediments should then track the local environment and if unfavorable conditions are observed, corrective measures already identified can be initiated.

Downstream of Nagymaros. The planned operation of the project will not significantly alter the flow characteristics or hydrology of the river downstream of Nagymaros. Some dredging has been done to improve the channel for navigation. Concern has been expressed that these efforts, or operation of the project, could disturb or affect the bank-filter wells present in the area.

The dredging work has been terminated, so that is no longer a factor. Because the project will not alter the flow of the river in this area, the project can not have a measurable impact on the performance of the wells. From a water quality standpoint, as discussed in the section on surface water, the project operation might result in an improved water quality except for a few months during the summer. The question of lower quality water occurring during the summer months should be evaluated as previously recommended. The bank filter wells located downstream from Nagymaros will yield water with the same water quality as found in Nagymaros reservoir. The occurrence and movement of ground water downstream of Nagymaros will not be affected by project operation.

2.2 BIOLOGY

2.2.1 Impact Methodology

The impact analysis for biological resources is based on information documents listed in Appendix 1, discussions with the Institute of Ecology and Taxonomy (ELTE) and VIZITERV experts, and general biological observations made during a field reconnaissance of the project area. The reconnaissance included the Dunakiliti reservoir, Gabcikovo barrage and power station, Nagymaros barrage construction sites, biological monitoring station no. 1 at Dunakiliti, a side channel/oxbow in the Szigetköz, and a fringe forest at Pilismarót. Information regarding biological resources in the project area varies greatly. Specific biological information is limited to 12 biological monitoring stations. Nine monitoring stations are concentrated in the Szigetköz-Gönyü reach, with two in Gönyü-Nyergesújfalu (Tát and Almásneszmély), and one at Szentendre Island.

The impact analysis provided by VIZITERV was limited to impacts on agriculture, silviculture, and fishing. Therefore, based upon the data provided, an impact analysis was done to determine potential impacts on biological resources, and develop mitigations and recommendations for the monitoring program.

Significance Criteria. Several factors were used in evaluating impact significance, these factors are the: importance (e.g., ecological, legal, scientific) of the resource; total size or areal extent of the population or habitat within the ecologically equivalent area; amount of the population or habitat expected to be affected; ecological ramifications resulting from the effect; and anticipated duration of effects.

An impact is considered "locally significant" if it is expected to directly or indirectly cause measurable change within the localized area in either (1) species' composition or abundance beyond that of natural variability, or (2) ecological function. To be locally significant, the size of the affected area would be relatively small compared to that of an ecologically equivalent area within the region.

3
Monitoring Program Evaluation

Section 3

MONITORING PROGRAM EVALUATION

3.1 MONITORING PROGRAM EVALUATION

The Gabcikovo (Bös)-Nagymaros Barrage (GNB) environmental monitoring program was reviewed for overall adequacy of the program to define potential project-related impacts as discussed in Section 2; assess effectiveness of planned mitigations and additional proposed mitigations; identify changes and trends in the environment resulting from project operations; and assess effectiveness of mitigations and operational rules designed to reduce adverse impacts or enhance beneficial effects.

Recommendations for the monitoring program focus on the adequacy of the preoperational database to define preproject conditions and quantify impacts, and additional data needed to define environmental conditions during operation. Monitoring stations established for structural engineering purposes were not considered. In our experience, preoperational environmental measurements are normally taken at more frequent intervals than operational measurements (until baseline conditions are established). Generally, preoperational data collection over a 1-year period is judged adequate. The frequency of measurements usually are reduced to a level appropriate to evaluate changes or trends in a particular resource area during operation.

The GNB project has collected a substantial amount of data over a number of years, which has established an extensive base for all aspects of engineering, hydrology, and hydraulic data required for the project. These data include streamflow, surface water quality, channel cross sections, ground water levels, sedimentation and ice conditions, as well as soils, land use, meteorology, archaeology, agriculture, and forestry. Additional data collection is recommended for biological resources.

Since August 1989, VIZITERV has started operating an integrated computer database for all information collected. This computerized database presents data in a wide variety of formats, including statistical, graphical summaries and in two-dimensional plans and maps. These formats are sufficient for data presentation necessary to evaluate changes in environmental resources. Once all environmental data are entered into the system, rapid review and analysis of data will be possible. Comparison of two or more interrelated aspects are also possible with the system, which can facilitate interdisciplinary resource evaluations. Overall monitoring will be an efficient, effective tool for analyzing project-related impacts and mitigation effectiveness.

Substantial cost savings will be realized by tailoring the monitoring system and sampling program to the operational requirements for tracking environmental changes over time. Once the baseline conditions are established, the number of locations and sampling frequencies can be reduced. The reduced program must be established by a detailed review of the key areas which signal changes in existing conditions. This entails selecting specific sampling stations which provide overall representative data throughout the project area. Additional sampling locations must be designated in specific areas which are more sensitive to changed environmental conditions.

The following discussion presents a general evaluation of the existing monitoring systems along with recommendations for future monitoring in specific resource areas. Table 3-1 summarizes monitoring program recommendations.

3.1.1 Surface Water Monitoring

A network of measuring stations for river flows, sediment transport, and water quality has been implemented. Data obtained from these stations have established the baseline condition for the project area surface water regime. Data will continue to be collected to expand this database up to completion of the GNB project. At the time of project commissioning, the network will be modified to monitor only the key surface water variables.

Table 3-1

SUMMARY OF MONITORING SYSTEM RECOMMENDATIONS

Type of Resource	Project Area	Monitoring Comments and Recommendations
Surface water streamflow	Total project	- Existing conditions database is satisfactory.
		- Develop streamflow correlations with sediment load and possibly pollutant loads.
		- Test various project operating rules to determine optimum rule for given input conditions (average daily streamflow, sediment load, and pollutant load).
		- Reduce number of streamflow measuring stations to all river and tributary project input points, after operation rules have been verified as effective.
Surface water levels	Total project	- Develop water level correlations for reservoir level vs landside ground water levels, Szigetköz sidearm surface water level versus adjacent ground water level, and reservoir level changes versus Gabcikovo powerhouse discharge.
		- Verify preliminary correlations.
		- Reduce existing and proposed stream gauging stations to headworks and tailraces of project structures, two locations along old Danube channel, and control structures for seepage/drainage interception channels near the Ásványráró heronry.
Surface water sediment transport	Hrusov-Dunakiliti reservoir	- Conduct cross section surveys at 1 km intervals along reservoir to establish areas of major deposition for first 2-4 years. After deposition areas are identified, reduce number of annual surveys to four cross sections. One cross section should be maintained at upstream end to check clearance in navigation channel.
		- Conduct annual analysis of bottom sediments to determine heavy metal content.
	Nagymaros reservoir	- Conduct annual cross section surveys during the first 2-4 years at 3 km intervals and at reaches where filter bank water wells are located (to monitor sediment deposition expected along the sidebanks of the 50 km downstream section of the reservoir). After areas of deposition are identified, the annual surveys should be reduced to five cross sections.
		- Conduct annual analysis of bottom sediments to determine heavy metal content.

Table 3-1 (Cont'd)

Type of Resource	Project Area	Monitoring Comments and Recommendations
Surface water quality	Total project	- Conduct water quality sampling and analyses during the first year of project operation for the two reservoirs, Mosoni Danube, old Danube channel, and the Szigetköz sidearm channel to check that the water quality model is properly calibrated, and the project operation is maintaining the required water quality level.
		- Increase frequency of sampling and analyses during summer months when algal blooms are occurring. After the first year, sampling frequency can be reduced to monthly, and the number of measuring stations may be reduced to selected key locations.
Ground water levels	Szigetköz	- Reduce measurement program both by number of locations and frequency of measuring now that extensive baseline data has been obtained. Select wells for a specific purpose or multipurposes. 1. Long-term trends to be recorded by semiannual measurements of all holes. 2. At least three representative profiles to measure response to surface flow fluctuations should be measured monthly. Continuous monitoring of two wells in each profile should be considered. Additional monitoring should be selected for specific needs in critical hydrologic areas such as sensitive biological sites and the biological monitoring stations.
	Downstream of Gönyü	- Reduce measurement program both by number of locations and frequency now that sufficient baseline data has been obtained to determine hydrologic characteristics. Wells to be selected for specific purpose: 1. Long-term trends recorded by semiannual readings in all holes. 2. Monitor special areas such as: potential areas of seepage for higher reservoir levels; critical biological or archeological sites; monitoring wells between the river and the bank filter wells (to detect variations in well efficiency and capacity).
Ground water quality	Szigetköz	- Begin vertical sampling of a few deeper holes (2 years of accumulated data is sufficient for the baseline conditions). Test water quality in critical areas and on a widely spaced grid covering both river and background areas on 3-month frequency, also for heavy metals if necessary.
	Downstream of Gönyü	- Develop and implement sampling program based on river and background including critical or sensitive locations. Sample monthly for 2 years to develop baseline data. Reduce frequency to every 3 months after baseline established.

Table 3-1 (Cont'd)

Type of Resource	Project Area	Monitoring Comments and Recommendations
Meteorology	Total project	- Reduce number of stations used to collect precipitation, air temperature, and evaporation data to at least the two reservoir sites.
Archaeology	Esztergom	- Monitor ground water levels in the Royal Town area of Esztergom quarterly, to ensure effectiveness of the Kis-Duna pumping system.
Land use	Total project	- Sufficient baseline data has been obtained for agriculture and forestry. Monitoring recommended for forestry to assure that ground water levels in Szigetköz are maintained at planned levels. No monitoring for acid rain effects is recommended.
Biology	Total project	
Vegetation		- Include ground water level data collection at each biological monitoring station.
Wildlife		- Conduct annual waterfowl surveys on main Danube channel and side arms along length of Szigetköz during breeding season and outside of breeding season. Compare survey results to preproject survey results (recommended in mitigation section).
		- Collect stream gauging and water quality data at sensitive waterfowl areas such as Ásványráró for correlations with changes in waterfowl use.
		- Conduct seasonal surveys on four protected bird species in the Szigetköz to compare to preproject conditions (seasonal surveys recommended as mitigation) and detect changes in habitat use and abundance.
		- Continue seasonal surveys during monitoring if protected mammal species are identified during recommended preproject surveys.
Fish		- Conduct annual fish surveys to monitor cumulative impacts on fish in main channel and side arms of Szigetköz and Mosoni. Include migration and spawning conditions in surveys.
		- Monitor DO levels.

The purpose of the operational monitoring network will be to provide sufficient information to verify that environmental requirements are being met. At the same time, it will also allow project operators to maximize the available water resource in terms of hydroelectric generation, navigation, and municipal, agricultural, industrial, and environmental water supplies.

In general, the surface water resource can be successfully managed by knowing all current project inflows (streamflow, sediment load, and water pollution loads). Knowing the current input values and verified interrelationships between these variables and other environmental factors, appropriate water releases through the power plants, shiplocks, and weirs can be selected.

The following evaluation of the GNB project surface water monitoring network is based on the above general data collection and processing approach. It is understood that VIZITERV is in the process of evaluating surface water variable interrelationships and developing system models. However, our review schedule did not allow us to examine the intended data processing work; therefore, some of the following recommendations may have already been implemented.

Streamflow. The current number of streamflow measuring stations is 14, all operated in Hungary. Another 15 stations, located both in Hungary and Czechoslovakia, are planned for project operation. This streamflow database will allow development of streamflow correlations with sediment load and possibly pollutant load. These correlations are important input to system models which will simulate project operation scenarios with resulting changes to the sediment transport and water quality indices. The key stations for stream flow monitoring will be:

- Bratislava
- Dunakiliti, Gabcikovo, and Nagymaros
- At all tributaries - located upstream away from backwater
- At all project water-regulating gates and pump stations

Both the eventual set of project operating rules or, alternatively, a computer model for selecting optimum operating rules, will require current and historic streamflow data from these stations.

Stream Water Level (Gauge). Monitoring water levels will be an important function because many project impacts are related to water levels (e.g., water level relationships between reservoir levels and ground water levels; surface water level in Szigetköz side arm channels; relationships with local ground water; and reservoir level changes during operation of the Gabcikovo powerhouse). To establish these relationships, over 150 stream gauges are being measured. Another 150 gauges are planned for the operating project to confirm the relationships for the new surface water regime. The number of stream gauges can be significantly reduced after the correlations and models are verified or revised. The minimum required number of stream gauges will not be estimated; however, some key locations will be:

- Headworks and tailraces of each project structure
- Two locations along the old Danube channel
- Control structures for the Szigetköz side arm channels
- Control structures for the seepage/drainage interception channels
- Near the Ásványráró heronry

Meteorological Stations. About 28 meteorological stations which record precipitation, air temperature, wind, and evaporation have been used to establish the environmental baseline conditions and to evaluate basin water balance. The amount of data available is extensive and sufficient for understanding baseline conditions.

For the operational GNB project, of the 28 stations, two is the minimum number of meteorological stations required - one at each of the two reservoir sites. These stations should record precipitation, air temperature, and evaporation.

About 85 percent of the project inflow is from the upper Danube basin above Bratislava. Therefore, local precipitation over the 160 km reach of the project area will not contribute such large amounts of runoff to warrant development of a precipitation runoff simulation model.

Bed Deformations and Sediment Transport. There are two impacts identified for sediment deposition in the reservoirs which will require monitoring:

- Sediment buildup in the navigation channel at the upstream end of the Hrusov-Dunakiliti reservoir
- Sediment deposits blanketing riverbed gravels in the Nagymaros reservoir which could reduce Danube River flow into the riverbank filter wells

At the Hrusov-Dunakiliti reservoir, benchmarks are being set every 500 m along the dike crest from which sediment deposition surveys can be conducted. Over the first few years of reservoir operation, surveys from a number of the 56 cross section locations should be conducted to establish the areas of concern. Later the number of survey sections should be reduced to four, with one survey always conducted at the upstream end of the reservoir.

A number of cross section surveys should also be conducted along the long, narrow Nagymaros reservoir - particularly along reaches with adjacent bank filter wells. After a few years, the surveyed cross sections could be reduced to about six, located at sites of noticeable sediment buildup.

The future monitoring program includes suspended sediment surveys along four cross sections of each reservoir. These surveys would be of interest to establishing sediment settling rates and flow velocity relationships. But after these relationships are verified these surveys should be discontinued.

Sediment measurements should be made at each river and tributary inflow location where streamflow measurements are also conducted, and downstream of the Nagymaros barrage. Such sediment surveys should be made once monthly and before and after flood events.

Water Quality. Seventeen surface water sampling stations, located along the Danube and Danube tributaries, have recorded water quality indices for a number of years. This database is sufficient to establish current baseline conditions. Currently 28 water components are evaluated for each water sample.

As previously discussed, historic combinations of principal water quality indices, together with corresponding streamflows, should be combined with a computer model of the GNB reservoir system to evaluate probable water quality levels under project conditions. Such evaluations are required to determine whether special mitigation measures are required to keep the project surface water quality equal to or better than historic levels. It would be desirable for such evaluations to also identify what trends in streamflow, water temperature, and dissolved oxygen (DO) levels at Bratislava would likely yield critical water quality conditions in the project reservoirs. By recognizing hydrologic trends which might lead to critical conditions, project operators would have lead times to initiate operation mitigation measures, such as releasing more flow over the barrage weirs to aerate the water, or changing the power plant operations to constant baseload mode to reduce reservoir detention times. Such measures could be temporary, for a week or a weekend, and might avoid critical conditions which would affect municipal water supplies and aquatic life.

During the first year of project operation, close monitoring of water quality in the reservoirs will be important. This data will be needed to check and revise the results from the water quality computer model. Approximately three cross sections across each reservoir should be sampled. Sampling locations and frequency will depend on parameters being monitored. Samples should be taken from about 1-m depths and analyzed for the 28 water components. At one sampling location in each reservoir, measurements for temperature, conductivity, and DO should be made at two additional levels to establish depth variations. Also, during the sample day, the DO measurements should be taken twice (morning and night) to record the diurnal DO changes.

About 21 new water quality measuring stations are planned for the operating monitoring system. After the first year of measurements have been evaluated and the preliminary correlations and water quality model have been verified, the number of monitoring locations can be reduced. At a minimum, measurements should be continued at Bratislava, all tributaries, and in the two reservoirs. Measurement frequency can be reduced to monthly.

3.1.2 Ground Water Monitoring

The following recommendations for the monitoring program will address that portion of the project area between Dunakiliti and Gönyü, and the area from Gönyü to Nagymaros. Because there is no impact associated with the project downstream of Nagymaros, ground water monitoring is not needed for this reach. In general, the monitoring for water level data is more comprehensive than for water quality monitoring. The data and monitoring program in the Szigetköz is more comprehensive than it is for the area downstream of Gönyü.

Dunakiliti to Gönyü. The network of over 200 monitoring wells and several years of water level measurements have produced a sufficient database to establish ground water level responses to changes in Danube surface water levels, and develop the Szigetköz ground water recharge plan.

During project operation, the monitoring well system should be modified to check that the water table adjacent to the Hrusov-Dunakiliti reservoir is being maintained near historic levels and that the Szigetköz ground water recharge plan is working. The seepage rate and water table responses have been predicted for the area adjacent to the reservoir. Nevertheless, actual response data for the filled reservoir is needed, both for verification of predictions and for safety of the structure. An array of wells is selected for that purpose. Once the initial verification of seepage rates is established and deviations from predicted conditions are explained and rectified as needed, the number of monitoring wells can be reduced to those used for monitoring seepage under the reservoir dike. The number of dike seepage monitoring wells will not be reduced because they are required for structural stability and safety.

It appears that the Szigetköz ground water can be properly observed by monitoring three general areas and other areas of specific concern. The general areas can be monitored with lines of wells already in place between the old Danube and the Mosoni Danube. These lines will provide information on the actual ground water profiles which can be checked against the planned ground water profiles. One or two lines are recommended for each general area, with six or more wells per line. The actual number of lines and wells per line should be based on a more detailed evaluation of the area subsurface characteristics.

The three general areas to be monitored are:

- o Bezenye-Dunakiliti area - which has shown slow responses of the water table to river fluctuations
- o Ásványráró area - which has shown rapid responses to the river fluctuations
- o Lower end of the Szigetköz - the area of ground water basin discharge

During project startup and the initial year of project operation, the monitoring wells in the Szigetköz and the surface water levels in the side arm channels should be measured weekly to allow adjustment of discharge into side arm channels to maintain the required ground water levels. Once the side arm discharge and ground water level relationship is properly calibrated, the monitoring can be reduced to continuous staff readings in key side arm locations and measurements three or four times per year at the monitoring wells.

There are some specifically sensitive areas in the Szigetköz which will require additional ground water monitoring because the local environments are less tolerant to water level fluctuations. These local environments include:

- o Biological monitoring stations
- o Bird habitat areas (such as Ásványráró)
- o Fish spawning areas

The number of monitoring wells and frequency of measurements must be established after more detailed evaluations of the local environments and potential project impacts.

Ground water quality monitoring is much less extensive than the water level measurements, both in number of wells sampled, and in length of time that monitoring has been conducted. The number of wells sampled is less than one third of the total monitoring wells and, according to the data provided, no regular sampling of wells open to deeper intervals in the basin has been conducted. Regular sampling of wells open to the shallowest zone, less than 30 m deep, commenced in 1988.

Once drilling and well construction effects are accounted for, 2 years of regular sampling on a monthly basis should be sufficient to establish the water quality character (including sampling variabilities) for a baseline reference. Once that baseline is established, frequency of monitoring is usually reduced to 3-month intervals. Recognizing that ground water migration is unusually rapid in this basin of extremely high permeability, it would seem that quarterly frequency is sufficient. In addition, the number of wells being sampled should be reviewed for possible reduction. Several wells may be found to be in an area of similar hydrologic characteristics and similar quality; thus, the number to be sampled may be reduced.

Important characteristic areas in which quality sampling should be performed are the recharge areas, particularly in the vicinity of Dunakiliti reservoir. In addition to shallow monitoring, at least one deep zone well should be monitored down gradient of Dunakiliti. Other well sites should be selected in reference to specific concerns, such as fish spawning areas in the basin discharge region in the vicinity of Vének, and the biological conditions of the heronry at Ásványráró.

The ground water quality parameters to be measured should continue to be those included in the current testing procedures. Additional testing parameters can be added to the present program should it become desirable to apply more stringent quality standards in specific areas. The current testing parameters are sufficient to cover the purpose for which the water quality is being monitored.

Gönyü to Nagymaros. The subsurface conditions in this subregion are more complex than in the Szigetköz. The ground water occurs in a series of small subbasins which in turn are comprised of multiple aquifers. Sufficient data have been collected from the nearly 200 observation wells in the area (at least one well is reportedly installed in each aquifer) to establish the hydraulic interrelationships between the ground water regime and the Danube. Most important is the fact that only the upper aquifer is in direct contact with the Danube. Further, ground water flow direction surveys have been conducted to establish the historic ranges of the water table gradient.

During project operation, ground water monitoring will be required to check that the seepage/drainage interception channels and pump stations are maintaining the ground water at desired depths, and special protective measures at industrial plants, urban structures, and historical sites are properly functioning. A specifically sensitive area which will require additional ground water monitoring because of the influence of water level fluctuations is the Royal Town area of Esztergom.

Initially, ground water level measurements should continue to be taken to confirm or revise the ground water gradient relationships with the water levels in the Nagymaros reservoir and in the seepage interception channels. These measurements should be made weekly until the relationships are firmly established. Operational control will subsequently be maintained according to automatic water level measurements in the interception channels and at the drainage pumping stations. Measurements in key observation wells can be reduced to four times per year. Measurements at specific structural sites should be made at intervals appropriate to the expected local ground water fluctuations.

Water quality data in the Gönyü-Nagymaros reach of the project area are apparently quite limited. It is recommended that the regular water quality monitoring program started in 1988 be continued. Monthly samples should be collected at least from a few wells in selected critical areas in each subbasin to establish baseline water quality. Water quality of both the deep and shallow aquifers should also be established. The ground water parameters being monitored should be the same as discussed previously for the Dunakiliti-Gönyü reach of the project.

Monitoring wells should be constructed and observed at locations between bank-filter wells to establish baseline data. With continued monitoring after reservoir filling, any decline in well performance can be related to sediment deposition in the reservoir and identified.

3.1.3 Biology

The project has planned and implemented preproject monitoring at 12 established biological monitoring stations. This monitoring system will provide valuable information on vegetation, birds, and invertebrates for use in detecting project-related operational impacts. This monitoring program was reviewed relative to the potential impacts that may result from the project.

Based on available information, some recommendations can be made at this time. Other recommendations for the monitoring program would need to be developed after reviewing the additional biological baseline data recommended for collection (see Section 2.2).

Vegetation. The monitoring program designed and implemented at the 12 biological stations provides a sound basis for evaluating impacts on natural vegetation in areas that may be affected by the project. The stations have been located in different habitat types in areas which could be expected to be affected by changes in hydrological conditions. The control or reference areas are also well located. Emphasis on vegetative monitoring in the Szigetköz is well founded. Additionally, the vegetative sampling scheme is well designed and the baseline information collected to date will provide a preproject comparison basis for evaluating operational impacts.

One additional recommendation for the monitoring program (if it is not already being conducted) is collection of data on ground water levels at each monitoring station or an existing nearby well. This information could prove useful should any changes in the vegetation be detected. Changes in species composition, abundance, and water requirements (Zolyomi's water requirement categories), and measured changes in ground water levels could be correlated.

Wildlife. The project plans to conduct monitoring of birds and six insect species selected as indicator species sensitive to changes in the water regime. Data collection is ongoing at the 12 biological monitoring stations, and baseline information is available.

The planned monitoring of avian species at the biological stations should be continued. The stations established are in a variety of habitat types which support a diversity of bird species. Operational monitoring data on birds can be compared to preproject data and correlated with any changes documented in the vegetative sampling. Quantitative data and information currently being collected on residents during the breeding season provide a good basis for assessing any changes during operations.

Because riparian/wetland vegetation provided by the main channel and the side arm system is important to waterbirds, a preliminary recommendation is to expand avian monitoring to include annual waterfowl surveys of the region both during and outside the breeding season. This monitoring should include the main channel and the side arm system along the length of the Szigetköz. These surveys should record species present, estimated numbers of waterfowl, and breeding activity. Survey results could be compared to the baseline waterfowl survey data recommended in Section 2 to determine whether any significant changes in distribution, estimated abundances, or breeding patterns occur during operation of the project. This recommendation should be reviewed and the survey design developed based on the data collected from the preproject surveys.

Also, stream gauging and water quality sampling should be conducted at several locations in the side arm system determined to be important habitat for waterfowl (e.g., Ásványráró). Water levels and quality should be monitored in these locations for correlation with any significant changes in waterfowl use detected by the monitoring program.

Additionally, monitoring surveys should be conducted for the four protected bird species described in the impact section. Once baseline surveys have identified their preproject seasonal habitat use of the area, monitoring surveys should be conducted to identify whether any significant changes in species' distribution, abundance, or seasonal habitat occur. These surveys should be designed based on the information collected in the baseline surveys.

If any protected mammal species are identified in the recommended 1-year baseline survey, a monitoring program should be developed for these species.

Fish. Currently, the monitoring of fish stock appears to be limited to collection of fish catch data. As noted in the report on the monitoring network, the fish surveys need to be expanded to include data on spawning grounds, spawning times, and restocking.

Several monitoring recommendations are made in this section, but it should be noted that these recommendations are preliminary and based on very limited information. The monitoring program should be reviewed and better developed after baseline fish surveys are conducted over a 1-year period prior to project operations.

Subsequent to the baseline seasonal fish surveys, annual fish surveys should be developed and conducted once the project is operational. These surveys would be designed to monitor for overall cumulative impacts on fish in the main channel (above and below the barrages), the side arm system, and the Mosoni. Such impacts could result from one or a combination of effects discussed in the impact section. Should this monitoring detect any measurable changes in fish stocks, more specific data collection programs could be designed to assess the reasons for the effect and mitigation that should be employed. The monitoring also should focus on migration and spawning to detect any changes in these activities which may result in reduced reproduction and recruitment over time.

A permanent monitoring system for DO and temperature above and below each of the barrages should be implemented. This is commonly done by use of an electronic system that automatically records continuous DO and temperature measurements. In conjunction with the preproject DO modeling results, this monitoring can be used to detect significant DO deficiencies developing during operations, and to guide the project in making operational alterations to mitigate DO deficiencies and effects on fish as needed. As described in the impact section, these measures may include:

- Spilling flows over the weir
- Mechanical aeration techniques such as pumping air through nozzles into the turbine draft tubes or some type of diffuser in the tailrace
- Operating the Gabcikovo power station in continuous mode, or alternating between peak and continuous operation (to reduce algal production)
- Drawing down the reservoir during certain conditions (algal blooms)
- Release of small discharges from the reservoir bottom (which tend to have low DO concentrations) mixed with surface waters

Federal licensing of hydroelectric plants in the U.S. often requires continuous monitoring of DO and temperature and special measures when DO levels fall below established criteria. As an example, the Martinsville Hydro Electric station must shut down whenever the DO measured falls below 6 mg/l, until the DO returns to 6 mg/l or it is demonstrated that the power plant operation does not further reduce the DO as recorded in the headworks. The Norris Hydroelectric Project operated by TVA has an air injection system which is activated when the DO drops below 5 mg/l.

Additionally, DO and temperature measurements should be collected at several locations in the side arm system and the Mosoni which would be determined after review of the baseline fish survey data.

Finally, operational surveys should be conducted to monitor the effectiveness the fish lock. Fish passage via this system should be monitored until it is established that the system provides an adequate means of migration.

3.1.4 Land Use

No forestry impacts are anticipated. Therefore, future forestry observations related to the project are not necessary, unless ground water monitoring indicates a trend (over 5 years) towards a decrease in ground water levels below those originally predicted in the Szigetköz. If ground water levels are lower than predicted, additional forestry monitoring could include the following parameters:

- o Tree growth
  - Species
  - Age
  - Average height
  - Average diameter at chest height
  - Timber volume
  - Comparison to earlier observations
- o Logging data
  - Date of logging
  - Logging site
  - Area cleared
  - Species logged
  - Lumber volume
  - Total tree volume
  - Lumber value
  - Comparison to earlier observations

Monitoring should be limited to only those areas experiencing a trend in decreasing ground water levels (below the predicted levels).

No monitoring for acid rain effects on forestry is recommended. While acid rain has been shown to be a problem that affects forestry productivity in the U.S., it is not associated with the project and could not be considered alone from the many factors potentially affecting forest productivity.

No agricultural impacts are anticipated. Therefore, no additional agricultural monitoring of crops or animal husbandry is necessary or recommended.

3.1.5 Archaeology/Historic Monuments

Increases in ground water levels above the existing mean level could affect the accessibility of deep-lying archaeological artifacts in the Esztergom Royal Town area (site no. 35.1.10). It is proposed that the ground water level in the area will be controlled by the Kis-Duna pumping station facilities at the mean ground water level of 103.5 m above sea level. Currently there is no proposed monitoring program for archaeological impacts. It is recommended that the existing wells in the Royal Town area continue to be monitored, as discussed in Section 3.1.2 - Ground Water Monitoring. These wells should be monitored quarterly to ensure that the Kis-Duna pumping system is effective in maintaining ground water levels at the current mean levels of 103.5 m above sea level.

3.1.6 Visual Resources

Monitoring of visual resource impacts is not necessary and is not recommended.

3.1.7 Recreation, Fishing Resources, and Tourism

A monitoring program is proposed for fishery resources and is discussed in Section 3.1.3. No additional monitoring is proposed or necessary for recreation resources or tourism.

3.1.8 Socioeconomics

No monitoring is proposed or necessary for socioeconomic considerations, with the exception of fisheries is discussed in Section 3.1.3.

3.2 SUMMARY OF RECOMMENDATIONS

Table 3-1 presents monitoring system recommendations.

3.3 EXISTING MONITORING PROGRAMS

The monitoring program implemented for the GNB project tracks a comprehensive array of hydrological and environmental parameters. Similar water management projects in the U.S. were reviewed to identify the scope and reliability of operational monitoring programs. Our review did not find any existing monitoring program which can compare to the GNB program with respect to the range of environmental parameters being measured. Perhaps the most comparable U.S. program is the one established for the Columbia River by U.S. and Canadian agencies. However, the Columbia, Ohio, and Tennessee River programs do provide important additional features which are applicable to the operational needs of the GNB Project.

3.3.1 Columbia River Operational Hydromet Management System

The Columbia River is a major river located in the northwestern portion of North America. The river drainage area is over 259,000 square miles. More than 100 hundred water management projects are currently operated on the river. These are multipurpose projects - power generation, navigation, water supply, and flood control - and are managed by government and private agencies. In a coordinated effort, these agencies have designed and implemented a basin-wide data collection, processing, and display system called the Columbia River Operational Hydromet Management System (CROHMS). The purpose of CROHMS is to provide project operations with an accurate, continuously updated database which allows more efficient management of water resources. The system was commissioned in 1978 and originally collected data from over 450 stations, covering stream flows, precipitation, air temperatures, snow depths, and hydroelectric generation. The database has since been expanded to include water quality parameters and fish counts.

Data are transmitted to the CROHMS computer center located in Portland, Oregon. The center is managed by the U.S. Army Corps of Engineers (USCOE). At the computer center, the data are validated and used in various computer simulation models which help develop monthly, weekly, and daily project operation rules.

CROHMS has proven to be an effective tool which aids project operators in maximizing the benefits of this large river resource. Plans are currently being developed to expand the database to include more environmental parameters and to develop new software which will screen incoming data and automatically issue alert notices whenever environmentally critical threshold conditions are being approached.

Literature which describe the Columbia River projects and the development of CROHMS are included in Appendix 4.

3.3.2 Ohio River

The Ohio River is 980 miles long and supports a variety of uses including navigation, power generation, industrial processes, municipal water supply, fish and wildlife habitats, and recreation. This river receives treated wastes from over 220 industrial and 126 municipal sources. There are 28 water control projects on the river. Three groups have major roles in managing the Ohio River. They are USCOE, federally licensed hydroelectric operators, and the Ohio River Valley Water Sanitation Commission (ORSANCO).

USCOE has been authorized by the U.S. government to construct and operate a series of locks and dams along the Ohio River for navigation service and flood control. The plan and profile of the USCOE Ohio River system is included in Appendix 4. The USCOE division office at Cincinnati, Ohio is responsible for general management of the Ohio River projects. Day-to-day management is assigned to four district offices which are each responsible for four to eight projects.

Each district office maintains a monitoring system which continuously measures river and reservoir water levels, precipitation, air temperature, and project releases through low level outlets, spillway gates, and navigation locks. These data are input to subbasin operation models to establish weekly and daily operation schedules. Water quality parameters - DO, water temperature, pH, and conductivity - are measured. Should undesirable water quality indices be observed, some project operation responses, such as releases over spillways, are activated to improve the water quality.

A number of hydroelectric powerhouses have been added to the USCOE dams. These powerhouses are owned and operated by public and private utilities under licenses issued by the Federal Energy Regulatory Commission (FERC). An example of such a project is the new Martinsville Hydro Electric Project which adjoins the Hannibal Lock and Dam. This power plant houses two 17 MW bulb turbine generator units and it must pass the incoming river flows as regulated by USCOE. The FERC License requires the continuous monitoring of DO and water temperature. Whenever the DO level falls below 6 mg/l, the power plant must be shut down and the river flows passed through the spillway gates in Hannibal Dam. Power plant operations cannot be restarted until the DO level returns to 6 mg/l or it is proven that the power plant operation does not further reduce the DO level as recorded in the headworks.

Each FERC licensed project is also required to transmit daily DO and water temperature readings to ORSANCO which maintains a basin-wide water quality database. ORSANCO is an interstate agency which has the primary function of promulgating standards of sewage and industrial waste water treatment and monitoring water quality along the Ohio River. The commission also maintains a quality assurance program. Aspects of this program include specifications of sample collection and handling techniques, service of electronic equipment, submission of check and duplicate samples collection and handling techniques, laboratory inspections, and immediate review of all data collected. A special aspect of the quality control program for a large river such as the Ohio is the need to assure that all monitoring locations are representative of conditions across the river. A program of cross sectional sampling, with analyses for all water quality parameters measured in the monitoring program, was initiated in 1984. Eight monitoring locations are scheduled to be covered each year. The types of water quality monitoring included in the ORSANCO program are discussed below.

Electronic Monitoring. Electronic monitors connected to the ORSANCO office in Cincinnati, Ohio, are operated at 15 Ohio River and 7 tributary locations. The monitors provide hourly measurements of DO, temperature, pH, and specific conductance.

Manual Sampling. Monthly samples are collected at 24 Ohio River and 14 tributary locations. Samples are analyzed for 25 physical and chemical constituents on a monthly basis; an additional 7 parameters are measured quarterly.

Constituents sampled include cyanide, phenolics, mercury, copper, zinc, lead, cadmium, iron, maganese, BOD, suspended solids, sulfate, hardness, nutrients total phosphorous, total Kjeldahl nitrogen, ammonia nitrogen, and nitrate/nitrate nitrogen.

Organics Detection System. Daily samples for organic compounds are collected by 13 participating utilities. Data from 11 of the utilities are used to provide a continuing record of ambient levels of 17 purgeable, halogenated organics. The other two utilities operate as spill detection sites.

Water Users Network. Results of river sampling by 12 water utilities, industries, and power plants on the Ohio River and its tributaries are currently utilized to augment the commission's other data sources. Data are collected for alkalinity, chloride, phenolics, and fecal coliform bacteria. The fecal coliform data are particularly valuable since the commission's stream criteria require a minimum of five samples per month for assessment. The water users provide the only continuous source of data at this required frequency.

Biological Sampling. The current biological monitoring program includes two major aspects: biennial lock chamber studies of fish populations, and sampling of macroinvertebrates through the use of artificial substrates. Both of these are cooperative efforts, with the commission coordinating participation by several state and federal agencies.

Special Studies. Special studies are often undertaken to evaluate emerging problems or to provide additional information on problems identified in the ongoing monitoring programs. Current studies include instream toxic effects screening and special sampling for fecal coliform bacteria.

3.3.3 Tennessee Valley Authority (TVA)

The TVA is a U.S. federal agency and is responsible for building and operating water control projects on the Tennessee River for navigation, hydroelectric generation, and other beneficial uses. The TVA plan and system profile are included in Appendix 4.

The TVA operates a data collection program for the operation of its water projects. The major parameters monitored are:

- Precipitation for each subbasin
- Streamflows
- Reservoir data including headwater and tailwater elevations; turbine, low-level, and spillway discharges
- Water quality - primarily DO and water temperature

The collected data are transmitted to the computer center located in Knoxville, Tennessee. The reservoir operation department is responsible for evaluating the incoming data and establishing project operation schedules. The precipitation data are input into precipitation runoff models. The resulting streamflows are verified by key streamflow measuring stations. The new streamflow data are then used in eight separate subbasin operation models to prepare weekly and daily project operation schedules which maximize the use of available water to meet electrical, water supply, and environmental demands.

Water quality downstream of reservoirs is also monitored. When undesirable DO and/or water temperature levels are detected, special reservoir releases from multilevel outlets are made to improve the downstream water quality.

A special feature exists at the Norris Hydroelectric Project, one project operated by TVA. The Norris power plant houses two 50 MW Francis type turbines with a design head of 165 feet. Whenever the reservoir DO drops below 5 mg/l, an air injection system is activated. The air injection system is comprised of air vents which connect to the hub of the turbine runners. When the air vents are open, the negative pressure under the turbine pulls air into the draft tube. This system can raise the DO above 6 mg/l.

3.3.4 Coachella Valley Water District

The Coachella Valley Water District is responsible for supplying municipal and agriculture water to a large service area located in southern California. Most of the water is delivered via 75 miles of open canal. To help operate this water delivery system, the district has developed an automated data collection and processing system which tracks water levels throughout the canal system. By knowing the water demand at each turnout structure, the operator determines the required water levels needed throughout the canal system to transport the accumulated water demand. Once the water levels are known, control gates are automatically adjusted to control the water at the specified levels. This type of water level control system would be applicable to the water level controls required for the GNB project seepage interception channels and the waterways in the Szigetköz area.

A more detailed description of the Coachella automatic control system is contained in Appendix 4.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Socio-economics	Nation	Utilization of a clean inexhaustible source of energy for the generation of electric power, reducing reliance on international sources of energy.	None.		Beneficial impact.
	Entire area	Improvement of international navigation, enhancing future opportunities for international trade and industrial development.			Beneficial impact.
		Improvement of flood protection, reducing property and structural damage over the life of the project.			Beneficial impact.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Recreation/ tourism	Nyergesújfalu Nagymaros	Elimination of existing boat landing sites, campsites, picnic areas, and bathing places.	Creation of a new riverside park along embankments with a bike and/or pedestrian trail.	Local planners should designate camping and picnicking areas adjacent to the new embankment area. Landscape new area, and provide sandy beach around new lake if possible.	Loss of some recreational opportunities, such as bathing and camping, but creation of a new recreational resource which would be beneficial to the region.
	Nagymaros Budapest	Elimination of existing boat landing and bathing areas.	Creation of new recreation areas to provide 30 ha of water surface in a chain of bays along Danube. Two observation towers. New riverside park along protective embankment.	None.	New riverside park would be a beneficial impact.
		Construction of the new roadway and sewage treatment facilities could result in increased tourism and growth in the Danube bend. This could impact community infrastructure and existing land use.	None.	Local authorities should develop land use plans to control growth and tourism impacts.	None.
Socio-economics	Szigetköz area	Potential for increased agricultural and forestry productivity, resulting in increased employment and income opportunities.	None.		Beneficial impact.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Recreation/ tourism	Szigetköz	Increased water flow and quality in Mosoni Danube and Danube side arms, improvement and enhancement of boating and swimming opportunities.	None.	None.	Beneficial impact.
		Increased recreation opportunities and installation of sewage treatment facility could promote tourism, potentially impacting existing land use and sensitive biological areas.	None.	Local authorities should develop recreation and land use plans to enhance benefits of new tourism opportunities while limiting adverse impacts to existing land use and sensitive biological areas.	None.
		Decrease in water flow of the old Danube channel would impact boating and fishing opportunities.	None.		Recreationists would most likely seek recreation opportunities in side arms of Mosoni-Danube.
		High fluctuation of water levels from Dunaremete to Gönyü, creating unsafe small boating and bathing conditions.	Modification of project operations to maximum fluctuations of 2.5 m tailrace (Danube confluence).	Additional modification to project operations during summer months to maximum fluctuation of 1 cm/min. If modifications to project operations are not made, bathing and small boating should be strictly prohibited.	None.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Visual resources	Gönyü-Komárom	Clearance of forests and riverside vegetation reducing the area's scenic quality.	Cover embankment slopes with grass or lawn, revegetate at foot of embankment.		None.
		Scenic quality improved with new park offering new viewing opportunities.			Beneficial.
	Komárom Nyergesújfalu	Elevated protection embankments vegetation clearance, in areas (not industrial in nature) where views of Danube are provided, would impact visual quality.	Cover embankment slopes with grass or lawn, revegetate at foot of embankment.		None.
	Nyergesújfalu Nagymaros	Clearance of forest and riverbank vegetation and construction of new protective embankments would impact visual quality.	Cover embankment slopes with grass or lawn, revegetate at foot of embankment.		None.
	Nagymaros-Visegrád	Construction of barrage facilities would introduce new structures in a natural and scenic landscape.	Extensive architectural design modifications. Development of an attractive recreation area adjacent to barrage site.	None.	Short-term significant visual impacts until landscaping is established, and visual expectations are modified.
		Introduction of bank protection structures and clearance of forests and vegetation, resulting in a disappearance of natural beaches and impacting the natural scenic quality of the riverbank.	Cover embankment slopes with grass or lawn, revegetate at foot of embankment.		None.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Archaeology	Nyergesújfalu-Nagymaros	Inundation of settlement of Copper and Celtic Ages, and a boat station at Dömös.	Protection of the boat station at Dömös.		Significance of these impacts cannot be determined by Bechtel.
		Changes in ground water level would reduce accessibility to deep-lying archaeological artifacts in the Esztergom Royal Town area.	Seepage system in Kis-Duna with pumping station to maintain mean ground water at 103.5 m/asl.	Implement a localized dewatering program in the future when excavation is desired. Monitor ground water levels to ensure that ground water is maintained at mean. If ground water level increases above mean, increase pumping along the seepage canal or Kis-Duna.	None.
	Nagymaros-Budapest	Inundation of a small fortress in Visegrád.	Excavation and protection of fortress.		None.
Visual resources	Szigetköz	Decrease in water flow in the old Danube channel resulting in the appearance of a dry "empty" riverbed and loss of vegetation.	None.	Implement a revegetation plan.	None.
		Introduction of new protective embankments along natural riverbank, reducing the area's scenic quality.	Cover embankment slopes with grass or lawn, revegetate at foot of embankment.		None.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Archaeology	Gönyü – Nyergesújfalu	Construction impacts to archaeological sites.	Agreement with archaeologists on which sites to preserve by modifying project design (described below).		Potential damage to 11 known sites. Significance of this residual impact cannot be determined by Bechtel.
		Impacts to watermill building of the XVIIth century.	Modification of flood protection.	None.	Benefit.
	Komárom	Water in the presently dry moat of Csillag fortress. Beneficial impact.	None.	None.	Benefit. Enhancement of aesthetic quality of the fortress.
	Nyergesújfalu-Nagymaros	Construction impacts on known archaeological sites.	Agreement with archaeologists of which sites to preserve by modification of project design (described below) and what construction techniques to be used to ensure that sites to be buried are left intact.		29 sites potentially affected by construction activities. Significance of this residual impact cannot be determined by Bechtel.
		Impact to 3 monasteries and the wall of Vizivaros and a Roman stone fortress.	Modification of flood protection.	None.	Benefit. Preservation and public display made possible.
		Inundation of Helemba sziget.	Partial excavation.	Full excavation, removal to museum.	Benefit. Preservation and public display made possible.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Land use agriculture	Szigetköz	Loss in arable land and production. Loss of production of 0.03 t/ha wheat, 0.27 t/ha maize without artificial recharge system.	Artificial recharge system.	None.	Benefit. Increase in arable land of 1,000/ha. Opportunity for increased crop production with more certain water supply. Reduction in risk of crop failure dependent on increased water requirements.
Forestry		Loss of forest in Dunakiliti reservoir and 250-300 m wide area along old Danube River channel.	Compensation has been made.		
		Transportation of forest products, elimination of barrage transportation. Increase in transportation costs. Compensation has been made for new road construction to mitigate transportation costs due to elimination of barrage transportation.	Maintain existing production except for approximately 300 ha - with reduced productivity - plant alternate species more suitable for drier conditions.		
	Downstream of Gönyü to Nagymaros	Loss in arable land and production of 667 ha, 9.94 X 10^6 ft. Change in production of 659 ha.	Compensation has been made.		
Archaeology	Györ	Construction of flood protection would impact a IX-Xth-century settlement.	Modification of design to protect two-thirds of site.		One-third of archaeological settlement lost.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Fish	Nyergesújfalu-Nagymaros	Potential DO deficiency effects cannot be determined without baseline fish servings.		Conduct system-wide DO modeling program to assess potential for effects. Based on results of DO modeling, develop appropriate mitigation as warranted.	Cannot be determined.
		Entrainment and turbine-induced mortalities at Nagymaros power station. Impacts cannot be determined without baseline fish survey.		Based on preoperational survey, develop appropriate fish protection and guidance system if warranted.	Cannot be determined.
		Blocked fish passage during spawning migrations.	Fish lock.	None.	Cannot be determined.
Vegetation	Nagymaros-Budapest	No impacts expected.			
Wildlife	Nagymaros-Budapest	No impacts expected.			
Fish	Nagymaros-Budapest	Potential DO deficiency effects cannot be determined without baseline fish surveys.		Conduct system-wide DO modeling program to assess potential for effects. Based on results of DO modeling, develop appropriate mitigation as warranted.	Cannot be determined.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Vegetation	Gönyü-Nyergesújfalu	Riparian vegetation and fringe forest lost due to flood protection structures and water level changes. Amount of loss cannot be determined without baseline survey of vegetation along river.		Establish revegetation program based upon established techniques to replace revegetation lost due to the project.	Cannot be determined.
Wildlife	Gönyü-Nyergesújfalu	Loss of wildlife and habitat due to construction of dikes and seepage inceptor channels and placement of riprap. No baseline data available to determine extent of impact.		Replace habitat lost through revegetation program.	Cannot be determined.
Fish	Nyergesújfalu-Nagymaros	Potential DO deficiency effects cannot be determined without baseline fish surveys.		Conduct system-wide DO modeling program to assess potential for effects. Based on results of DO modeling, develop appropriate mitigation as warranted.	Cannot be determined.
Vegetation	Nyergesújfalu-Nagymaros	Loss of natural vegetation, fringe forest and other riparian vegetation due to project structures and rise in water level of reservoir.		Establish revegetation program based upon established techniques to replace vegetation lost due to the project.	Cannot be determined.
Wildlife	Nyergesújfalu-Nagymaros	Loss of wildlife and habitat due to construction activities related to flood protection and bank stabilization		Replace habitat lost through revegetation program.	Cannot be determined.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Fish	Szigetköz-Gönyü	Potential DO deficiency effects on fish in reservoir, side arm system, Mosoni, and main channel. Effects cannot be determined without baseline fish surveys and DO/temperature measurements.		Conduct system-wide DO modeling program to assess potential for effects. Based on results of DO modeling, develop appropriate mitigation (e.g. spill flows, mechanical aeration, alternating operational modes) as warranted.	Cannot be determined.
		Loss of access to spawning habitat in side arm system due to diking of outlets and weir at Ásványráró and resultant reduction of populations of some species. Impact cannot be determined without baseline data on fish species' distribution, abundance, and spawning times and locations.		Evaluate ability to operate Gabcikovo power station on basis that maintains adequate flow to main channel, or install a fish passage gate rather than a weir at Ásványráró which can be opened to allow fish movement during spawning periods.	Cannot be determined. Cannot be determined.
		Entrainment and turbine-induced mortalities at Gabcikovo power station. Impact cannot be determined without baseline fish survey.		Based on preproject survey, develop appropriate fish protection and guidance system, if warranted.	Cannot be determined.
		Blocked fish passage during spawning migrations.	Fish lock.	None.	Cannot be determined.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Wildlife	Szigetköz-Gönyü			Less effective mitigation is to monitor vegetation changes during project operations and adjust flows to side channels or main channel.	Cannot be determined.
		Potential loss of other (non-avian) wildlife. Baseline data needed to determine impact.		Determine occurrence of wildlife species in area of Szigetköz that would be affected by project through literature review. Based upon literature review conduct seasonal surveys to determine occurrence and habitat use. Adjust flows to reduce effects to important habitat identified.	
Fish	Szigetköz-Gönyü	In the main channel, fish stranding mortalities after initial project startup and after flood releases.		None.	
		Changes in species composition and abundance due to slow-moving water.		Increase flow rate to main channel seasonally, to simulate preproject patterns.	Cannot be determined.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Wildlife	Szigetköz-Gönyü	Potential loss of breeding and feeding habitat at Ásványráró and other areas in side arms of Danube, particularly habitat of gray herons, night herons, and black storks as well as cormorants, mute swans, and other waterfowl.	Recharge plan for side arm system.		**Cannot be determined.**
				For initial Danube diversions reduce flow in incremental steps to assure stable ground water level in side arm system.	
				Establish a permanent preserve for protection of herons and water birds from all human activities at the area near Ásványráró.	
		Potential loss of habitat of four protected birds: little ringed plover, willow tit, treecreeper, penduline tit. Baseline data needed to determine impacts.	Some utilization of similar aquatic and riparian habitat in adjacent side arm system.	Conduct baseline seasonal surveys to determine distribution, abundance and seasonal habitat use in area of Szigetköz potentially affected by lower ground water table including side arms. Monitor areas where habitat use occurs and adjust flow rates inside channels or main channel to maintain breeding habitat.	**Cannot be determined.**

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Ground water	Szigetköz	Sediment deposition in reservoir potential source of quality impairment of recharge water.		Monitor sediment deposition and water quality. Removal of sedimentation if necessary.	
	Gönyü-Nagymaros	Rise of water table in high areas. Potential seepage into floors of buildings.	Installation of cutoff walls and sump pump to maintain dry conditions.		
Biology vegetation	Szigetköz-Gönyü	Loss of natural forest and riparian vegetation in Dunakiliti reservoir due to clearing.		Reestablish riparian vegetation with revegetation program around Dunakiliti reservoir.	Cannot be determined.
		Lowering of ground water table along 25 km of Danube resulting in vegetation changes in 250-300 m wide zone.		1) Increase flows seasonally to main channel of Danube. 2) Reestablish expanded acreages of remnant native hardwood forests along Mosoni Danube.	Cannot be determined.
Wildlife	Szigetköz-Gönyü	Changes to habitat along 250-300 m wide zone along 25 km of Danube. Baseline data needed to determine extent of impact.		Conduct seasonal surveys to establish waterfowl species habitat usage in order to determine expected changes in habitat resulting from ground water changes and to determine appropriate seasonal flow increases to old Danube River channel.	Cannot be determined.

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Surface water quality	Nagymaros Reservoir			Possible mitigation measures can then be tested to determine the most cost-effective means to maintain the desired water quality, e.g., periodic flushing of flows through both reservoirs, treating pollutant loads at source and/or treating well water.	
Sediments, heavy metals	Nagymaros reservoir	Same as described for the Hrusov-Dunakiliti reservoir. However, additional heavy metal loads have been measured from the left bank tributaries. These tributaries contribute 10% of the inflow into Nagymaros reservoir.		Same as discussed for the Hrusov-Dunakiliti reservoir.	
Ground water	Szigetköz	Water table lowered up to 5 m, potentially impairing vegetation, forestry, wildlife.	Maintain water table by releasing surface flows into side channels, infiltration canals.	Recommend detailed analysis of critical areas to ensure acceptable water levels can be maintained.	
		Shift of recharge from old channel to Dunakiliti, rise of water table, and waterlogging in area adjacent to reservoir.	Seepage interception channel installed parallel to reservoir dike to contol rise of ground water level.	None.	

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Surface water quality		Flow in the Mosoni Danube between Györ and the Danube main channel will be reversed daily due to peak power operations. Raw sewage discharged into the Mosoni Danube at Györ will be restricted from flow into the Danube due to the reversed flow.	Construction of sewage collection and treatment facilities will be completed by 1993 before Nagymaros barrage is operational.	None.	Benefit.
Sediment deposits	Nagymaros	Sediment deposition over riverbed gravels will decrease flow into the riverbank filtration wells.	Construct channel side bank walls upstream of water wells. Constricted channels will accelerate river flow and pass suspended sediments downstream of water wells.	Lower gates at Nagymaros weir and flush sediments. Remove sediments with special dredger.	
Surface water quality	Nagymaros reservoir	The upstream reservoir provides 85% of the inflow into Nagymaros reservoir. Poor quality water might be passed from the upstream reservoir during the summer months. This poor quality water could pass into the riverbed gravels and flow into the riverbank water wells.		The degree of water quality degradation in the upper reservoir should be quantified using the QUAL2E and QUAL2E-UNCAS computer program. Should the upper reservoir water become degradated, the water quality changes occurring in the lower reservoir should also be quantified. Finally, the changes to the well water quality should be quantified.	

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Surface water quality	Old Danube channel, Szigetköz area	Surface water quality will be controlled by the quality of water released from the Hrusov-Dunakiliti reservoir. Releases from the Dunakiliti weir will be aerated when the flow tumbles over the energy dissipation blocks. Flows in the side arm channels will be continuous compared to stagnate waters for the existing conditions.			
Surface water	Nagymaros reservoir	Surface runoff will be blocked from draining into the Danube by new and improved river levees along the right bank. Also, the normal reservoir water levee will be above right bank ground surfaces in some areas. Both cases will impact landside surface drainage by causing some areas to be temporarily inundated.	Seepage/drainage interception channels will be constructed parallel to the levees. Pumping stations will be located at the downstream end of each interception channel to lift the intercepted flows into the Danube. The pumping stations will maintain channel water levels below the adjacent ground surface levels.	None.	
Surface water	Nagymaros reservoir	Peak power generation at the Gabcikovo power plant, according to original project agreement (KET) will raise upstream reservoir water surface by 2.5 m^3/min and 3 m/24 hours.	VIZITERV has prepared alternative operation plan which would decrease the upstream water surface rise to 0.75 m^3/min and 2 m/24 hours.	Consider alternate mixes.	

Table 2-2 (Cont'd)

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Surface water quality	Hrusov-Dunakiliti reservoir	Surface water quality could improve due to clarification with sediment deposition and longer detention time for biological breakdown of organics providing sufficient DO is present. During summer months, water quality may be significantly reduced due to temperatures, nutrient loads and longer detention times. Increases in algal blooms may occur.	Lower gates at Dunakiliti weir and flush water downstream, temporarily reducing reservoir detention time.	No quantitative evaluation has been made to determine if water quality degradation will occur. Water under project conditions should be modeled using available computer programs to quantitatively determine changes to water quality indices. Such evaluations should establish what combination of parameters river flood, organic load, DO, etc. would yield reduced water quality. When critical conditions are identified, proposed mitigations can be modeled to determine the most cost-effective mitigation measures.	
Sediments, heavy metals	Hrusov-Dunakiliti reservoir	Heavy metals may combine with fine sediments. These sediments will be deposited in the reservoir. When the DO content above the deposited sediments is depleted, the heavy metals in solution could be passed into the ground water and thereby reduce its quality for drinking water standards.		The amount of ground water contamination due to inflow of heavy metal from the deposited sediments have not been quantified. If the resulting ground water quality proves to be undesirable, alternative mitigation measures should be evaluated, i.e., dredging, reduce heavy metal inflow by treatment at industrial plants, and sediment flushing.	

Table 2-2

SUMMARY OF IMPACTS AND MITIGATION MEASURES

Issue Area	Project Area	Impact Summary	Proposed GNB Project Mitigations	Additional & Recommended Mitigations	Residual Impact
Surface water	Hrusov-Dunakiliti reservoir	Impound water at a normal level above the adjacent right bank ground surface. Seepage from the reservoir dike will raise landside ground water level and inundate local depressions.	Seepage/drainage interception channel will be constructed parallel to the reservoir dike. The seepage will be intercepted and routed to the side arm channels. The water level in the interception channel will be kept below the adjacent ground surface level at existing ground water level.	None.	None.
Reservoir sediment deposition		Sediment deposition will be largest at upstream end of reservoir where flow velocities are daily reduced to 0.1 m/s. This deposition may block passage of navigation.	Assuming an even distribution of sediment deposits, the dead storage portion of the reservoir will be filled in about 60 years. Dredging or sediment flushing by lowering the gates at Dunakiliti may be required after 60 years.	Remove excessive sediment deposition in navigation channel areas by dredging.	
Surface water	Old Danube channel Szigetköz	Inflows, up to 4,000 m^3/s, will be diverted from 30 km of the old Danube channel.	Continuously release 100 m^3/s to the old Danube channel, 50 m^3/s to the left and right bank side arm channels, and 20 m^3/s to the Mosoni Danube. Increase these minimum releases as necessary to meet area environmental requirements.	None.	
		Peak flood discharges in the old Danube channel will be reduced by 4,000 m^3/s.	Increase land development opportunity in newly protected area on land side of the flood levels.		Benefit.

2.8 SUMMARY OF POTENTIAL IMPACTS AND MITIGATION MEASURES

Table 2-2 summarizes the potential project related impacts and mitigation measures proposed by the project and additional measures recommended by Bechtel.

- o Compensation for loss of lands, income, buildings, etc.
- o Monitoring program costs (labor, computer, etc.)

Benefits associated with the project (over the life of the project) should also be quantified. Benefits include:

- o Employment and income
  - Number of construction and operations employees and estimated income
  - Number of hectares of new farm land resulting from the project and resulting income
  - Increased productivity on farm and forestry lands resulting from water supply
  - Estimate of annual increase in tonnage (and revenue) associated with improved navigation
  - Estimated income tax revenue generated for the government
  - Estimated local spending by construction workers
- o Flood protection
  - Cost of maintaining and repairing existing flood protection system
  - Loss of crops and livestock revenues resulting from floods without the project
  - Loss of human life without the project
  - Cost to repair structural damage caused by floods (infrastructure, buildings, homes, etc.)
- o Generation of electricity
  - Number of residences and businesses which will use the electricity
- o Sewage treatment
  - Capacity in terms of number of people to be served

Hungary. Unfortunately, neither local nor national savings have been quantified. Hence, the true value of this benefit will require further research. The supplementary water recharge system of the Szigetköz area will also have a beneficial effect on agriculture and forestry. Irrigation water will become readily available for agricultural production at any time, while the drainage of excess water will be quicker than is currently possible. As a result, the northern part of the Szigetköz, where waterlogging damage occurs frequently, should no longer experience this effect (Szöny-Komárom area, Feketeerdö at Almaspuszta, and in the vicinity of Szentlélek and Kenyérmezo Creeks). Consequently, there is potential for these lands to be reclassified as agricultural (e.g., from grass to arable land, or even meadow or ploughland instead of forest). On the section downstream from Gönyü, the possibility of extracting surface water for irrigation will improve as a consequence of controlled water management.

Recommendations. The true cost and benefits of the project have not been quantified and therefore cannot be determined. If possible, a project cost/benefit analysis should be conducted. The quantification of public benefits could help increase public support for the project.

The cost/benefit analysis should quantify all costs associated with the project over its estimated life. These costs include:

- Construction costs
  - Purchased or leased material and equipment
  - Labor cost broken down by Hungarian labor and other labor
- Operational costs
  - Repairing and maintaining the system
  - Labor costs
  - Energy costs (if any) to operate
  - General operational costs
- Mitigation costs
  - Costs of mitigation measures (biology, fisheries stocking, archaeology, etc.)

Although the project would double cargo transport it would not be expected to double the Hungarian share of cargo shipments (which is less than 10 percent). Hungarian industrial growth (and resulting cargo) is dependent on national growth and national policies. The rate of industrial growth is not related to navigational shipping opportunities. However, improvement of this relatively inexpensive means of transportation, coupled with national industrial growth, could eventually lead to an increased percentage of Hungarian cargo ships and fleets on the Danube. This could be very valuable as international markets open up to Hungary.

Water Management. Another primary objective of the project is water management. Water management includes flood protection, river training, riverbank regulation, and water supply.

Flood levees have been constructed along the Danube and its tributaries requiring substantial investment and high maintenance expenditures. Although the dikes were constructed to offer a relatively high level of safety, they cannot provide full protection against the floods that endanger large areas along both sides of the river. Alluvial deposits of greatly varying geological character form the layers underlying the flood levees. During floods or long-lasting high water levels, finer particles may be leached out of the levees, a situation that might cause dike ruptures. In 1954, there were three dike failures on the Hungarian side, while in 1965, the dikes of the Czechoslovak side failed at two locations. With the construction of the river barrages, the total discharge capacity of the old Danube channel in the Szigetköz and the new diversion canal will provide protection against the 10,000-year flood in the region upstream of Palkovicovo/Szap. Along the downstream reaches, levees would provide protection against the 1,000-year flood. Over the life of the project, this should result in significant protection to Danube River landowners and residents, who could experience agricultural and silvicultural loss, structural damage to buildings, and even loss of life during large floods.

The cost of maintaining and repairing flood protection dikes over the life of the project should also be reduced, ultimately resulting in savings to

The GNB project provides an inexhaustible, clean source of energy, does not require imported goods, and relies on a new and as yet unused resource. Although the power to be generated by the river barrage system will provide only a small portion of the nation's total power production, it could play a significant role due to the peak-energy generation possibilities of the daily hydraulic storage scheme.

International Navigation. Maintaining and developing the Danube River as an international waterway are the tasks of the riparian countries, as formulated by the proposals of the Danube Commission. One of the main objectives of the GNB project is improved navigation. The Bratislava/Pozsony-Nagymaros river reach is the narrowest part of the Danube, in terms of navigational requirements, and is a significant obstacle to the development of international shipping transportation. This reach is impeded by 20-25 shallow crossings to such an extent that the average annual navigation time is restricted to 250 days. Navigation obstacles have been gradually eliminated in both the upper and lower Danube reaches. Consequently, the reach between Bratislava and Budapest has now become a bottleneck to international navigation.

Understandably, the implementation of the river barrage project is of international importance. Anticipated improvements resulting from construction of the river barrage system are as follows:

- Navigation time would be increased to 330 days annually
- Nighttime navigation would become permanent
- The efficient use of freighter fleet cargo capacity would be increased by at least 20 percent
- The probability navigation accidents would decrease

These benefits would be shared by the Danube countries, as well as other countries involved in navigation along the waterway. It is anticipated that project construction will double the tonnage of cargo shipped on the Danube in 10 years.

provide new sewage capacity and eliminate the need to restrict construction in the floodplains. Increased sewage capacity, coupled with improved roadway access, will foster regional growth. This growth could be beneficial to local economies, but adverse impacts could occur if not properly planned. If local authorities control the amount and rate of growth, adverse impacts to local infrastructure and public services will not occur. In addition, vacation homes are already infringing upon the nature preservation area in the hills surrounding Nagymaros. This should be strictly controlled by local authorities.

Nagymaros-Budapest. Socioeconomic conditions for the settlements potentially affected by the project are described in the previous discussion for the Nyergesújfalu-Nagymaros reach.

2.7.3 Impact Discussion - Regional, National, and International Conditions

Generation of Electric Power. The need for electrical energy is increasing in both Hungary and Czechoslovakia due to rapid economic development. Historically, electrical power demands were met primarily by using oil or relatively poor quality brown coals in power plants. In recent decades, there has been increased public pressure to shift the emphasis away from brown coals, which have a high sulphur and ash content, to cleaner sources of energy. Under international agreements, Hungary must comply with a commitment to reduce SO_2 and NO_x emissions by 30 percent. These environmental measures represent significant additional costs for power plant production. The project's total annual power output of 3,775 GWh would be equivalent to the combustion of 3.8 million tons of brown coal or 1 million tons of oil.

The possibilities of exploiting fossil fuels are limited and, realistically, imported electrical energy can be increased only to a limited extent. Rising fuel prices in the world market put the Hungarian power industry at a disadvantage and jeopardize the country's foreign currency holdings. Consequently, developing inexhaustible Hungarian sources of energy is one of the primary economic interests of the nation.

The Szigetköz side arms will be diked, eliminating access from the Danube. Fish populations which currently migrate to the area to spawn will no longer be able to do so. A decrease in these populations is anticipated. Stocked fish which do not rely on the Szigetköz side arms for reproduction are not expected to decrease or increase due to project implementation. The success of fishing hauls will become more dependent on restocking efforts.

The project is not expected to significantly increase other employment and income opportunities along this stretch. Tourists could increase due to the development of the new riverside linear park. However, because other popular tourist areas (such as Esztergom) are also nearby, tourism is not expected to increase significantly unless local planners establish additional recreational facilities - such as camp and picnic sites adjacent to the proposed park.

Nyergesújfalu-Nagymaros. Land use between Nyergesújfalu and Nagymaros is varied and includes agricultural, recreational, residential, and some industrial uses. Industrial plants of medium size are found only in Esztergom, and smaller plants can be found in Szob and Nagymaros. It is not anticipated that the project will produce significant increases in employment and income from increased agricultural and industrial productivity along this reach. Project effects on fishing productivity are similar to those discussed previously under Gönyü-Nyergesújfalu.

Regional growth is anticipated for this portion of the project area due to project implementation. The project will significantly improve sewage treatment and collection, flood control, and roadways. In conjunction with construction of the river barrage project, new roadways will be built between Nagymaros and Szob on the left bank and between Visegrád and Dömös on the right bank. The new bridge across the barrage structure will become an important interconnecting roadway between left and right banks. These road improvements will increase accessibility to settlements in the Danube bend area.

Development in the Danube bend area is currently limited by the lack of adequate sewage treatment and floodplain restrictions. The project will grounds exist within this reach of the Danube due to bottom disturbance from commercial dredging. However, this reach of the river does have a variety of fish species and a relatively abundant fish stock. This is due to the fact that during spawning season, large populations of fish migrate into the Szigetköz side arms and successfully spawn. In addition, this portion of the river is stocked with carp, northern pike, pike perch, silure, and aspius.

Fishing data collected for this reach indicate that the fishing yield has been declining for commercial species, such as carp, northern pike, and aspius. Up to the early 1970s the share of carp in the total catch was around 5 percent but had dropped to around 3 percent by the early 1980s. The catches of northern pike have remained relatively constant over the past 11 years. The steady population downstream of Komárom is attributable to continuous restocking. Pike perch are sensitive to oxygen levels in the river, and the young require sufficient amounts of planktonic crustaceans. Of the young introduced, less than 10 percent are likely to survive, regardless of continuous restocking efforts.

The silure population declined in the late 1960s, but have begun to recover in recent years. Being responsive to water pollution, the growing population may imply improving water quality in the Danube. For example sturgeon, which require very clean water, were rare in the late 1960s but have been increasing in the 1980s. The Aspius is less responsive to water quality changes, because its proliferation rate depends primarily on the food chain (the presence of Albuinus sp.). Large numbers were caught in the early 70s, but less in the mid-80s.

Barbel (Barbus barbus) is typical in the main stream of the Danube. Barbel feed on organisms living in the vicinity of the bottom and, therefore, are sensitive to increases or decreases in bottom pollution.

White amur and grazing carp utilize the Danube lateral arms and oxbows. The ecological conditions prevailing along this reach of the Danube have been favorable to these grazing fish and the stocked young develop to commercial size within brief periods of time.

As discussed in previous sections (Section 2.3 - Land Use and Section 2.6 - Recreation and Tourism), community growth can be both beneficial and adverse to local settlements and their existing community services and infrastructure. If well planned and implemented appropriately, growth can increase the affected settlements' employment opportunities and income levels. If not well planned, rapid growth can exceed the capacity of existing infrastructure and services.

In addition, growth in the Szigetköz area could adversely affect the existing land use patterns of agriculture and silviculture if vacation homes or new infrastructure begins to infringe upon, or replace, these land use areas. This area is also biologically sensitive and planners must be extremely careful to regulate recreation use in critical habitat areas (see Section 2.2 - Biology).

Overall, growth in this area will benefit the local population if it is planned for and strictly regulated. If the area begins to experience strain on existing infrastructure, planners could enforce temporary growth controls (limited building permits) until infrastructure has been improved to meet the new demands. Anticipated future infrastructure improvements can also be partially financed through additional fees incorporated into building permits.

Gönyü-Nyergesújfalu. Between Komárom and Nyergesújfalu there are numerous industrial plants located along the Danube. These industries dominate the region, as they provide employment and are an integral part of the industrial structure of the country. Most of these industries use road and rail transport while some also use water transport. As is the case with Györ and Mosonmagyarovar, industrial growth is dependent on the national economy and national policies. However, enhancing navigation along the Danube River will allow existing industry to increase its annual cargo shipments and will make future industrial growth advantageous.

It is anticipated that fishing productivity along this reach will be affected by the project. The waters downstream of Gönyü do not provide the necessary natural conditions for fish proliferation. Virtually no natural spawning system. Natural reproduction for some species will be completely eliminated, while stocked species, able to adapt to the new environment, will do well.

Consequently, the fishing hauls of some species are anticipated to decrease. The fishing hauls for other species will increase with increased stocking efforts. In 1986, restocking included 8,000 specimens each of pike and pike perch, 35,171 kg of carp, and 200 kg of other species. Future stocking efforts should be focused on specific species able to survive and reproduce under the new environmental conditions.

In this portion of the project area, industrial development is only located in Györ and Mosonmagyarovar. It is estimated that approximately 45,000 persons are employed in Györ in industrial jobs. A benefit to industrial development in Györ, and even Mosonmagyarovar, will be the improved navigation along the Mosoni Danube and Danube River. However, industrial development is primarily dependent on the national economy and national policies, and will therefore not be expected to surge immediately following project construction. Consequently, industrial employment is not expected to increase in the short term due to project construction, but improved navigation, a relatively inexpensive means of transport, will be advantageous to industrial growth in the long term.

The artificial water recharge system of the Szigetköz will not only have a beneficial effect on agriculture and forestry, it will also improve the existing recreational opportunities in the area. Both the quantity and quality of the water in the Mosoni Duna and the side arms will increase. There will be year-round flows in the area providing boating, fishing, and bathing opportunities. As recreation improves, visitors to this area would increase as will the demand for vacation homes. Additionally, the project will provide a new sewage treatment facility which will be advantageous to new growth in the area. These two factors are likely to contribute to an increased rate of growth in both permanent residencts and seasonal tourists (with and without vacation homes).

2.7 SOCIOECONOMICS

Construction and operation of the project could affect the study area's social and economic conditions. For purposes of this evaluation, the following social and economic conditions were qualitatively evaluated by reach: employment, income, growth, and development.

Regional, national, and international social and economic conditions could also be affected by the project. These have been discussed under the following headings:

- Generation of Electric Power
- International Navigation
- Flood Protection

2.7.1 Significance Criteria

Social and economic impacts are considered adverse if they bring about the following changes:

- Annual decrease in employment or income
- Increased demand for community services and infrastructure which exceed operating capacities
- Rapid increase in population
- Increased traffic on currently congested roadways, or on roadways operating at or near capacity

Social and economic impacts are considered beneficial if they bring about the following changes:

- Improvement in community services and infrastructure (water, wastewater treatment, electricity, schools, medical services, grocery stores, etc.) allowing communities to meet the existing and future demands
- Improvement to existing navigational capacity
- Annual increase in employment and income
- Improvements in flood protection reducing structural, agricultural, and silvicultural damage

- o National decrease in the international dependency on energy supplies and sources

2.7.2 Impact Discussion - Employment, Income, Growth, and Development

The following socioeconomic evaluation does not quantify impacts on social and economic conditions. Consequently, the significance of adverse or beneficial impacts is not indicated.

Szigetköz-Gönyü. In the Szigetköz area, between the main Danube and the Mosoni Danube arm, down to the villages of Vének and Gönyü, agriculture and silviculture represent approximately 84 percent of the land use. In this area, the majority of the population works in agriculture and silviculture. It is anticipated that the project will result in an increase in agricultural and forestry productivity due to three factors: agricultural and forestry losses due to floods will be reduced; controlled ground water levels will reduce the amount of hectares subject to waterlogging; and a controlled water source for irrigation will reduce risks to agricultural production dependent on water availability.

This will benefit the employment and income levels of the local population.

The diverse and extensive side arm system, and the permanent inundation in many locations, provide favorable spawning grounds for mature fish populations and suitable habitats for offspring. There are 55 different species of fish living in this area. The most commercially important include the following: carp, pike, pike perch, stone perch, catfish, barbel, sterlet, amur, and eel.

Hauling data for the last 19 years indicate a decrease of 11 percent between 1968-1986. The hauled stock is also getting younger, which is a possible indication that natural reproduction is becoming imparied in the Szigetköz area. The annual average of 5 years of fishing production of 200 tons, valued at 11 million florints.

The project will eliminate the natural water flow from the main branch through the Szigetköz area back to the main channel. The area will become a closed

Nagymaros barrage and one downstream. This new recreation area would provide 30 ha of water surface which could potentially provide bathing opportunities (if the water quality of the interconnecting Danube improves), small boating, and possibly fishing opportunities (if stocked fish can survive in this manmade environment).

Most importantly, the area would be nicely landscaped and visually pleasing. In addition, observation towers along both sides of the river have been constructed. This would be a new tourist attraction offering scientific information and sightseeing opportunities.

Construction of the new roadway over the river barrage would enable a larger number of tourists to visit the Nagymaros-Visegrád areas. In addition, the new sewage collection network could promote the growth of vacation homes. This increase in recreation and tourism could adversely impact the local settlements if not properly planned and controlled. Vacation homes are already intruding upon the nature preservation area in the hills surrounding Nagymaros. This should be strictly controlled by the local authorities.

To promote the desired appearance of a Nagymaros-Visegrád recreational town, an architectural review committee could be created to oversee the permitting of new structures to ensure that they are visually compatible with the existing and desired town structures. Any construction of small structures currently not subject to the permit process should be regulated in the future.

In summary, it is anticipated that construction and operation of the project will eliminate ± 10 km of riverside recreation area. This will reduce the present and future opportunities for bathing, boating, and camping. Some of this impact will be offset by the 180 ha water area adjacent to the Kis-Duna and the new lake and recreation area at Pilismarót. Additionally, due to water pollution and border protection, bathing and boating is rather limited along this reach. Consequently, impacts to the existing recreational opportunities are not considered to be significant.

The proposed riverside recreation park will also provide new recreational opportunities for biking, hiking, sightseeing, and picnicking. This will be a beneficial impact.

Tourism in this area could be expected to increase primarily due to the new sewage treatment facility and the new roadway over the dam. Construction of vacation homes in this area is somewhat restricted because of inadequate sewage treatment. With improved sewage treatment and the new roadway, this area could experience new growth. Growth could be beneficial to local economies, but adverse if not properly planned. It could place heavy demands on other infrastructures (roads, water supply, etc.) and public services (schools, hospitals, police, grocery stores, etc.). If local authorities control the amount and speed of growth, and appropriate infrastructure and public services are enhanced, these impacts will not occur.

Nagymaros-Visegrád. The discussion of the types of recreational impacts for the previous reach of the Danube Bend apply to this reach of the study area and therefore are not repeated in this subsection.

Impacts to the natural beauty of the narrow gorge of the Danube are described in the visual resources section of this report. The following describes the mitigation measures proposed to reduce the recreation impacts along this reach.

The Visegrád-Dömös bay, where the Danube River has currently been diverted for construction of the Nagymaros barrage facilities, will be filled up and a chain of bays at the riverside will be created. Three of them upstream of the

Island will eliminate ports and camping sites at the main Danube branch site. The existing pleasure craft landing in the Kis-Duna branch will be moved to the main Danube branch since access by ship or pleasure craft to the Kis-Duna branch will be restricted. Project plans include building ports for boats and sports boats at the Primas Island flood levee; a landing place for boats at Csenke Creek; and a planned 10-ha bay downstream of the existing ship port to accommodate tourist pleasure craft. These plans provide mitigation measures for existing ports and boat landings that will be eliminated by project construction and operation (estimated at five in total).

As with the Gönyü to Nyergesújfalu reach, pleasure boating along most of this reach (up to Zebegény) is limited by permit. The number of pleasure boats using the river in this stretch is not known.

An open water surface of 180 ha, used as a borrow area during construction, will be used as a water sports center following project construction. To further enhance the recreational opportunities, a sandy bathing beach could be created and the area around the water surface could be landscaped.

By protecting the islands and controlling the water levels in the Kis-Duna, pleasure boating and other recreational opportunities in this area will not be impacted.

The Pilismarót area is a recreation area. Waterfront bathing, camping, and picnicking opportunities exist and approximately 500 vacation homes have been constructed. This area was in danger of being inundated by the original project design. It is now proposed that a protection dike be constructed to protect the vacation homes (19 will be lost); a small lake of 40 ha created; and a bay established. To enhance the recreational value of this area, the lake should be flushed frequently so it can be used for bathing and water sports, and a sandy beach or lawn area provided. A bike/walking trail on the top of the dike around the bay could provide additional recreation. The area immediately around the bay should be landscaped and camping sites and picnic areas could also be provided.

As previously stated, tourism along this reach of the Danube is relatively low, and recreational opportunities are few. As part of the project, a new linear riverside recreation park will be developed from Nagymaros up to Györ. By using the dikes and protective embankments, a paved biking/hiking trail will be created along the river. This will introduce new recreational opportunities (biking, hiking, sightseeing, etc.) to the region. The trail will also interlink the numerous settlements along the river and help disperse tourism away from heavily concentrated recreation centers in the Danube bend area. This could benefit tourism along this reach of the Danube.

Nyergesújfalu-Nagymaros. The Danube bend (which extends to Visegrád) is one of the most significant recreational resorts of Hungary. It accommodates about 10 percent of the total national tourism demand and ranks fourth (after Budapest, Lake Balaton and Matra-Bükk) among the recreational regions. The tourist attractions include the Danube, with its water sports and riverside recreational facilities; the forested Pilis and Börzsöny mountains; the natural beauty of the narrow gorge of the Danube at Visegrád; the thermal water resources; and the historic settlements rich in cultural values.

Landing and camping sites for water tourism are available in the region and during recent years, pleasure craft tourism and pleasure craft landing ports have started to develop (e.g., Esztergom-Primas Island and Nagymaros motorboat club). Less than one-fourth of the 40-km-long shoreline is suitable for riverside recreation and water sports. Public bathing areas (with a total capacity of 10,000) may be found at all of the settlements and their receiving capacity is well below the regional demand.

Construction and operation of the project will significantly change the recreational resources at the riverside. Protective dikes and embankments will be built along the riverbank and on the islands, and certain areas will be filled, eliminating the existing boat landing sites, campsites, picnic areas, and 10 km of bathing area.

The existing bank protection will be reinforced and land cuts and fills made in Esztergom along the low banks. The flood levee to be constructed at Primas page 75/a

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where raw sewage is currently discharged, potentially decreasing water quality. The poor water quality problem will be mitigated by installing a wastewater treatment facility and with the increased flow in the Mosoni Danube.

Both Vének, located at the confluence of the Mosoni Danube, and Nagybajcs, on the bank of the Danube, are popular riverside recreation resorts with beaches. These beaches will be replaced with slope-stabilizing riprap and water sports will be eliminated due to high fluctuations during the peak operating mode.

To mitigate the adverse impacts created by fluctuations during the peak operating mode, the project could be operated so that the rate of change in the water level would be less than 1 cm/min. This would substantially reduce the safety concerns for bathing and pleasure boating, and would reduce the level of erosion along this reach - possibly eliminating the need to preserve the beaches with riprap.

Gönyü-Nyergesújfalu. This reach of the Danube has fewer recreational opportunities and lower visitor use. Komárom, Koppanymonostor, and Almásneszmély offer the best tourist attractions along this portion of the river. Opportunities provided include riverside recreation, thermal baths, and cultural tourism. A few of the smaller settlements have bathing opportunities at the riverside. No construction impacts are anticipated along this reach.

Bathing opportunities will be eliminated because of restricted access due to riprap and protective dikes, and high surface water fluctuations during peak operating modes. However, riverside bathing is currently limited along this reach due to pollution. Consequently, the project impact is considered to be insignificant.

Small pleasure boating along this reach will also be a safety concern. However, due to border protection, pleasure boating opportunities along this reach of the Danube are limited and controlled by permits. The number of annual pleasure boaters along this reach is not known and, consequently, the impact of reduced pleasure boating in this area cannot be determined.

with sensitive biological resources. Construction of new vacation homes should be limited by local authorities to areas around existing settlements, outside of agricultural and sensitive biological areas. Local control of tourism by directing and diverting recreational activities to certain locations, and by restricting vacation home development should ensure that increased recreational opportunities and tourism do not adversely impact this sensitive area. If properly controlled, increased recreation-tourism will be beneficial to both the general public and to local economies, while remaining compatible with the natural values of the Szigetköz area.

Operation of the project will adversely affect pleasure boating opportunities in the Danube channel from the Dunakiliti weir to the confluence with the tailrace. The reservoir will impair river boat traffic (small pleasure boats) from upper to lower stretches of the Danube. Recreational boating may be further restricted from Dunaremete downstream to Gönyü due to high surface water fluctuations which could be as great as 5 m daily (over a 5-hour period). The high fluctuation will create safety hazards for small pleasure boats. Consequently, due to safety considerations, continuous river traffic for small- and medium-size pleasure boats may need to be restricted. Alternately, modification of the power station peaking operations could be considered.

It is anticipated that the fishing resource along the Danube channel (below Hrusov-Dunakiliti reservoir) will be significantly reduced, adversely impacting fishing opportunities in this stretch of the Danube. Bathing opportunities along this stretch will also decrease, especially below Dunaremete, due to high water fluctuations. The reduction in recreational fishing and bathing opportunities could be mitigated with increased recreational fishing and bathing opportunities in the side arms due to continuous fresh water inflow from the reservoir.

Fluctuations in Danube surface water during the peak operating mode will also cause fluctuations up to Györ on the Mosoni Danube. High fluctuations along this stretch could decrease the natural flushing of the Mosoni in this reach, arms, decreased flows in the old Danube channel, and fluctuations in the surface water level in the Danube. The impacts associated with project operation, which will be both adverse and beneficial, are summarized below.

Although the reservoir at Dunakiliti would have a large surface area, pleasure boating in the reservoir will be restricted due to reasons of border protection (though this may change in future). The steep slope of the reservoir bank and area's generally windy condition will not be attractive for bathing. No project-related recreational facilities are planned for this area. Previous recreational activities along the Danube in the vicinity of the reservoir were not characterized. The significance of the impacts on recreational resources in the area of the reservoir cannot be determined. However, without boating and bathing opportunities, it is not anticipated that the reservoir will produce beneficial impacts.

It is anticipated that the planned release of controlled flows into the side arms and the Mosoni Danube on a year-round basis will improve water quality and enhance the recreational opportunities in the Szigetköz inland from the old Danube channel. In addition, water quality should improve in the Mosoni due to installation of the proposed sewage treatment facility at Dunakiliti. Hence, bathing and boating opportunities are expected to improve. Sport fishing in this area could also improve if proposed fish stocking is successful.

Tourism in the Szigetköz can be expected to increase due to two factors - improved recreational opportunities, and installation of a new sewage treatment facility which will increase the number of vacation homes. Due to the fragile biological conditions in this area, specific protective measures are necessary to preserve its natural state. A recreation plan for the area should be developed by local authorities. Specific recreation areas and facilities could be developed outside the biologically sensitive areas to help reduce the impact of increased tourism. Recreation areas should be set aside for public use and could provide such facilities as parking lots, picnic benches, restrooms, and trash containers. Recreation sites should be identified after consultation with biologists to reduce potential conflicts

Significant recreational impacts are determined according to the nature of the impact, the magnitude of change, and the duration of change. Temporary impacts lasting less than 2 years or two visitor seasons, are generally considered insignificant.

Beneficial impacts on recreational resources include the following:

- o Creating new recreation areas, facilities or opportunities, such as parks, campgrounds, water impoundments, boat camps, ports, hiking trails, etc.
- o Improving the quality of the recreational resource, such as better water quality, improved landscaping, and upgraded recreational facilities

Any reduction in tourist expenditures due to the project could result in a reduction of income and employment. Impacts on tourism are directly related to project effects on visual resources, recreation, community infrastructure, cultural resources, and transportation. Significant adverse impacts on one or more of these resources, all of which contribute to the quality of a region traditionally known for tourism, could create significant decreases in tourist-related revenues. Conversely, improvement or enhancement of these resources could beneficially affect tourism.

2.6.2 Discussion of Impacts

Szigetköz-Gönyü. The natural beauty of the smooth backwater and floodplain forest coupled with the numerous waterways (Danube River, the side arms and backwaters, and the Mosoni Danube) provide an outstanding recreation experience in the Szigetköz. Because the area is quiet and uncrowded, riverside recreation is popular. During construction of the project, the drainage and artificial recharge system and dikes will be constructed in this area. Construction activities should be of a short duration lasting less than 2 years and should not impact the recreation resources of the Szigetköz.

Project operation impacts on recreational resources in this segment of the project area would be related to the creation of the Hrusov-Dunakiliti reservoir, increased and controlled flows to the Mosoni Danube and the side

2.6 RECREATION AND TOURISM

Recreational resources are defined as geographical areas which provide enjoyment and relaxation to the public (local, regional, national, or international). Recreational resources include developed and formally designated recreation areas (such as parks, campgrounds, boating facilities, national monuments, etc.) as well as undeveloped areas where public opportunities for solitude or unconfined recreation exist, such as the Szigetköz area.

Fishing resources within the project area provide recreational opportunities for sports fishing, but also represent an important commercial resource. For this reason, potential effects on the area's fishing resource is discussed in Section 2.7 - Socioeconomics.

Tourism plays an important role in the local economics along the Danube River. Tourism refers to the stock of lodging facilities, measured in terms of number of rooms, lodging room revenues, and expenditures made by visitors for lodging and overnight expenses.

2.6.1 Description of Significance Criteria

Impacts on recreational resources are considered significant if they threaten the physical viability of a resource or its recreational quality, or if they prohibit access to a resource. Impacts are considered significant if they meet the following criteria:

- Permanently alterating a recreational resource, e.g., using recreation lands or waters; destroying a recreational area's unique vegetation, habitat, or outstanding landscape characteristics; or eliminating the possibility for specific recreational activities
- Reducing the quality of the recreational experience, such as reduced visual quality due to landscape modification, reduced water quality, reduced sport fishering, etc.
- Restricting access to recreation areas and to riverside areas used for recreation

Along the Visegrád-Dömös bank, where the Danube River has currently been diverted due to construction of the Nagymaros barrage facility, the area would be elevated and filled and a chain of bays would be created. Three of the bays would be upstream of the Nagymaros barrage and one downstream. The surface waters would provide over 30 ha of water surface with a natural shoreline of roughly 5,000 m. This new recreation area would be landscaped with ornamental trees. It would substantially reduce the overall impact associated with the new barrage, especially if it is well landscaped with large attractive trees and green lawns. Creating a visually attractive area adjacent to the barrage would help break up the view of the barrage structure and also help direct the viewer's eye away from the structure.

The new barrage and its auxiliary structures would significantly change the visual appearance of this scenic landscape. The impact would, however, be substantially reduced by the architectural design of the structures and creation of the new recreation area. The short-term visual impacts would be considered significant. In the long term, after landscaping has been completed and the viewer's expectations of what the scenery should look like have changed, the barrage facility would not represent a significant visual impact. In fact, to some it will become a point of interest.

The project would also introduce new linear structures, such as bank protection structures and roads. New road construction includes service roads built on bank protection structures, old roads diverted to new locations, and elevating old roads. It is not anticipated that the impact from construction of these roads would be as significant as construction of the bank protection structures.

Due to the permanent high water level upstream of the barrage, and the necessary bank protection structures, shingle beaches and sandy riverbanks would disappear and forest and riverbank vegetation would be cleared. Visually this would significantly reduce the riverbank's scenic quality. To mitigate this impact all areas disturbed will be immediately revegetated.

and foothills of the Pilis mountains are situated somewhat at a distance from the river while the foothills and ridges of the Gerecse mountains reach almost all the way to the riverbank.

The landscape is further shaped by a number of different land uses including national parks, environmental protection areas, holiday resorts, small settlements, vacation homes, and industrial and mining activities. Visibility along this reach is good. Views are provided from the hillsides, rail- and roadways, and six lookouts. The potential population exposed to project visual changes include a number of tourists, weekend recreationists, and residents.

Expected changes in landscape character, riverbank formation, and scenic views caused by construction and operation of the Nagymaros River barrage system will alter the area's existing appearance. The barrage structure would represent a new large structure in the predominantly natural viewshed. On the Nagymaros bank there are existing industrial facilities and introducing an additional structure would therefore not be as severe. This would not be true for the nonindustrial Visegrád-Dömös. The view of the river from both banks would no longer be open and unobstructed. The immediate landscape would be dominated by the barrage structure.

The aesthetic aspects were a major consideration in the design of the front view of the Nagymaros barrage structures to be built in the bed of the Danube River and along the riverbank. The barrage would have a new road across the top. The roadway approach to the barrage would be curved so as not to create the visual image of a long straight line across the horizon. The new roadway would be built on elevated/filled land, which would also help the road and the barrage blend into the surrounding hilly terrain.

The riverbank structures would be partly hidden underground (panel-beam storage and utility transmission lines) or designed to fit into the landscape by up-to-date architectural means (service buildings, residential buildings, heating plant, boat lift). The control tower has also been constructed as an observation tower, open to the public.

embankments. These visual impacts would be reduced to insignificance when the slopes of the embankments are covered by grass or lawn, natural vegetation reintroduced at the foot, and the new riverbank recreation park is created.

Nyergesújfalu-Nagymaros. This reach of the Danube is characterized by a relatively narrow strip of riverbank. This landscape is dominated not only by the Danube, but also by the foothills of the Pilis, Börzsöny, and Gerecse mountains which provide a scenic variation to the terrain. This reach of the project area provides high scenic quality.

Roughly half of the riverbank in this portion of the project area has been slightly modified or not modified at all. From Esztergom upstream to Nagymaros there are sections of gallery forests, willows, and thick riverside vegetation. Visibility of the Danube and the potential population exposed to project impacts are high along this reach. Views of the Danube can be seen from numerous hillsides and mountain ridges, 12 lookouts, and segments of the road and railways, as well as from the popular tourist settlements of Esztergom, Pilismarót and Dömös, and other small settlements. Approximately 300,000 people visit this region annually and enjoy these views, not to mention residents who live in the area.

Any adverse visual change in this area would represent a significant impact, especially along those portions of the riverbank which have only been slightly modified and where gallery forests and riverbank vegetation are thick. Because of the sensitivity of these visual impacts, it is important that all embankments be covered with lawn, and revegetation started immediately following construction. Once revegetation has been established the visual impacts would not be obtrusive in the surrounding landscape. In addition, the proposed riverbank recreation park will increase the visibility of the Danube to the viewing public using the park.

Nagymaros-Visegrád. The natural beauty of the Danube at Visegrád is outstanding. This is one of the most - if not the most - scenic areas along the Danube. The intensively eroded volcanic hills of the Visegrád mountains are scattered around the Danube bend in an uneven pattern. The rocky peaks natural riverbank along this stretch has been slightly modified in certain areas and scenic quality is considered to be high. Between Komárom and Nyergesújfalu the Danube riverbank is flat. This section of the Danube is dominated by builtup areas with industrial plants, factories, slurry pumps, and settlements. Most of the riverbank along this stretch has been modified, only a small portion is left in natural condition. There are fewer strips of gallery forest and willows along this reach, with more planted trees and scattered vegetation. The scenic quality along the Danube riverbank is considered to be medium in areas not dominated by industrial facilities. Where industrial plants and factories are located along the riverbank, the scenic quality is low. Public views of the Danube from Gönyü to Komárom are limited to the settlements Gönyü, Koppanymonostor, and Komárom and small segments of local roadways. The number of people exposed to these views is unknown. From Komárom to Nyergesújfalu, visibility of the Danube is much greater, with views available from major segments of the railway and roadway, four lookout points, and a number of small settlements. It is assumed that there are more members of the viewing public along this reach.

As a result of construction and operation of the project, the riverbank character and Danube scenery would not change significantly along the reach from Gönyü to Komárom. Visual impacts from disturbance related to reinforcement of some embankments would be short term and would be reduced to insignificance after the embankments are revegetated. In addition, the proposed riverbank recreation area, with a bike and pedestrian path along the top of the embankments, will provide new viewing opportunities of the Danube to the public using the park. This will be a benefit.

The visual changes to the riverbank would be more visible along the lowland stretch from Komárom to Nyergesújfalu. However, most of the riverbank has already been modified and the scenic quality is medium to low along this reach. The industrial areas along the Danube would absorb and block a major portion of these visual changes. No visual impacts would be expected in the industrial portions of the landscape. Those areas which offer open views of the Danube to the public (from road and railways) would experience significant visual impacts. Views of the Danube will be blocked by the elevated

These changes would only be visible in the immediate Danube riverbank. Beyond the immediate riverbank, forested areas along the side arms and the topographic terrain (lower elevation of the riverbed) would reduce the degree of visibility considerably. Consequently, most of these visual impacts would be absorbed by the landscape condition within 0.5 m from the Danube.

The potential population exposure to these changes is relatively low. The old Danube is currently visible from the existing riverbank and a few Szigetköz embankments, and from the settlements of Nagybajcs and Vének. The old Danube is not visible from roads, railways, or lookouts. This area is used for recreation to some degree, and visual changes would consequently be visible to people using it for this purpose. Overall, the population exposed would be limited, except for the settlements of Nagybajcs and Vének.

The drop in the flow of the old Danube and the presence of the Dunakiliti weir would substantially alter the natural condition of the riverbank, degrading the scenic quality of the area. However, due to low population exposure and the ability of adjacent landscapes to limit views of the changes, these impacts are considered to be insignificant. However, it should be noted that revegetation of the old Danube would preserve its natural appearance.

The construction of protective embankments would also alter the natural appearance of the old Danube riverbanks. This could significantly impact the scenic quality in the area of Nagybajcs to Vének. To mitigate this impact the embankment slopes will be covered with grass, or lawn. Natural vegetation should be planted at the foot of the land side of the embankment (refer to Section 2.2 for recommended vegetation). This would reduce this impact to an insignificant level.

Gönyü-Nyergesújfalu. The Danube River section between Gönyü and Nyergesújfalu is primarily of lowland terrain becoming more mountainous towards Nyergesújfalu. The Danube River is the dominant visual feature. The Danube riverbank between Gönyü and Komárom is high. Agricultural and forestry activities cover a significant area, recreational activities occur at Koppanymonostor, and Ács woods is an environmental protection area. The

Szigetköz-Gönyü. The Szigetköz region is visually characterized by its lowland floodplain terrain, with dense forest vegetation along the Danube and its side arms in the floodbed area, and agricultural fields and small settlements between the Danube and its floodbed and the Mosoni Danube. The natural beauty of the smooth backwater and floodplain forest coupled with the numerous waterways (Danube River, the side arms and backwaters, and the Mosoni Danube), and the regions generally undisturbed nature contribute to the area's high scenic quality. The most dominant feature in this landscape is the Danube and it's side arms. Overall, the landscape condition of the area has not been drastically altered from its natural state of appearance, with the exception of the introduction of poplars in the floodbed and agricultural fields.

Operation of the project would result in a significant drop in the water level in the old Danube River channel, from the reservoir to approximately Dunaremete. The drop in the river would significantly alter the appearance of the existing river bed channel from one which alternates from being covered with water during high flow exposing dry riverbanks during low flows; to one of a dry "empty" riverbed with a much smaller water surface. Perhaps the most significant visual change would not come from the dry "empty" riverbed, but instead from the modifications to the riverbank vegetation. The river would no longer provide the necessary ground water to support the riverbank forests and vegetation. Consequently, the forests and natural riverbank vegetation along the existing floodbed would die or be harvested (refer to Section 2.2 for a complete description). However, eventually new riverbank vegetation will re-establish along the new riverbank over a period of several years.

The Danube banks are currently in a somewhat natural state with only slight modifications in a few areas. The lower portions of the Danube bank (below Nagybajcs) would be modified with protective embankments which would change the visual appearance of the Danube. Other project induced visual changes would result from the Hrusov-Dunakiliti reservoir and structures. The structure of the weir from the old Danube will be very visible and intrusive. After a few years, the reservoir itself would be a water surface which would eventually look natural for the area.

observed and the viewing point, with specific reference to the amount of scenic detail that is apparent from these points; 2) the relative value the public places on maintaining the existing landscape characteristics; and 3) the visual dominance of the facility from key viewing locations such as roadways, recreation areas, and residential areas.

The factors above are analyzed and synthesized in an overall evaluation of landscape visual sensitivity to a proposed project. The determination of "significance" is based on:

- The extent to which the potential facilities would alter, or contrast with, the existing dominant landscape features (landform, vegetation, water, and structures), and visual elements (color, form, line, and texture)
- How sensitive these changes could be to the viewing public

An impact is normally considered significant if the project component contrasts with an existing landscape of high scenic quality, the existing landscape is unable to absorb the resulting visual changes, and the project feature is perceived by the public as obtrusive. Visual impacts are considered insignificant if they do not change the overall visual condition of an area; they temporarily change the visual condition of an area for 2 years or less; (e.g., revegetation would take place); and they change the visual condition of an area of low or medium scenic quality with low population exposure. Visual impacts are considered beneficial if they improve the visual condition of the landscape. For example, returning previously disturbed landscapes to a more natural condition.

2.5.2 Discussion of Impacts

Where possible the landscape features for the project area were evaluated according to the four factors that affect visual sensitivity: scenic quality, landscape condition, predicted visibility, and potential population exposure. It should be noted that most of the project area was not seen by the Bechtel team, and that visual characterizations are based primarily on available data sources.

2.5 VISUAL RESOURCES

Visual resources are the physical characteristics of a landscape that determine its scenic quality and relevant value to the viewing public. These characteristics are both natural and manmade features that make up a specific landscape scene. Natural features include water, landform, vegetation, and soils. Manmade features include physical structures, roads, and so on. Since scenic quality is a measure of human sensory experience, the visual resources most important are those within the "seen area" of areas accessible to people (road and railways, waterways, trails, recreation sites, residential areas, etc.).

2.5.1 Description of Significance Criteria

Visual impacts are determined by simultaneous consideration of four aesthetic factors. The four factors are defined as follows:

- Scenic Quality: Scenic quality is directly related to the distinguishable features in the landscape, such as vegetation, water, landform, and soil; human modification (e.g., buildings, fences, roads, etc.); and their contribution to the line, form, color, and texture of the landscape composition. A key determinant of high scenic quality is the visual dominance of some element (form, line, color, texture) of at least one landscape feature (land or water surface, vegetation, physical structure) that makes that particular landscape stand out among surrounding landscape.

- Landscape Condition: The landscape condition addresses the degree to which the landscape has been altered from its natural state and the inherent capacity of the landscape to absorb visual changes resulting from the project.

- Predicted Visibility: The predicted visibility addresses the degree of visibility that project facilities would have in the landscape. This is based on the position of facilities relative to significant topographical or physiographic features, as viewed from those areas where the proposed facilities could be seen by an observer standing at ground level.

- Potential Population Exposure: Potential population exposure takes into account the number of people and the locations from which people could potentially view proposed facilities. Three aspects of public visual exposure are incorporated into this factor: 1) the distance between the landscape being the Hungarian conquest. This is a historical-archaeological monument of outstanding significance. The relics of early Hungarian town history can be found here, in some places at a depth of 4-5 m beneath the surface (102 m above sea level). The ground water level in the area will be controlled by the Kis-Duna pumping station facilities at the mean ground water level of 103.5 m/asl. Occasionally, the ground water could possibly rise to 104.8 m/asl during flood conditions.

Controlling the ground water level at 103.5 m/asl will reduce the accessibility of deep-lying resources in this area, but it will also improve the accessibility of those resources buried above the mean ground water level. Currently, access to these artifacts is limited due to extensive surface development (buildings, roads, etc.).

Accessibility to these areas in the future could be ensured by construction of a local dewatering system. The system could be operated during those times in the future when archaeologists require access to these resources. Because of the limited surface access to these sites and the uncertainty of future excavation, it is not recommended that funding for a dewatering system be included as part of the project. Future funding of excavation activities should include dewatering system.

During project operations, this area as well as the new town centre area should be monitored to ensure that the ground water level does not rise above the mean ground water level (except for short durations during flood conditions). If monitoring indicates that the ground water level is increasing, then increased pumping along the seepage canal or Kis-Duna should be implemented by the project.

Because the GNB project may involve river dredging, additional archaeological relics (artifacts, arms, ship remains, ornamental pieces, etc.) may be recovered. All archaeological relics found should be collected and delivered to an appropriate museum.

Nagymaros-Budapest. No additional impacts are anticipated.

A qualified archaeologist should be present during construction activities that could potentially affect archaeological sites. Construction activities should be scheduled well in advance, both with the museum and with archaeologists, to ensure that there is sufficient time to make appropriate arrangements. This would help ensure that special construction methods are followed, and it would reduce the likelihood of false accusations about impacts resulting from construction.

Project operations could also result in significant adverse impacts to archaeological and monument sites in this area. Helemba sziget will be inundated (site no. 35.1.29). On this site, there are remnants of settlements of the Neolithic, Bronze, and Celtic Ages (pits in the earth, houses, furnaces, etc.), remnants of an Arpadian Age Church and the graves of its cemetery, as well as the walls of the archiepiscopal holiday palace. Only 10 percent of the settlement and medieval cemetery have been excavated. To mitigate this impact, the entire site should be excavated and significant artifacts and relics removed to the museum. A small fortress in Visegrád built in the IVth century (site no. 38.1.1) is of outstanding significance for its archaeological and monument value. It has been excavated and further project plans have been prepared for its protection. Watchtower foundations of the Roman Age (41.1.1) would be inundated; however, they are currently being excavated which will mitigate this impact. A settlement of the Copper and Celtic Ages would also be inundated during project operations (site no. 41.1.2).

One monument (no. 37.2.5) would be inundated. The monument is the boat station at Dömös, built in 1910. This cast concrete station building is characteristic of the first decades of the century and is the only remaining example of station-building in the Hungarian section of the Danube. Project plans have been prepared for its protection.

Changes in the ground water level could also potentially affect the accessibility of archaeological artifacts in the Esztergom Royal Town area (site no. 35.1.10). This area has settlements from the Copper, Bronze, Celtic, and Roman Ages, and has been a flourishing settlement from the time of

Table 2-1 (Cont'd)

Site No.	Area	Description
41.1.6	Szob	Another site of outstanding significance approximately 550 x 200 m in size with finds of Neolithic, Copper, Bronze, early Iron Ages, Quad, and Arpadian settlements presently under railroad tracks, additional riprap would be placed on riverside slope of railroad track.
42.1.1	Ipolydamásd	Prehistoric settlement of 100 x 50 m could be damaged during construction of the roadway.
42.1.3	Ipolydamásd	A site with a few pieces of prehistoric pottery would be, or has been, partially or totally destroyed by construction of the road.
43.1.1	Letkés	A site of outstanding significance (800 x 100 m) with a settlement of the Neolithic, Copper, Celtic, Quad, late Avar, and Arpadian Ages and a cemetery of the early migration period. About 5 percent of the site has been excavated. Construction of the dike did damage to the site.
43.1.2	Letkés	One of the most important sites along the Ipoly. About 50-60 percent excavation has been completed on a 150 x 100 m site with graves of the late Bronze Age. Dike construction did damage to this site.
43.1.3	Letkés	The village of Davidrév of the XIV-XVth centuries. Was impacted by dike construction.
43.1.4	Letkés	On the site of 700 x 100 m there were settlements of the Copper, late Bronze, Celtic, and early Arpadian Ages. Was damaged by dike construction.

Table 2-1 (Cont'd)

Site No.	Area	Description
37.1.1	Dömös	Roman watchtower foundations would be buried during construction of the dike.
37.1.2	Dömös	Roman watchtower foundations and settlement of the Bronze Age, would be under fill.
37.1.3	Dömös	Roman watchtower foundations would be buried.
37.1.5	Dömös	Construction of a new roadway would traverse a settlement and cemetery of Arpadian Age. Northern portion of this site would be dredged or inundated. The greatest part of the site has not been excavated.
37.1.6	Dömös	Traces of prehistoric and medieval settlements not yet excavated. Site would be traversed by the new roadway, and the northern portion would be dredged or inundated.
40.1.1	Zebegény	Prehistoric pottery has been found at this site. Future road construction would make future excavation difficult.
40.1.2	Zebegény	Sporadic Scythian arrow heads found at this site. Future road construction would make future excavation difficult.
40.1.3	Zebegény	A site approximately 500 x 50 m in size immediately on the Danube bank where settlement traces of the Copper, Bronze, Celtic, Quad, and late Avar Ages are present. Bank regulation and construction of the roadway would make future excavation difficult.
41.1.3	Szob	On the Danube bank there is a site of outstanding significance with the remains of a settlement of the Copper, early Iron, Celtic, and late Avar Ages which would be difficult to excavate due to embankment fill. Small amount of excavation has been done.
41.1.4	Szob	Relics of the medieval village. Very small amount of excavation has been done. Would be difficult to excavate due to embankment fill.

Table 2-1

ARCHAEOLOGICAL RESOURCES AFFECTED BY CONSTRUCTION ACTIVITIES

Site No.	Area	Description
35.1.16	Esztergom	Roman watchtower foundations (half soured by Danube) would be buried by slope protection eliminating the possibility of future display or research.
35.1.18	Esztergom	Roman watchtower foundations would be buried in the embankment eliminating the possibility of future display or research.
35.1.21	Esztergom	Roman watchtower foundations would be buried in the embankment eliminating the possibility of future display or research.
36.1.1	Pilismarót	Roman watchtower foundations. Would be buried in the embankment or inundated.
36.1.3	Pilismarót	Roman watchtower foundations. Would be buried in the embankment or inundated.
36.1.4	Pilismarót	Roman watchtower foundations. Would be buried in the embankment or inundated.
36.1.5	Pilismarót	Settlements of the Neolithic, Iron, Celtic, and Roman Ages, prehistoric and medieval graves. About 30 percent of the site has been excavated. Site would be dredged during construction activities.
36.1.6	Pilismarót	Roman watchtower foundations. Would be buried in the embankment or inundated.
36.1.7	Pilismarót	Roman watchtower foundations. Would be buried in the embankment or inundated.
36.1.10	Pilismarót	Settlements of the Neolithic, Bronze, Iron, Celtic, and Roman Ages. No excavation has been done. Site would be buried during construction activities.
36.1.11	Pilismarót	Traces of a Bronze Age settlement. Not uncovered yet. Site would be buried.
36.1.13	Pilismarót	Remains of settlements of the Bronze and Late Bronze Age. Not excavated. Site would be dredged during construction activities.

Construction impacts, resulting from earthmoving activities and the use of heavy construction equipment, could impact a number of archaeological sites. Additionally, construction of protection levels and embankments would bury a number of Roman watchtower foundations, eliminating future access for scientific research or public observation. Table 2-1 lists potential archaeological sites which could be damaged.

The original project design would have resulted in significant adverse impacts to the very important monasteries of Szentkirály (site no. 35.1.5) and Sziget (site no. 35.1.7), and the wall of Vizivåros (site no. 35.1.11). Following coordination with project engineers, these three sites will be protected and the possibility of future display ensured. Construction of the originally proposed project would also have damaged site no. 36.1.2, the remains of a Roman stone fortress of 30-38 m in size. As a mitigation measure, this site will be rescued and future display made possible by the redesign of the project.

Agreement was reached with archaeologists as to which archaeological sites were to be preserved by modification of project design. The significance of impacts to those archaeological resources not preserved cannot be made by Bechtel.

A construction plan was also developed with the archaeologists to mitigate impacts to specific archaeological sites. To further mitigate potential impacts, the construction plan should be expanded to include sites listed on Table 2-1. The plan should clearly identify sites which are considered to be of outstanding significance and therefore warrant further excavation. Excavation should be completed prior to construction.

no. 29.1.1, where clay pits and waste pits belonging to a potters' settlement were found; site no. 29.1.2, Roman fortress foundations; and site no. 29.1.3, a Roman settlement (Canabae, Castrum, municipium). The significance of this potential impact would be determined by the overall damage to currently unexcavated archaeological resources resulting from construction activities. In the Almásneszmély area a number of archaeological relics have been discovered. However, a relatively small percentage of the area has been surveyed. It is anticipated that during construction a number of additional relics could be encountered and potentially damaged by earth recovery and the creation of a new bed in the Altalér. Archaeological sites (sites no. 31.1.1-6) on the Danube bank of Lábatlan could also potentially be damaged during construction of the embankment.

On the bank of the Altalér there is a Turkish watermill which would have been destroyed during construction of the barrage project (site no. 30.2.3). By modifying the flood protection dike, this irreplaceable XVIIth-century monument will be preserved. This can be considered a benefit of the project.

Project operations could also impact archaeological resources along this stretch of the Danube. A cemetery on the Lovad meadow could be affected due to its location on lowlands along the Danube. A section of the Roman road in Komárom running along the bank of the Danube, and the foundations of a Roman watchtower (site no. 26.1.1.) could be inundated.

Project operations would produce a beneficial impact on the Csillag fortress in Komárom. The seepage system has been designated so that there would be water in the presently dry moat. This would enhance the aesthetic quality of the fortress.

Nyergesújfalu-Nagymaros. This stretch of the Danube has the greatest concentration of archaeological and monument resources. A number of sites have been successfully excavated due to project funding (a project benefit). Mitigation measures have been developed in conjunction with the Monument Plan Council of the National Committee for Technical Development to protect some of the most significant resources. In spite of this effort, impacts to archaeological and monument assets could potentially occur in this area.

2.4.2 Discussion of Impacts

Szigetköz-Gönyü. Both construction and operation impacts could potentially occur within this segment of the project area. Construction impacts resulting from proposed bed cuts for the recharge system and the water outlet canals could potentially affect currently unknown archaeological relics in the areas of Darnözseli, Püski, and Dunaremete. The significance of any potential impact would be based on the presence of archaeological resources, the importance of these resources, and the overall damage to these resources resulting from construction activities. The bed dredging of the old Danube River channel could also potentially impact currently unknown archaeological resources in the Kisbajcs, Nagybajcs, and Vének areas.

Construction of the originally proposed flood protection system in Győr could have impacted a IX-Xth-century settlement containing the first semifinished raw iron rod find in Hungary (site no. 24.1.11). The water engineering director of Northern Transdanubia, in agreement with the museum, modified the design of the proposed system to protect two-thirds of the archaeological site. This will reduce the overall impact to this site.

During the bed regulation and the resulting drop in surface water level of the old Danube, ethnographically significant relics may come to the surface in the Lipót and Ásványráró areas. This will be a beneficial impact, if archaeological relics are present within areas of the riverbed.

Gönyü-Nyergesújfalu. Future construction activities along this stretch of the Danube could potentially impact archaeological sites. Construction impacts generally result from earthmoving activities (such as blasting, cutting, grading, and earthfilling) and from heavy construction equipment, such as bulldozers, which can easily crush archaeological artifacts.

Construction activities near the mouth of the Bakony could impact Roman Age relics which have not been excavated (site no. 25.2.3). In the vicinity of Szőny, construction of the proposed sewage treatment facility and disposal canal could potentially affect three archaeological sites. These include site

2.4 ARCHAEOLOGY AND HISTORIC MONUMENTS

2.4.1 Description of Significance Criteria

Methods for identifying impacts to archaeological and historical resources are based on criteria used in determining the significance and importance of the resources and impacts on the resources.

In general, an archaeological or historical artifact, object, or site should be evaluated on the basis of its integrity and quality, research potential, ethnic and historical value, and potential for public appreciation. For purposes of this evaluation, the determination of significant project-related impacts is based on the following criteria:

- Significant impacts are those that result in the loss or overall reduction in the integrity or research potential of important archaeological or historical resources
- Beneficial impacts are those which would improve conditions relative to preproject conditions. With regard to archaeological and historical monuments, this would apply to project-related effects which could improve future accessibility to sites (for scientific research and public observation), or which would improve or enhance the quality of the archaeological or historical monument

The archaeological and monument values in the project area have been described in the informatory document prepared for the GNB project. Bechtel has not questioned or disputed the technical expertise and judgments regarding the value of the archaeological and monument assets evaluated in this document.

If previously unknown archaeological and historical monument sites should be uncovered during project construction, construction must be halted and a qualified archaeologist consulted to determine the significance of the site and the need to excavate. This general rule is designed to minimize adverse impacts. Construction workers will not be allowed to collect or damage any archaeological resource.

Implementation of the planned artificial recharge system integrating agricultural and forestry concerns will also produce several beneficial impacts. Agricultural and forestry losses due to floods will be reduced (not yet quantified). With more controlled ground water levels, hectares of arable land can be increased by reducing areas subject to waterlogging, especially in the northern part of the Szigetköz, Szöny-Komárom, and Feketeerdö at Almaspuszta, and in the vicinity of Szentlélek and Kenyérmezo Creeks. Gross revenues anticipated from increasing arable land are estimated at about 9.1×10^6 Ft/ha/yr. Controlled water sources for irrigation and crop selection/rotation will reduce the uncertainties and risk of agriculture production dependent on water availability, since the amount of water available for irrigation would be known. This benefit has been estimated at an additional gross income of 104.0×10^6 m^3/year.

Agricultural activities downstream of Gönyü include approximately 25,249 ha or 69 percent of the 41,440 ha Komárom County area. Agricultural production on 677 ha will be lost due to the project (approximately 14.76×10^3 Ft/ha or 9.99×10^6 Ft). This loss in agricultural production is less 2 percent of total production for the county. Changes in production value on 659 ha are also projected at 1.132×10^6 Ft/ha. Compensation for these losses has been made and no significant impact on agricultural production is anticipated.

Project plans call for certain improvements to be made near settlements (i.e., sewage and waterworks system) and new roadways to be built from Györ to Nagymaros to replace theose affected by reservoir and protective dike construction. This new infrastructure could promote growth in areas where present growth is restricted due to limited sewage, water supply, or road capacity. Anticipated growth is discussed in Section 2.6. Losses of 100 residences and 20 public buildings have been compensated through the court system. Given these compensations, no significant impact is anticipated on land use.

Without mitigation measures, potential impacts associated with the project in the Szigetköz area would have included reduced productivity of crops and forests due to changes in ground water levels. However, this potential impact will be mitigated by the implementation of the artificial recharge system.

The recharge system is designed to maintain existing ground water levels and flooding regimes in the side channels during operation of the project. Plans call for the system to be augmented by a monitoring program to determine changes needed during operations to maintain ground water levels. Without the artificial recharge system, timber productivity would be reduced by one-third, and one-fourth of the current value would be lost.

With the artificial recharge system in place, approximately 300 of 7,803 ha of forest land will be adversely affected by changes in the ground water levels along a 250-300 m strip adjacent to the Danube River. This area represents approximately 3 percent of total forest area. Mitigation to reduce this impact focuses on substituting more xeric tree species for more water intensive poplars. Shift to the more xeric species would constitute a loss in timber value of approximately one-third of present production, along this stretch of the Danube. This future loss in timber value was compensated. No significant impact on forest production is anticipated.

The transportation costs of timber harvested in the Szigetköz area would increase due to the diking of the side arms of the Danube. Harvested timber is currently transported by barge along those side arms. The dikes which are part of the artificial recharge system will make barge traffic impossible and alternate means of transportation are necessary. Compensation has been made through funding for new road construction, to provide alternate transportation means. While this will likely increase transportation costs, the increase cannot be quantified.

Approximately 1,100 ha of forest stands in the Dunakiliti reservoir area have been cleared. While the area was previously forest intermixed with meadow/pasture, no net loss in production has occurred since the Rajka farm cooperative was compensated for the loss with other land.

residential properties affected, and the number of project-related conflicts and incompatibilities with affected settlement patterns.

Special land use conflicts resulting from the project, (e.g., encroachments on nature conservation areas), and the significance of the conflicts is a function of the extent of the area affected, and the regulatory protection afforded the special use. Impacts on special land use are significant if the special land use area is decreased or objectives of the special land use area cannot be met as a result of the project. Beneficial impacts would be realized if special land use areas were increased or objectives exceeded.

Growth-inducing impacts associated with the project reflect the ability of a community to absorb effects such as increased traffic or potential conflicts with local policies designed to achieve physical, social, and economic goals.

An impact is considered significant if it causes a change in existing land use patterns, and/or growth or development trends. The change must be an identifiable trend. Land use trends may be affected either directly or indirectly by construction or project operations. For example, constructing new infrastructure to support project activities, such as sewage treatment facilities and roadways, can also enable new industrial, commercial, and residential land uses to develop that could conflict with existing land uses. An impact may be significant if it affects other existing or proposed land uses or conflicts with land use plans and policies. For example, a reduction in agricultural land use may affect agriculture-related industrial or residential patterns.

2.3.2 Discussion of Impacts

The principal land use in the Szigetköz area (composed of 40,100 ha) of the project area, between the Mosoni Danube and main arm of the Danube from Rajka to Gönyü, is agricultural and forestry (84 percent of land use). Below Gönyü to Visegrád and Nagymaros, agricultural, recreational, residential, and industrial land uses are intermixed near settlements such as Komárom and Süttö.

2.3 LAND USE

2.3.1 Description of Significance Criteria

Identification of land use impacts related to the project is based upon significance criteria, which determines the importance of a land use change, either beneficial or adverse. Assessment of impacts on land use considers the effects of the project on existing and proposed agricultural, industrial, sylvicultural, residential, and special land uses. Recreation impacts and fishery impacts are discussed in Sections 2.6 and 2.2, respectively. In addition to land use changes brought about by the project, impacts created by induced population growth and future development should also be considered.

Significant impacts to land use include conflicts with adopted environmental plans and goals of affected communities, substantial increases in population concentration, disruption or diversion of an established community, loss of agricultural land, or reduced productivity. Criteria used to determine significance of impacts include loss or gain in agricultural production caused by the project, including construction activities, access to markets, and traffic. Impacts to agricultural land uses should be assessed by identifying the areal extent in hectares that would be affected, crops affected, and value of resource lost or gained. The greater the value of the resource loss or gain, the more significant the impact. Any long-term loss of high-value agricultural land is a significant impact.

Significance of impacts on industrial enterprises would include considerations of whether the project would interfere with or displace industrial operations, or interfere with access to industrial facilities. The extent of the disruption would reflect the level of significance of the impact.

Impacts to residential land use are significant if new land use is incompatible with proposed development and existing residential land use. Improvements for residential land uses, such as increased access, or improved water supply or sewage disposal, would constitute a beneficial impact, but it could also result in adverse impacts if it induces population growth. The significance of impacts on residences is gauged according to the number of recommendations and mitigation developed were described under the Szigetköz-Gönyü reach. Potential disruption of fish migration due to the barrage has been mitigated by the use of a fish lock as described for the Gabcikovo barrage/power station. (Impacts on migratory fish inhabitating this reach, but spawning in the Szigetköz side arm system were discussed under the Szigetköz-Gönyü reach.)

Nagymaros-Budapest - Vegetation. Natural vegetation along the reach from Nagymaros to Budapest, downstream of the project facilities associated with the Nagymaros barrage system, is not expected to be affected by the project. Because the system will be operated in the continuous, run-of-the-river mode, no changes in water levels and associated bank or flood protection measures are planned. Consequently, no vegetation will be cleared.

Nagymaros-Budapest - Wildlife. No baseline surveys were conducted to characterize wildlife use of this reach. Limited data on birds observed at Szentendre Island (biological monitoring station) were available. Because the Nagymaros barrage is a run-of-the-river system, it will not significantly alter the downstream flow of the Danube or the recharge of Szentendre Island. No significant impacts on wildlife are expected.

Nagymaros-Budapest - Fish. The only impact on fish identified for this reach is potential for DO deficiency effects downstream of the Nagymaros barrage and power station. Reduction in DO concentration below this power station would be cumulative from the two barrage systems. Mitigation for such impacts could be developed (as described for the Szigetköz-Dunakiliti reach) if warranted by the system-wide DO modeling effort. (Impacts on migratory fish species inhabitating this reach as adults, but spawning in the Szigetköz side arm/oxbow system were discussed in the section on the Szigetköz-Gönyü reach.)

habitat use. Similarly to the previous discussion of the upstream reach, construction activities related to flood protection and bank stabilization are expected to result in temporary noise disturbance, mortality and injury of individuals, and wildlife displacement due to loss of habitat. Impacts resulting from habitat losses could be mitigated to some extent by a revegetation program as described previously.

The Nature Conservation District of Börzsöny (bordering on the left bank of the Danube Bend from Zebegeny to Nagymaros) is known to support protected birds, reptiles, and amphibians. A number of endangered birds of prey may be found including the imperial eagle (Aquila heliaca), the lesser spotted eagle (Aquila pomarina), the saker falcon (Falco cherrug), the short-toed eagle (Circaetus gallicus), the red kite (Milvus milvus), and the black kite (Milvus migrans), and rare species may also be present including the eagle owl (Bubo bubo) and black stork (Ciconia nigra). Several protected mammals also inhabit the closed forests of this conservation area: (Martes martes), (Martes foina), (Mustela erminea) and (Mustela nivalis).

No specific information could be obtained on the occurrence of these species in the vicinity of ongoing project-related construction activities near Nagymaros. Discussion with biologists at ELTE and others suggest that these species tend to occur toward the interior of the area, away from affected riparian areas. Whether any avian nesting trees would be affected along this reach of the Danube could not be determined. The project has reduced impacts on raptors and migrating waterfowl from transmission lines (i.e., electrocution, collision injury) by using underground cable mains.

Nyergesújfalu-Nagymaros - Fish. A potential impact on fish identified for this reach would be DO deficiency effects should this condition develop in the Hrusov-Dunakiliti reservoir (as described previously). Mitigation would be the same as that described for the previous reach (i.e., system-wide DO modeling and mitigation as required). Fish entrainment and turbine-induced mortalities similar to those described for the Gabcikovo power station are expected to occur at the Nagymaros power station. Baseline survey of fill is needed, the project plans to spread the fill material throughout existing fringe forest rather than first cutting and clearing such areas. Filling and grading would be conducted in phases (i.e., fill would be placed in the same area at two different times), in an attempt to avoid killing the trees.

This method was used by the project on the island of Bergman Sziget near Nagymaros, where the local residents were concerned over the potential loss of a 40-50 year old stand of poplar (Populus canadensis) trees. On this island, a total depth of 1-1/2 m of sandy/gravel fill material was applied in two phases, in an attempt to reduce the impact of resultant changes in ground water levels on the poplars.

The effectiveness of this technique over time is currently being studied, and to date shows variable results. The trees have died in some areas, but not in others. It was suggested that this technique could be improved by placing an apron of rocks 4-5 m high around the trees as a sort of filter.

This mitigation is not believed to be an effective and cost-efficient mitigation in the long term. A phased approach to filling and grading will be costly because it requires mobilization of construction crews and activities at two different times. Use of the proposed rock aprons placed around individual trees would be very labor intensive, time consuming, and costly. Furthermore, the proposed phased filling method is unproven and not considered likely to be very successful for maintaining the fringe forest over time.

A more effective mitigation measure would be the development and implementation of a revegetation program along the Danube as described earlier. This program could apply several different treatments designed to facilitate reestablishment of natural vegetation and would be a more effective means of maintaining riparian vegetation in the project area.

Nyergesújfalu-Nagymaros - Wildlife. Project-related impacts on wildlife along the Nyergesújfalu-Nagymaros reach cannot be accurately assessed because no baseline surveys were conducted to characterize species' occurrence and reach (i.e., system-wide DO modeling and mitigation as required). Impacts on migratory fish inhabitating this reach, but spawning in the Szigetköz side arm system, were discussed previously.

Nyergesújfalu-Nagymaros - Vegetation. Generally, impacts on natural fringe forest along this reach of the Danube would be similar to those described for the previous reach. This area, however, appears to have more natural vegetation left undisturbed along the Danube (i.e., less industrial development and fewer settlements).

Much of the reach from Nyergesújfalu to Esztergom is bordered by low stream banks. Consequently, much of the remaining fringe forest is expected to be lost to dikes constructed for flood protection. From Esztergom to Nagymaros, much of the reach is bordered by high stream banks, which will require less clearing and diking. These areas, however, may experience an increase in the ground water table associated with the rise in mean water level from elevation 102 to approximately 108 m/asl once the Nagymaros barrage system is operational.

As a result of construction and operation of the project, some stream bank vegetation will be inundated, some will be lost to slope protection (e.g., armoring with riprap), some will be lost to fill in the vicinity of project structures, and some will change toward more hydrophilic associations. The acreage of natural vegetation to be affected by the project could not be estimated.

Overall, loss of and changes to the natural vegetation along the Nyergesújfalu to Nagymaros reach are expected to affect a substantial portion of the remaining fringe forest and other riparian vegetation. Such changes are expected to be permanent. This is considered to be a long-term significant impact.

The project has identified a potential technique proposed to reduce loss of the fringe forest in some areas between Nagymaros and Dömös where fill will be required to raise the streambank. In areas along the river where 1-3 m depth vegetation, and then the areas should be planted or seeded with native plant species. Several different revegetation treatments could be used for different conditions. For example, some riparian areas (with high soil moisture content), could be planted with shrubby vegetation (e.g., Salix purpurea). Other areas could be planted or seeded with tree species (e.g., Quercus robur, Q. pubescens, Acer campestre, Sambucus nigra), and possibly understory species (e.g., Cornus mas, Sanguinea ligustrum vulgare) as appropriate.

The biologists at ELTE have collected and developed information that would be very useful in designing a cost-effective revegetation program. Revegetation recommendations could be made based on established revegetation techniques, the experts' knowledge of the existing natural vegetation in currently undeveloped areas, species water requirements (based on Zolyomi's water requirement categories), and Simon's nature conservation ranking system. The development and implementation of a revegetation plan could mitigate a portion of the loss of natural vegetation that will result from the project.

Gönyü-Nyergesújfalu - Wildlife. The wildlife inhabiting this reach, including protected birds or mammals, was not characterized prior to project development. Consequently, impacts cannot be accurately assessed. Generally, construction impacts would include temporary noise disturbance, mortalities, injuries to individuals, and displacement resulting from loss of habitat due to dike and seepage interceptor channel construction and riprap placement (as described previously). The fringe forest along this reach does not support the diversity or abundance of bird species found in the Szigetköz.

Impacts could be mitigated by replacing habitat lost to flood protection and riverbank stabilization through the development and implementation of a revegetation program (as previously described).

Gönyü-Nyergesújfalu - Fish. The only potential impact on fish identified for this reach would be effects of DO deficiency on fish in the main channel should this condition develop in the Hrusov-Dunakiliti reservoir (as described previously). Mitigation would be the same as that described for the previous

Effects on fringe forest and other riparian vegetation are expected to be long term or permanent. This reach appears to have proportionally less natural vegetation remaining along the Danube, due to more settlements and industrial development. A substantial portion (approximiately 300 ha) of the natural fringe forest along this reach is expected to be lost or altered. This is considered to be a significant impact.

The most effective mitigation for these impacts on vegetation would be to operate the Gabcikovo (Bös) power station in the continuous mode. This would eliminate the periodic increase in the water depth, the daily water level fluctuations and associated slope stabilization measures (i.e., riprap), and the resultant impacts on natural vegetation.

Alternatively, a revegetation program could be developed to replace the natural vegetation lost to project development. A revegetation program plan could be developed by a multidisciplinary team including project engineers and biological experts - such as the ELTE staff who are performing the biological monitoring and are familiar with the natural vegetation of the Danube floodplain. Such a program should consider slope stability, erosion control, appropriate vegetation, and visual considerations.

First, to maintain the structural integrity of the dike system, areas where it is undesirable to reestablish trees or understory vegetation, such as tops of dikes or steep banks, should be identified. For revegetation, consideration should be given to using native species of grasses or non-native species that provide both suitable erosion control (e.g., rapid establishment of adequate cover) and habitat value to wildlife. Using native grasses adapted to the local area and site-specific conditions is advantageous because native species will establish permanent cover that does not require periodic maintenance treatments (such as reseeding), and provide better wildlife habitat.

Reestablishment of native shrubs or forest to replace a portion of that lost to project development should be considered. Where possible, topsoil should be spread over fill material to provide a substrate conducive to supporting

Gönyü-Nyergesújfalu - Vegetation. The vegetation along this reach was only generally characterized in the project's summary documents, and consequently the impact analysis is limited to general conclusions. Natural riparian vegetation along this reach of the Danube floodplain is generally poor and limited to a zone of willow-poplar fringe forest with willow shrub undergrowth. Oak-elm-ash fringe forest occurs along higher streambanks in areas around Gönyü, Ács, Komárom, and Nyergesújfalu. Large settlements and industrial areas have developed along the Danube, with a resultant reduction of fringe forest, and agricultural and silvicultural use have contributed to the degradation of the remaining stands of natural vegetation.

Areas of natural riparian and vegetation wetlands will be lost due to armoring streambanks with riprap to minimize bank erosion due to water level fluctuations. The acreage of natural vegetation to be lost (i.e., cleared and filled or excavated) due to dike reinforcement or strengthening, channels, or placement of riprap for slope stabilization could not be estimated because the fringe forest vegetation along this reach has not been inventoried. The river bank slope fluctuation will occur along dike exposed to daily water level fluctuations and will generally be protected from erosion through placement of riprap. It is expected that a significant portion of the existing fringe forest will be permanently lost to flood protection.

Due to the rise in water depth in the Danube (estimated at 2 m at Komárom and 3.5 m at Nyergesújfalu relative to mean water level) and daily fluctuations in water level, the ground water level will change in some areas adjacent to the Danube River. This will result in changes in vegetation. In low-lying areas, ground water levels will be maintained to approximate current conditions through the use of dikes, seepage interceptor channels, and pumping stations. Thus, the potential for effects on adjacent vegetation will be reduced to some extent. Areas of higher streambanks are expected to experience greater increases in ground water levels, and the composition of the vegetation in such streambank areas may tend to change toward more hydrophilic plant species and communities.

bar rack system is selected, consisting of a rack of vertical steel bars or louvers spaced 5-10 cm apart placed at the intake and angled to the direction of water flow and fish movement.

However, the appropriateness of such a system must be reviewed, taking into account the physical configuration of the barrage/powerhouse system and the river, and the fish species present. For example, considerations must include: whether the protection system is expected to be effective for the fish species; the physical potential for orienting such a system appropriately to the flow of water and fish relative to the location of the powerhouse; the size of fish to be protected and compatibility of appropriate bar spacing with the operating head of the facility; and potential incompatibility with ice floes and large debris.

An innovative fish protection device has recently been proposed for one project which consists of a 490 m long porous rock dike upstream of the powerhouse intake. Prototype evaluation studies were performed for such a structure in Massachusetts which concluded that it was nearly 100 percent effective for screening juvenile and adult fish, but resulted in the loss of zooplankton, fish eggs, and larvae presumably eaten by filter-feeders living in the dike. The structure also had a reduced volume of flow (although head was unaffected) due to clogging which had to be backflushed.

Barrage systems also present the potential for blocking fish passage of migratory species. The project has incorporated a fish lock into the Dunakiliti barrage system to accomodate fish passage. It is an automatic system operating on a 2-4 hour cycle. Fish are attracted to the entrance by means of flowing water (simulating the natural flow in the channel) and a light duct. After approximately 2 hours, the lower gate is closed, the upper gate is opened, and the sluice is filled from the headwaters during which time the fish migrate upstream and exit the fish lock. The fish lock design is based on a system currently in use in Austria which is demonstrating good results, and is reportedly preferred over a fish ladder. It is assumed that this system will mitigate impacts on migrating fish.

turbines at Gabcikovo presents three potential means of injury or mortality to fish. First, fish or other organisms can be physically struck by the rotating turbine blades which can result in fish being cut apart or other severe trauma. Secondly, fish can be injured by rapid changes in water pressure (associated with the hydraulic system). Such pressure changes may result in rupture of their air bladders. The third type of injury may result from shear associated with differential water velocities occurring near solid walls or turbine blades. This tearing action can result in immediate death or delayed mortality. Damage from entrainment into turbines is generally more severe on larger fish.

Studies of turbine-induced mortalities have shown varied results. For example, large numbers of mortalities (American shad, striped bass) were recorded in the Bay of Fundy, while low numbers of mortalities of salmon were recorded in the Columbia and Merrimack Rivers.

Entrainment and mortality studies are complex and expensive. In lieu of performing mortality studies, some projects have quantified entrainment rates and developed appropriate compensation for assumed losses. Quantification of entrainment, however, also is difficult using current techniques. Netting is logistically problematic in turbine wells and discharges and acoustic sampling does not provide reliable species identification.

Alternatively, some projects install fish protection devices rather than performing difficult and expensive entrainment and mortality studies. This would be the preliminary recommendation for this project, but this recommendation should be reviewed in conjunction with turbine design once the one-year baseline studies have been completed establishing the species distribution, abundance, and migration patterns. Data could reveal that fish use of this upper reach does not warrant installation of a fish protection system.

Fish protection and guidance devices include lights, noise, electric fields, physical barriers, screens, and bar racks. Often a louver system or angled

Other species which inhabit the side arm system year-round or those which are artificially stocked and raised in dead side arms or abandoned borrow pits will not be adversely affected in this manner. From a managed fisheries standpoint, this may not be considered adverse, because stocking efforts may be used to maintain fisheries production. From an ecological viewpoint, however, this is expected to be a significant adverse impact on the already reduced natural fish stocks of the Danube.

The most effective mitigation would be to maintain sufficient flow in the main channel, but this apparently is not compatible with operation of the Gabcikovo power station as planned. It is recommended, nonetheless, that an evaluation of alternative means of operating the Gabcikovo barrage/power station system (including seasonal changes) be conducted to assess the feasibility of maintaining the natural fish stocks which spawn in this area.

At a minimum, consideration should be given to a means of maintaining migratory fish access to the side arms during spawning times. Baseline surveys recommended previously should be conducted to identify the locations and timing of spawning in the side channel. Once this information is available it should be assessed to determine how spawning can be maintained.

One possibility is the installation of a gate (rather than the rockfilled drop structure) at the location near Ásványráró to hold water in the side arms, which could be opened to allow fish passage upstream into the side arms system during the spawning migrations. This could be disadvantageous to other aquatic-dependent biota (e.g., waterfowl, wetland vegetation), however, unless adequate water levels can be maintained during the period the gate was opened. This mitigation would allow some fish passage to spawning areas in the side arms.

<u>Mitigation Measures - Mortality</u>. Entrainment and turbine-induced mortality also will result from the project. Organisms that may be entrained include phytoplankton, zooplankton, fish eggs and larvae, and juveniles or smaller (< 5 cm) of certain fish species. Passing through the hydroelectric

projected based on available information. As discussed previously, DO, temperature, and nutrients may change in the side arm system which may lead to changes in fish productivity, species composition, and distribution.

For example, pike perch are sensitive to DO concentrations, and additionally, pike perch populations are dependent on the fry (present in April and May) obtaining sufficient numbers of planktonic crustacean prey which in turn is related to inundation of the side arms. If fry of this species do not obtain this specialized prey, large numbers of mortalities occur. If this affected multiple-year classes of pike perch due to changes in the side arm habitat, it could result in a significant long-term impact on this species. These types of potential changes could not be addressed in the scope of this study.

<u>Mitigation Measures - Spawning</u>. Operation of the project as planned is expected to adversely affect the natural spawning of some fish species in the side arm system. The species that will be affected are those that live in the main channel as adults, but migrate into the side arms to spawn. As described previously, some species migrate 50-150 km upstream in the main channel and then into the side arms (which currently have their outlet ends open to the main channel). Once they have spawned, the adults return to the main channel while the fry drift in the side arm channels and feed for a period of time before joining the adults in the main channel.

During operation of the project, all of the remaining side arm outlets to the main channel will be diked. Additionally, a rockfilled drop structure will be installed near Ásványráró in order maintain the water level in the side channel system. Although this is advantageous from the standpoint of maintaining water in the side arms needed to support resident fish, riparian/wetland vegetation, and waterbird habitat, it will result in the permanent blockage of migratory fish access to spawning habitat in the side arm/oxbow system, which currently provides much of the remaining natural spawning habitat to support fish stocks in the Hungarian reach of the Danube. Natural stocks of some species are expected to be reduced over time with continued low recruitment. This loss of access to spawning habitat is expected to result in regionally significant, long-term impacts on some fish species (e.g., pike perch, sturgeon).

- o Operating the Gabcikovo power station in continuous mode, or alternating between peak and continuous operation (to reduce algal production)
- o Drawing down the reservoir during certain conditions (algal blooms)

DO deficiency associated with the Hrusov-Dunakiliti reservoir could affect not only fish in the reservoir but also fish in the Mosoni Danube, the side arm system, and the main channel of the Danube, all of which will receive flow from the reservoir. If DO levels in the reservoir are adequate to maintain fish production, no significant impacts would be expected on fish in these downstream systems. If a DO deficiency developed in the reservoir, however, it could adversely affect fish in the Mosoni, the side channels, and/or the main channel.

A definitive determination of the potential for DO deficiency could not be made based on available data. For example, the current DO levels in the side channels are not documented. During operation of the project, the DO concentration of the water in the side channel system may increase due to increased flow at the reservoir end. Alternatively, increased light conditions due to sedimentation in the reservoir could result in increased algal production and decreased DO concentrations in the side arm system. In addition, nutrient exchange, currently occurring from seasonal flooding over the dikes along the reach downstream of Dunakiliti to Ásványráró, will be altered (i.e., managed annual flooding will be discharged at one point, from the side wall of the ship lock at Dunakiliti). This in turn may affect algal production and decomposition rates and DO concentrations in the operational closed side arm system. The net effect of the changes in this system could not be predicted at this time.

Changes in water quality due to operation of the project also may affect fish in the Mosoni, side arm system, and the main channel. If no DO deficiency develops at the reservoir, water quality in the Mosoni may be expected to improve relative to fish needs, due to the increased rate of flow which will allow for increased dilution of waste waters. Temperature effects cannot be

The second method is to compare the DO concentrations to the EPA criteria which have been developed for various types of effects on different life stages. These criteria take into account complex interactions between fish size, temperature, and other water quality features. These criteria are as follows:

- o Early life stages:

No production impairment	=	6.5 mg/l+
Slight production impairment	=	5.5 mg/l
Moderate production impairment	=	5.0 mg/l
Severe production impairment	=	4.5 mg/l
Limit to avoid acute mortality	=	4.0 mg/l

- o Other life stages:

No production impairment	=	6.0 mg/l+
Slight production impairment	=	5.0 mg/l
Moderate production impairment	=	4.0 mg/l
Severe production impairment	=	3.5 mg/l
Limit to avoid acute mortality	=	3.0 mg/l

A third method which could be used is bioenergetics modeling, which develops quantitative estimates of production impairment over an annual growing season under different scenarios. These models consider the interaction of juvenile fish growth with oxygen concentration, temperature, fish size, and other water quality factors such as dissolved ammonia concentration. Bioenergetics models have attained widespread use in the U.S. for assessing potential impacts on fish.

Based on the results of the DO modeling program, a determination can be made regarding the potential for dissolved oxygen deficiency. If the modeling reveals a potential for adverse effects on fish, mitigation can be developed to operate the project while maintaining adequate DO concentrations.

<u>Mitigation Measures - Oxygen</u>. If deemed necessary, mitigation measures that could be considered include:

- o Spilling flows
- o Mechanical aeration techniques such as pumping air through nozzles into the turbine draft tubes or some type of diffuser in the tailrace

increased water residence time, sedimentation, and light resulting from impoundments constructed during this period along the upper reaches of the Danube. Based on observed trends and data, it has been estimated that the Dunakiliti reservoir will at least double algal production in the Danube.

To date, however, DO concentrations at Rajka have been measured at 6.7 - 10.2 mg/l which does not indicate current oxygen deficiency effects on fish. It cannot be determined at this time how much increased algal production, bacterial decomposition, and oxygen consumption will result from the reservoir or whether these changes will produce adverse DO effects on fish.

DO Modeling Program. It is therefore recommended that the project conduct a DO modeling program prior to operation. This is a technique that has been applied to other river systems with proposed multiple barrages (e.g., the Ohio River). Modeling would enable better determination of the potential development of DO deficiencies, provide a realistic basis for any necessary mitigation, and could be developed into an operational monitoring program to avoid adverse DO effects on fish.

A DO modeling effort is based on measured concentrations of DO and temperature data collected above and below each barrage. The data are used to calculate the expected change in DO downstream. Such a model should be run for several conditions (e.g., low flows, moderate summer flow, and average flow). It is used to predict how much the DO concentration will decrease and over what distance the decrease will extend. Because the cumulative decreases in DO resulting from a multiple-barrage system can be greater than the decrease for either system operating independently, a cumulative, system-wide model should be run.

Once the model has been run, the projected DO concentrations can be compared to DO criteria developed to minimize or avoid impacts on fish. There are three methods which can be used. The first is to compare the DO concentrations to the water quality criterion of 6 mg/l which is used in the U.S. where rivers run through multiple states. This criterion, however, is not recommended for this project because more recently developed criteria are more useful.

Another potential impact of the project is a reduction in DO concentrations, as explained in Section 2.1.10, and associated effects on fish. Low DO concentrations can affect fish adversely by decreasing their growth rate (and consequently their reproductive potential) which may occur at DO concentrations of approximately 6.5 mg/l; and by causing fish mortality, which may occur at 3-4 mg/l (but varies greatly by species).

Qualitatively predicting changes in DO concentrations is difficult due to the complexity of factors influencing such concentrations. Under natural conditions, DO in a waterbody comes from dissolution at the water/air interface and as a byproduct of photosynthetic activity by algae. Dams may aerate water. Oxygen in water is reduced by respiration of aquatic organisms or biological decomposition. Further complicating the predictability, DO concentrations are related to temperature.

The potential for DO reduction and effects on fish is known to be associated with changes that can result from creation of reservoirs. Once the Dunakiliti reservoir has been filled, residence time of the water is expected to increase from about 1 day to 2 to 3 days. This, in turn, is expected to result in increased sedimentation and an associated increase in light penetration into the reservoir. Increased light is expected to stimulate additional algal production in the reservoir. Bacterial decomposition will consume oxygen and result in lower DO concentrations.

Algal numbers in the Hungarian reach of the Danube are believed to be limited primarily by light which is related in part to seasonal changes. Under existing conditions, seasonal trends in algal production have been observed. Increases in algal densities correlate with periods when the Danube is characterized by low turbidity and high light conditions. Nutrient supply in the Rajka reach of the Danube does not limit algal production.

Based on a review of the nutrient supply in the Danube and observed baseline algal production, it is apparent that algal blooms may potentially result from the Dunakiliti reservoir. Since the early 1960s, a five- to tenfold increase in algal production has been documented in the Danube and attributed to

A number of effects of the construction and operation of the project may impact fish in this reach, including fish stranding, DO effects, changes in species composition due to alteration of water flow, loss of fish spawning, and entrainment/turbine-induced mortality. Due to the lack of data on fish, only potential impacts can be identified at this time. Once baseline fish surveys are completed, these impacts should be reevaluated more accurately.

Due to the reduction of surface water flows in the main channel, some fish may be stranded in pools isolated from the channel by the drop in water levels. Mortality may result. This is expected to occur immediately after diversion of most of the flow from the main channel to the diversion canal. It may also occur occasionally following temporary discharge of high flood flows which are discharged to the main channel. Because fish populations are generally resilient to limited numbers of mortalities, this is not expected to result in a significant, long-term impact on fish species, and is not expected to warrant mitigation.

Alteration of water flows resulting from the use of reservoirs and diversion canals is expected to lead to changes in the species composition of the fish stocks. Species that inhabit rapidly flowing water (e.g., sturgeon, barbel, pike perch) are expected to decrease in numbers in this reach due to decreased flow rates resulting from the creation of the reservoir and the diversion of flow from the main channel of the Danube. This effect has been observed as a result of the hydroelectric plant at the Iron Gate where sturgeon moved upstream to areas with greater water velocities. Other species adapted to slow-moving waters or lake environments (e.g., Centrarchidae) are expected to increase in numbers. Baseline data on the fish species' distribution and abundance would enable a better assessment to be made of the expected changes. Some significant, long-term changes in species composition and numbers, however, are likely to occur in the Dunakiliti reservoir and in the main channel once the flow rate is reduced by nearly 95 percent of the flow. This impact could be reduced by increasing the rate of flow discharged to the main channel.

Second, several pollution-sensitive species (e.g., barbel, sturgeon, silure) which had been observed to have decreased in fish catches (believed to have been due to deteriorated water quality and/or pollution of bottom sediments), appear in recent years to be increasing in the area. The observed increase in numbers of non-stocked species is attributed to a recent trend toward improvement in water quality in the main channel of the Danube. Increasing numbers of other species (e.g., sterlet, carp) are due to stocking efforts in the area.

A third trend noted from fish catch data is the increasing proportion of young fish caught which, considered with the steady restocking rate, indicates that the natural proliferation rate is decreasing. As an example, the pike, which has a relatively low oxygen demand and high-vitality young which begin predator feeding early, is declining. This decline is believed attributable to a decreasing proliferation rate combined with intensive fishing.

Potential Impacts. Although the fish stocks of the Szigetköz region are generally known, no specific information on species' abundance, distribution, seasonal habitat use, spawning times, or spawning areas was available. Due to the lack of specific data, impacts on fish species cannot be accurately identified. The following discussion identifies potential impacts expected to occur, but cannot defensibly quantify the impacts or predict differential impacts by species. Seasonal fish surveys are strongly recommended to provide a preproject database. The database can be used to better assess the impacts expected to occur, develop appropriate mitigation and/or monitoring programs, and monitor impacts during project operations.

The fish surveys should be designed to identify all species present, their abundance, seasonal habitat use, migration patterns, spawning locations, and spawning schedule. The surveys should be conducted over a period of 1 year prior to project operation (i.e., diversion of the water from the main channel). These surveys should include standard sampling techniques (e.g., electroshocking, gill nets, and long lines) selected to characterize different species and life stages in appropriate locations in the main channel, the side arm system, and the Mosoni Danube.

A number of species migrate into the side channel system to spawn (e.g., white fish, sterlet) and then return to the main channel. The side arm system is extremely important habitat for spawning, due to the loss of most spawning habitat in the main channel; and supporting fry, which drift through the side channels feeding on abundant plankton for several weeks before being swept downstream and eventually into the main channel. Spawning in the side arm system supports fish stock that inhabit the main channel of the Danube below Komárom. Seasonal flooding of the side arm system includes considerable sedimentation which provides organics to support food organisms. Approximately 30 spawning locations are identified on a map of the Szigetköz side arm system.

The Mosoni Danube also provides important fish habitat. Masses of adult fish migrate upstream from the Danube into the Mosoni to spawning grounds. The water quality in the Mosoni varies considerably by area and over time depending on waste water loads discharged from Györ and other locations. Occasional fish kills have been observed in the Mosoni Danube.

General Trends. The fish fauna of the Danube River has been altered considerably over time due to several activities. The most significant changes were due to river control activities including diking, dredging, and channelizing - which eliminated natural habitat (including important spawning beds). The fish fauna also has been affected by stocking with artificially hatched fish including grass and bighead carp, sterlet, pike, eel, and pike perch to support commercial fishing and angling. Also, several species have been affected by deteriorated water quality and eutrophication resulting from waste water discharges into the Mosoni and the Danube. Other species have been overfished (e.g., sterlet).

Several trends are notable as indicative of the current condition of the fish stocks and their habitat in this reach. First, the annual total catch has decreased by 11 percent from 1968 to 1986 despite stocking efforts. The amount of fish in the Mosoni Danube has declined more significantly than the overall catch of the Szigetköz area. The proportion of carp, pike, and pike perch decreased over this time.

Szigetköz-Gönyü - Fish. This reach is recognized as important to the fish ecology and is known to support 55 fish species. Although no fish surveys were conducted for the project, generalizations can be made regarding the abundance and distribution of some species based on fisheries production and harvest data. The carp family (Cyprinidae) is dominant both in terms of species richness and abundance. Some species have been introduced into this reach by direct stocking (e.g., grass carp, silver carp) or by escaping from other stocked areas (e.g., eel).

Significant Habitats. The reach from Dunakiliti as far downstream as Komárom is particularly important due to its varied hydrological conditions, which support many different fish species and life stages. The availability of heterogeneous habitat in this reach of the Danube and its laterals is advantageous to the fish populations as it provides diverse conditions to support different species, spawning and rearing habitat, and abundant food organisms. This reach is a complex system consisting of three distinct, but interrelated, water bodies: the main channel of the Danube, the side channel/oxbow system, and the Mosoni Danube.

The main channel of the Danube includes a diversity of water and substrate conditions. This reach of the Danube includes rapidly moving water masses and other conditions important to some species (e.g., barbel, pike perch, asp) which live in the main channel. Many of these species inhabit the Danube throughout most of the year, migrating upstream 50-150 km in the spring to spawn in the side channels. Currently, there is little remaining natural spawning habitat in the main channel except for five locations in protected backwater channels behind islands.

The side channel/oxbow system in the Szigetköz also provides important habitat for fish species. Currently, these laterals are closed to the Danube at their upsteam ends, open to the main channel at their downstream end, and predominantly recharged by seasonal flooding over the dikes from the Danube. Some species inhabit the side channels, dead arms, and ponds year-round (e.g., tench and crucian carp). Other species, artifically populated through stocking efforts, are common in the side arms and uncommon in the main channel (e.g., grass carp, bighead carp).

Particularly sensitive are the heronry and a black stork nest at Ásványráró. The heronry has been estimated to have 100-120 nests regularly used by gray herons (Ardea cinerea) on a single island 1-2 ha in size. The island is vegetated with Populus canadensis and Salvix alba estimated to be 40-50 years old. Additionally, a tree was observed to have approximately 20 nests. One lake in this area is of particular importance as feeding habitat for adult and young herons, due to its high density of crustaceans. The lake has been connected to a side arm/oxbow by a shallow, narrow channel which allows it to be flooded occasionally. The location of the black stork nest is known only to local foresters.

This area currently has many side channels seasonally connected to and exchanging water with the main channel. These inlets would be diked off prior to project operation in order to confine water to the side channels. The oxbow system at Ásványráró would then receive flow from one upstream channel. The flow rate should be regulated during operations so that changes in water levels and water quality will not affect the heron feeding lake or nesting trees, otherwise changes could result in a long-term regionally significant impact on the species.

Additionally, it is recommended that the area near Ásványráró which is important to herons and other waterbirds be established as a permanent preserve protected from human activities. Human use (e.g., timber management, development, recreational facilities) should be avoided to prevent additional stresses on this biologically important area.

The potential for impacts on other wildlife (e.g., protected mammals) could not be assessed because no baseline mammal surveys have been conducted. A literature search on mammals (particularly protected species) should be conducted to identify possible occurrence in the Szigetköz area that may be affected by project operations. Based on the literature search, seasonal surveys should be implemented to characterize occurrence and habitat use over a 1-year period prior to project operations.

Plans have been developed to maintain the preproject ground water levels in the Szigetköz area by releasing water from the Hrusov-Dunakiliti reservoir into the side arm channel system and fortifying the dikes which already separate the side arm channels from the main channel. Together with the intermediate closures in the side arms, ten small pools will be formed. Water overtopping these riprap dikes will feed successive pools. The side channel flow will recharge the ground water. The excess flow will pass over a rockfill drip structure at the downstream end of the side channel system and return to the main channel. To control variable seepage into the ground water, flow levels in the side channel system can be regulated.

To minimize the risk of an unwanted drop in the Szigetköz area ground water level and associated adverse impacts to important habitats when the flow is initially diverted from the main Danube channel, it is recommended that the flow at the Dunakiliti weir be reduced in incremental steps. At each step, the reduced flow in the main channel is held constant until the new flow into the side channel system has sufficiently stabilized the local ground water level. This procedure should continue until the Danube flow is reduced to 100 m^3/sec or the selected minimum old channel flow. This procedure should be followed when flow is diverted from the Danube channel for the first time.

Due to the uniqueness of this system and the lack of baseline data, impacts on wildlife, particularly waterbirds using the side arm system, cannot be assessed accurately. In the event that the surface water levels dropped significantly in the side arms, important breeding and feeding habitat could be lost and adverse impacts on waterbirds could result, which should be avoided by all means.

<u>Ásványráró Area</u>. It is evident from the limited data that one area in which the hydrolic regime requires special attention is located near Ásványráró. This area is known to support significant numbers of waterfowl, including nesting gray herons, night herons, cormorants, mute swans, mallards, coots, and a pair of black storks.

Project-related impacts on any of these four protected bird species could be long-term and regionally significant due to their limited distribution and abundance and specific breeding habitat requirements. Special attention should be directed toward preventing changes to the hydrologic regime which could adversely affect habitats of these species.

Mitigations to maintain adequate water levels and flow should include alternatives to the operation mode and flow releases. Another mitigation would be planned monitoring of changes in vegetation at these sites during project operations, and adjustments in the flow in the side channels and/or main channel should the vegetation begin to be affected adversely. A baseline survey of the four protected bird species to characterize the distribution, abundance, and seasonal habitat use of this area of the Szigetköz is recommended. Data from the surveys could be used to map seasonal habitat use so that specific areas could be monitored for adverse changes during project operations. Monitoring results could then direct any adjustments necessary in flow rates and timing in the side channels system and/or main channel to maintain these breeding habitats for these sensitive species.

Wetlands and Riparian Areas. Project operations also present the potential to affect wildlife inhabiting the wetlands and riparian areas in the floodplains of the side arm/oxbow system of the Danube. Most of the inlets of this side arm system have been diked off from the main channel and intermediate dikes have been constructed, so that the surface water in the side arm system is only recharged by seasonal flooding (i.e., "white flood" from January to March and "green flood" in May-June). Currently, the ground water gradient is such that at low river stages it slopes towards the Danube, whereas at high stages the Danube recharges the ground water in this area. Once the project is operational, around 100 m^3/s of flow are released to the main channel at Dunakiliti (compared to an average preproject flow of 2,000 m^3/s). The ground water table in the area adjacent to the old channel is expected to drop by 5 m at the Dunakiliti weir decreasing to 0 m at the confluence with the tailrace channel. This is expected to result in potential loss of water from the side arms which could result in loss of wetland or riparian habitat important to waterfowl.

habitat (based on the expected increase in depth to ground water and water requirements of dominant plant species). This would allow more definitive prediction of the expected impact and could be used for determining the mode of operation and flow release to the old Danube River channel.

Four protected bird species which utilize habitat potentially affected by project operation were identified. The little ringed plover (Charadrius dubius) is known to nest and breed between stones in the sandy areas of the floodplain along the main channel of the Danube. This species could be adversely affected by the alteration of habitat along the main channel during project operations. The likelihood of this impact cannot be assessed due to lack of information on its distribution and habitat use in the vicinity of the project.

In the Szigetköz, the protected willow tit (Parus montanus) is only known to occur and breed in the hardwood forest at Dunasziget (biological monitoring station no. 2). The oak gallery forest which it inhabits is on an elevated floodplain circumscribed by two branches of the side channels and the main channel of the Danube. Any change in habitat would adversely affect this species. While no change in the water regime is expected, additional information regarding its distribution and habitat use is needed to determine the likelihood of adverse impacts to this species.

The treecreeper (Certhia familiaris) is known to breed in the Dunasziget forest (biological monitoring station no. 2) and also has been observed at Ásványráró (biological monitoring station no. 7), but not during the breeding season. Conditions similar to those described for Parus montanus apply to this species.

The fourth protected bird species which could be affected by the project is the penduline tit (Remiz pendulinus) which nests and breeds in the willows at Dunaremete (biological monitoring station no. 5). While the ground water table maintained by the release into the side arm system is not anticipated to affect the willow habitat which this species inhabits, the likelihood of adverse impacts to this species cannot be determined at this time.

An impact is considered "regionally significant" if it is expected to directly or indirectly cause measurable change within multiple localized areas or a single large area. In other words, it is considered regionally significant if the affected area is a relatively large portion of the ecologically equivalent area within the region.

An impact is considered "long-term" if the change in species composition or abundance or ecological function is expected to continue for 5 years or longer. Measurable changes expected to last less than 5 years are considered "short-term."

The threshold for significance is determined by scientific judgment and considers the relative importance of the species and/or habitat affected. Where there is uncertainty about the determination of an impact due to the limited database, judgments were conservative. In such cases, uncertainties are identified and the rationale for the conclusion is explained. In selected instances, a most likely case and a less likely, but more severe, case are both identified - particularly where impacts are generally expected to be insignificant, but could become significant given certain conditions. The probability of a significant impact in these cases is indicated to the maximum extent feasible. Identifying more than one possible level of significance may also occur where baseline information on biological resources is inadequate to support a scientific judgment.

Although the same criteria are applied to protected species (e.g., threatened, endangered, or rare), effects on only a small area of their habitat or a few individuals could result in a determination of significance. Due to factors such as limited distribution, low population numbers, or limited ability to recover from impacts, a lower level of potential impact (than for non-endangered biota) would generally result in a determination of a significant impact on rare, threatened, or endangered species.

Biological resources for which additional baseline (e.g., preproject) data are needed to enable prediction of impacts also are identified, and general guidance on the types of additional data needed is given.

Aster spp.. An estimated 1,100 ha of managed poplar forest were cut and cleared for construction of the Dunakiliti reservoir.

Areas that are not easily accessible to equipment and narrow visual buffer strips have remained unmanaged. Areas that are not planted in poplars (20-30 percent) consist of natural, but altered vegetation including the following associations: willow thicket (Salicetum purpureae, Salicetum triandrae); willow-poplar gallery forest (Salicetum albae-fragilis); and ash-oak-elm gallery forest (Fraxino pannonicae-ulmetum pannonicum). It can be extrapolated from the above information that 200-300 ha of natural vegetation were cleared for the Dunakiliti reservoir and are permanently lost as habitat. Mitigation for this impact is discussed below in conjunction with the loss of vegetation due to aridification.

Aridification. Once the project is operational, diversion of approximately 95 percent of the average flow of the Danube into the navigation canal will lower the ground water table between the main channel of the Danube and the diked-off side channel system, which will concommitantly result in alteration of floodplain vegetation. As described in more detail in Section 1.3, the planned operational discharge of 100 m^3/s (continuous) into the main channel which has an average natural flow of 2,000 m^3/s is expected to lower the ground water table approximately 1-3 m. It has been estimated that a 250-300 m wide zone of vegetation will be affected by this aridification. This drier zone will extend approximately 25 km downstream along the main channel of the Danube to just upstream of where the tailrace canal rejoins the Danube (i.e., the backwater confluence). Approximately 20 percent of the vegetation in this zone is natural vegetation with most of the area consisting of planted poplar.

Based on the correlation between vegetative associations and annual mean water levels in the soil, it is expected that the natural vegetation within this zone will change over time. Areas of willow (Salix purpurea, S. triandra) and willow-poplar gallery forest (Salix alba, S. fragilis) are expected to be replaced by vegetation adapted to dryer soils, such as oak-steppe and dry grasslands.

2.2.2 Impact Discussion

The construction and operation of the GNB project has the potential to affect biological resources inhabiting the Danube River and adjacent floodplain areas.

Significant impacts expected to result from the construction and operation of the project are identified, their significance is assessed, project-planned mitigation measures are described, and additional mitigation measures are recommended below. In some cases, available information does not allow a determination of the likelihood or significance of an impact. In these cases, potential impacts are identified and the additional data needed to adequately assess and mitigate such impacts are described briefly. Biological impacts are identified for each of four reaches, Szigetköz-Gönyü, Gönyü-Nyergesújfalu, Nyergesújfalu-Nagymaros, and Nagymaros-Budapest.

Szigetköz-Gönyü - Vegetation. Discussion of impacts on vegetation in this section focuses on effects on natural vegetation. Effects on agricultural crops and managed (i.e., harvested) forests are discussed in Land Use (Section 2.3).

Construction of the Hrusov-Dunakiliti reservoir, the diversion canal, the Gabcikovo (Bös) Barrage System, and ancillary support facilities (e.g., access roads) included clearing of forest and riparian vegetation which is permanently lost. Although the vegetation of this area was not specifically characterized prior to clearing activities, some general conclusions can be made regarding loss of the natural vegetation.

General Impacts. Generally, the floodplain vegetation of this reach of the Danube has experienced strong anthropogenic effects from flood management, silvicultural practices, and management of wild game species. An estimated 70-80 percent of the floodplain vegetation consists of artificial (i.e., managed) stands of poplar. These poplar plantations do not support the natural understory vegetation, but instead develop an herbaceous layer following flooding. This layer consists primarily of 3 m tall stands of *Impatiens glandulifera*, (an introduced species), *Urtica dioica*, and

Loss of willow thicket and willow-poplar gallery forest vegetation due to clearing for the Dunakiliti reservoir and lowering of the ground water table in the zone along 25 km of the Danube will measurably reduce the number of these natural habitats in the Szigetköz area. This loss of vegetation will be a long-term impact of the project. Vegetation cleared for the Dunakiliti reservoir is permanently lost, and alternation of willow thicket and willow-poplar forest vegetation to associations requiring less water is also expected to be permanent.

These habitats already have been reduced in the Szigetköz, and the additional reductions resulting from the project will include a considerable portion of the remaining natural vegetation. Additionally, these natural vegetation types are ecologically important because they support a greater diversity and abundance of bird species than do the planted poplar stands in the floodplain of the Danube. Because of the importance of this natural vegetation, the extent of the area to be affected, and the long-term nature of the effect, this is considered to be a long-term, regionally significant impact.

Mitigation Measures. Three types of mitigation are possible for this impact on natural vegetation. First and preferably, the impact could be reduced by increasing the flow released continuously to the main channel of the Danube. The degree of mitigation would depend on the increase in flow and associated ground water levels.

Second, this impact could be reduced somewhat by developing and implementing a revegetation plan to reestablish natural vegetation in the Szigetköz. To facilitate reestablishment of natural vegetation, riparian areas around the Dunakiliti reservoir could be planted with suitable native species. For example, the possibility of sprigging with unrooted Salix species should be considered. Riparian vegetation, however, is expected to establish naturally around the reservoir. This mitigation measure would expedite replacing lost habitat, but would not fully offset the acreage lost permanently to the project.

Third, a revegetation plan also could be developed to begin implementation of the planned, but currently unfunded, expansion of the remnants of native forest along the Mosoni Danube, which is one of the objectives of the Szigetköz Landscape Protection Area policy. For example, acreage immediately adjacent to the remnant oak hardwood forest at the Hédervár forest monitoring station could be obtained, cleared, and planted with appropriate species. Reestablishment of this type of natural, high-diversity vegetation which supports a more diverse fauna could offset the adverse impact of the loss of natural vegetation in the floodplain. The minimum mitigation recommended for the project includes increasing the flow releases to the main channel and reestablishment of expanded acreage of the remmant hardwood forests along the Mosoni Danube. Facilitating reestablishment of riparian vegetation at the Dunakiliti reservoir also should be included but is not considered as important as the other two mitigations.

Other Impacts. Other potential impacts on vegetation identified in the Szigetköz-Gönyü reach were evaluated and considered to be insignificant. No significant impacts are expected on the old forest vegetation (e.g., Hédervár, Feketeerdö) and associated protected plant species (e.g., *Lilium bulbiferum*, *Ophrys spp.* and *Iris sibirica*) along the Mosoni Danube because the flow of the Mosoni will be maintained (i.e., slightly increased) during project operations, and ground water levels in the adjacent areas are not expected to change (Section 2.2). Additionally, the project will not alter any land within these "strictly protected areas" of the Szigetköz.

Natural vegetation occurring in the vicinity of the Danube side channel/oxbows is not expected to experience significant adverse impacts. Reeds, willow-poplar gallery, willow thicket, and other natural vegetation comprise approximately 20 percent of the total vegetation and exist in areas not suitable for silviculture (e.g., abandoned borrow pits). This type of vegetation will be supported by maintaining the water level in the side channels. Although some localized changes in species composition are expected in response to alteration of ground water levels (e.g., decreased ground water levels toward the center of larger islands in side arms), these changes are not expected to result in significant impacts on the natural wetland and riparian vegetation.

The effectiveness of the system to maintain water in the side channels will need to be monitored. If the ground water level drops, significant impacts on natural vegetation could occur.

Areas of water-lily mats (e.g., Nymphaea alba, Nuphar lutea) are considered rare in the area (Simon and Lang, 1989), occurring in an estimated 20 locations among the side channels in shallow water depths (2 m or less). Water lily mats may be expected to be lost in localized areas where water depths increase beyond 2 m, but to develop in areas where water depths decrease to suitable depths (2 m or less). Overall, this is not expected to be a significant impact.

Szigetköz-Gönyü - Wildlife. A limited amount of specific information on birds in the Szigetköz is available and was used in assessing impacts. Due to lack of data, identification of impacts on other wildlife species and habitats is limited to a general discussion of potential impacts.

Construction Activities. Generally, exposing birds and mammals to construction noise disturbs them temporarily. It can also result in the abandonment of breeding sites or habitat, which could result in a significant adverse impact on species which have very limited abundance or specialized breeding habitats. However, no such species are known to occur, or expected to have been affected, in the vicinity of the Dunakiliti reservoir site. Because similar habitats exist in the area, and no known species of particularly sensitive bird and mammal occurs, the temporary construction noise disturbance is expected to have no significant impact. However, a definitive impact determination cannot be made because the fauna of the area was not surveyed and identified prior to construction.

Construction activities at the Dunakiliti reservoir will result in some bird and mammal mortality and displacement of additional individuals due to loss of habitat. As with construction noise impacts, this is not known to have affected any bird or mammal species of limited numbers or restricted habitat. Such impacts are not expected to be significant. Again, however, this is not a definitive determination because preconstruction, species-specific information for the reservoir site is not available.

Operating Activities. Operation of the project will result in additional displacement impacts on birds and mammals. This will be due to the loss of, or changes to, habitat along the old channel of the Danube resulting from lowering of the ground water level in the 250-300 m zone between the old channel and the diked off side arms (as described under vegetation). Because habitats and associated wildlife of this area have not been characterized and mapped, this impact cannot be quantified or assessed by species.

Danube Floodplain. It is generally known, however, that the Danube floodplain area to be affected by the project supports a wide diversity of bird species, including significant numbers of waterfowl, some of which are residents of the area during the breeding season (as observed at monitoring station no. 4) including: little grebe (*Podiceps ruficollis*), garganey (*Anas querquedula*), teal (*Anas crecca*), green sandpiper (*Tringa ochropolus*), and common sandpiper (*Tringa hypoleucos*). It is considered likely that the 95 percent reduction of flow to the old channel and resultant loss of aquatic and riparian vegetation (within the zone between the main channel and the side arm system) will affect a wide diversity of species and substantial numbers along the 25 km reach. This is expected to be a regionally significant long-term impact. Some utilization of aquatic and riparian habitat may be shifted to similar habitats in the adjacent side arm system. This will depend upon the comparable quality of the habitat and existing faunal populations. This possibility needs further study.

Increasing the operational flow to the old Danube River channel could also reduce this impact. The resultant impact on aquatic and riparian habitat and waterfowl would be smaller as the continuous minimum releases increase.

To better determine the potential impact and evaluate the need for this mitigation and alternate flow releases, quarterly seasonal surveys of waterfowl species, habitat usage, and habitat type are strongly recommended. These surveys should be conducted for a 1-year period within the area that may be affected by project operation. Once these data have been collected, the waterfowl usage and wetlands habitat of the area can be mapped. The information could then be compared to an estimation of the expected changes in